E-Commerce

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Preface

E-commerce provides immense capability for connectivity through buying and selling activities all over the world. During the last two decades new concepts of business have evolved due popularity of the Internet, providing new business opportunities for commercial organisations and are being further influenced by user activities of newer applications of the Internet. Business transactions are made possible through a combination of secure data processing, networking technologies and interactivity functions. Business models are also being subjected to continuous external forces of technological evolution, innovative solutions derived through competition, creation of legal boundaries through legislation and social change.

The web environment supports business transactions and is mainly dependent on user interface designed around business web sites. The major advantage of e-commerce is that a business can dynamically and quickly assist customers and also function effectively through rapid business transactions, allowing business to focus on services, enhancing performance and providing a means for quick decision making. Web based e-commerce is also more convenient to customers because it enables them to access web sites from different physical locations and without restrictions time zones.

The main purpose of this book is provide the reader with a familiarity of the web based e-commerce environment and position them to confidently deal with a competitive global business environment. The book contains a numbers of case studies providing the reader with different perspectives in interface design, technology usage, quality measurement and performance aspects of developing web-based e-commerce.

What is in this book?

The contents of this book have been provided by experienced practitioners and academic researchers who have influenced changes in the e-commerce environment since its conception. This book recommended for practitioners and academic researchers alike involved in development of e-commerce. The case-studies covered in this book provide a balance of theoretical foundation and practical challenges in e-commerce models, interface design, technology and system environment in various countries.

This book is organised in four parts consisting of a total of 15 chapters. These are:

Part I: Models for E-commerce (Chapter 1-4): SOA, Satisfaction, TECTAM and Enterprise model

Part II: Serviceable Web (Chapter 5-8): Cross-Organisation, Social Network in Business, Culture and Color

Part III: Quality and Improvement (Chapter 9-11): Quality Assurance, Performance and Watermarking

Part IV: E-commerce Place (Chapter 12-15): A Case in Developing Country, System, Mobile Commerce and Cellular Data System

Chapters and topics:

1. A conceptual framework and an extended SOA model for consumer-oriented e-commerce
2. E-Commerce Customer Satisfaction Model Assessment under Fuzzy Situation with Fuzzy TOPSIS Method
3. TECTAM: A Propose Model for Studying Technology Acceptance Model to Gain Knowledge on the Adoption and Use of E-Commerce/E-Business Technology in Small and Medium Enterprises in Thailand
4. Autonomous Decentralized Enterprise Model
5. Modular architecture framework for cross-organizational electronic interaction
6. Ranking Companies Based on Multiple Social Networks Mined from the Web
7. Considering Culture in Designing Web Based E-commerce
8. Effects of The Colors of E-commerce Websites upon Memorization and Intent for Buying
9. A Framework for Quality Assurance of Electronic Commerce Websites
10. Improving performance in recommender system: collaborative filtering algorithm and user's rating pattern
11. Attacks on Two Buyer-Seller Watermarking Protocols and an Improvement for Revocable Anonymity
12. Electronic Commerce Readiness in Developing Countries: The Case of the Chinese Grocery Industry
13. Can a Recommender System induce serendipitous encounters?
14. A Mobile Commerce Model for Automobile Rescue Services
15. A Traceability Function of the Cellular Data System

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A Conceptual Framework and an Extended SOA Model for Consumer-Oriented E-Commerce

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1. Introduction

Value creation in e-commerce is dominated by business-oriented approaches. For example, the two basic types of e-commerce, B2B and B2C, aim at business cooperation or exchanges and increased sales, respectively. The tacit assumptions here are that business firms know (better) customers' needs and value comes for the business firm and the customer alike through the improvement of the business processes.

A shift in the conceptualization of value creation from business-oriented to consumer-oriented approaches is taking place gradually in the recent literature. The consumer is recognized as a "co-creator of value" and the business firm as a "service provider", which operates to provide benefit (i.e. "service") to the consumer. The value for the consumer derives from the combination of service elements that usually come from different providers, because of the complex nature and the diversity of people's needs. The role of the business firm is to support the consumer in creating value by enabling his participation in value creation and by producing products and services as the pre-conditions for value creation.

This chapter contributes in the development of consumer-oriented e-commerce, that is e-commerce models that focus on the needs of the consumer (the end-customer, the individual), by providing a conceptual framework and an extended SOA model. The purpose of consumer-oriented e-commerce is to empower the consumer in the creation of value according to his personal preferences and needs by composing service from different business firms. Consumer-oriented e-commerce is based on the conceptualization of service, which attracts multidisciplinary interest, and a consumer-oriented ideology that reverses the traditional, business-oriented value creation concepts. The conceptual framework considers service as a collaborative knowledge-based process for value creation. The extended SOA model suggests the use of SOA beyond operational practices for the integration of business processes and the interoperation of information systems and considers the strategic impact of SOA for the development of innovative business models in electronic markets. The extended SOA model can become the technological underlay for the composition of service

and value from different business providers and Semantic Web Services can become a key enabling technology in this effort.

2. An overview of customer-oriented concepts

In this section we review some consumer-oriented concepts that have been developed in the literature in business-related and IT-related fields, including service management, value creation, e-services, business ecosystems, enterprise architectures, SOA and Web Services and the Semantic Web and the Web 2.0., we analyse their meaning and evaluate their impact.

2.1. Consumer-oriented concepts in value creation

There is quite a lot of research recently that focuses on the concerns and the role of the consumer in economic transactions and promotes consumer-oriented concepts in value creation. All this research suggests that a paradigm shift is apparently under way in regard to the concept of value and the way it is created. The evidence of this shift is not clearly manifested in business practice yet, because it challenges deeply rooted theories of business management and suggests reconsidering the role of the business firm in the economic setting.

We can distinguish three approaches on value creation: a) the production-oriented approach, b) the marketing-oriented approach and c) the consumer-oriented approach.

The *production-oriented approach* conveys the traditional ideas of the manufacturing paradigm and expresses the notion of "value-in-production". Here emphasis is put on the role of the producer. The basic assumption is that the producer creates value, which is embedded in the product and becomes an attribute of it. The customer, on the other hand, consumes the value that has been created. As a result, each piece of product should normally contain the same amount of value and each customer should receive the same amount of value by consuming any piece of product. The value chain analysis is a key instrument of this approach, with value being added incrementally in each business activity that takes place along the intra-firm or the inter-firm value chain.

The *marketing-oriented approach* is an extension of the production-oriented approach that introduces the notion of "value-in-dissemination" and draws attention to the role of marketing in organisations as a means for the creation and dissemination of value. The marketing mix is the key instrument of this approach, with value being added on the total offering to the consumer through the successful manipulation of the "four P's". The product is still a container of value, but emphasis is put on the way that the firm manages to promote it, disseminate it and sell it.

A marketing-oriented organisation recognizes the significance of the customer, tries to understand the customer concerns, develops an interest for the customer (genuine or not) and tries to develop new approaches to become more responsive to the customer needs. Yet, value is still developed as business value. In other words, it is the business firm that recognizes customer needs, groups customers together and dictates how customer can satisfy their needs; it is the business firm that uses the acquired knowledge for the customer and develops marketing techniques to manipulate the customer choices. The role of the consumer remains passive and exogenous to value creation (Lusch et al., 2007).

The *consumer-oriented approach* introduces the notion of "value-in-use" by suggesting that value is created only when products or services are used by the consumer. The basic assumption here is that the consumers, not the business firms, have value-adding activities (Normann & Ramirez, 1993) and activity chains (Sawhney et al., 2003) and that the business processes create the pre-conditions for the creation of value. Value is, in fact, defined by the consumer during the selection of offerings, i.e. products or services, and created by the consumer during the consumption of the offerings. Business offerings have value to the degree that consumers can use them to leverage their own value. The role of the business firm is still important, but shifts from a "value creator" to an "enabler of value creation". According to Vargo and Lusch (2004), the firm can only make value propositions and then, if the proposition is accepted, to co-create value with the consumer. The consumer, on the other hand, becomes a "co-creator of value".

The concept that the consumer participates in the creation of value is well established in the literature (e.g. Normann & Ramirez, 1993; Prahalad & Ramaswamy, 2004; Zuboff & Maxmin, 2004; Von Hippel, 2006). Lusch et al. (2007) distinguish between value co-creation and value co-production; the former refers to the determinant and catalytic role of the consumer in the creation of value, while the latter refers to the supportive role of the consumer in the execution of business processes (e.g. in self-service settings, in design processes, in finishing products or services, etc.). Customer participation and co-production schemes are popular in the context of business-to-business collaboration; however, they are still a grey area in the relationships with the consumer and a question mark whether they truly serve the consumers needs. Customer self-service, for example, is frequently imposed on consumers in order to reduce operational costs, regardless of their willingness to do it. Even worse, customer self-service sometimes forms the basis for discrimination between customers, with the frequent or good customers being served by professional, while the others are doomed in the self-service mode.

The consumer-oriented approach in value creation generates a new situation for businesses and affects their relationships with the consumer. Some authors describe the new situation as the "relationship economy" or the "support economy" (Zuboff & Maxmin, 2004), with markets being transformed into "forums" (Prahalad & Ramaswamy, 2000), in which consumers can enter into dialogue about their needs with business firms and peers and synthesize individualized solutions that fulfil their needs.

2.2. Consumer-oriented concepts in service management

The development of consumer-oriented concepts found fertile ground in the field of service management and service marketing. The Service-Dominant Logic (Vargo & Lusch, 2004) and the Nordic School of service management (e.g. Grönroos, 2006) in particular endorse consumer-oriented concepts.

The Service-Dominant Logic has been recognized as a conceptual foundation for a service-based economy, as well as for the development of service science (Lusch et al. 2007b, Maglio & Spohrer, 2008, Spohrer et al., 2008). Service is defined here as the application of specialized competences (knowledge and skills) for the benefit of another entity (Vargo & Lusch, 2004). Hence, the fundamental unit of exchange in all cases is the application of specialized skills and knowledge, despite the fact that the embodiment of knowledge in tangible outputs creates the deceptive distinction between products and services. In essence,

all economies are service economies, because the exchange of knowledge and skills characterizes all economic activities (Vargo & Lusch, 2004).
According to the Service-Dominant Logic, value creation is based on service provision. Since the benefit from the service provision is manifested in the context of the customer, it means that what firms provide should not be understood in terms of outputs with value, but rather as inputs for a continuing value-creation process with and by the consumers.
The Nordic School takes a customer-oriented and relationship-focused perspective on business and considers that the concept of serving the customer should be spread throughout the organisation and embedded in all business functions. Service management seeks to understand the utility or value received by consumers in consuming or using business offerings and how services alone or together with physical goods contribute to this utility (Grönroos, 1990). A service management perspective changes the general focus of management in all firms from the product-based utility to the total utility in the consumer relationship. The focusing on the total utility, instead of more narrowly on the product-based utility, means that the value added for the consumers coming from other elements of the relationships with the consumer is considered equally important as the value that is intrinsic in the business offering.
Gummesson (1994) argues that the traditional division between goods and services is void. The business offering consists of many components, some of them being activities (services), some being things (goods). The consumer does not buy goods or services, but an offering, which renders service to the consumer and creates value for the consumer. As a result, we need to redefine our theories and develop them from a consumer perspective. The shift in focus to the concept of service is a shift from the means and the producer perspective to the utilization and the consumer perspective.
If the consumer-oriented concepts for value creation are right, then the business firms should reconsider their business models according to the concept of service and they should try to identify how to innovate with services and co-create value with the consumer. This is, in general, the purpose of service science (Chesbrough & Spohrer, 2006), which is conceived as a multidisciplinary effort to understand the nature of services, how they should be designed, produced and delivered and how to innovate in a service-based economy.

2.3. Consumer-oriented concepts in e-services

The bulk of services are data and knowledge intensive (e.g. consulting services, technical support services, healthcare, etc.). In addition, the composition, coordination and delivery of services for the consumer are data and knowledge intensive processes. Consequently, information technology and the Internet have great significance in a service-based economy.
The term e-service is not defined precisely in the literature. Rust & Lemon (2001) consider that the term is used in general to denote transactions in which information is the primary value exchanged. Gronroos et al. (2000) claim that e-service is any product or service that is exchanged over the Internet. Others restrict their scope on services that are delivered electronically (Javalgi et al. 2004) or over electronic networks (Rust & Kannan, 2003).
Assuming that e-service is based on the concept of service, as presented in the previous section, then it has all the attributes of the service and it is consumer-oriented, too. Information technologies and the Internet are supposed to favour consumer-oriented concepts, because they provide more consumption and transaction options to the consumers. Besides, the consumers can obtain more and better quality information for the

various options they have and they become more knowledgeable and, therefore, more powerful. The Internet tends to shift bargaining power to end consumers in their transactions with businesses (Porter, 2001), because it allows the end consumer to get in contact directly with a great number of producers. In certain cases, disintermediation becomes so extensive that consumers acquire access to services that were used to be available only to professionals. For all these reasons, the information technologies and the Internet tend to enable the consumers to play an active role in the selection and composition of service according to their personal preferences and needs and in the creation of value for themselves.

Another source of benefit comes from the decreased cost of customization of digital services, which makes selling customized services economically feasible, even in small market segments. The concepts of "mass customisation" (Gilmore & Pine 2000), "one-to-one marketing" (Peppers et al., 1999) and "long tail economics" (Anderson, 2006) are based on the premise that, with the support of the information technologies, business firms are able to target each consumer separately, personalise their services and disseminate them efficiently. Information technologies enable also the business firms to interact and build relationships with consumers with the use of a variety of channels. As far as the communication with consumers becomes more flexible and less expensive, it is easier for the business firm to provide personalised information and service to different consumers.

2.4. Consumer-oriented concepts in business networks and ecosystems

In traditional business thinking, value creation in considered a linear business function, with the one firm passing its output to the next link along the supply/ value chain, until the consumer. However, as customer needs become more complex and varied, so do the products or services and the processes that are required to produce them. Linear relationships are no longer effective because a variety of inputs from different producers are fused simultaneously in the production process.

Network structures have been developed as a means for the collaboration of a great variety of business firms, including partners, allies, suppliers and consumers. The underlying goal of these networks is to work together to co-produce value by creating an improved fit between business competencies, on the one hand, and customer needs, on the other. In business networks, the focus shifts from the supplier to the whole business network as an entire value-creating system.

We can distinguish between business-oriented networks and customer-oriented networks; the former are created to support business objectives mostly, such as the need for efficiency, and tend to be organised in long-standing structures, such as business alliances; the latter are created to serve the increased and specialized customer needs and may be organised either in stable structures or in a per-project basis. Virtual organisations, for example, are temporary networks that are formed to execute a specific project according to the requirements of the customer. In customer-oriented networks, the role of the customer is outstanding, because the business network in developed to respond to his special needs, which should reflect on the purpose, the structure and the operations of the network.

In the literature we can find different kinds of business networks, such as business constellations (Normann & Ramirez, 1993), extended enterprises (Prahalad & Ramaswamy, 2003), value nets (Bovet & Martha, 2000), virtual enterprises (Sawhney & Parikh, 2001;

Walters & Lancaster, 1999), strategic networks (Jarillo, 1988) and business ecosystems (Moore, 1996; Iansity & Levien, 2004).
The concept of business ecosystem is a metaphor that steps forward the movement towards symbiotic and co-evolutionary business networks. The business ecosystem is an economic community comprised of a number of interacting organisations and individuals, including suppliers, producers, competitors, consumers and other stakeholders, that produces goods and services of value for the consumers (Moore, 1996). All the entities in a business ecosystem are interconnected to each other, in a sense that they have an affect on each other. Business ecosystems propose a holistic way to examine the business enterprise and its relationships with its environment, showing concern for all the stakeholders.
Business ecosystems can be thought as a sophisticated kind of business network, with several advantages over other forms of business networks. For example, business ecosystems concentrate large populations of different kinds of business entities. They transcend industry and supply chain boundaries and assemble a variety of organisations that can complement each other and synergistically produce composite products. Interdependence and symbiotic relationships are inherent attributes in business ecosystems; as a result, the participants counter a mutual fate and co-evolve with each other. But in parallel, members compete with each other for the acquirement of resources and the attraction of consumers.
Fragidis et al. (2007) believe that the role of the end customer is undervalued in business ecosystems and propose a conceptual model of a customer-centric business ecosystem. It is a constellation of other business ecosystems and individual business entities that are dynamically developed around the customer, according to his/her preferences and needs. Connections among business entities are flexible and temporary and dissolve after the fulfilment of the customer needs. Public administration agencies are included in the customer-centric business ecosystem, too, because they perform activities that either add value directly or regulate the provision of products or services from the business partners.

2.5. The consumer-oriented potential of Web technologies

Consumer-oriented e-commerce cannot be developed unless there are the necessary Web technologies for this. Here we examine the capability of Service Oriented Architectures (SOA) and Web Services, which are considered the basic organizing paradigm and technological method, respectively, for the development of Internet-based business systems, to serve as the technological foundation for the development of consumer-oriented e-commerce models.
A SOA is a paradigm that is based on the concept of service for the organization, use and delivery of business functionality. The OASIS Group defines SOA as a powerful framework for matching needs and capabilities and for combining capabilities to address those needs (OASIS, 2006). Services in SOA are defined in a similar way to the definition of service in the business world, that is as deeds performed by the service provider for the benefit of the service client. In other words, the service provider has some capabilities that are expressed as services and get invoked by the service client in order to satisfy their needs. Consequently, from a conceptual point of view, SOA could be used to provide the technological foundations that are required for the empowerment of consumers in the selection, composition and consumption of products or services in electronic markets.

It is acknowledged that the philosophy of SOA is to be used in business environment to support the execution of business-to-business transactions. The major concern is the execution of business processes, resulting in the development of interoperability along the supply chain, the enhancement of the reusability of software resources and the achievement of organizational agility, defined in terms of flexible business transformation and costless development of new business processes. If SOA are going to be technological foundations for the development of consumer-oriented e-commerce models, then some enhancement is required in the typical SOA model.

From an operational point of view, a SOA can be implemented with the use of Web Services. The basic Web Services model endorses three roles (service requestor, service provider and service registry) and three operations (publish, find and bind). Web Services follow the "find, bind and invoke" paradigm, where a service requestor performs dynamic service search by querying the service registry for a service; if the service exists, the registry provides the requestor with contact details for the service.

Such an operational model is clearly consumer-oriented and could support consumer-oriented value creation. The service requestor recognizes some need, searches for solutions, makes the selection, invokes the service and composes it with other services in his own context, in order to create value for him. Hence, value creation is performed by the service requestor. The service provider has a passive and supportive to the requestor's value adding activities role; the service provider creates services that will be used by service requestors and disseminates them through intermediaries. The model includes intermediaries that support also the customer in creating value, by collecting a great array of services from different providers and providing information for their functionality, invocation and use. The OASIS Reference Model for SOA makes the distinction between the provider of the capability and the provider of the service that enables access to that capability (OASIS, 2006), which means that the provider of the service can be an intermediary, while the provider of the capability is the producer.

2.6. Consumer-oriented concepts in the Web 2.0 and the Semantic Web

The Web 2.0 and the Semantic Web are emerging phenomena that promise to exercise great impact on the future of e-commerce. In general, they are both distinguished by the belief that the Web technologies are moving to a next level of sophistication and by the ambition to revolutionize the way that people interact and transact on the Web. However, their definitions are still vague -or even equivocal- and their potential to bring significant business effects and concrete outcomes remain to be proved in practice.

Even though the term "Web 2.0" has received several interpretations by different people, the definition of O' Reily (in Musser, 2006), that it is a set of economic, social and technology trends that are based on user participation, openness and network effects, seems to be a common place. It is beyond doubt that consumer-oriented concepts can easily grow in such an environment. For instance, the most well-known success stories of the Web 2.0 (e.g. Wikipedia, Facebook, YouTube, etc.) are based on the concept of user participation. In all these cases, instead of business-generated content we see user-generated content; the users contribute directly or indirectly and collectively co-create content or experiences. The users are not only consumers, but also co-developers; they do not expect passively the fulfilment of their needs by the business firms, but they participate actively in the development of the products and services that meet their needs. Their motives for participation are related with

their needs to be heard by business firms, to create products, services and websites that fulfil their personal interests, to tailor offers according to their preferences, to experiment, learn and gain experiences, to contribute to the community, to offer to their peers and to communicate and share with the others.
The success of the Web 2.0 thus far, even though it is based on some new technologies (e,g, Ajax, Java, REST, RSS, mashups, etc), doesn't come solely from them. We consider that the success of the Web 2.0 stems from the development of a new business mentality that prioritizes users' needs and favours customer participation and co-creation. The question is whether this new consumer-oriented mentality can be transferred beyond the creation of content and entertainment activities to become a universal mode of transactions on the Web.
The Semantic Web, sometimes referred to as the "Web 3.0", was initially conceived as a virtual environment in which "a customer's value chain is dynamically created on the Web [with the support of] intelligent agents that collect Web content from diverse sources, process the information and exchange the results with other agents, each one adding value, to construct the final product requested by the end-user" (Berners-Lee et al., 2001). In other words, it implies that the consumers have, in fact, value-adding activities and the Semantic Web aims to support the consumer in the composition of personal solutions through the facilitation of mediating software agents. Therefore, the Semantic Web fosters in principle consumer-oriented concepts in value creation and could support the development of innovative business models regarding the role of consumers, providers and intermediaries. Nonetheless, the use of intelligence in order to manipulate the consumer, instead of supporting him, seems to be a strong temptation that can derail the Semantic Web from the consumer-oriented route. In a later section we discuss how we can exploit the semantics that the web services carry and what the expected benefits are in case we employ such a solution.

3. A conceptual framework for consumer-oriented e-commerce

The traditional business thinking is dominated by business-oriented concepts that emphasize the role of the producer. The development of e-commerce followed in the first stages this business-oriented tradition and sought to transfer the established business models from the physical to the digital world. However, as presented in the previous section, there is some evidence, both in the literature and the business practice, that the customer or the consumer has an important role in value creation. The Web technologies seem to have come to such a level of sophistication that they can support the development of innovative e-commerce models that are based on consumer-oriented approaches in value creation. Under these circumstances, it seems that we have reached to a maturity level for the development of consumer-oriented e-commerce models.
Consumer-oriented e-commerce cannot be another buzzword or a marketing trick that deceptively claims to serve the consumer's needs, while focusing on the business interests and pursuing to manipulate the consumer. Consumer-oriented e-commerce is a true opportunity for the business firms that wish to exploit the Web for the development of innovative business models in engaging the customer in business operations and empowering him in creating value. Some of the key characteristics of consumer-oriented e-commerce must the following:

- The role of the consumer is to participate and contribute in business operations and – most of all- to create value by composing offerings from one or different providers. The consumer is not an object, but the subject of the value adding processes.
- The role of the provider is to provide service to the consumer and support the consumer in participating and in creating value. Products and services are the pre-condition for value creation. The provider cannot have a better knowledge on the customer needs, which deprives him from the right to make the choices on behalf of the consumer and dictate consumption solutions.
- Business offerings are developed in a modular way and according to open models, so that the consumer can make choices and compose solutions from different providers.
- The distinction between B2C and C2C models is not important anymore. The important is who uses the value and how does it. Value creation takes place by composing elements from different sources, either by professionals or peers, either for money or free of charge.
- The composition of solutions and the creation of value for the consumer require support by specialized intermediaries that facilitate finding of the business offerings, evaluating and selecting the best alternatives, composing consumption solutions and coordinating the business processes that produce the required value. The role of such intermediaries in consumer-oriented e-commerce will be similar to the role of search engines in the Web.

A conceptual framework for consumer-oriented e-commerce can be based on a service-based view of business and, in particular, on the concept of service as a collaborative knowledge-based process for value creation. The concept of service as an activity that somebody does for the benefit of somebody else offers the right basement for this effort. First of all, the concept of service is value-oriented and customer-oriented, because the provider's activity is important only if it creates benefit for the receiver. In addition, service is a universal concept that covers all kinds of business offerings, including both tangible products and intangible services, because the purpose of every business offering is to bring some benefit to the customer; hence, business offerings are considered as service elements. Moreover, the concept of service can serve as the basis for a universal business model that includes the aspects of both the provider and the consumer; from the provider's point of view, service can be defined as a business process, while from the consumer's point of view, service can be defined as benefit and value. A service system, then, is not only a structure for the execution of business activities, but for the participation of the customer in the creation of value, as well. At last, service is information and knowledge intensive, which makes the development of innovative service-based e-commerce models an opportunity.

Since the basic conceptualization of a service is an activity that somebody does for the benefit of somebody else, then a service can be defined by the roles of the provider and the consumer and by the benefit or value that is delivered to the consumer. The role of the consumer is the primary in a service interaction; the consumer not only determines what has value and evaluates the value potential of the service elements, but creates value as well, by executing activities and by selecting and composing service elements. The provider, on the other hand, is an enabling factor for value creation by the consumer, by providing the service elements as the pre-condition for value creation by the consumer.

The importance of knowledge in service interactions is well-presented in the literature, where service is generally thought as the application of resources and specialized

competences by the provider for the benefit of the consumer. However, this notion of service emphasizes the role of the provider, as it considers that the knowledge resides in the provider's side. Here we claim that the consumer, as the deciding evaluator of the value potential of service elements and the final integrator of service elements, performs knowledge-intensive functions, too. The consumers create value idiosyncratically, in the context of their own lives and according to their needs, and tend in general to integrate a variety of service elements, in order to tailor valuable outcomes that can satisfy their needs. in other words, service elements are the "resources" that the consumers use in their value creation processes. Both the selection of service elements in the first place and the integration of service elements thereafter are knowledge-based processes for the consumer.
Value creation is a collaborative knowledge-based process, both for the consumer and the producer, in which the former integrates the benefits provided by the latter. Value creation is a collaborative process because the consumer cannot receive input and create value without the support of the producer; the producer, on the other hand, does not enter into business activities, unless they are going to be consumed. Value creation is a knowledge-based process for the consumer because the selection and composition of services is based on their knowledge for the uses, the qualities and the benefits of the available options, as well as their past experiences. It is a knowledge-based process for the producer, as well, because knowledge is a key resource for all the business functions. Hence, service systems are normative structures that facilitate the collaborative knowledge creation and advancement (i.e. improvement of existing knowledge) between the customer and the provider.
Knowledge is also a basic type of the benefit for both the consumer and the producer, because their current decisions and functions are based on the knowledge they acquire now or have collected in the past from their participation in similar situations. In this setting, the role of knowledge is twofold: on the one hand it represents business capability that delivers benefit to the customer; on the other hand, it is an integral part of the benefit delivered to the customer, contributing to the creation of value by the customer, either directly or indirectly (i.e. by leveraging to customer's opportunities for value creation). Hence, provider's knowledge (business knowledge) is an enabling factor for value creation; customer's knowledge, however, being either proprietary though personal experiences or obtained through service, is the key determinant of the created value. Proprietary knowledge, in particular, allows for the creation of value ("added value") for the customer through the consumption of service elements and the integration of the benefits they provide.

4. An extended SOA model for consumer-oriented e-commerce

The development of models of consumer-oriented e-commerce requires an extension in the typical SOA model, so that the outputs of the business processes become visible to the consumer, who will be able to select and combine business services to create value. In this section we propose an extended SOA model for consumer-oriented e-commerce and outline the key conceptual requirements for the development of such a model.

4.1 The architecture

The extended SOA model for consumer-oriented e-commerce is based on the technological foundations of SOA and complements them by introducing two additional layers on top of

it, in order to connect business processes with their outcomes and the needs of the consumer. The model is depicted in Figure ure 1.
The model is comprised of two parts:
a) *A business-oriented part*, which refers to the typical SOA model. This part is the technological underlay for the composition of products or services and the creation of value for the consumer, through the orchestration, execution and management of Web Services.
b) *A consumer-oriented part*, which refers to the extension that introduces the consumer's perspective in the composition of services and aims to support the consumers in the creation of value and the satisfaction of their needs.
The extended SOA model for consumer-oriented e-commerce is developed in five layers: the application layer, the Web Service layer, the business process layer, the business service layer and the consumer need layer. The first three layers refer to the business-oriented part and the next two layers refer to the consumer-oriented part of the architecture.

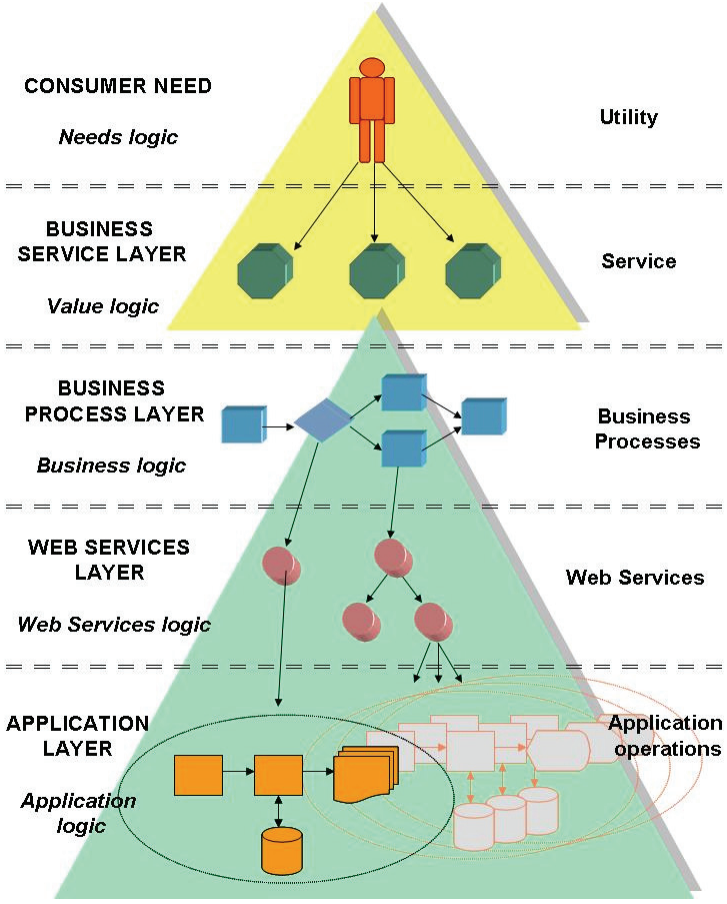

Fig. 1. An extended SOA model for consumer-centric e-commerce

The Application Layer contains all the IT infrastructure and IT resources that support business operations. This level is dominated by the "application logic" for the automated or in general IT-supported execution of business processes.
The Web Service Layer contains the Web Services that join together business functionality and application operations and allows for the flexible combination of application operations for the development and execution of business processes. This level is dominated by the "Web service logic", as it is described by the service-orientation principles for the design, advertising, invocation, composition and execution of services.
The Business Process Layer refers to the business processes that are performed for the production of products or services. This level is dominated by the "business process logic" for the analysis of processes into activities and tasks. In service-oriented environments, activities and tasks are mapped into Web Services (at the Web Service layer), which call and orchestrate the execution of application operations (at the application layer).
The Business Service Layer refers to the service (i.e. benefit) that is provided to the consumers by the business firms through their business processes for the satisfaction of their needs. The concept of service here includes both products and services that are produced by business firms as the pre-conditions for the creation of value for the consumer. This level is dominated by the "value logic" (i.e. consumer value logic) that aims to enable consumers to participate in the value creation processes by combining together complementary standalone products or services from one or different business providers and by creating unique solutions that can meet their problems and satisfy their needs.
The Consumer Need Layer refers to the needs of the consumers. This level is dominated by the "need logic" that extends beyond consumption and dictates the satisfaction of consumer needs. The basic assumption here is that needs motivate consumers to take products or services from business providers, aiming at the benefit they will obtain from their consumption. Moreover, as consumer needs tend to be quite complex and diverse, they can be satisfied by the consumption of compositions of different product or services.

4.2 Key conceptual requirements of the model

The extended SOA model for consumer-oriented e-commerce is designated to support the composition of products or services from different providers according to the consumer's preferences and needs. Such functionality is analogous to the composition of Web Services in a SOA for the execution of the business processes and the fulfilment of the business needs. Hence, the general idea of the proposed model derives from the example of SOA, accompanied by an anticipated market opportunity to develop consumer-oriented models that keep an active role for consumers in the creation of value. The practical use of the proposed framework requires that it is developed similarly to the SOA framework, with business service (i.e. products and services) being analogous to Web Services.
In this section we are based on the OASIS Reference Model for SOA [] to provide the key concepts and relationships that serve as a guideline for the development of the extended SOA model for consumer-oriented e-commerce. Additional concepts, not provided in [], are the solution, the need and the need description. The relationships between these concepts are provided in Figure 2. Concept mapping notation is used, with concepts represented as ovals and relationships represented as arrowed lines pointing at the concept that has some kind of conceptual dependency (e.g. derives from, is implemented by, etc.).

Extended SOA Model for consumer-oriented e-commerce	OASIS Reference Model for SOA
Service	Service
Service description	Service description
Visibility	Visibility
Consumption	Interaction
Intermediation context	Execution context
Consumption effect	Real world effect
Contract and policy	Contract and policy

Table 1. Key concepts of the extended SOA model for consumer-oriented e-commerce

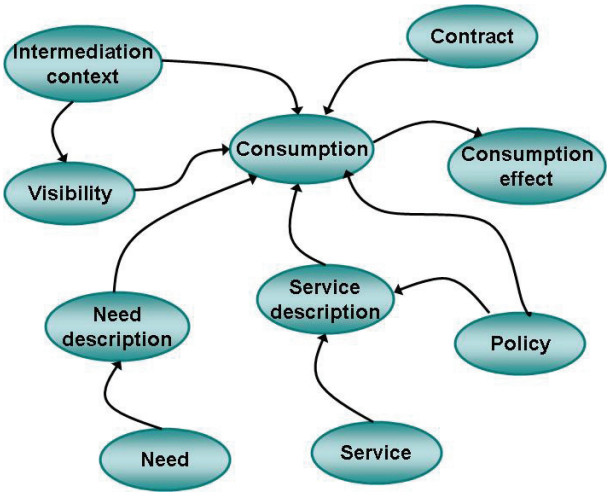

Fig. 2. Key concepts of the extended SOA model for consumer-oriented e-commerce

Service. It refers to the concept of service as the benefit that is provided to the consumer through the execution of business processes. As explained elsewhere, service elements include both products and services. Service is analogous to Web Services in SOA. Note that service has a dual character, as it refers to both the outcomes of a business process and the benefit for the consumer. Thus, the concept of service is the bridge that connects consumers and providers and enables a dialogue for the creation of value for the consumers. The composition of business service into solutions produces added value for the consumer; *solutions* are compositions of products and services.

Other basic principles of SOA, such as granularity, loose coupling and separation of concerns, apply in the extended SOA model for consumer-oriented e-commerce as well. Service can be defined in any level of granularity, with single and simple service elements becoming parts of more compound service elements (e.g packages). A need may be satisfied by different service elements, depending on the profile and the preferences of the consumer, while the same service element may be used by different consumers to serve different needs. Consumers are interested in the benefit or utility they receive and overlook the details of the business processes; the opposite is true for business providers, who are not involved in the value creation and the consumption process of the consumers.

Service description. The discovery, selection and composition of service elements are based on their descriptions. Being a manifestation of the benefits that can be delivered from the consumption of services, service descriptions are the basis for matching services with consumer needs and for the development of consumption solutions. Note that business services are difficult to be fully described, because of the great variety of their attributes and functionality. For this, the exact structure of business service description must be adapted on the specific business or market domain. The business service description should be expressed both in text and in machine-processable format. The use of semantics is necessary and a domain ontology (or a set of ontologies) will support the common definition of the terms used.

With this in mind, we consider that any business offering description should include at least the following: a) general attributes (e.g. physical characteristics), b) functional attributes (e.g. uses, requirements), c) operational attributes (e.g. delivery details), d) price (e.g. price, discounts), e) effects (the results that can be achieved as a result of the their consumption. E.g. arriving at one place.), and f) policies (e.g. validity of offers, constraints, liability, warranty, etc.).

Need. It is a want or a problem of the consumer that must be satisfied or resolved. A need refers to what the consumer wants to be achieved through the use of services.

Need description. It supports the discovery of suitable business services and their composition into solutions that can meet consumer needs. Needs description is difficult because consumer needs tend to be vague. Need descriptions must be domain-specific, such as business offering descriptions, because different market domains are expected to be related with the satisfaction of different needs. In addition, need must be described in a formal way to enable intelligent support in the service discovery and matching process.

Visibility. It refers to the requirements of achieving contact and interaction between consumers and providers in order to enable the consumption of service and satisfy consumers' needs. Visibility here has, in general, the same meaning and significance, as in the OASIS Reference Model for SOA. Visibility and its preconditions (i.e. *awareness*, *willingness* and *reachability*) are supported by the role of intermediaries. Unlike registries in SOA, which have a limited role and serve usually as simple repositories, the intermediaries in a consumer-oriented e-commerce model should have a key role in the discovery, the evaluation and the composition of services, as well as in the orchestration and management of the business processes of the different service providers. Note that the intermediary is a business role, not a technology. Besides, it is consumer's agent in the composition of solutions, not a retailer of products and services.

Consumption. It refers to activities that enable the use of a service for the satisfaction of a consumer need. Such activities are the selection and composition of services from the consumer and the activation and coordination of business processes at the provider's side from the intermediary. The concepts of *interaction*, *execution context* and *service interface* defined in [10] refer to the technical details of using Web Services for the interaction between the intermediary and the business suppliers and the execution of business processes. The *intermediation context* refers to the systems and technologies used, the policies applied and the processes followed by the intermediary for the execution of its role and the interaction with the consumer and the business provider.

Consumption effect. It refers to the outcomes for the consumer from the consumption of services. Note that, while the service description gives the provider's outlook on the

outcomes of the consumption of services, the consumption effects refers to the way the consumer perceives these outcomes. Verbal descriptions provided by the consumer, rating systems, unstructured ways of capturing information and, in general, technologies that attempt to capture consumer's disposition and feelings will be useful in this effort.
Policy. A policy represents some constraints or conditions on the delivery and consumption of services. It can be imposed by the business provider or the intermediary (or both).
Contract. A contract refers to any bilateral or multilateral agreement of the consumer, the intermediary and the business provider for the delivery and consumption of services. A contract usually includes the policies.

5. Semantic web services in consumer-oriented architectures

So far we have discussed and establish both an architecture and a conceptual framework for supporting consumer oriented web services. Using the conceptual model we can identify the semantics each concept brings either by its meaning or through the relationships with the rest of the concepts. We can then try to identify the semantics carried or needed by the different layers of the architecture and discuss how we can exploit them in order to provide a smoother experience for the customer. It should be noted here that although we advocate the responsibility of the customer for the selection, the composition and final exploitation of the services' results by the customer this is neither an easy nor a trivial task.
The first thing that the customer would try to do in a web service environment would be to try and "understand" what each service that is available in the ecosystem brings into the picture so as to evaluate its suitability for the task at hand. This means that the customer should understand the semantics of the process that will take place in order to solve the problem at hand (process semantics) (Kashyap et al., 2008) and the individual semantics that each service carries, since a process might be fulfilled by composing more than one services together. Moreover the customer would need to understand in various cases what the data that a service needs/uses /produces might mean either as the output of a process or as an inut for the process to follow (data semantics) (Kashyap et al., 2008). On the other hand there is a wealth of languages that support services' description (e.g. WSDL – W3C, 2009), discovery (e.g. UDDI – OASIS, 2004), composition and orchestration (BPEL – OASIS, 2007). But these languages cannot be used as such by the customer, since they are mostly oriented towards machines and try to automate the overall process. Nevertheless this is not the basic deficit that we can identify, this would be the fact that consumers would not be able to use these languages because these languages carry no semantics about the service itself, they just describe in computer terms what to expect as a result and how to do the composition or orchestration. Finally, usually the users appreciate the chance to annotate the Web Services (Kungas & Matskin, 2007) that exist in order to be able to identify them later and exploit their annotations. Using ontologies or other conceptual schemas that carry semantics is a common annotation technique and is easily understandable by both humans and machines and thus highly appreciated in a consumer oriented environment (Seth et al., 2005).
So in order to make things more concrete we can identify Semantic Web Services as web services that are described under a common schema (aka conceptual model) and provide the necessary affordances to exploit semantic web tools to search, compose and annotate these services (Cardoso & Seth, 2006). Moreover the consumer would be able to understand that conceptual model and find the services whose semantics match (are closer) to the

understanding about the problem at hand. With the current explosion of the semantic web many services and data already carry these semantic descriptions; data being semantically described at a greater extend than services. Additionally a wealth of tools ranging from query languages like SPARQL (W3C, 2008) and RQL (Karvounarakis et al., 2004) to frameworks (JENA, 2009) and ontologies (WSMO, 2222) is already available to support discovery (by querying), adaptability (by evolving) and composition (by merging and matching) of web services described according one or more conceptual models.

Finally, one interesting property of the Semantic Web Services for the consumer is the fact that there are already tools that can support the consumer's conceptual model (or the value-logic of the consumer as we described it earlier) and can compare it to the conceptual model of the system, i.e. the services. Thus we can find mappings between the two models and better identify the web services that fit the value-logic of the consumer. As already mentioned if this is coupled with the capabilities of conceptual models and semantics to evolve (and thus to adapt to the changes of consumer's perspective on the value of the services), we can understand that we have at hand a powerful tool that can help the consumer better understand the value of services and thus maximize his overall benefit but also allow the user to do that over time (Kotzinos et al., 2008) in a seamless and fairly easy to understand and handle way.

If we look closer to the layers identified for the extended SOA model for consumer-centric e-commerce we can already identify the layers where the semantics have a role to play and can be further enhance the consumer's capabilities. The first layer of interest is, as expected, the Web Services Layer, where we can substitute the more traditional web service descriptions with semantically rich ones and then use the corresponding semantic web tools to search for, choose, compose and orchestrate the web services basing the consumer's understanding either on the process or the data semanics. The second layer of interest is the Business Process Layer where we can exploit the process semantics identified in the previous (Web Services) layer. Since processes and tasks carry semantics and they are mapped into web services (or series of web services) we can exploit the semantics described under a common conceptual model to provide better mappings that are understandable by both humans and machines, moreover we can reason on these descriptions to infer new knowledge from that and further enhance the consumer's experience.

The last layer of interest would be the Business Service Layer where the consumer would be able to harvest most of the advantages of the semantics. There we can provide mappings or (in a weaker sense) understandings between the consumer's "value-logic" model and the value produced by the services. Thus the consumer would have the capability to bring closer to his own understanding the meaning of the services and the produced results. Moreover the consumer would be able to exploit his own or other consumers' annotations on the services, supporting and extending the understanding but also supporting and extending the mappings that would allow him to make a safer choice. This means that we can see the situation that each consumer would bring in his own conceptual model about the (expected) value of the processes and try to match that to the service semantics that would be used to serve this process. This makes the whole model almost infinitely (in terms of concepts, the complexity of course might hinder such unconstraint extensions) extensible and provide the consumer with the ability to keep his own understanding and value model and match it against the one(s) the services carry. Moreover it allows for evolution on both

parts: consumer and services can evolve their semantics without having to change things on either side.

6. Future research

Consumer-oriented e-commerce is an opportunity for the creation of innovative models that engage the consumer in business operations and empower him in creating value. Future research for the development of consumer-oriented e-commerce should be related to both the development of a consumer-oriented theoretical framework and the development of the necessary technological infrastructure.

This chapter makes a preliminary contribution for the development of a consumer-oriented theoretical framework. Here emphasis is put on service as a collaborative knowledge-based process for value creation, which is a dense concept that needs to be analyzed and elaborated further. Future work should try to exploit further the concept of service; here some service-based theories, such as the Service Dominant Logic and the Nordic School of service management, and trends, such as the development of the service science, can have a great contribution. Another stream of future research comes from the development of typical models for consumer-oriented e-commerce; such models will derive from the critical analysis of business practices that adopt consumer-oriented approaches (e.g Web 2.0).

The extended SOA model presented in this chapter can become the conceptual platform for the implementation of consumer-oriented e-commerce models. First of all, it is necessary to refine the extended SOA model by adopting elements from sources other than the SOA Reference Model. For example, other reference models or particular architectures that claim to be customer-oriented could provide further input. The implementation of consumer-oriented e-commerce models requires the definition of a set of available technologies; thus, it is necessary to find out which of the existing technologies are suitable for this at each level of operations and what kind of amendments are necessary. Emphasis will be put on the technologies that are required for the expression of consumer needs and business services, as well as for the composition of business services. It is necessary to suggest extensions to the currently available web services and business processes languages and the corresponding conceptual models (ontologies) like the ones mentioned earlier that would allow us to bring into their semantics consumer oriented semantics (both concepts and relationships) and also propose additional composability operators based on those semantics. At last, pilot implementations and case studies will provide further knowledge and will contribute in the improvement of both the theoretical models and the practice.

7. Conclusion

This chapter presented some current, customer-oriented trends in the conceptualization of value creation, according to which the consumer is not a passive receiver and a plain evaluator of value, but becomes the utmost determinant and an active co-creator of value. These ideas suggest that there is an opportunity for the development of innovative business models in engaging and empowering the customer in co-creating value. The Web can be an extremely fertile field for the development of consumer-oriented e-commerce, because the new Web technologies can support innovative ways in the interaction with the customer and they can enable the participation of the customer in value co-creating activities.

This chapter contributes in the development of consumer-oriented e-commerce by providing a relevant conceptual framework and an extended SOA model. The purpose of consumer-oriented e-commerce is to empower the consumer in the creation of value according to his personal preferences and needs by composing services from different business firms. Being based on the concept of service as a collaborative knowledge-based process for value creation, the conceptual framework provides the theoretical background for the development of consumer-oriented e-commerce models. The extended SOA model complements the OASIS Reference Model for SOA, on which it is based, by introducing the consumer's perspective in the composition of business services and in the creation of value. Hence, SOA can become the technological underlay for the composition of service and value from different business providers and Semantic Web Services can become a key enabling technology in this effort.

Even though there are some consumer-oriented ideas in the literature and the existing technologies have apparently the required properties for the development of consumer-oriented e-commerce models, it will be neither straightforward nor imminent, because it has to prevail beforehand over the traditional, egocentric business thinking.

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2

E-Commerce Assessment in Fuzzy Situation

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1. Introduction

Customer satisfaction degree is critical for e-commerce enterprises. Thus, more and more commercial organizations attend to “customer satisfaction “ as their main strategy (Mihelis et al., 2001).
Customer satisfaction means the satisfaction degrees of customers purchasing commodities. Under electronic commerce, how to raise the consumers’ degree of satisfaction and gain the consumers’ loyalty has become the key factor relating with whether ecommerce enterprise can survive. The view of the philosophy of modern management scientific holds that, "customer satisfaction is the basic criteria of enterprise". Nowadays, more and more commercial organizations take customer satisfaction as their main strategy object (Mihelis et al., 2001).
Customer satisfaction and customer satisfaction index have been widely developed in both theory and applications (C. Albert, 2002, E.W. Anderson & C. Fornell, 2000, P. Hackl et al., 2000, D.J. Michael, 2004). Fornell (C. Fornell, 1992) developed the first model of customer satisfaction in 1992. The American customer satisfaction index (ASCI) was set up in 1994 (Yin Rongwu, 2000), Swedish SCSI, European ECSI and Korean KCSI etc. Chinese Customer satisfaction Index (CCSI) started in 1998, are still on the stage of exploration and learning (Zhao Pengxiang, 2001).
Customer satisfaction has been used frequently in the quality system certification of ISO9000 of 2000 edition, which shows the important of this concept (Xiaohong Liu et al., 2008). Also, Many countries are conducting Customer Satisfaction Index studies since Customer Satisfaction Index can be used as a predicator for profitability and value of the organizations (S.-H. Hsu, 2008).
Nowadays, more attention has been paid to the problem of e-commerce customer satisfaction (M. Wang, 2003). The e-commerce customer satisfaction parameters should be visible for customers. The more important parameters have been chosen based on the literature review: independency, comparable, and feasibility (Mihelis et al., 2001, Yan Xiao-Tian & Wei Hong-Jun, 2005, Yin Rongwu, 2000, Zheng Yue-Fang, 2005, Liu, 2007).
Each index should independently represent the service quality satisfaction from some aspect (Fasanghari & Roudsari, 2008). While customers represent their satisfaction value of e-commerce, the indexes should be comparable for different customer. Thus, the indexes of e-commerce customer satisfaction have been obtained based on literature review so that support all of the customer satisfaction area for e-commerce.

To evaluate the e-commerce customer satisfaction quantitatively, many countries established their own index of customer satisfaction degree, namely customer satisfactory Index, which is a new set of indexes evaluating an enterprise and a trade or an industry completely from customer's angle (Liu Peide, 2007).
The e-commerce customer satisfaction should pay attention to the parameters which are visible for customers. The more important parameters have been chosen based on the literature review: independency, comparable, and feasibility (Mihelis et al., 2001, Yan Xiao-Tian & Wei Hong-Jun, 2005, Yin Rongwu, 2000, Zheng Yue-Fang, 2005).
Customer evaluation for e-commerce would be possible if the independency among the indexes exist. The selection of indexes, therefore, should be high enough in resolution to help distinguish the factors. Each index should independently represent the service quality satisfaction from some aspect.
To clarify, indexes should be comparable, as the model should evaluate the different customer inputs, which express the satisfaction value for e-commerce; consequently, the indexes should be comparable for different customer while they represent their satisfaction value of e-commerce.
At last, identification and reduction of customer satisfaction are the objective of e-commerce customer satisfaction. The title and content of each index, hence, should be well understood by the customers.
In this paper, in the next section, fuzzy set theory and the principals of triangular fuzzy number have been presented. Then, the model for e-commerce customer satisfaction has been illustrated. A case study has been done, as validation of presented method; finally, conclusion has been presented.

2. Fuzzy Set Theory

Fuzzy set theory provides a framework for handling the uncertainties. Zadeh initiated the fuzzy set theory (Zadeh L. A., 1965). Bellman presented some applications of fuzzy theories to the various decision-making processes in a fuzzy environment (Bellman R. E. & Zadeh L. A., 1970). In non-fuzzy set every object is either a member of the set or it is not a member of the set but in fuzzy sets every object is to some extent member of a set and to some extent it is member of another set. Thus, unlike the crisp sets membership is a continuous concept in fuzzy sets. Fuzzy is used in support of linguistic variables and there is uncertainness in the problem. Fuzzy theory is widely applicable in information gathering, modeling, analysis, optimization, control, decision making, and supervision.
Special cases of fuzzy numbers include crisp real number and intervals of real numbers. Although there are many shapes of fuzzy numbers, the triangular and trapezoidal shapes are used most often for representing fuzzy numbers. The following describes and definitions show that membership function of triangular fuzzy number, trapezoidal fuzzy number, and its operations.
A fuzzy number $\tilde{A}$ is convex, if

$$\mu_{\tilde{A}}[\lambda x_1 + (1-\lambda)x_2] \geq \min[\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)]. \qquad x_1, x_2 \in X, \ \lambda \in [0,1] \tag{1}$$

Alternatively, a fuzzy set is convex if all α-level sets are convex.

A fuzzy set Ã in the universe of discourse X is normal if (A. Kaufmann & M.M. Gupta, 1988, S. Mabuchi, 1988)

$$\sup_x \mu_{\tilde{A}}(x) = 1 \tag{2}$$

A nonempty fuzzy set Ã can always be normalized by $\mu_{\tilde{A}}(x) / \sup_x \mu_{\tilde{A}}(x)$.

A triangular fuzzy number can be defined by $\tilde{A} = (a_1, a_2, a_3)$, where $a_1 \le a_2 \le a_3$, its member function represented as follows.

$$\mu_{\tilde{A}} = \begin{cases} 0 & x < a_1 \\ (x - a_1) \big/ (a_2 - a_1) & a_1 \le x \le a_2 \\ (x - a_3) \big/ (a_3 - a_2) & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases} \tag{3}$$

Let $\tilde{A}$ and $\tilde{B}$ be two fuzzy numbers parameterized by the (a_1, a_2, a_3) and (b_1, b_2, b_3), respectively. Then the operations of triangular fuzzy numbers are expressed as (S.J. Chen & C.L. Hwang, 1992a):

$$\begin{aligned} \tilde{A}(+)\tilde{B} &= (a_1, a_2, a_3) + (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \\ \tilde{A}(-)\tilde{B} &= (a_1, a_2, a_3) - (b_1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3) \\ \tilde{A}(\times)\tilde{B} &= (a_1, a_2, a_3) \times (b_1, b_2, b_3) = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3) \\ \tilde{A}(\div)\tilde{B} &= (a_1, a_2, a_3) \div (b_1, b_2, b_3) = (a_1 \div b_3, a_2 \div b_2, a_3 \div b_1) \end{aligned} \tag{4}$$

Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems (C.H. Cheng & Y. Lin, 2002), and the primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation.

In this paper, the triangular fuzzy number is used for measuring customer satisfaction. More details about arithmetic operations laws of trapezoidal fuzzy number can be seen in (Lee et al., 2004).

Considering experts E_i provide the satisfaction degree with $\tilde{A}^{(i)}$. The evaluation values given by each expert (E_i) are presented in the form of a triangular fuzzy number:

$$\tilde{A}^{(i)} = (a_1^{(i)}, a_2^{(i)}, a_3^{(i)}), where \quad i = 1, 2, ..., n \tag{5}$$

The average $\tilde{A}_m$ of all $\tilde{A}^{(i)}$ is computed using average means

$$\tilde{A}_m = (a_{m1}, a_{m2}, a_{m3}) = \left(\frac{1}{n}\sum_{i=1}^{n} a_1^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_2^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_3^{(i)}\right) \tag{6}$$

For defuzzification of $\tilde{A}_m$, the following formula can be used:

$$A_m = \frac{a_{m1} + 2a_{m2} + a_{m3}}{4} \tag{7}$$

3. The Model for E-Commerce Customer Satisfaction Evaluation

3.1 Determination of Indexes

Some of the researches constructed evaluation index from commercial content, customer's concern, effective navigation, website design, safety, convenience, merchandise planning, contact convenience, customer service information, convenience of getting product information, accuracy, content relatedness, integrity, variety in displaying, information timely updating, easy application, system rapidity, service response in time, and guaranteed service (Duo Qi, 2003, Liu Peide, 2007, Yu Hongyan, 2006, Gao Dan, 2004, Gan Yong, 2006).
Based on literature, this paper constructs customer satisfaction index of BtoC e-commerce enterprise, and evaluates customer satisfaction of BtoC e-commerce enterprise by adopting Fuzzy Triangular Numbers for Linguistic Variables and using fuzzy TOPSIS method Table1.

Object	*Indicator*	*Description*
Product	Customization (Pr1)	The degree of customer needs satisfying
	Value (Pr 2)	The unique product characteristics
	Information (P r3)	Accessibility to the information of the products
	Scope (Pr 4)	The dimensions which the product satisfy them
	Accuracy of quality (Pr 5)	The quality parameters satisfaction
	Guaranty (Pr 6)	The confidence of the product quality
Service	Attitude (S1)	How services are received
	Information (S2)	Accessibility to the information of the services
	Distribution (S3)	The method and tools of service delivery
	Response and feedback (S4)	The quality of feedback of services
	Call center (S5)	Availability of a call center for customer care
	Quality (S6)	The quality parameters satisfaction
	Management (S7)	Determination of service process and control indexes
Network system	Safety (N1)	Security degree of networks
	Reliability (N2)	The amounts of risk
	Operability (N3)	The network support of the customer needs
	Accessibility (N4)	The availability of network in 24*7
	Humanization (N5)	Consideration of human computer interaction
payment	Accuracy of fee calculation (Pa1)	The trust in financial computation
	Accuracy of fee collection (Pa2)	The trust to the system of fee collection
	Method (Pa3)	The technical methods relating to the payment
	Facilities (Pa4)	The quality and suitability of facilities used for payment

Table 1. Indexes of e-commerce customer satisfaction evaluation

3.2 Determination the Weight of Indexes

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method is presented in Chen and Hwang (S.J. Chen & C.L. Hwang, 1992b), with reference to Hwang and Yoon (C.L. Hwang & K. Yoon, 1981). TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives. The basic principle is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance

from the negative ideal solution. The procedure of fuzzy TOPSIS can be expressed in a series of steps:

E-commerce customer satisfaction is a typical Multi Criteria Decision Making (MCDM) problem. An MCDM problem can be formulated as follows:

$$X_k = \begin{array}{c|cccccc} & C_1 & \dots & C_j & \dots & C_n \\ \hline A_1 & x_{11k} & \dots & x_{1jk} & \dots & x_{1nk} \\ \vdots & \vdots & & \vdots & & \vdots \\ A_i & x_{i1k} & \dots & x_{ijk} & \dots & x_{ink} \\ \vdots & \vdots & & \vdots & & \vdots \\ A_m & x_{m1k} & \dots & x_{mjk} & \dots & x_{mnk} \end{array} \tag{8}$$

$$W_k = \begin{bmatrix} w_{1k} \\ \vdots \\ w_{jk} \\ \vdots \\ w_{nk} \end{bmatrix} \tag{9}$$

where $K = 1,...,p$ decision makers select an alternative out of $i = 1,...,m$ alternatives (A_i) according to $j = 1,...,n$ criteria (C_j).

x_{ijk} is the performance of alternative A_i with respect to criterion C_j estimated by decision maker k, while W_{jk} is the weight of criterion C_j given by the decision maker k. X_k and W_k are respectively the decision matrix and the weight vector for the decision maker k.

In the fuzzy TOPSIS procedure, the criteria weights ($\tilde{w}_j, j = 1,2,...$ triangular fuzzy number of criteria) and characteristic values of alternatives at criteria ($\tilde{x}_{ij}$, $i = 1,2,...$ number of alternatives, $j = 1,2,...$ number of criteria) are inputs and placed in matrix form (P. Sen & J-B. Yang, 1998, C.-T. Chen, 2000, Fasanghari et al., 2008) as shown in step 1.

Step 1: Inputs are expressed in matrix format as;

$$\begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \tag{10}$$

$$\tilde{W} = \left[\tilde{w}_1, \tilde{w}_2, ..., \tilde{w}_n\right] \tag{11}$$

$\tilde{w}_j$ are triangular fuzzy numbers as $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$.

Step 2: the normalized decision matrix is constructed using equation (12) (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$\tilde{n}_{ij} = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{n} \tilde{x}_{ij}^2}} \tag{12}$$

Step 3: The weighted normalized decision matrix is,

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n}, i = 1,2,...,m, j = 1,2,...,n. \quad (13)$$

where,

$$\tilde{v}_{ij} = \tilde{n}_{ij} \otimes \tilde{w}_j \quad (14)$$

Set 4: each fuzzy number is defuzzified using equation(15). For triangular fuzzy number $\tilde{v}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ its defuzzification value is defined to be

$$v_{ij} = \frac{a_{ij} + 2b_{ij} + c_{ij}}{4} \quad (15)$$

And defuzzified weighted normalized matrix determined as $V = \left[v_{ij}\right]_{m\times n}$, $i = 1,2,...,m$, $j = 1,2,...,n$.

Step 5: The ideal solution, $A^+(A_i^+; i = 1,2,...,N)$, is made of all the best performance scores and the negative-ideal solution, $A^-(A_i^-; i = 1,2,...,N)$, is made of all the worst performance scores at the measures in the defuzzified weighted normalized decision matrix. They ate calculated using equations (16) and (17). In these equations, the measures can be divided into two classes: the first is of an input or cost nature, so that smaller performance scores at these measure are preferred; the second is of an output or benefit nature and larger performance scores at these measures are preferred (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$A^+ = \left\{v_1^+, v_2^+, ..., v_n^+\right\} = \left\{(\max_j v_{ij} \mid j \in I), (\min_j v_{ij} \mid j \in J)\right\}, \quad (16)$$

$$A^- = \left\{v_1^-, v_2^-, ..., v_n^-\right\} = \left\{(\min_j v_{ij} \mid j \in J), (\max_j v_{ij} \mid j \in I)\right\}. \quad (17)$$

Step 6: The distance of an alternative j to the ideal solution (d_i^+), and from the negative ideal solution (d_i^-) are calculated using equation (18) and (19) (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$d_i^+ = \sqrt{\sum_{j=1}^{m} (v_{ij} - v^+{}_j)^2} \quad i = 1,2,...,n; j = 1,2,...,m, \quad (18)$$

$$d_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v^-{}_j)^2} \quad i = 1,2,...,n; j = 1,2,...,m \quad (19)$$

Step 7: The ranking score (R_i) is calculated using equation (20) (H.S. Byun & K.H. Lee, 2004, P. Sen & J-B. Yang, 1998).

$$R_i = \frac{d_i^-}{d_i^- + d_i^+}, \qquad i = 1,2,..,m. \quad (20)$$

The object of fuzzy TOPSIS method is to choose the alternatives that have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. Even though TOPSIS introduce two reference point, it does not consider the relative importance of the distance from the points (G.R. Jahanshahloo et al., 2006).

4. Case study

In order to assess the proposed methodology, we select 5 e-commerce websites as our alternatives and 10 customers which procure their needful. Experts fill in the questionnaire with fuzzy triangular numbers. Table 1 presents the index of the e-commerce assessment; we use these indexes for the selected websites assessment. As the first step, equation (10) is formed as Table 2. The weights of the indexes are equal in view point of the experts. Steps 2, 3, 4 and 5 are done and the defuzzified weighted normalized decision matrix, A^+, and A^- is computed. In step 6, the $d_1^+, d_2^+, d_3^+, d_4^+, d_5^+, d_1^-, d_2^-, d_3^-, d_4^-$, and d_5^- are calculated respectively: 3.6675, 3.8247, 2.9372, 4.9262, 5.3357, 6.3497, 7.4314, 6.7605, 5.3349, and 4.2002. The final results of fuzzy TOPSIS method is obtained as R_1=0.6339, R_2=0.6602, $R_3 = 0.6971$, $R_4 = 0.5199$, and $R_5 = 0.4405$. Obviously, the third website (alternative number 3) is in first row of the website ranking and has the highest score in ranking. Unlike, the fifth website (alternative number 5) has the lowest score in ranking method of fuzzy TOPSIS.

5. Conclusions

The main contribution of this paper is proposing a ranking method for assessing the e-commerce under uncertain situations. In fact, combination of fuzzy triangular rubbers, TOPSIS method, and e-commerce indexes is proposed in this paper. Hence we can assess the customer satisfaction of e-commerce, and we run a case study in which the 5 e-commerce websites are assessed with 10 experts of e-commerce who are familiar with the selected websites. Fortunately, all of the experts are pleased of the obtained results.

Index	*Fuzzy number*	*Alternatives*					*Index*	*Fuzzy number*	*Alternatives*					*Index*	*Fuzzy number*	*Alternatives*				
		A1	***A2***	***A3***	***A4***	***A5***			***A1***	***A2***	***A3***	***A4***	***A5***			***A1***	***A2***	***A3***	***A4***	***A5***
Pr1	a1	8.06	0.98	6.13	3.72	5.55	S3	a1	5.12	2.40	0.73	3.03	0.29	N4	a1	6.82	7.52	2.64	4.67	2.41
	a2	9.54	7.95	8.67	4.70	9.27		a2	8.44	8.23	6.27	8.12	0.68		a2	9.50	8.15	9.32	7.89	3.71
	a3	9.87	9.29	8.92	7.51	9.67		a3	9.26	9.31	8.61	8.72	6.04		a3	9.90	9.19	9.64	9.44	5.51
Pr2	a1	1.45	1.98	9.62	0.69	7.20	S4	a1	0.69	0.98	1.44	5.17	5.19	N5	a1	1.80	4.53	5.77	3.42	7.64
	a2	4.39	6.06	9.65	8.26	8.18		a2	1.68	9.97	4.21	9.95	7.19		a2	3.99	5.56	7.98	5.41	8.82
	a3	8.11	9.99	9.84	8.77	9.67		a3	4.09	9.97	4.69	9.98	7.84		a3	6.14	5.66	8.85	7.45	9.47
Pr3	a1	7.52	6.49	1.62	4.89	1.68	S5	a1	6.51	3.16	4.08	9.59	9.57	Pa1	a1	0.78	5.83	3.34	4.50	4.42
	a2	9.18	9.45	9.44	8.36	2.38		a2	9.16	5.15	5.09	9.70	9.98		a2	1.97	9.10	7.54	9.74	5.44
	a3	9.78	9.79	9.57	8.80	7.35		a3	9.66	6.37	7.01	9.84	9.98		a3	8.39	9.97	8.25	9.82	7.41
Pr4	a1	1.37	1.00	8.52	4.97	3.41	S6	a1	5.96	1.92	2.27	9.30	2.66	Pa2	a1	6.32	7.56	3.40	1.85	1.73
	a2	5.92	4.30	9.08	9.73	6.58		a2	6.43	9.50	9.45	9.56	7.81		a2	7.06	9.29	8.57	6.90	1.81
	a3	8.89	8.67	9.59	9.98	8.60		a3	8.67	9.72	9.51	9.63	9.94		a3	7.72	9.97	9.76	8.51	7.14
Pr5	a1	5.70	3.65	8.27	8.78	6.27	S7	a1	8.96	9.35	6.78	1.12	2.40	Pa3	a1	9.47	9.04	5.06	8.04	6.39
	a2	6.95	4.92	9.05	9.42	9.47		a2	9.79	9.75	7.24	3.49	7.54		a2	9.70	9.10	8.36	9.39	7.73
	a3	7.10	9.95	9.75	9.48	9.74		a3	9.87	9.99	9.37	5.09	8.17		a3	9.94	9.25	8.75	9.67	8.76
Pr6	a1	5.29	8.33	9.67	1.23	5.28	N1	a1	7.22	9.96	0.89	4.85	0.36	Pa4	a1	7.48	8.38	7.18	0.72	4.36
	a2	7.95	9.72	9.80	3.95	6.60		a2	9.80	10.00	8.21	5.92	2.19		a2	7.80	9.97	8.74	4.58	8.74
	a3	9.87	9.77	9.95	5.14	9.25		a3	9.85	10.00	9.62	6.57	6.68		a3	8.39	9.97	9.77	4.90	9.14
S1	a1	7.99	6.15	6.14	5.82	4.61	N2	a1	7.04	7.43	7.64	2.24	8.18							
	a2	8.51	6.28	7.95	6.68	9.06		a2	9.78	9.47	8.35	6.88	9.01							
	a3	9.66	7.32	9.47	6.88	9.29		a3	9.87	9.51	9.26	8.36	9.73							
S2	a1	5.01	0.80	6.35	1.58	0.33	N3	a1	5.82	4.63	5.96	9.24	9.42							
	a2	8.75	2.14	7.78	7.92	4.56		a2	9.44	6.75	7.54	9.36	9.72							
	a3	8.98	3.69	8.50	9.48	9.21		a3	9.50	6.87	8.14	9.94	9.75							

Table 2. E-commerce customer satisfaction value for the 5 selected e-commerce website

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3

TECTAM: An Approach to Study Technology Acceptance Model (TAM) in Gaining Knowledge on the Adoption and Use of E-Commerce/ E-Business Technology among Small and Medium Enterprises in Thailand

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1. Introduction

One of the four pillars of knowledge management according to Stankosky (2000), Calabrese (2000) and Baldanza & Stankosky (2000) is the technology pillar. It is important to study knowledge management (KM) based on this pillar in diverse dimensions. The technology pillar consists of a number of disciplines including computer science, computation mathematics, operation research, electrical engineering, mathematics/statistics, and logic. Moreover, data warehousing, database management, multimedia repositories, groupware, decision support system, expert systems, corporate Intranet, business modeling systems, etc. are also representative key sub-elements defining this pillar (Calabrese, 2005). In another aspect of KM, gathering, using and sharing knowledge are executed by Information and Communication Technology (ICT) implemented as a Knowledge Management System (KMS). ICT can facilitate and integrate knowledge among businesses that have adopted ICT to run their business processes. It is reasonable to mention that this pillar concerns with a range of studies on innovation adoption based on a variety of aspects. Gaining knowledge on the adoption and use of e-commerce/e-business technology based on KM concept would be expected to be conducted by using the proposed approach, TECTAM which is presented in this chapter.

In the studies of the adoption of information systems/technology, Technology Acceptance Model (TAM) is one of the most dominant research models which have been used widely. TAM composes of two key determinants: perceived usefulness (PU) and perceived ease of use (PEOU). In this study, these factors are hypothesized to be the essential basis for verifying user acceptance of e-commerce/e-business technology in Thailand based within the context of KM practices. This chapter reviews the TAM concepts and proposes an approach to modify the TAM for investigating and gaining knowledge on how small and medium enterprises (SMEs) in Thailand adopt e-commerce technology (ECT). The rapid growth of ICT in Thailand has made user acceptance an increasingly critical issue in

technology implementation and management. PU and PEOU of Thai public organisations, SMEs, and online customers are investigated in this study to predict the Thai SMEs' adoption and use ECT.

2. E-Commerce Technology Adoption by SMEs in Thailand

In 2000, the Thai government released the SMEs Act for promoting and developing SMEs in Thailand. In the meantime, the Office of Small and Medium Enterprises Promotion (OSMEP), the Institute for Small and Medium Enterprises Development (ISMED), and the Small and Medium Enterprise Development Bank of Thailand were also founded in order to contribute towards the development of Thai SMEs for elevating them to the global commercial scene. There are three key platforms or vehicles in the Thai government's SMEs promotion policy: a) investment promotion, b) financial assistance, and c) technical and management consultancy (OSMEP, 2001a; OSMEP, 2001b).

It is recongnised that the predominant factors influence the achievement of the e-commerce adoption and use are: ICT groundwork, government planning and policy, payment systems, taxation, law concerning e-commerce transactions, data protection, consumer protection, intellectual property rights, e-commerce security and safety, efficient transportation, and people recognition (ECRC, 2000; OSMEP, 2001a). Furthermore, in the ***Thailand Vision towards a Knowledge-Based Economy (IT 2010)*** document, it points out that ICT is an enabler to increase business productivity and capacity for business competition (NITC, 2002). However, the e-commerce adoption and use of Thai SMEs are currently in a state of early growth. Most of the entrepreneurs who use e-commerce strategy for competitive advantages are still mainly within the hospitality businesses, and a relatively small portion in the trade and retailing sector. In summary, Thai SMEs' lack of e-commerce innovation is mainly due to their limitation of resources in terms of budget and e-commerce knowledgeable personnel (OSMEP, 2001b).

Thailand Investor Service Centre (TISC, 2006) pointed out that the important and long term policies of the Thai government should be: construction of ICT network to support the production factor; developing worldwide marketing strategies; encouraging SMEs to do business in e-commerce, and, establishing channels of communication among industries in the capital and regional areas. Thailand, which now has two categories of Internet Service Providers (ISPs). This comprises of twenty-one commercial ISPs and four non-commercial Internet hubs. Two Internet exchanges have already been set up:

a) The ThaiSarn Public Internet Exchange (PIE) is a peering point for Thai ISPs to access public information on the ThaiSarn Public Access Network (PubNet) operated by the Network Technology Laboratory (NTL) of the National Electronics and Computer Technology Center (NECTEC).
b) Communication Authority of Thailand (CAT)—National Internet Exchange (CAT-NIX) has two sectors: International Internet Gateway (***IIG)***which is the Internet gateway of Thailand connecting Thai ISPs to the global networks, and, ***NIX,*** is the national exchange among all ISPs in Thailand providing exchange for the domestic traffics.

Furthermore, to date, Thai domain names which are registered under '.th' have registered a total of 42,194 domain names in which the 20,392 of them are '.co.th'. This amount is about 48.3% of the total number of Thai domain names. This ratio indicates the growth of online business. The growth rate of '.co.th' during 2000-2009 has exceeded more than 400%(

NECTEC, 2009a). The rate of increase for the Internet users in Thailand since 2000has also indicated a constant strong growth. This has provided ample opportunities for the Thai population to access information resources worldwide, and they are able to carry out online shopping or carry out business operations through e-commerce (NECTEC, 2009b).

3. Technology Acceptance Model (TAM)

TAM is adapted from the Theory of Reasoned Action (TRA) model which describes human behaviours in a specific situation (Fishbein & Ajzen, 1975). TRA proposes that a person's behaviour is determined by the person's intention to perform the behaviour; and the 'intention' is a function of the person's attitude toward the behaviour and subjective norms. Therefore, 'intention' is the best predictor because it cognitively represents a person's readiness to perform certain behaviour which is antecedent. 'Intention' is determined by three factors: attitude towards the specific behaviour, subjective norms, and perceived behavioural control (Ajzen, 2002).

The main purpose of TAM is to present an approach to study the effects of external variables towards people's internal beliefs, attitudes, and intentions. TAM proposes the perceived ease of use (PEOU) and perceived usefulness (PU) as the most important factors for explicating technology acceptance. Davis (1989) and Davis, Bagozzi & Warshaw (1989) pointed out that external variables such as direct experiences, objective usability, and self efficacy intervene indirectly to PEOU and PU (in TAM), attitude, and subjective norms (in TRA). Furthermore, Davis (1989) used methods of Fishbein & Ajzen (1975) for assessing the users' Attitude Towards using (AT) and Behavioural Intention to use (BI). However, subject norms were excluded because of their slight effect on BI. On the other hand, Venkatesh and Davis (2000) reconsidered the influence of subjective norms to people behaviour and found that the subject norms have effects towards the behaviour. Venkatesh and Morris (2000) used the proposed model to analyse how some factors such as gender and experience also influence the intention to use information systems.

In summary, TAM has developed and evolved continually over the years. It has verified and confirmed by many scholars as a practical theoretical model for the investigation of users' behaviour. In this chapter, it is therefore utilized to study the acceptance of ECT by the Thai SMEs based on the notion of knowledge management within the Thai SMEs context.

4. Relationship between TAM and Other Models

Although TAM has been verified by scholars worldwide, combining TAM with other theoretical models is more useful for investigating the technological acceptance by users. For example, attitude toward behaviour (AI) and subject norms from the TRA model are used by Davis (1989) in conjunction with TAM to clarify how the subjective norms affect technology adoption and acceptance. Taylor & Todd (1995) combined three core constructs from the Theory of Planned Behaviour (TPB) with TAM to develop a hybrid model for investigating technological acceptance. The three core constructs are: attitude towards behaviour, subjective norm, and perceived behavioural control. Rogers (1995) proposed a five stage model for the innovation decision process. The five stages are: knowledge, persuasion, decision, implementation, and confirmation. Subsequently, the model was

applied to study an individual decision making process of whether to adopt or reject innovation in TAM context (Wymer & Regan, 2005; Kiraz & Ozdemir, 2006).
TAM is also linked to the Task-Technology Fit Model (TTF).The core concept of TTF is how to measure the ability of information technology to support organisation tasks (Goodhue & Thompson, 1995). Four main constructs of TTF model are: task characteristics, technology characteristics, task-technology fit, and utilization or performance. These constructs are inter-related to each other. The TTF and TAM have recently been combined to predict e-commerce adoption by consumers (Klopping & McKinney, 2004). Dishaw and Strong (1999) extended the TAM with the TTF to workplace technology adoption. Zigurs et al. (1999) used TAM-TTF to predict group decision support system acceptance.
Vankatesh et al. (2003) developed the Unified Theory of Acceptance and Use of Technology (UTAUT) which formulates, integrates and broadens further than the TAM. UTAUT is a new theory which combines eight theories together: TRA, TAM, MM (Motivational Model), TPB, TAM-TPB, MPCU (Model of PC Utilization), IDT (Innovation Diffusion Theory, and SCT (Social Cognitive Theory). The UTAUT consists of four key determinants of intention and usage: performance expectancy, effort expectancy, social influence, and facilitating conditions. Furthermore, the variables of gender, age, experience and voluntariness of use moderate the relationship in the model (Vankatesh et al., 2003). Anderson & Schwager (2003) used the UTAUT for investigating wireless LAN technology adopted by SMEs.
In a similar fashion, the proposed model in this chapter is based on TAM and extended with variables which have been proposed in models such as TRA, TRP, UTAUT and TTF. It is expected that the extended model will be able to provide a comprehensive framework to identify the influencing factors for ECT adoption and use by SMEs in Thailand. The model is described in the next section.

5. TECTAM—Thai E-Commerce Technology Acceptance Model

This chapter aims to propose a model based on TAM to investigate ECT acceptance and adoption by Thai SMEs and related stakeholders. A number of previous predominant TAM research reports have been reviewed in order to establish the appropriate variables, research tools, methodologies and how to apply them to the context of this study. The TECTAM model is developed and proposed as shown in Figure 1. The model is largely based on TAM theory and it is believed that it is appropriate for the investigation of ECT acceptance and adoption by SMEs in Thailand.

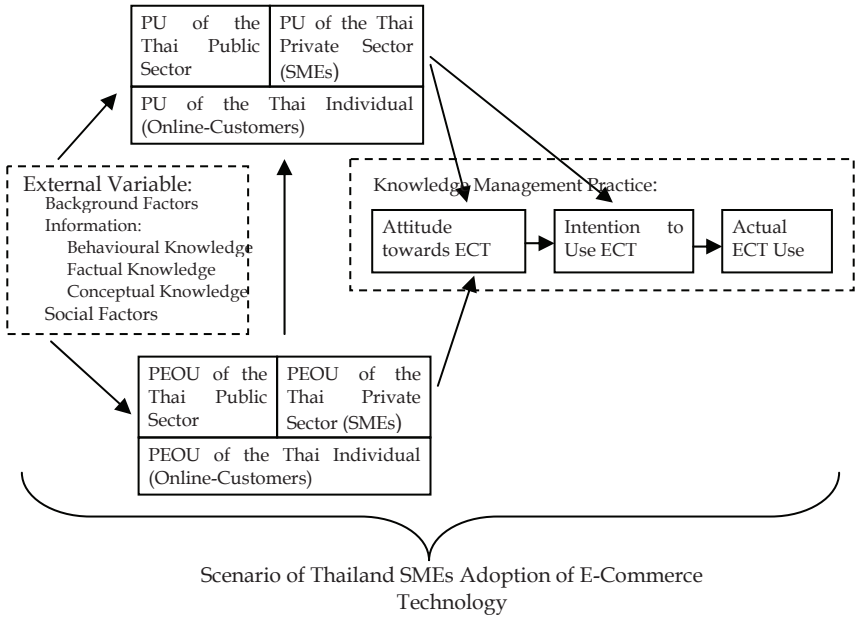

Fig. 1. TECTAM Model for Assessing the Adoption of ECT by Thailand SMEs

Three types of questionnaires are developed for gathering data from SMEs, online customers, and related government organisations and institutions. Background factors of respondents are design based on Ajzen (2005)'s notion. They are: personal factors (general attitudes, personality traits, values, emotions, and intelligences), social factors (age, gender, education, and income), and information (experience, knowledge, and media exposure). Moreover, three types of knowledge (Bunge, 1979) are designed as part of the external variables. In the context of this study, the knowledge is referred to:

a) Behavioral Knowledge which is the knowledge of Thai public sector, SMEs, and online-customers concerning with how to do, what to do, and what action to undertake about ECT.

b) Factual Knowledge which is the knowledge of Thai public sector, SMEs, and online-customers about information and events related to ECT.

c) Conceptual Knowledge which is the knowledge of Thai public sector, SMEs, and online-customers on high level abstract concept, ideals and judgments about ECT.

The validation and evaluation of TECTAM will be based on survey and interviews. The construction of questionnaires and interview questions are derived from Ajzen & Fishbein (1980), Davis et al. (1989), Legris et al. (2003), Venkatesh et al. (2003). Data will be collected and analysed to prove the following hypotheses:

- PU of the public sector, SMEs, and online customer are positively related to attitude towards ECT
- PU of the public sector, SMEs, and online customer are positively related to intention to use ECT
- PEOU of the public sector, SMEs, and online customer are positively related to PU

- PEOU of the public sector, SMEs, and online customer are positively related to attitude towards ECT
- Attitude towards ECT of the public sector, SMEs, and online customer are positively related to intention to use ECT
- Intention to use ECT the public sector, SMEs, and online customer are positively related to actual ECT use
- External variables of the public sector, SMEs, and online customer are positively related to PU
- External variables of the public sector, SMEs, and online customer are positively related to PEOU

Finally, methodologies for the study are a) field study by questionnaire survey; b) the Multiple Regression which will be used for measuring the eight hypotheses.

6. Conclusion

A proposed model based on TAM theory in this paper integrates three sectors involved with SMEs in Thailand. Much of the previous research on ECT adoption has focused on individual and separate sectors. It is difficult to assess the effects of ECT adoption from a country's perspective. In this chapter, it is intended to emphasise an integrated model comprising all these sectors and to explore the situation of ECT adoption by Thai SMEs in holistic approach. It is expected that the outcomes from the study using TECTAM will not only produce a report card on the current situation, but also provide appropriate suggestions to the relevant stakeholders on the policies and steps of ECT development and promotion to be taken. It is anticipated that such measures will promote the adoption of ECT and contribute to Thailand's economy.

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Autonomous Decentralized Enterprise Model -A New Wave in Web 2.0 Type E-commerce[1]

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1. Introduction

At the beginning of the twenty-first century, business conducted over the Internet (referred here as 'e-commerce'), with its dynamism, rapid growth, and high competitiveness, promises new avenues for the creation of wealth (Amit, Zott, 2001). Established firms are creating new online businesses, while new ventures are exploiting the opportunities the Internet provides. Moreover, since the emergence of Web 2.0 in 2004, users can do more than just retrieve information. The role of common customer in business has changed to a great extent, the customers have become more influential on sales and on new item development through their Internet activities (weblogs, forums, personal web pages, wikis, podcasts, social bookmarks, RSS feeds and other forms of many-to-many publishing). To some extent, Web 2.0 facilitates the construction of autonomous decentralized network outside the enterprises. This network, composed of autonomous customers and suppliers, and has become a topic, which caused extensive attention in the theoretical research and business practice.

Accompanying the environmental shift outside the E-enterprises, inside the business organization, traditional pyramid-style management models, such as the functional structure, multi-divisional structure or matrix organizational form, no longer suit the new external environment. In this chapter, a new wave of organization model inside enterprises the Autonomous Decentralized Enterprise Model (ADEM) will be described, and its process and formulation mechanism will be analyzed.

The chapter will be organized as follows:

First, the paradigm shift in the external business environment, which urges the transformation of the enterprise organization, will be introduced as background; then, the Autonomous Decentralized System (ADS), as the theoretical origin of ADEM, and its development will be presented as a revolutionary viewpoint in interdisciplinary fields. The practical application in real-time production system and theoretical innovation in business and management field based on the ADS will also be reviewed. The main part of the chapter

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will describe the mechanism and organizational characteristics of ADEM, which describes an inter-organization of enterprises through broad collaboration and interdependence between agents. All agents in a mutually dependent relationship can benefit from increased adaptability over their environment. Finally, the case study of a Japanese E-commerce enterprise will be examined to afford detailed cognition about ADEM. Yumenomachi Souzou Iinkai (Japanese for "dream creation committee") is a burgeoning Internet portal enterprise in Japan; most of its current staffs aim to become independent and start their own Internet business companies in the future. The CEO, Ms. Nakamura, has been encouraging their ambitions, thinking that that will lead to her company's emergence as a virtual cluster of new Internet businesses owned by her current employees. This new organization model is still at an early stage of ADEM, but it already demonstrates the rudiments of an autonomous decentralized inter-organization system.

2. The paradigm shift on the E-business Model in Web 2.0 era

2.1 E-commerce and e-commerce enterprises

The emergence of E-commerce has created a novel marketplace. However, There are various ways to definite what constitutes e-commerce. Bakos (1997) argued that it is the electronic market systems that create a space where buyers and sellers converge. Zwass (1996) proposed an architecture that embraces the aforementioned perspectives as two components of an e-commerce structure. Chang, Jackson (2002) argued that e-commerce includes not only buying and selling goods, but also various processes within and across organizations. E-commerce can also be loosely defined as a business process that uses the Internet or other electronic medium as a channel to complete business transactions. As classified by Geoffrion and Krishnan (2001), e-commerce consists of three areas: (1) consumer-oriented activity and (2) business-oriented activity supported by (3) the e-commerce technology infrastructure. The consumer-oriented activities consist of business-to-consumer (B2C), consumer-to-consumer (C2C), and government-to-consumer (G2C) activities. The business-oriented activities comprise business-to-business (B2B), business-to-government (B2G), and government-to-business (G2B) activities. The technology infrastructure relates to network infrastructure, network applications, decision technologies, and software tools and applications. In the terms of E- commerce firms, Amit and Zott defined an e-commerce firm as one that derives a significant proportion (at least 10%) of its revenues from transactions conducted over the Internet. This definition of an e-commerce firm is quite broad. It includes, for example, Internet Service Providers, and companies that have not aligned all of their internal business processes with the Internet but that use the Internet solely as a sales channel. On the other hand, it excludes providers of Internet related hardware or software, that is, firms that facilitate e-commerce but that do not engage in the activity themselves (e.g., a backbone switch manufacturer, such as Cisco Systems). The companies that derive all of their revenues from e-commerce (so-called “pure plays”) are relatively easy to identify using publicly available descriptions of their major lines of business (e.g., Amazon.com).

Within this broad definition of e-commerce activities, we are inclined to the definition that e-commerce as the use of computing and communication technologies to engage in a wide range of activities up and down the value-added chain, both within and outside the organization (Chang, 2002). And we will restrict our attention mainly to consumer-oriented and business-oriented activities, as well as decision technologies, strategy management that

are employed for intra-organization of EC. The business activity of Yumenomachi B2B2C (business-to-business-to-consumer), which is originated from B2C, is defined as e-commerce model in which a business provides some product or service to a client business that maintains its own customers.

2.2 Web 2.0 and e-commerce business model

In recent years, the emergence of the phrase Web 2.0 is a trend in web design development and can refer to a perceived second generation of web-based communities and hosted services — such as social-networking sites, wikis, and folksonomies — which aim to facilitate creativity, collaboration, and sharing between users. Many of the technology components of "Web 2.0" have existed since the early days of the Web. However, the concept of Web 2.0 was explicitly formulated in the first O'Reilly Media Web 2.0 Conference in 2004. As Bart Decrem, founder and former CEO of Flock, declared, the most outstanding characteristic of Web 2.0 is "participatory Web". This new environment certainly will affect the marketing strategy and organization management of the entities in the value chain, especially for the 'pure plays' of EC.

Don Tapscott and Anthony D. Williams argued (2006) that the foundation of Web 2.0 economy is mass collaboration. They claimed that the new media companies should utilize well this feature of Web 2.0 to make profit. According to Tapscott and Williams, openness, sharing, peering, and global thinking would be crucial aspects of the success of this new "Wikinomic", or collaborative Internet economy. Tapscott and Williams also classify the Web 2.0 business models in seven categories, suggesting that using these models could help a company to successfully enter in the modern Internet business by using the new wave of software applications. In this era, the line between creators and consumers has become vaguer than ever before, and in some cases most of the creative work and content creation is done by the users (Youtube.com, Slashdot.com or Wikipedia.org). Tapscott and Williams (2007) finally propose "models where consumers, employees, suppliers, business partners, and even competitors co-create value in the absence of direct managerial control".

In the Web 2.0 era, users can do more than just retrieve information. They can build on the interactive facilities of "Web 1.0" to provide "Network as platform". Users can own the data on a Web 2.0 site and exercise control over that data. These sites may have an "Architecture of participation" that encourages users to add value to the application as they use it. As an IBM social networking analyst, Dario de Judicibus, has proposed, Web 2.0 focused more on social interactions and architectural implementation: "Web 2.0 is a knowledge-oriented environment where human interactions generate contents that are published, managed and used through network applications in a service-oriented architecture."

According to NEC (Nippon Electric Company), the substantial change to the enterprise management and business strategy caused by Web2.0 could be summarized as three points:

(1) The marketing has changed. Before purchase, the potential customers always retrieve information from the user side and compare with other commodities in internet. In addition, after purchase, they also send their impression and evalutaion to the interent. Therefore, consumers have become more influential on sales or new items development by enterprises through their Internet activities in the Web 2.0 era. Thus, an interactive participation marketing operation corresponding to such Web2.0 purchase action is requested for the enterprises.

(2) The manner of communication in/out enterprises has changed. Out the enterprise, a large amount of information, which is sent and exchanged by blogs, SNS and so on, formed the so called "collective intelligence". This kind of participative wisdom will produce new and useful information in succession. If a similar phenomenon could happen inside the enterprise, the emloyees' capability for receiving and sending information would be upgraded. Therefore, an enviroment of active communication will cause a revolution of the enterprise culture.
(3) The means of the enterprise information system have changed. In Web2.0, accompanying the advancement of the web technology, more and more enterprises disclose and provide their own services and information by network. Whereby, it becomes more possible to construct the information system at low cost in short term by combining the external service and information.

In contrast to the old traditional websites system, in some extent, Web 2.0 facilitates the construction of the autonomous decentralized network "outside" enterprises. This network is constituted by each autonomous customers and supplier.
E-commerce, which entered to the EC2.0 era correspondingly, has attracted tremendous attention of scholars in the fields of how to manage the new customers relationship, how to integrate the intelligence of the customers, which is the resource of the network outside the enterprises. However, in terms of the inter-organization of the e-commerce in Web 2.0 era, yet, the research is currently comparatively sparse. The literature to date has neither articulated the central issues related to this new phenomenon, nor has it developed a theory that captures the unique features of the virtual organization in this market. This chapter attempts to initiate some research prospective by seeking to identify some characteristics of inter-organization in e-commerce in the new era.

3. Autonomous Decentralized System (ADS)

3.1 What is ADS?

Worldwide, markets and technologies have been rapidly changing and advancing. The users requirements have been diversified and grown unpredictable. The service time of the application systems are required to be longer and longer. The cost reduction of the computing networks resources has required for the easy-to-use, easy-to-construct and easy-to-modify. As the computing resources become less restrictive, the on-line property consisting of on-line expansion, fault-tolerance and on-line maintenance is required more (Mori, 1984). However, the conventional technologies have been developed under the extension of the centralized system concept based on the standpoint that the totality has to be previously defined. This standpoint is inconsistent with the new requirements of the system. Under these evolving situations, as the breakthrough over the conventional system, Autonomous Decentralized System (ADS) has been proposed in 1977 for resolving the on-line property to achieve the step-by-step expansion, maintenance / test and fault-propagation prevention without stopping the total system. The research and development has been accelerated in the world not only for the control systems but also for the wide-area information systems (Mori, 2004). The technologies have been developed in the diverse fields of transportation, factory automation, utility management, satellite on-board control, newspaper printing factory, information services, e-commerce, community service, and so on.

The ADS concept was derived from an analogy to living organisms. Every living thing is composed by cells and performs effectively by virtue of the biological operations of the functional organisms. Each cell is totally self sufficient for the information for its living and multiplication. None of these cells is involved in any master-slave relationship. They are completely autonomous in their survival and function. In the body, all the organisms are performing their own function in unit with other organs. Compared to the homogenous functions of cell, the functions of the organs can be characterized to be heterogeneous. Their basic autonomy is not violated by any communication between cells and organs. Therefore, the living body could perform its function of living and growing through its cellular structure while ensuring assurance, agility, mobility and autonomy. In conclusion, according to Mori (Mori, 1984) the system as a biological organism has the following attributes:

(1) The system always has faulty parts.
(2) It changes constantly, alternating between operation, maintenance, and growth.
(3) It keeps accomplishing its objective and function almost completely.

That is, the system is defined under these two standpoints:

(1) Being faulty is normal;
(2) The system is a result of the integration of subsystems.

In other words, the decentralized system integrates several subsystems and has a composite life cycle. The independent subsystems of the decentralized system consist of uniform components, which are capable of interacting with each other to perform global functions. However, nothing monitors or controls these subsystems in an integrated manner. The monitoring system is only a subsystem and, like an organ in a living organism, there is no hierarchy of subsystems. Moreover, a whole system cannot be previously defined. The system is the integration of the current subsystems, some of which may be faulty, undergo modification and repair. On this standpoint, ADS should satisfy the following two properties.

(1) Autonomous controllability: If any subsystem fails, is repaired and/or is newly added, the other subsystems could continue to manage themselves and to perform their own responsible function.
(2) Autonomous coordinability : If any subsystem fails, is repaired and/or newly added, the other subsystems can coordinate their individual objectives among themselves and it can operate in a coordinated fashion.

These two properties assure on-line expansion, fault tolerance and on-line maintenance of the system. Every subsystem is required an intelligence to manage itself, without directing to and being directed from the other subsystems and to coordinate with the other subsystems.

If ADS is employed in a homogeneous system, the system has the following representative characteristics:

(1) Fault tolerance: The partial failure of the system does not hinder the system operation in any way. The normal designed operation of the system can performed without propagating the fault to the rest of the system.
(2) On-line expansion: The system operation is not affected in any way when additional subsystem are added or deleted.
(3) On-line maintenance and testing: Routine maintenance and testing operations can be carried out on the system without stopping system operation.

If ADS is employed in a heterogeneous system, the properties, which the ADS should satisfy, are exhibited as follow:

(1) System agility: The environment should match the dynamics of the system flexibility.

(2) Mobility: The functional behavior of each subsystem should incorporate mobility so it can migrate to other systems.

(3) Assurance: The system should be able to collaborate with other systems in case it is unable to perform its function alone under evolving conditions (Ahmed, 2004).

The subsystems, in order to realize an autonomous decentralized system with autonomous controllability and autonomous coordinability, are required to satisfy the following three conditions:

(1) Equality: Each subsystem must be equal. That means every subsystem can manage itself without being directed or giving direction to others.

(2) Locality: Each subsystem manages itself and coordinates with others only based on local information.

(3) Self-containment: Each subsystem is self-contained in functions to manage itself and coordinate with others.

3.2 The application of ADS and trends

The ADS has been applied to a number of applications that involve the production system, management of information and control function in an adaptive information service system. The concept has been successfully applied in traffic control and information systems, for example, the ATOS (Autonomous Train Operation System), which is deployed in Tokyo metropolitan train traffic control system. Telecommunications-based information services, which are envisaged to expand in the future giving rise to more intelligent networks, are another beneficiary of ADS technology. A typical application of the ADS concept applied to production systems has been in the newspaper production. ADS allows immediate changes in format and volume according to the article contents, as well as coordinated production between locally distribute printing plants. The architecture allows flexible change of the production schedule while ensuring reliability. The technical concepts of ADS are also applied in highly reliable steel manufacturing system. Distributed systems that include many autonomous entities can benefit from the ADS technology.

The future of ADS is seen to be associated with the autonomous community concept where each component of the community will be autonomously handled. ADS has been instrumental in boosting productivity and lowering costs in manufacturing systems and has been approved as the de-facto standard in factory automation.

4. The ADEM

4.1 The proposal of ADEM

The concept of ADS is adopted in the field of the inter-organization of enterprises through broad collaboration and interdependence between each element. Interdependence refers to mutual dependency between units within an organization. Both units in a mutually dependent relationship can benefit from increased power over their environment. Following the traditional classification of Thompson (1967), there are three grades of interdependence. In the “pooled dependency”, the most basic form of interdependence, only the resources are

shared, there is no real interaction between the different groups. In the "sequential dependency", the output of a group becomes the input of another. And, finally, in the "reciprocal dependency" each group receives and produces work from and for several other groups in an interactive manner, forming a complex network.

Organizations can improve their performance by increasing dependency of organizational units. Lee, Pak observed the inter-firm collaboration in B2B electronic commerce. Based on the survey conducted in the grocery industry, they pointed out that the real source of performance improvement in B2B EC is the collaboration enabled by the electronic network.

Next, the applicability of the ADEM in Web 2.0 era will be analyzed. At present, the autonomous decentralized model is just a new emerging organization model phenomenon in Japanese E-commerce enterprises. Maybe its applicability and viability in the future will be doubted as any other fangle. This chapter just initiated a tentative analysis, which will be focused on two dimensions as follow: external environment and internal factor.

In the viewpoint of external environment, the prevalent application of Web 2.0 offers chance as well as requirement to new organization models. On one hand, the competition was enhanced broadly. During the past 15 years, we have witnessed the proliferation of Internet firms and the subsequent large-scale collapse of the Internet sector, which triggered an economic recession. According to Webmergers.com (2002), more than 800 Internet firms have gone out of business since January 2000. Those that remained had to adapt to the marketplace by changing their organizational strategies to survive. The sustainable development becomes an urgent topic in the field of EC. An effective and applicable organizational model is under expectation. More extensive collaboration and interdependence seems to be viable approach to exploit the development space. On the other hand, Web 2.0 also affords the unprecedented opportunity for enterprises to integrate the intelligence of all entities involved in the supply chain and value chain, including the suppliers, partners, customers and even competitors. For example, ERP (enterprise resource plan), CRM (customers relationship management), EDI (electronic data interchange), SCM (supply chain management), advanced planning and optimization solutions (APS) have been already realized and executed by many enterprises to maximize their profit and promote their efficiency in the Web 2.0 market. Also, the entry barrier is decreased, allowing more entrepreneurs to participate in the business. More participators make it more favorable to establishment and realization of collaboration network.

In the viewpoint of the internal factors, for a lot of individuals with their own small-scale start-ups, they are seeking for the external technological, financial, customer resource sharing cooperation actively. They want to realize their dream to play a role in some field, keep their own independence, not just simply merge or be acquired. The employees in the enterprises also seek for opportunities to create their own business inside the enterprises. They need the technology or marketing platform of the enterprises. Therefore, the management system faces to expansion or reduction any time as same as the computing system.

Combining both the external and internal factors, the predicted wave may still be doubted. Nevertheless, there is no doubt that the rapid growth and adoption of the collaboration and connection between EC enterprises has already had great impact on all the aspects of their business, including customer acquisitions, marketing, human resource management, finance, information systems and operations.

4.2 Case study

The detailed data was gathered on the case study company mainly from field survey, formal/informal interview and publicly available sources: IPO prospectuses, annual reports, reports from investment analysts, and the web site of the company.

4.2.1 Basic data of Yumenomachi Souzou Iinkai Co.,Ltd

Yumenomachi, which translates as Dream Street Creation Committee, aims to create exceptional services to assist people to live more conveniently and comfortably. Yumenomachi was established in 1999 in Osaka. Currently it has 40 employees. The main business includes:

1) Food delivery service website "Demae-kan"
2) Home maintenance service website "Kaketsuke-kan"
3) Take-out food and dinner reservation service website "Yoyaku-kan"

Yumenomachi began to gain profit from August 2005, fives years after its delivery service launched. In 2006, it became IPO Company. Figure 1 shows the revenue and profit shift of Yumenomachi after its launch.

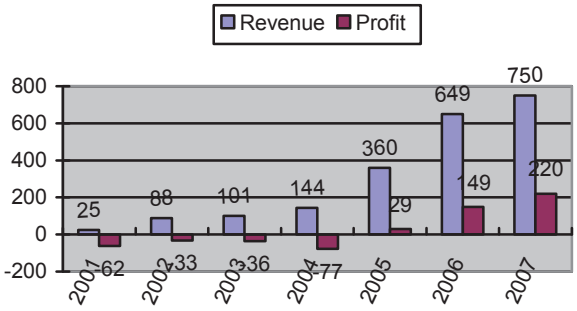
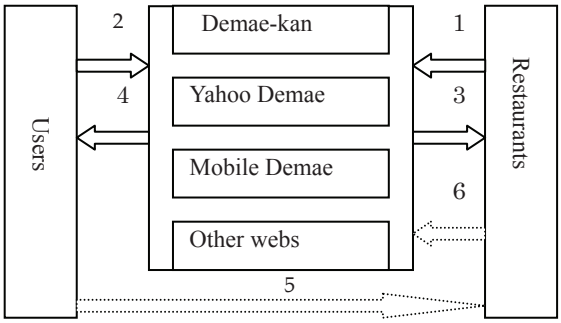


Fig. 1. Profit and revenue from 2001-2007 of Yumenomachi Unit: Million Yen
http://www.yumenomachi.co.jp/news_release/press/071015_3.pdf

Demae-kan is the first and also main business of Yumenomachi. In Japan, the food service industry has undergone a decreasing tendency for these ten years after its peak in 1997, but the market scale of takeout and delivery food has enlarged steadily along with a decrease of the size of households and the change of lifestyle in Japan. According to the statistics, the delivery food market reaches around 1600 billion Japanese yen per year. Demae-kan website was originated from the idea to afford order service in Internet conveniently and quickly. Figure 2 shows the B2B2C business model of Demae-kan.



1: publish the menu and ads
2: order 3: order information
4: confirm order 5: payment
6: charge and month fee
Fig. 2. Business flow chart of Demae-kan
http://www.yumenomachi.co.jp/ir_information/

Customers can order food, such as Pizza, Sushi, Chinese food or others through Demae-kan for free; Demae-kan will send the order message to the appointed restaurants by fax. After the confirmation of the menu and cooking time from restaurant, Demae-kan will send it back to customers to reconfirm. Then the restaurant will send the food to the customers and get the paid directly from them. Demae-kan obtains revenues through a member fee of the restaurants (monthly advertisement publishing fee 3,000 yen) and a 5% commission on each order.

Till November 2007, there are already 7613 restaurants joined in Demae-kan, and around 300,000 orders per month. In Kansai and the Tokyo metropolitan area, the number of the restaurants increases by around 130 stores every month.

One of the outstanding features of the Demae-kan is to concentrate on not only the chain stores but also the community-based stores like local noodle restaurants. However, the chains stores have its advantage to the business of Demae-kan, the treatments are the same as local small stores according to the principle of CEO, Ms. Nakamura, because one of her wish is to assist the local development and prosperity.

As the sister website of Demae-kan, Kaketsuke-kan started in September, 2005. Its business focuses on homemaking service. The customers can order through Internet for gas changing, key changing, tap fix, pest killing and other related services. This website is constructed based on the service of major consignment company Japan Best Rescue System Company.

The third business, Yoyaku-kan, launched in June, 2007. The customers can make reservation before they go to the restaurant or take-out food with the service in Yoyaku-kan.

4.2.2. Organization strategy

The B2B2C business model and its forerunner position are the advantageous of Yumenomachi. Moreover, its unique organizational strategy seems to be the requisite of the sustainable development of the company.

1) Independence of the employees

As a high-speed developing EC company, most of the staffs are young people; the average age of the staff is around 32 years old. The promotion and salary are only decided by the achievement of the staff, no relationship with the diploma or working time.
The manager pays attention to the independence of each staff. She always encourages them and also promises to support them to initiate their own business. During the process of recruitment, the company prefers the applicants who have the intention to start their own business. The personnel can learn the business knowledge and strategy working in this company. The manager expects that the employees can be independent in their own field of business and then collaborate together to form a bigger network. 60% of the male staff has their own entrepreneur ideas. One of the staff wants to open a sports equipment delivery website in the future.

2) Collaboration inter-enterprises and intra-enterprises

Since its establishment, Yumenomachi has constructed its collaboration network with several major companies. Its process of development is also a process to enlarge the cooperation with its partners. The Table 1 shows the detail of the cooperation relationship of Yumenomachi.

Date	Partner	Established Service
July, 2004	Index Company http://www.index-hd.com/	Mobile delivery service
August, 2004	Yahoo	July 2005, Portal site "Yahoo Delivery Service"
June, 2005	Japan Best Rescue System Company http://www.jbr.co.jp/	Kaketsuke-kan
August, 2005	AU official website	Mobile delivery service
August, 2006	Net Café (Hot-Station Company http://www.hot-station.co.jp/)	
August, 2006	Mediaflag Company http://www.mediaflag.co.jp/	Capital and business cooperation
October, 2006	Mitsui Sumitomo Card Company and GMO Payment Gateway Company	Credit service began in "Demae-kan"
October, 2006	"Hot pepper" of Recruitment Company	“Hot pepper” delivery service
April, 2007	So-net M3 Company which manages the biggest website related with health care in Japan http://www.m3.com/index.jsp	"M3.com" delivery service

Table 1. The cooperation relationship of Yumenomachi

Dot-com companies went through its freeze-up in the beginning of 21 century. After this, the surviving and the new companies became more cautious, avoiding high risks. From 2004, Yumenomachi cooperated with the Index Company and Yahoo parallel. It can be thought that, the strategy was able to avoid risks even if either failed. On February 28, 2007, Index Company terminated the joint business contract and its stocks were taken-over (19.4%) bid by Yahoo which became the largest shareholder (41.84% of the stocks). The collaboration with Yahoo has made Yumenomachi more stable. Based on the platform of Yahoo, the

business has expanded quickly in recent years. The win-win relation was mutually constructed, and the synergy effect seemed to be significant.

4.3 The characteristic and architecture of Autonomic Decentralized Enterprise System

This unique intra-organization network gestated in Yumenomachi may be still an intangible concept. While the goal of the actors involved in this business model is still hard to test in a long-term view. However, according to the basic concept of ADS, the essence ideology of the framework and the configuration of this intra-organizational network could be preconceived. The two main characteristics are autonomous and collaboration.

4.3.1. The characteristics of ADEM

(1) Autonomous controllability.

The autonomous controllability is about the flexibility of the human resource management style in the enterprises. As Takaki (1995), Limerick and Cunnington (1993) comment, the new organization of information era is different from the traditional pyramid organization based on the bottom-up vertical relations. The new organization puts emphasis on the horizontal relations among members. In AEDM organization, each member is independent and not affiliated or controlled by any other. Instead of waiting for the instruction from up, along the direction of the whole enterprise, they integrate the necessary business resources to tackle their own situation. Their target is not to satisfy what the up tiers demand or order, but to seek for creative and innovative solution. The motivation of this kind of spontaneous and autonomous activity is the intrinsic motivation called by Deci (1975), which means the motivation is from inside of the performer, brought by curiosity and concern, and the action does not depend on rewards or punishments. The encouragement and satisfaction come from performing an activity rather from a result of the activity.

(2) Autonomous Participation

This feature is about the freedom of the business entity. All business entities have freedom to join or exit the network. No one monitors or controls them in an integrated manner. Therefore, the system can be enlarged or reduced without any influence on the performance of the whole network. In the viewpoint of business innovation, ADEM affords all the participants the platform to establish their own business. The low barrier to enter and the freedom to leave is a driving force that attracts the participants to embrace a variety of E-commerce business. Here in Yumenomachi case, the staffs are encouraged and expected to use the delivery service business platform to build their various delivery service websites.

(3) Autonomous Collaboration

All members connect and collaborate with each other; they share data, information, knowledge, technology and customer resource. In this network, the myriad of powerful computing and communications technologies that facilitate these resources are transparent and easily transplanted.

In the aspects of the individual staffs, if any one adjusts his/her activity according to his/her situation, the others can still coordinate their individual objectives among themselves and it can operate in a coordinated fashion. Considering the business aspect, if any business unit joins or exits from the network, other business units can still operate fluently. Even there is both horizontal and vertical resource integration and connection among them.

4.3.2 The architecture of ADEM

In the study case of this chapter, most of the employees in Yumenomachi have their own clear targets, and their motivation is high. Their enthusiastic devotion to new business could give momentum to the entire company. As mentioned in 4.3.1, the relationship among members in the organization is described in Fig 3 (Right). After the establishment of the institution, all the individuals are expected to take the initiative in solving problems. However, he or she could still obtain assistance from others in the organization.

At present, there are three website services in Yumenomachi. In the future, maybe other start-ups established by other employees will also join this system, such as the aforementioned sports equipment delivery service. They will upgrade the former network while they benefit more from the network if the quantity of members grows up. Then, the new network will attract more members to join in. In the end, it will form the benign circulation. Because the members may be from different business fields, the ADEM model is different from an industrial consortium, and because there is no leader or supervisor, it differs from the branches under a head office.

Figure 3 (left) shows the business architecture of Yumenomachi based on the concept of ADEM. The system with the basic features of equality, locality and self-containment can be realized under this architecture, where there is no central controller or coordinator, all members are not affiliated or controlled by any other. They have their own management system, the Autonomous Management Officer (AMO), to manage themselves and coordinate with others. The self-contained elements, including their respective AMOs, are integrated into system.

In this network, all the business units are connected through the Resource Field (RF); all resources will be broadcasted into the RF and the data itself will be reserved and updated in the RF by integrating the intelligence of all the partners; RF will be established based on the principle of "wikis", as any member can access and update it. Therefore, the RF allows all the participants to create, share and use strategic knowledge to improve operational and strategic efficiency and effectiveness. However, the broadcasting of the resource has one basic rule. As researches argued, the information human being can understand contains two levels (Bateson, 1979). One is the information/message itself, the other is the context of the message. Without the context, it is tough for human beings to understand the information itself. Therefore, instead of the code for sender and receiver, the context should be added during the information being broadcasted. Besides, the members also communicate with each other in the real world. The system management structure may vary depending on the joining or leaving of the subsystems. However, the operation of the each unit will keep as usual. In order to realize a stable implementation of the whole system, the autonomous subsystem has to recognize and evaluate the heterogeneous resources in the RF, to select the appropriate resource and to satisfy its individual requirements by cooperating with other subsystems.

The thinking of ADEM will open up a completely new dimension to E-commerce by enabling individuals to use the convenience of the RF in addition to traditional resources. Also, the ability to share resources across the homogenous business field (delivery service) has made it easier for enterprises to have collaborative planning and design, which removes inefficiencies in the expansion process.

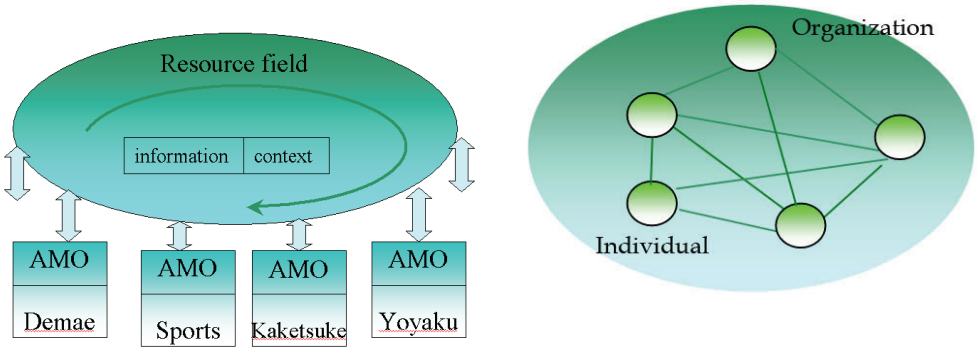


Fig. 3. Architecture of Autonomous Decentralized Enterprises Model

4.3.3. The two drive-wheels of ADEM organizations

Seeking for profit is the nature of the enterprises in most cases. If the members cannot realize profit in the system, they will exit and no new one will join in. The system will exist only in name. On the other hand, if the free rider phenomenon becomes very severe, resources will be used out but without updating. However, ensuring the sustainable development of the ADEM organization, the president of Yumenomachi, Ms. Nakamura summarized the two philosophies of business of Yumenomachi, which are also considered as two drive-wheels of ADEM organization. One is the revenue and pure profit, and the other is contribution to the society. They cooperate and interact with each other to boost wealth and promote efficiency in the viewpoint of the whole society. First of all, as private entities, actors in ADEM organizations expect to obtain merit and advantage. It is quiet realistic and essential for the ADEM organizations whether the actors are capable to obtain profit. As Chang, Jackson and Grover illustrated that growth without profitability is not sustainable. Many e-commerce companies had high valuations based on an excessive focus on high growth shown by their attracting new customers. However, their inability to generate profit proved detrimental. Therefore, Gross Profit Margin (GPM) is the real measure of an organization's performance efficiency. The contribution to the society, as the joint vision of ADEM organizations is the other wheel. It could be considered to be the stimulant of spiritual dimension for all actors as a long-term vision of the organization. The social joint-vision will work as a catalyst for knowledge sharing, innovation and cooperation inside the organization. Meanwhile, the social contribution oriented mission of the organization will facilitate attainment of empathy and cooperation from outside. As a consequence, the harmonic inside and outside environment will be favorable to realize the profit for all the actors in the organization.

5. Conclusion

The rapid popularization of Web 2.0 coupled with the growth of e-commerce gives rise to enormous opportunities as well as changes for the creation of new intra-organization models. In the evolving environment of the E-business, this study has attempted to contribute to the framework description of a new type of inter-organizational model in e-commerce enterprises: Autonomous Decentralized Enterprise Model. From this case study,

one conclusion is that the emergence of autonomous decentralized model is not accidental, but generated from the dual effects of the external environment and the internal catalyst factor. Moreover, the foundational features and configuration blueprint of the ADEM according to the rudiment organization of Yumenomachi is also described in this chapter.
For these years, the greatest impact of Web2.0 has been its ability to create linkage outside the enterprises and platforms inside the enterprise. The ADEM might not have existed just a few short years ago because there was no widely accepted platform for continuous and unattended share and exchange of information and knowledge about markets, customers, demand, inventories and so forth. Today, such autonomous and collaborative networks could be evolving in every economic field, as they support the business-to-consumer commerce, business-to-business commerce, government-to-citizen interactivity, peer-to-peer exchanges, and internal connectivity. Such organization based on the ADEM will allow enterprises to be dynamic and flexible, thereby allowing rapid changes in their strategies and activities. Meanwhile, the participants can use the platform afforded by the organization to create new business opportunity easily, leading to further improvements in collaboration and sustainable development of the organization. One predication is that ADEM could generate positive performance and its application could be promising in the Web 2.0 era, even the emerging Web 3.0 era recently. However, the free rider is always inevitable phenomenon. Only the emphasis on the social contribution and self-conscious might not be effective enough to avoid the failure caused by free rider. Therefore, the reasonable principles or standards to define the responsibility are necessary. This will be key point for the future study.

6. Acknowledgment

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5

Modular architecture framework for cross-organizational electronic interaction

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1. Introduction

Nowadays governmental authorities as well as companies have to manage a rising number of dynamic inter-organizational business relationships, calling for means that allow for their efficient and effective management (Hagel & Singer, 2008). Gartner Research emphasizes the increased relevance of information technology (IT) in this context: "We expect that by 2011, midsize- and large companies will have at least doubled the number of multienterprise integration and interoperability projects they're managing and will be spending at least 50% more on B2B projects, compared with 2006. We also believe that, from 2008 to 2013, multienterprise traffic will at least triple."(Lheureux & Malinverno, 2008)

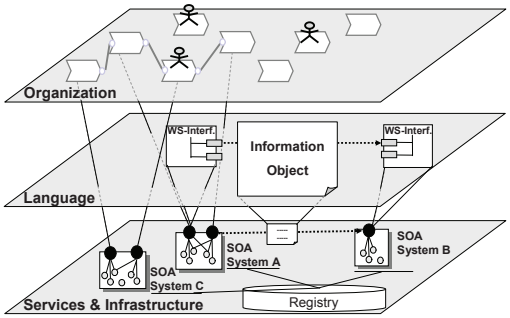

Fig. 1. Service-oriented architecture, according to St. Gallen Media Reference Model (MRM)

During the past years, **Service-Oriented Architectures** (SOAs) have become an acknowledged general architectural style underlying the implementation of cross-organizational electronic interaction (see Figure 1). The widely accepted normative OASIS Reference Model for SOA defines SOA as "…a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations"(Mackenzie et al., 2007). Figure 1 illustrates the fundamental concept of SOA. On the lowest level,

organizations expose dedicated services (black circles) and make them publicly retrievable via certain registry mechanisms. Such services can be composed of a number of other, only internally visible services (symbolized as small gray circles), complying with the principle of information hiding. On the basis of this infrastructural level, a common understanding of the semantics of exchanged messages needs to be ensured. The second level in Figure 1 illustrates the requirement of mutually comprehensible information objects. On the third level, services are orchestrated according to the previously specified structural as well as process-oriented organization.

Despite of the advent of SOA, **the emergence of a huge number of mutually unconnected island solutions could not be prevented**. As illustrated in Figure 2, most business communities rely on a medium (in our context, the term medium refers to any kind of IT infrastructure that enables the interaction of agents) that is designed in a proprietary fashion, both on an organizational, a semantic, and an infrastructural level. In case governmental authorities or companies (referred to as agents in Figure 2) which are connected to different media intend to exchange information, all involved stakeholders face huge challenges. Organizational models, the "languages", as well as infrastructural standards differ significantly (as symbolized by the red flash in Figure 2), and thereby prevent from seamless interoperability.

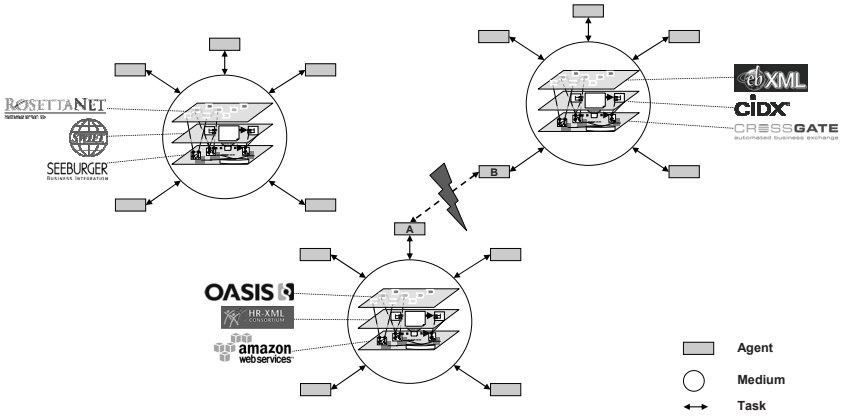

Fig. 2. Challenge: huge number of unconnected island solutions (Schroth & Schmid, 2009)

This article will address these challenges inherent in cross-organizational electronic interaction. Through the identification and establishment of a **commonly acceptable architecture framework**, different organizations and business communities will be enabled to build electronic media which both consider their individual requirements and still allow for seamless interoperability with the media of other business communities. The design rules constituting this architecture framework rely on the basic paradigm of service-orientation and cover all three above mentioned levels: Organization, Language, and Services & Infrastructure. First relevant approaches on all three levels have been published in (Müller et al., 2009) as a comprehensive position paper. The following paragraphs briefly outline some major aspects to be covered by the design rules:

- **Organization**: The types of the interacting agents have to be defined explicitly through the introduction of role descriptions. Also, the procedures of interaction must be defined, be it in a declarative way as rules, or procedurally as traditional processes. Existing methods for modelling cross-organizational interoperation predominantly follow a unitary, process-oriented approach. In this article, we argue for a novel modular method that considers both structural as well as process-oriented organization.
- **Language**: The second "language" level defines the types of the objects of interaction, i.e. the objects, on which the agents act, and which they exchange. Today, experts are forced to understand every syntactic and semantic detail of proprietary application interfaces (based on, e.g., CIDX, HL7, PIDX, SWIFT, etc.). in order to interconnect them. A novel approach is required which provides common design rules for this layer and also proposes a library of modular semantic building blocks that act as common basis for modelling different information objects.
- **Services & Infrastructure**: On the technical level, agents and the services they provide have to be connected physically in order to allow for their interaction. Existing platforms and standards for the implementation of cross-organizational business relationships can mostly be considered as proprietary island solutions. For this reason, we propose an augmented version of the Event-Bus Switzerland standard which allows for the set-up of a federated event bus infrastructure that shall act similar to a cross-organizational operating system (Schroth, Schmid & Müller, 2009).

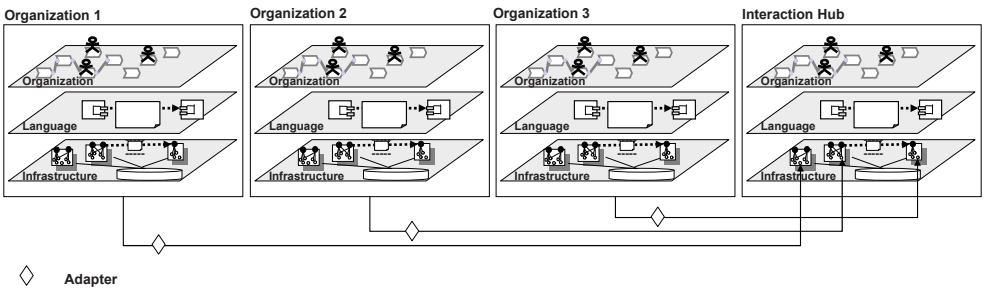

Fig. 3. Goal: seamless cross-medium interoperability

Figure 3. illustrates the focus of this article: Different organizations or business communities may build their respective electronic media (see organizations 1, 2, and 3) to support the interaction of their internal agents (such as individuals, or whole departments). As long as they adhere to a minimal set of architectural design rules, they may also act as agents in another business community (referred to as interaction hub in Figure 3) and mutually interact. The **design principles of modularity and recursivity are key to success**: Each organization must be allowed to encapsulate internal design information from the outside and act as a single agent in arbitrary, other business communities. A Swiss canton, for example, may want to hide internal operations and data from other governmental offices, but still desires to interoperate with other cantons, municipalities, or federal offices. **Adapters are required** for the interconnection between media which follow different design

rules. Such adapters need to intermediate between different technical, but also semantic, and organizational models

The remainder of this article is organized as follows: In section two, existing approaches regarding the design and implementation of cross-company electronic interaction are presented. The systematic analysis of merely organisational approaches, approaches aiming at a common language, technical solutions, service-oriented development methodologies, as well as existing architecture frameworks and reference models builds an adequate foundation for the specification of our research contribution. In section three, a novel modular architecture framework is presented which extends the basic design paradigm of SOA and covers all three above mentioned layers (organization, language, and services & infrastructure). The framework shall provide general design rules which allow for the organization and implementation of both centralized, hierarchical, and decentralized, heterogeneous cross-company business relationships. Through the incorporation of modularity, it shall enable the efficient set-up as well as the redesign of multiple autonomous, yet interconnected groups of companies. On the basis of a case study in the field of public administration in Switzerland (section four), we show the framework's real-world applicability and its improvement potential. Section five closes the work with a brief summary and an outlook on future work.

2. State-of-the-Art

While SOA represents a general architectural style, it does not provide concrete methodologies for the design and implementation of electronic business relationships that span across corporate boundaries. In fact, as depicted in Figure 4, five major clusters of approaches have been identified that help enterprise architects to actually build a cross-organisational SOA:

First, a substantial variety of approaches exists which focus on merely **organizational modelling**. The UN/CEFACT Modelling Methodology (Hofreiter & Huemer, 2003), as well as the Business Process Execution Language (BPEL), or the ebXML Business Processes Specification Schema (BPSS) are examples of practical, widely used standards which are readily available. Significant scientific contributions to the modelling of cross-organisational interaction include, but are not limited to the following examples: Chebbi, Tata, & Dustdar (2006) proposed a meta-model for defining cooperation policies, including partner roles as well as their coordination, data flows, and inter-visibility levels. Jiang, Shao, Qiu, & Li (2008) suggest a timed coloured Petri-net and process-view combined approach to design cross-organizational workflows for Collaborative Product Development (CPD). Gugliotta et al. (2005) proposes a semantic model for the central, business process-based service orchestration. These and related methods are invaluable for capturing and reorganizing the process-oriented (Hammer, 1990), organizational aspects of a given interaction scenario. However, they often do not provide integrated methods or modelling notations for the specification of the structural organization or the information objects exchanged in the course of interaction of companies. The lacking consideration of structural organization entails deficient organizational abstraction and thus flexibility (Schmid et al., 2009). As also argued by other scholars, the principle of information hiding is required to allow for the encapsulation of company-internal design information and also for clearly specified

interfaces between private and public (visible to other organizations) views. Non-modular, comprehensive workflow models, which are based on predefined process logic, offer little support for today's complex and dynamic business environments. Particularly business networks that comprise knowledge-intensive tasks (which may also be subject to strong variations) require novel ways for reducing the complexity and increasing the agility are required. Also, all surveyed approaches act on the assumption that the business processes governing the interaction of one single specific business community need to be specified. They do not foresee possibilities to organize several communities in parallel of which each follows an individual organization but is still interoperable with the other communities. In other words, organizational artefacts available today require the design of each community from scratch and do not support their mutual interoperability.

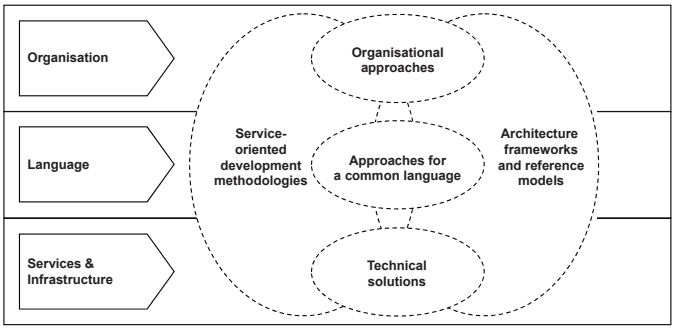

Fig. 4. State-of-the-art overview

The second "**language**" level of analysis concerns the objects of interaction, i.e. the objects, on which the agents act, and which they exchange. In fact, a plethora of different, mostly industry-specific standards exist which enable and at the same time often prevent from cross-domain interoperability. In order to seamlessly interconnect applications which follow different standards across corporate boundaries, huge efforts are usually undertaken. "Mapping experts" and "data consultants" are forced to understand every syntactic and semantic detail of the proprietary application interfaces in order to allow for their connection. BASDA, CIDX, cXML, FpML, HL7, HR-XML, IFX, Open Travel Alliance, papiNet, PIDX, RosettaNet, RSS, SIF, TWIST, UBL, and XBRL represent only a few of the existing data standards in the field of cross-company electronic interaction. These mostly domain-specific, often monolithic standards prevent true interoperability and require huge mapping efforts between the different data fields and their respective representation. A novel approach is thus required which defines commonly acceptable design rules for the flexible structuring of information objects, while leaving a sufficient degree of design freedom for the incorporation of individual requirements. Such a novel approach shall also provide modular semantic building blocks that act as common basis for modelling different information objects. This set of common design rules as well as libraries encompassing information object building blocks are expected to increase cross-organizational interoperability without establishing yet another proprietary standard (Schroth, Pemptroad, & Janner, 2007).

The third level of investigation concerns existing solutions for the **technical implementation** of cross-organisational electronic interaction. Since the wide acknowledgment of the above introduced design paradigm of SOA, the concept of Web services has experienced great interest: The so called Web services stack today represents one of the most accepted means for building a SOA. It provides a system-independent way for interlinking potentially dispersed software applications in a flexible way. Web services can be considered as "plumbing […] for information systems to interact without human involvement" (McAfee, 2005); they provide an invaluable fundament for the uniform description, retrieval, and consumption of heterogeneous capabilities and incorporate the principle of information hiding. However, as also found by the analyst firm Gartner as well as scholars such as Andrew McAfee from Harvard Business School, Web services alone are not sufficient to prevent from the establishment of insular IT service infrastructures for cross-organizational electronic interaction. Service interconnections that span across company borders require electronic business media that implement the structural as well as the process-oriented organization of interaction, define the formats and types of information objects exchanged between the companies and also offer a set of operational services (e.g. for encryption, routing, format adaptation). Since the Web services stack does not provide a comprehensive specification for such IT service infrastructures, groups of companies today frequently build or buy rather proprietary integration platforms which can be considered as island applications.

Dozens of firms have emerged by today that offer integration platforms: Integration-as-a-Service (*IaaS*) providers, for example, offer reliable communication, partner management, technical integration services and application services. Firms such as Amazon have very recently started to provide Web services with business functionality that can be used by developers to implement Web-based business applications which span across company boundaries. In addition, *Amazon* has started offering computing ("Amazon EC2") and storage ("Amazon S3") resources as well as a message-bus platform ("Amazon SQS") that allows for the reliable, secure, and transparent exchange of XML-based messages between distributed business applications. Finally, *Mashup platforms* are considered as tools that empower users to loosely couple readily available pieces of content or functionality, to enrich and compose them into novel services, which can eventually again be made publicly available. The wealth of existing technical e-Business standards (particularly the Web services stack), in combination with novel promising architectural styles such as Event-Driven Architectures (EDAs) represent a valuable technological basis for implementing cross-organizational electronic business relationships. However, particularly in case of large-scale, heterogeneous interaction scenarios which involve different business communities, existing technical solutions are often insufficient. Existing platforms tend to interconnect application interfaces in a proprietary fashion. Registries for information objects, implementations of structural and process-oriented organization, as well as additional operational services (e.g., for encryption, data mapping, identity and access management, or data management) are built according to individual requirements. In other words, today's technical approaches allow for tight application integration rather than loosely coupled interoperation. Many "B2B communities" merely focus on shared, isolated business functionality and are implemented as stand-alone island solutions for specific purposes. Investigations conducted by the international analyst firm Gartner confirm these findings (White, Wilson, & Lheureux, 2007). Potential changes such as the on-boarding of a

new organization into an existing community or the partial interconnection of two or more existing communities requires considerable effort, thereby delimiting operational agility of the involved enterprises.

Apart from the above discussed, rather focused artefacts for organizing and implementing cross-organizational electronic interaction, a number of more holistic, **service-oriented development methodologies** have emerged which explicitly build on the aforementioned SOA paradigm and cover different parts of a software lifecycle such as analysis, design, and implementation. IBM´s Service-Oriented Application Development (SOAD) proposes elements that should be part of a service-oriented analysis and design methodology. SOAD builds upon existing, proven technologies, such as Object-oriented analysis and design (OOAD), Component-based development (CBD), and Business Process Management (BPM). It also introduces SOA-specific techniques, such as service conceptualization, service categorization and aggregation, policies and aspects, and more. This and other methodologies represent first relevant attempts to systematically develop SOAs. The architecture framework proposed in this article will consider the most valuable aspects of existing methodologies and extend these to particularly address the inter-rather rather than the intra-organizational realm where one single homogeneous service architecture can be established.

Finally, existing **architecture frameworks and reference models** need to be examined with regard to their strengths and weaknesses in the context of cross-organizational electronic interaction. The discipline of enterprise architecture treats organizational and technical aspects as two distinct, but complimentary viewpoints on an overall company: According to Lankhorst et al. (2005, p. 3), an enterprise architecture comprises "a coherent whole of principles, methods and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure". Enterprise architecture frameworks and reference models are required to align business and information technology in a seamless fashion, to reduce costs for technology through discovery of redundancies, and to have a comprehensive "building plan" available which allows for the systematic design and implementation of information technology. Exemplary frameworks include the Business Engineering Framework (Österle, 1995), the Federal Enterprise Architecture Framework (Lee et al., 1999), and the Department of Defense Architecture Framework (DoD, 2007). These and other, related frameworks represent essential means for managing intra-enterprise architectures as they structure architectures into domain-specific views to reduce inherent complexity. However, many of them can be considered system-centric since they mainly focus on aspects within the boundaries of an enterprise and thus do not necessarily optimise the design or governance of federated environments which need to accommodate heterogeneous requirements. Others already acknowledge the need for federated architectures but do not provide comprehensive methodological means for the decomposition of interaction scenarios and their subsequent assembly.

To sum up: artefacts focusing on merely organizational aspects have been found to frequently lack support for the combined modelling of process-oriented and structural organization. They also exhibit deficient support for organizational abstraction, modularisation, and consequent agility. Finally, they do not provide methodological and notational means for coping with multiple (potentially heterogeneously organized), interconnected business communities. Efforts undertaken for the establishment of a

common “language” have led to a plethora of standards which are highly domain-specific. The existence of such monolithic and proprietary standards, however, prevents from efficient cross-organizational interoperability. From a technical perspective, existing e-Business standards have been analysed. Also, providers of readily available products or services for cross-organizational interoperation - both in the private and the public sector - have been investigated. These have been found to focus on integration rather than loosely coupled interoperation: B2B platforms tend to offer shared business functionality and are implemented as stand-alone island solutions for specific purposes, including proprietary message standards as well as realizations of the process-oriented and structural organization governing their interaction. In case of changes, huge efforts are required to implement the novel organization. Architecture frameworks and reference models encompass both an organizational and a technical viewpoint. However, existing approaches to cross-organizational enterprise architectures are either system-centric as they follow an integrated approach or lack methodological advice for the decomposition, modelling, and subsequent implementation of IT service infrastructures that span across corporate boundaries.

3. A Modular Architecture Framework

In general: MRM, basic structure of the whole thing.

3.1 Physical Component

The physical component of the architecture frame work discussed in this article builds on the two complementary architectural styles of Service-Oriented Architectures (SOAs) and Event-Driven Architectures (EDAs). In specific, it relies on and augments the Event-Bus Switzerland (EBS) specification (Müller, 2007).

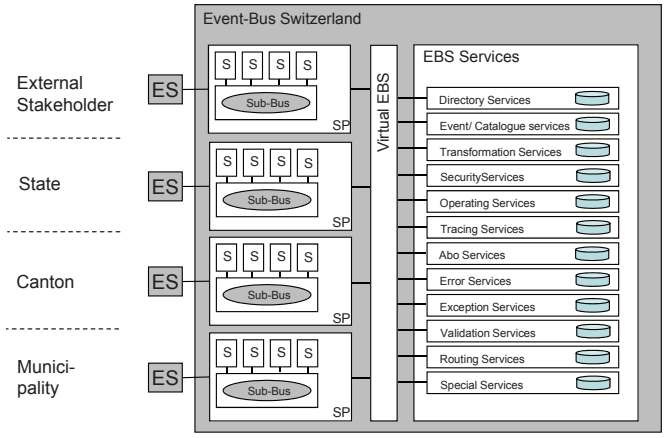

Fig. 5. The basic Event Bus Switzerland architecture (Müller, 2007)

The EBS standard comprises a set of design guidelines for the creation and continuous evolution of a federated system of numerous event buses (referred to as EBS sub-buses;

"Teilbus" in German) which allow for fulfilling heterogeneous, individual requirements and still enable cross-bus interoperability: Figure 5 shows an overview of the basic EBS architecture. The EBS realm comprises several service providers (SPs) who operate the so called sub-buses (TBs). These sub-buses act as electronic media which allow for the seamless interconnection between agents. In Figure 5, these agents are represented by "End-systems", i.e. local and potentially very heterogeneous IT applications. As one of the central design paradigms inherent in the EBS concept, all these sub-buses need to adhere to certain design rules in order to be interoperable. In that case (all sub-buses comply with these rules), agents which are connected to different sub-buses can still collaborate across sub-bus boundaries. The Event-Bus Switzerland can thus be considered as virtual concept comprising design rules but does not represent a physical medium itself. In fact, the EBS delineates infrastructural services such as routing services, error services and directory services (see Figure 5). As long as all sub-buses adhere to these service specifications, interoperability is ensured.

Figure 6 illustrates the most central components of our extended specification (Schroth, Schmid, & Müller, 2009): Rather than implementing the interaction between a set of agents based on one electronic medium, interaction scenarios are decomposed into so called interaction modules (IAMs). For each of those modules, a sub-bus is realized (in this example, a first module IAM0 comprises medium M1 which enables the communicative exchange of agents 1, 2, and 3) and implements a number of services:

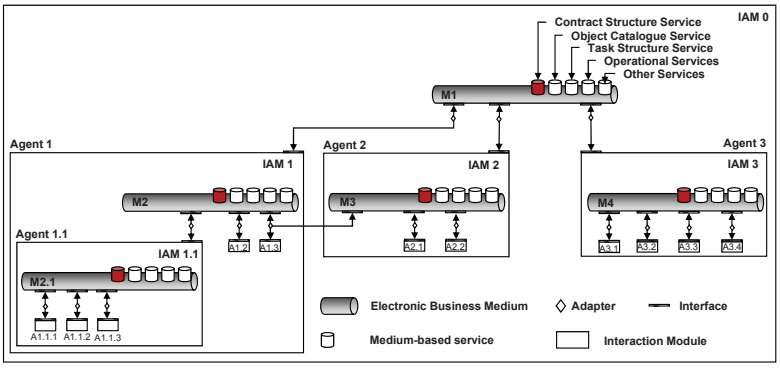

Fig. 6. Modular system of bus media (Schroth, Schmid, & Müller, 2009)

The *contract structure service* implements the structural organization within each bus. It specifies the agents connected to the bus, their roles, and the tasks they are authorized to perform within their respective IAM. The *task structure service* implements the process-oriented organization established within the respective IAM. For each of the tasks that can be performed by defined agents within an interaction module, this service documents precedence relationships to other tasks. It also specifies the mutual relationships between tasks as they constitute one-way or two-way interaction patterns (this organizational specificity will be explained in section 3.3). The *object catalogue service* specifies all the information object schemata which may be exchanged via the bus medium. *Operational services* (e.g. encryption, decryption, routing) assume operating system functionality and are

well described in (Müller, 2007). The recursivity inherent in this design allows for information hiding where required and thus supports decoupling: Agent 1, for example, may assume a defined role within IAM0, while it encapsulates the interaction of a number of sub-ordinate agents (A1.1, A1.2, A1.3) who interact via a hidden medium. As long as the general design rules (based on the above outlined services) are considered when designing a modular system of such sub-buses, cross-bus interoperability and efficient redesign is facilitated. The following example illustrates the flexibility of this design: In case a service provided by a so far hidden agent (e.g., A1.1.1) shall be made available to a number of other agents (connected to different bus media), for example, all design information required for its consumption can be "propagated upwards" through the design hierarchy (by means of updating the above mentioned services). The red data base symbols in Figure 6 represent the contract structure services of the 4 depicted bus media. In order to "publish" a service provided by agent A.1.1.1 to other agents (for example those connected to medium M4), the respective data base entries in the M2.1-based contract structure service can easily be transferred to the M4-based service as they obey to the same design rules.

3.2 Logical Component

The architecture framework propose a modular, core-component-based modelling approach which augments emerging standards such as the OASIS Universal Business Language (UBL), the UN/CEFACT Core Component Technical Specification (CCTS), and, on a technical level, the W3C XML schema (see Figure 7). The approach is new as it spans the bridge between unstructured modelling of data and core-component-based, formal representations and also because it integrates contextual information in order to allow for deriving tailor-made business information documents from generic information object classes. The resulting modelling approach ranges from (tool-supported) graphical data models to the technical representation of the business documents such as XML schema documents designed in compliance with the UN/CEFACT XML schema Naming and Design Rules (NDR).

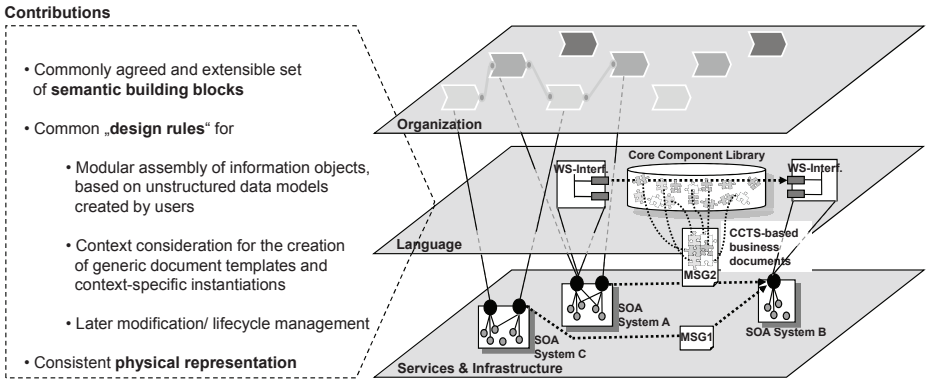

Fig. 7. Modular design of information objects

Four abstract entities constitute the core of the information object modelling approach: First, generic core components are employed as reusable building blocks for the design and

assembly of comprehensive generic business documents. The CCTS methodology proposes the four core component types Core Data Type (CDT), Basic Core Component (BCC), Association Core Component (ASCC), and Aggregate Core Component (ACC). Generic document descriptions (see the rectangle on the left in Figure 8) encapsulate the organization of whole documents such as order or invoice documents. They can be compared with classes in the software programming context as they can be instantiated several times in different contexts. The instantiations of generic business documents are referred to as specific business documents. Such specific business documents are constituted of specific core components, i.e. the context-specific instantiations of their generic counterparts, the generic core components. The mechanism by which specific documents and core components are derived corresponds to the mechanism of "restriction inheritance". Only those information object constituents are selected that are relevant in a given context (see the three context-specific instantiations on the right side of the figure). Our framework augments the above mentioned standards as it provides a guided procedure for the graphical modelling of unstructured data and its subsequent transformation into standard-compliant data components, as it introduces a comprehensive methodology for the incorporation and management of contextual information, and as it proposes an XML schema-based representation of generic business documents, including context parameters (Schroth, Pemptroad, & Janner, 2007).

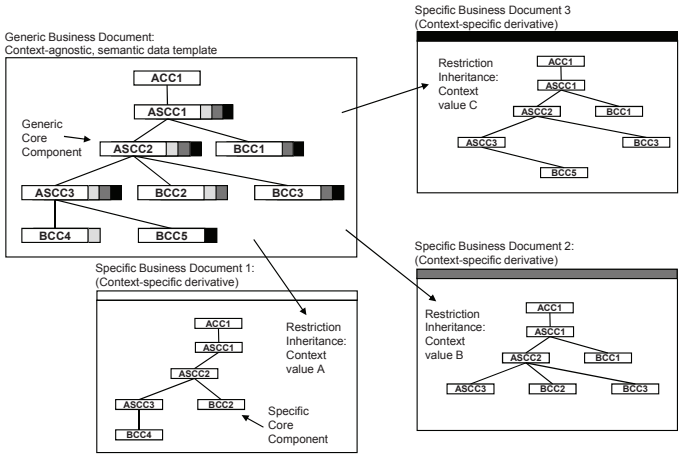

Fig. 8. Context-specific instantiations of a generic business document (Schroth, Schmid, & Müller, 2009)

This information object design approach allows for increased reuse and thus productivity through the establishment of a common library of standardized data building blocks. It also improves modifiability of information object representations (and thus also service interfaces) since components of an object model can be easily augmented, excluded, split, or substituted. This differs from conventional, rather monolithic approaches since information objects do not require a holistic redesign in case changes are required (Janner et al., 2008).

3.3 Organizational Component

To achieve a modular organization of electronic interaction, an interaction scenario first of all has to be decomposed into its constituent, fine-granular tasks (business activities, performed by agents, defined as operations related to specific information objects).

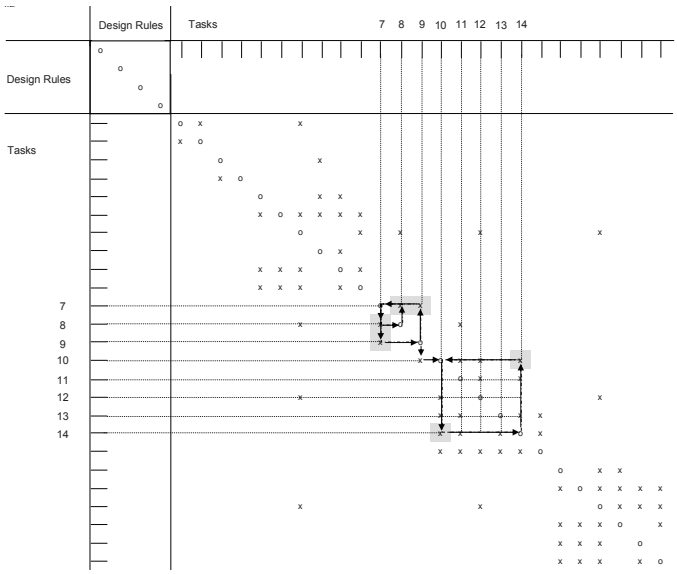

Fig. 9. Capturing interaction patterns from the structural and process-oriented organization

The identified tasks (lowest level of organizational abstraction) are then assigned to both the x- and the y-axis of a task structure matrix (Baldwin & Clark, 1999). In case task i precedes task j, a mark (x) is put in column i and row j of the matrix to document precedence relationships between the various tasks (see Figure 9). From the marks, we can then identify one-way and two-way interaction patterns (IAPs) which represent the second level of organizational abstraction. IAPs encompass two tasks and feature parameters for detailed behavioural modelling (Schroth & Schmid, 2009). An IAP comprehensively addresses a dedicated unit of interaction among agents (who assume roles): It can be instantiated as either one-way or two-way pattern: In the former case, the modelled pattern comprises the transmission of an information object from a sending to a receiving role ("one-way"). In the latter case, an information object is sent from one role to another one who is required to respond in a clearly specified manner ("two-way").

Figure 9 illustrates the identification of three two-way and a single one-way IAP: First, task 7 needs to precede task 8. In other words, the information object associated with task 7 represents a necessary input for task 8. Task 8, in turn, is a direct response to task 7. This request/ response relationship can be modelled as two-way IAP: One mark is entered into row 8 and column 7, while another one is entered into row 7 and column 8. In order to make the interrelationship of the two marks visible, the respective cells in the matrix are coloured gray. In this exemplary case, task 8 is not the only possible successor of task 7. Instead, task 9

may be executed alternatively. As a consequence, a second two-way IAP can be identified (marks in row 9, column seven, as well as in row 7, column 9). Tasks 9 and 10, on the other hand, are governed by a one-way IAP: A single mark is entered into row 10, column 9. As a final example, tasks 10 and 14 can again be described with the help of a two-way IAP (see Figure 9).

The resulting fields within the matrix which feature an increased amount of marks mean highly interdependent groups of business activities and thus suggest the specification of the afore mentioned interaction modules (IAMs) that reside at the third level of abstraction (see Figure 10). As few as possible interdependencies shall exist between the tasks comprised by different IAMs (indicated by off-diagonal xs which are not included in one of the IAMs). These interdependencies either need to be made explicit and become the basis for the development of interfaces (relying on context-specific, descriptive design rules (CSDR)) or can be removed through the definition of prescriptive design rules. The organizational design is completed by defining a design hierarchy diagram that clearly specifies the nested hierarchy and the inheritance relationships between the modules (Figure 10 corresponds to Figure 6).

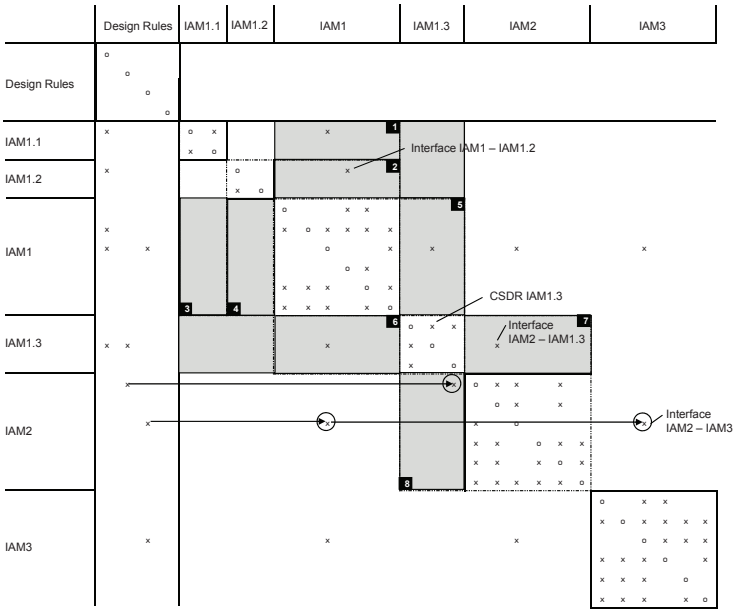

Fig. 10. Organisational modularisation into IAMs (Schroth, Schmid, & Müller, 2009)

4. Case Study: Applying the Framework in the Swiss Public Sector

4.1 As-is-Situation

In this section, we elaborate on a case study that was conducted in the course of the government-funded project HERA (HERA, 2009). The project aimed at the improvement of the tax declaration procedure in the federal system in Switzerland. It serves as example for

the interaction of defined stakeholders who electronically interact to achieve a common goal: As depicted in Figure 11, there are mainly four stakeholders involved in the cross-organizational process of creating a tax declaration. First, a company (also referred to as JP) itself submits a tax declaration that complies with laws, is consistent with the forms issued by the various cantons (Swiss states) and is optimised with respect to the resulting tax load in an as efficient way as possible. Accountants can either be represented as company-internal departments or external service providers. They create comprehensive financial statements and also provide consulting services with respect to profit appropriation strategies. Auditors have to be organizationally separated from accountants (by law) to ensure their independency. They examine and verify compliance of financial statements and profit appropriations. Finally, the cantons (states) receive the completed tax declaration and initiate the assessment/ enactment process.

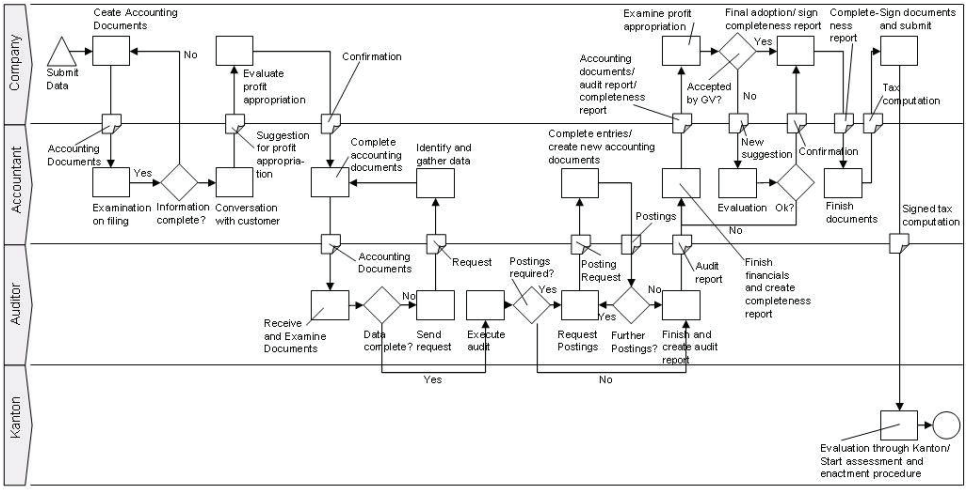

Fig. 11. Simplified tax declaration business process (Schroth & Schmid, 2009, p.86)

Municipalities play a certain role within the tax declaration process in some of the Swiss cantons, but are left out in this work due to space constraints. Also, the visualized, cross-organizational business process represents a cut-out (which is valid in the canton of St. Gallen) of the full process with all its canton-specific deviations. During this procedure of creating a tax computation, the division of labour among the players induces the need for coordination and information exchange between them which follows certain process choreographies. As a consequence, numerous documents (as visualized in the graphic) are passed from one stakeholder to the other and are thereby processed in different ways until they reach the end of their respective "lifecycles".

Today, all stakeholders depicted in Figure 11 interact with each other via different communication channels. Some information is exchanged in paper format; other documents are transferred via e-Mail or proprietary electronic interfaces. Resulting media breaks, the lack of standardized interfaces and the strong involvement of humans into information processing induces high transaction costs and increases the risk of errors, thereby limiting

service quality. Also, services are only rarely subject to quantifiable performance metrics. The study has shown that especially non-functional properties of services such as delivered quality or exact time required for completion are usually not provided in a clear, formal and quantifiable way. The heterogeneity of used media prevents from standardization with respect to terminology, processes, pieces of information, and therefore deteriorates the productivity of seamless collaboration across the stakeholders' boundaries. Frequently, decisions have been found to be made on the basis of best practices instead of formalized rule sets. Also, the cross-organizational process-oriented organization strongly varies from case to case, depending on a number of parameters. The concerned canton's legislation, the individual stakeholders and their particular preferences, the exact partner constellation (is a separate accountant involved or is the company in charge of accounting activities), context-dependent factors and the quality of exchanged information (this may cause iterative, additional claims for documents) represent only some of the factors influencing the exact process organization.

4.2 Modular Reorganization and Evaluation

Following a traditional, non-modular approach (see Figure 11), designers would try to comprehend the situation as a whole, model "one", fixed business process governing the interaction and implement an electronic business medium to avoid media breaks and partially automate the interaction. However, as also argued by Gartner (Lheureux & Malinverno, 2006), the design of another highly proprietary, inflexible and thus inefficient island solution would not add sustained value. In fact, the above described approach resembles the "Spaghetti-code era" which abetted the software crisis in the 1970s. The resulting business medium would require huge effort for design and creation (as it was not modular, thus complicating concurrent work or redesign), could only hardly be changed and could not be seamlessly connected to other business media as it would not follow any global design rules. For this reason, an electronic business medium (**the HERA platform**) has been designed and implemented, based on the modular architecture framework presented above.

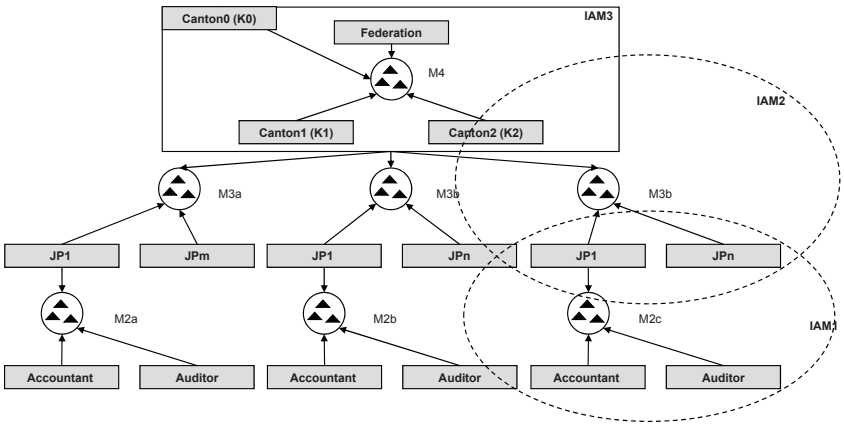

Fig. 12. System of media and agents, organized in interaction modules (IAMs)

As a first step towards our modular design, the overall interaction scenario to be structured (decomposed) into fine-granular, atomic activities. Secondly, we assign each of the tasks specific roles to define the agents who are allowed to perform these. As a third and final step, the diverse sub-tasks shall be decoupled by defining mutually independent, organizational interaction modules (IAMs) as argued above. In our case, three generic modules could be identified: the first one concerns the specific interactions between companies, accountants and auditors; the second one exclusively comprises the interactions between companies and the cantonal tax offices; the third and final one focuses on the interaction between the governmental tax offices. Benefits resulting from this task modularisation include: first of all, responsibilities for tasks and related information (data access rights) can be clearly separated and limited to those roles which are explicitly involved in a certain module. Secondly, operational agility and manageability can be improved: In case of modifications (e.g., required by legal changes), the modules can be re-organized without affecting other modules. The IAMs were defined based on the task structure matrix-based methodology discussed above. Due to length restrictions, the detailed derivation of the three IAMs is not provided here.

Figure 12 illustrates the resulting organization of decentrally operated interaction modules: the module "governmental interaction" is instantiated once (IAM3): it allows cantonal authorities to exclusively exchange data in order to define the share of the tax load as described above. All the internal interaction between different cantonal tax offices can thus be hidden from the outside in order to reduce operational complexity. The assessment/ enactment module (IAM2) is supposed to be instantiated once per canton to account for their individual needs with respect to data formats, business processes and other organizational artefacts. In other words, each canton may establish an individual assessment/ enactment interaction module which encompasses all the tasks dealing with submitting a tax declaration and the subsequent assessment as well as enactment procedures. Independent from these modules, the accounting/ auditing interaction modules (IAM1) can be instantiated. On the basis of the HERA business medium, each company shall be enabled to establish an individual structural and process-oriented organization governing the interaction between itself and external accountants and auditors. The independence of this module can be emphasized with the following example: Companies may submit their tax declaration via the HERA business medium without having used HERA for accounting/ auditing purposes before. The two modules can be considered fully independent and may thus be reorganized autonomously. However, to ensure interoperability and fast exchangeability, all interaction modules follow a set of common design rules and provide clear interfaces to the outside.

In order to **implement** these mutually independent yet interoperable interaction modules, the HERA platform (HERA bus) has been developed which augments the above mentioned Swiss governmental initiative "Event Bus Switzerland (EBS)" (Figure 13): first, in order to physically realize the interaction of agents, a bus medium has been proposed which features a set of operational services: Abonnement services (supporting Publish/subscribe message dissemination), directory services (allowing for publishing and retrieving business partners and their respective profiles), event catalogue services (documenting all messages which may be disseminated via the bus including the agent roles which may send/receive them),

transformation services (accounting for mediation of electronic artefacts which adhere to different format standards), security services (encryption and decryption), operating services (for media administration purposes), error services (automatic failure detection and removal), routing services, and validation services (e.g., for evaluation of correctness and integrity of exchanged information. Agents (individuals or software applications) are connected to the HERA bus via defined interfaces describing the events they are authorized to send and to receive. If agents do not obey to the design rules established as part of the HERA bus specification, adapter modules are required. Within the HERA bus, additional coordination services (e.g., completeness control, process visibility and due date monitoring) have been deployed which do not only enable reliable message transport but also interpret and react upon message content. In addition, a Process Server service, a Document Management System (DMS) service as well as an Identity & Access Management (IAM) service have been deployed. The process server service stores the structural and process-oriented organisation for each of the interaction modules. In other words, it ensures that interaction patterns (IAPs) are only used by authorized agents, and that precedence relationships between the tasks are considered. The HERA platform does not only foresee agile interoperability within the sphere of one "business community" and its business medium, but also allows for loosely coupling of several buses which again may connect diverse agents. For cross-medium interoperability, each bus can incorporate an individual service design as long as it adheres to minimal "global design rules" which require the implementation of a standardized directory service, an event-catalogue service and the conformance to a specific message envelope standard (Müller, 2007).

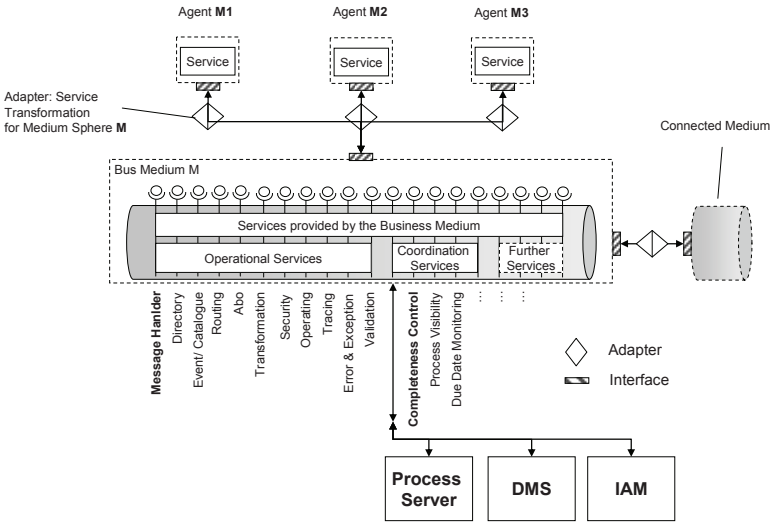

Fig. 13. Technical view: the HERA-bus and its core constituents (Streit et al., 2009)

5. Conclusion and Outlook

In this work, we analysed organisational and technical weaknesses inherent in existing approaches to support the electronic interaction across corporate boundaries. To cope with these challenges, we presented a modular architecture framework and employed it to the scenario of collaborative tax declaration in Switzerland to illustrate its real-word applicability. In this way, we proved that both the physical medium's design as well as the organization of agent interaction could be truly modularised.

As one of the next steps, the economic potential of the HERA platform has to be investigated thoroughly in order to exactly quantify the advantages of the architecture framework compared to existing, more monolithic designs. In (Schmid, Schroth, Miche, & Janner, 2009), we proposed an initial architecture valuation method which tries to capture the value of modular designs. With the help of expert workshops conducted in the course of the HERA project, we identified interoperability, agility, and data security as the major business drivers underlying the analysis of architectural benefits. Based on fine-granular quality attributes and associated scenarios, we were able to estimate the economic value of organizing and implementing electronic interaction based on our architecture framework. One of the key insights gained was: The systematic splitting apart of cross-organizational interaction scenarios as well as their underlying information technology into modules with clearly defined interfaces allows for an unprecedented degree of agility. Modularity accommodates uncertainty and multiplies design options, thus creating a "portfolio of options" rather than an "option on a portfolio" (Baldwin & Clark, 1999). In modular designs, options can be leveraged through applying one or more of the modular operators discussed above. In the case of systems supporting cross-organizational electronic interaction between agents, for example, agent or media modules can be added, excluded, split, substituted, inverted and ported. These operators are applied entailing costs and benefits different from those in case of monolithic systems.

Future publications will deal with leveraging the fundamental insights gained in the financial sector regarding option pricing for the development of quantitative theoretical valuation framework for modular IT service infrastructures. As opposed to the simple, Net Present Value (NPV)-based valuation techniques often used today, a model considering the availability of design options is now needed to exactly capture the benefit of modular architectures (Banerjee & deWeck, 2009; Feurstein, & Natter, 1998; Yeo, Qiu, 2002).

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6

Ranking Companies Based on Multiple Social Networks Mined from the Web

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1. Introduction

Many rankings existing for popularity, recommendation, evaluation, election, etc. can be found in the real world as well as on the Web. Many efforts are undertaken by people and companies to improve their popularity, growth, and power, the outcomes of which are all expressed as rankings (designated as target rankings). Are these rankings merely the results of its elements' own attributes? In the theory of social network analysis (SNA), the performance and power (i.e. ranking) of actors are usually interpreted as relations and the relational structures they embedded. For example, if we seek to rank companies by market value, we can extract the social network of the company from the Web and discern, and then subsequently learn, a ranking model based on the social network. Consequently, we can predict the ranking of a new company by mining its relations to other companies. We can learn from existing rankings to expect other target rankings. We can learn from existing rankings to expect other rankings. Furthermore, we can understand the kinds of relations which are important for the target rankings; we can determine the type of structural extension of companies that can improve the target rankings.

This study specifically examines the application of a social network that provides an example of advanced utilization of social networks mined from the Web. We present ranking learning approaches using a social network that is mined from the Web. The proposed model combines social network mining and ranking learning, which further uses multiple relations on the Web to explain arbitrary rankings in the real world. Experimental results for learning to rank companies based on multiple social networks mined from the Web confirm the effectiveness of our models for explaining target rankings as well as real world phenomena using multiple social networks. Several findings including social networks vary according to different relational indices or types even though they contain the same list of entities. Relations and networks of different types differently impact on target of ranking. Multiple networks have more information than single networks for explaining target ranking. Well-chosen attribute-based features have good performance for explaining the target ranking. However, by combining proposed network-based features, the prediction results are further improved. This study specifically examines the application of a social network that provides an example of advanced utilization of social networks mined from the Web.

The following section presents a description of an overview of the ranking learning model. Section 3 briefly introduces our previous work for extracting social networks from the Web. Section 4 describes proposed ranking learning models based on extracted social networks. Section 5 describes the experimental settings and results. Section 6 presents some related works before the paper concludes.

2. System Overview

Our study explores the integration of mining relations (and structures) among entities and the learning ranking of entities. For that reason, we first extract relations and then determine a model based on those relations. Our reasoning is that important relations can be recognized only when we define some tasks. These tasks include ranking or scores for entities, i.e., *target ranking* such as ranking of companies for job-seekers, CD sales, popular blogs, and sales of products. In short, our approach consists of two steps:

> **Step 1: Constructing Social Networks** Given a list of entities with a target ranking, we extract a set of social networks among these entities from the Web.
> **Step 2: Ranking learning** Learn a ranking model based on the relations and structural features generated from the networks.

Once we obtain a ranking model, we use it for prediction for unknown entities. Additionally, we can obtain the weights for each relation type as well as relation structure, which can be considered as important for target rankings. The social network can be visualized by specifically examining its relations if the important relations are identified. Alternatively, social network analysis can be executed based on the relations.

3. Constructing Social Networks from the Web

In this step our task is, given a list of entities (i.e., companies) $V=\{v_1,\ldots,v_n\}$, we construct a set of social networks $G_i(V, E_i)$, $i \in \{1,\ldots,m\}$, where m signifies the number of relations, and $E_i=\{e_i(v_x, v_y) \mid v_x \in V, v_y \in V, v_x \neq v_y\}$ denotes a set of edges with respect to the i-th relation, where $e_i(v_x, v_y)$ is equal to 1 if companies v_x and v_y have relation i, and 0 otherwise.
A social network is obtainable through various approaches; one is to use Semantic Web data. With developments in the Semantic Web, the Web includes growth of machine-readable descriptions of people: FOAF documents. The FOAF provides an RDF/XML vocabulary to describe personal information, including name, mailbox, homepage URI, interest, friends, and so on. Using FOAF documents, we can construct social networks among people. Given a list of persons V, we first use *foaf:Person* to mapping each name with FOAF instances, then connect persons with several meaning of relational properties such as *foaf:knows*, *foal:interest*, *foaf:location*, *foaf: publications*, and *foaf: currentProject* properties. Consequently, we can construct social networks G_i of different kinds. When a person is described in more than one FOAF document, we must fuse information from multiple sources using identical properties such as *foaf:mbox*, *foaf:homepage* and *foaf:Weblog* and generate aggregated information about the person (Finin et al., 2005). Furthermore, by combining FOAF documents to DBLP data, we can construct more kinds of social networks such as *authorship* network, *citation* network (Aleman-Meza et al., 2006; Zhou et al., 2008).

Another is to extract social networks using Web mining. Several studies have particularly addressed the use of search engines as well as text mining for social network extraction. Through this study, we detail the co-occurrence approach and relation-identification approach used by Matsuo et al. (Matsuo et al., 2006) and Jin et al. (Jin et al., 2008), respectively, as a basis of our study. We are interested only in undirected networks.

3.1 Co-occurrence-based approach

The social network of the first kind is extracted using a co-occurrence-based approach. This approach was used originally by Kautz et al. (Kautz et al., 1997), and was recently applied and modelled by Mika (Mika, 2005) and Matsuo et al. (Matsuo et al., 2006) to extract researcher networks automatically from the Web. The fundamental idea underlying the co-occurrence approach is that *the strength of a relation between two entities can be estimated by co-occurrence of their names on the Web*. The strength of relevance of two persons, x and y, is estimated by putting a query x AND y to a search engine: If x and y share a strong relation, we can usually find various evidence on the Web such as links found on home pages, lists of co-authors of technical papers, organization charts, and so on. An edge will be invented when the relation strength by the co-occurrence measure is higher than a predefined threshold. Subsequently, we use the Overlap coefficient $n_{x \cap y} / \min(n_x, n_y)$ (used by (Matsuo et al., 2006)) as well as the Matching coefficient as relational indices and thereby construct co-occurrence-based networks of two kinds: an *overlap network* ($G_{overlap}$) and a *cooc network* (G_{cooc}). Many advanced algorithms are described in (Matsuo et al., 2006).

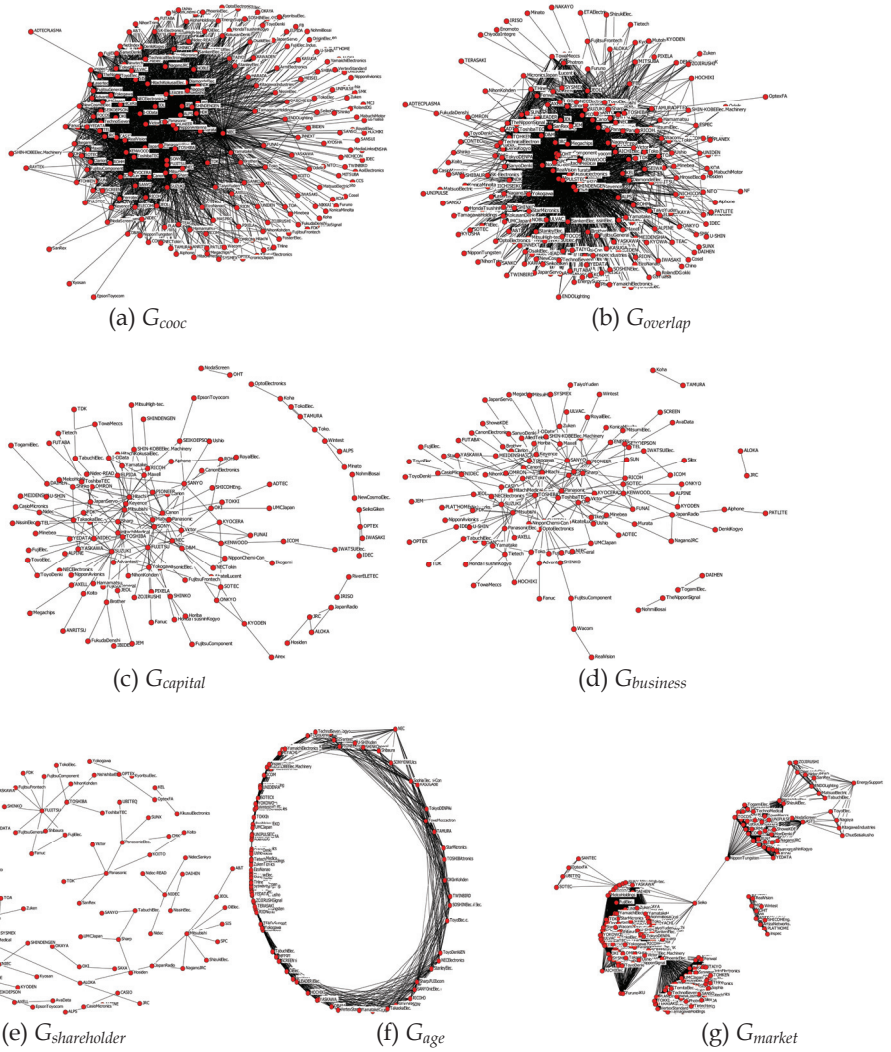
3.2 Relation-identification approach

We proposed the *relation-identification* approach to extract target relational social networks in (Jin et al. 2008). This approach emphasizes real-world relations such as a mutual stock holding relation, capital combination, trade relation, personal relation (i.e., mutual dispatch of officials), rivalry, and a competitive relation. These relations are published in news articles or by news releases that might be obtained easily from the Web.

Given a list of companies and target relations as input, the method extracts a social network of entities. To collect target relational information from the tops of Web pages, it makes elaborate queries to emphasize a specific relation, and applies text processing to those pages to form an inference of whether or not the relation actually exists.

First, queries are produced by adding *relation keywords* (such as "*alliance* AND *corporate*") to each pair of companies. Relation keywords are in advance for each target relation by measuring the Jaccard relevance from given seed words. Then, to extract target relations from Web documents, a simple pattern-based heuristic is useful: First pick all sentences that include the two company names (x and y), and assign each sentence the sum of relation keyword scores in the sentence. The score of companies x and y is the maximum of the sentence scores. An edge is invented between the two companies if that score is greater than a certain threshold. Subsequently, we extract two kinds of relational networks: a *business-alliance network* ($G_{business}$) and a *capital-alliance network* ($G_{capital}$).

Extracted networks for *312* companies related to the electrical products industry from Japan are portrayed in Fig. 1. It is apparent that the social networks vary with different relational indices or types even though they contain the same list of entities.



(a) G_{cooc} (b) $G_{overlap}$

(c) $G_{capital}$ (d) $G_{business}$

(e) $G_{shareholder}$ (f) G_{age} (g) G_{market}

Fig. 1. Social networks for companies in electrical industrial with different relational indices or types.

4. Ranking Learning Model

For the list of nodes $V = \{v_1,\ldots,v_n\}$, given a set of networks $G_i(V, E_i)$, $i \in \{1,\ldots,m\}$ (constructed by section 3) with a target ranking $\mathbf{r}^*$ ($\in R^t$) (where t ≤n, and r_k^* denotes k-th element of the vector $\mathbf{r}^*$ and means the target ranking score of entity v_k), the goal is to learn a ranking model based on these networks.

First, as a baseline approach, we follow the intuitive idea of simply using approach from SNAs (i.e. centrality) to learn ranking. As the second approach, multiple relations are

combined into one to consider a combination model for ranking. Finally, to learn ranking, we propose a more useful algorithm that generates various network features for individuals from social networks.

4.1 Baseline Model

Based on the intuitive approach, we first overview commonly used indices in social network analysis and complex network studies. Given a set of social networks, we rank entities on these networks using different network centrality indices. We designate these rankings as *network rankings* because they are calculated directly from relational networks. We use $\boldsymbol{r}_i$ ($\in R^n$) to denote network ranking that is directly attributable to the i-th relational network G_i. Our task is to find a ranking model based on network rankings that maximally explain the target ranking.

4.1.1 Choosing the most predictive type of relation

To address the question of what kind of relation is most important for companies, we intuitively compare rankings caused by relations of various types. Although simple, it can be considered as an implicit step of social network analysis given a set of relational networks. We merely choose the type of relation that maximally explains the given ranking. We rank each type of relational network; then we compare the *network ranking* with the *target ranking*. Intuitively, if the correlation to the network ranking $\mathbf{r}_{\hat{\imath}}$ is high, then the relation $\hat{\imath}$ represents the important influences among entities for the given target ranking. Therefore, this model is designed to find an optimal relation $\hat{\imath}$ from a set of relations:

$$\hat{\boldsymbol{i}} = \arg\max_{\boldsymbol{i}\in\{1,\ldots\boldsymbol{m}\}} \boldsymbol{Cor}(\mathbf{r}_{\boldsymbol{i}}, \mathbf{r}^*) \tag{1}$$

We define a ranking function $h(G)$ that returns a vector of network ranking ($\in R^n$) for given network $G(V, E)$. Therefore, the i-th network ranking $\mathbf{r}_i$ is obtained from $h(G_i)$. Here are the other questions for what kind of ranking indices are most appropriate to explain the target ranking. In the next section, we treat several *centrality* measures from SNAs as our different network ranking function $h(G)$.

4.1.2 Choosing the most predictive type of centrality indices

Different meanings of prominence and importance can be generated from a network, such as "having a powerful position", and having "more opportunities" and "fewer constraints". Several *centrality* measures are useful to rank network entities with these different meanings: degree centrality, betweenness centrality, and closeness centrality and other centralities. Bellow, we introduce these different meanings of centrality.

- *Degree centrality* is an assessment of the number of relations that any given actor is engaged in. Actors with more ties to other actors might be in advantaged positions, which can be defined as

$$\boldsymbol{C}_{\boldsymbol{d}}(\boldsymbol{v}_{\boldsymbol{I}}) = \frac{\boldsymbol{d}(\boldsymbol{v}_{\boldsymbol{I}})}{(\boldsymbol{n}-1)} \tag{2}$$

  Therein, $d(v_I)$ is the degree of node v_I, and n is the number of nodes.

- *Betweenness centrality* measures an actor as central if it lies between other actors on their geodesics. More actors depend on one actor v_l to make connections with other actors (geodesics passing through).

$$C_b(v_l) = \frac{\sum_{(v_p, v_q) \in (V \times V), v_p \in V, v_q \in V} g_{v_p, v_q}(v_l) / g_{v_p, v_q}}{(n-1)(n-2)} \tag{3}$$

where g_{v_p, v_q} is the number of shortest geodesic paths from node v_p to v_q, and $g_{v_p, v_q}(v_l)$ is the number of shortest paths from v_p to v_q that pass through node v_l

- *Closeness centrality* is a sophisticated measure that is defined as the mean shortest path between an actor i and all other actors that are reachable from that actor. Closeness can be regarded as a measure of how long it will take information to spread from a given actor v_l to other reachable actors in the network.

$$C_c(v_l) = \frac{\sum_{v_p \in V, v_p \neq v_l} g_G(v_l, v_p)}{(n-1)} \tag{4}$$

In that equation, $g_G(v_l, v_p)$ is the shortest geodesic paths from v_l to reachable node v_p.

These measures characterize some aspects of the local (i.e. degree) or global (i.e., closeness, betweenness) network structure, as indicated by a given actor's embeddedness in the network (Wasserman & Faust, 1994). Intuitively, given a target ranking, the most predictive type of centrality measure is finding optimal centrality measure h_j for target ranking $\mathbf{r}^*$ from a set of ranking functions.

$$\hat{j} = \arg\max_{h_j \in \{h_1, \ldots, h_s\}} Cor(\mathbf{r}_j, \mathbf{r}^*) \tag{5}$$

For different relational networks, the network ranking from i-th network with j-th ranking can be presented as $\mathbf{r}_{i,j}$ ($\in R^n$), which is obtainable from h_j (G_i), where $h_j \in \{h_1, \ldots, h_s\}$, $i \in \{1, \ldots, m\}$. Therefore, the first method can be extended simply to find a pair of optimal parameters $< \hat{i}, \hat{j} >$ (i.e., i-th network by j-th ranking indices) that maximizes the coefficient between network rankings with a target ranking.

$$< \hat{i}, \hat{j} >= \arg\max_{i \in \{1, \ldots m\}, h_j \in \{h_1, \ldots, h_s\}} Cor(\mathbf{r}_{i,j}, \mathbf{r}^*) \tag{6}$$

4.2 Network Combination Model

Many centrality approaches related to ranking network entities specifically examine graphs with a single link type. However, multiple social networks exist in the real world, each representing a particular relation type, and each of which might be integrated to play a distinct role in a particular task. We combine several extracted multiple social networks into one network and designate such a social network as a *combined-relational network* (denoted as $G_c(V, E_c)$). Our target is using combined-relational network, which is integrated with multiple networks extracted from the Web, to learn and predict the ranking. The important

questions that must be resolved here is *how to combine relations to describe the given ranking best*.

For G_c (V, E_c), the set of edges is E_c={e_c (v_x, v_y)| $v_x \in V$, $v_y \in V$, $v_x \neq v_y$}. Using a linear combination, each edge e_c (v_x, v_y) can be generated from $\Sigma_{i \in \{1, \ldots, m\}} w_i e_i$ (v_x, v_y), where w_i is i-th element of $\mathbf{w}$ (i.e., $\mathbf{w} = [w_1, \ldots, w_m]^T$). Therefore, the purpose is to learn optimal combination weights $\hat{\mathbf{w}}$ to combine relations as well as optimal ranking method h_j on G_c:

$$< \hat{\mathbf{w}}, \hat{\boldsymbol{j}} >= \underset{\mathbf{w}, \boldsymbol{h_j} \in \{\boldsymbol{h_1}, \ldots, \boldsymbol{h_s}\}}{\arg\max} \boldsymbol{Cor}(\mathbf{r}_{c,j}, \mathbf{r}^*) \tag{7}$$

Cai et al. (D.Cai et al. 2005) regard a similar idea with this approach: They attempt to identify the best combination of relations (i.e., relations as features) which makes the relation between the intra-community examples as tight as possible. Simultaneously, the relation between the inter-community examples is as loose as possible when a user provides multiple community examples (e.g. two groups of researchers). However, our purpose is learning a ranking model (e.g. ranking of companies) based on social networks, which has a different optimization task. Moreover, we propose innovative features for entities based on combination or integration of structural importance generated from social networks.

In this study, we simply use Boolean type ($w_i \in$ {1, 0}) to combine relations. Using relations of m types to combine a network, we can create 2^m-1 types of combination-relational networks (in which at least one type of relation exists in the G_c). We obtain network rankings in these combined networks to learn and predict the target rankings. Future work on how to choose parameter values will be helpful to practitioners.

4.3 Network-based Feature Integration Model

The most advanced method in our research is to integrate multiple indices that are obtained from multiple social networks. A feature by itself (e.g. a centrality value) may have little correlation with the target ranking, but when it is combined with some other features, they may be strongly correlated with the target rankings (Zhao & Liu, 2007). The idea in this model is the integration of all network features for individuals from networks as a context of the actors to learn the target ranking. Those features are expected to be useful to interpret a given target ranking accurately.

We integrate multiple indices from social networks, thereby combining several perspectives of importance for individuals from different relational structures. Simply, we can integrate various centrality values (described in the Baseline model) for each actor, thereby combining different meanings of importance to learn the ranking model. Furthermore, we can generate more relational and structural features from a network for each, such as how many nodes are reachable, how many connections one's friends have, and the connection status in one's friends. We might understand some about the behaviour and power about the individual as well as we predict their ranking if we could know the structural position of individuals. Herein, we designate these features generated from relations and networks as *network-based features*. The interesting question is *how to generate network-based features from networks for each*, and *how to integrate these features to learn and predict rankings*. Below we will describe the approach of generating and integrating network-based features.

4.1.1 Generating Network-based Features for nodes

For each x, we first define node sets with relations that might effect x. Then we apply some operators to the set of nodes to produce a list of values. Subsequently, the values are aggregated into a single feature value. Therefore, we can generate several structural features for each node. For example, when calculating the closeness centrality (i.e., average distance from node x to all others) of node x, we discern its value fundamentally in three steps: we first select reachable nodes from x; secondly, we calculate the distance between node x and each node; finally, we take the average of these distances. Additionally, we can discern the value of the closeness centrality of node x. For that reason, we can construct indices used in SNAs through these steps. Below, we explain each step in detail.

- Step 1: *Defining a node set*
  First, we define a node set. Most straightforwardly, we can choose the nodes that are adjacent to node x. The nodes are those of distance one from node x. The nodes with distances of two, three, and so on are definable as well. We define a set of nodes $C_x^{(k)}$ as a set of nodes within distance k from x. For example, we can denote the node set adjacent to node x as C_x^1. In addition, we use $C_y^{(k)}$ to express a set of nodes within distance k from y (where $y \neq x$).
- Step 2: *Operation on a Node Set*
  Given a node set, we can conduct several calculations for the node set. Below, we define operators with respect to two nodes; then we expand it to a node set with an arbitrary number of nodes. The simple operation for two nodes is to check whether the two nodes are adjacent or not. We denote these operators as $s^1(x,y)$, which returns 1 if nodes x and y are mutually connected, and 0 otherwise. We also define operator $t(x,y) = argmin_k\{s^{(k)}(x,y) = 1\}$ to measure the geodesic distance between the two nodes on the graph. These two operations are applied to each pair of nodes in N if given a set of more than two nodes (denoted as N). This calculation can be defined as follows.

$$Operator \circ N = \{Operator(x, y) \mid x \in N, y \in N, x \neq y\} \quad (8)$$

  For example, if we are given a node set $\{n_1, n_2, n_3\}$, we can calculate $s^{(1)}(\{n_1, n_2\})$, $s^{(1)}(\{n_1, n_3\})$, and $s^{(1)}\{n_2, n_3\}$ and return a list of three values, e.g., (1, 0, 1). We denote this operation as $s^{(1)} \circ N$.

  In addition, to s and t operations, we define two other operations. One operation is to measure the distance from node x to each node, denoted as t_x. Instead of measuring the distance between two nodes, $t_x \circ N$ measures the distance of each node in N from node x. Another operation is to check the shortest path between two nodes. Operator $u_x(y,z)$ returns 1 if the shortest path between y and z includes node x. Consequently, $u_x \circ N$ returns a set of values for each pair of $y \in N$ and $z \in N$. The other is to calculate the structural equivalence between node x and y. This is denoted as $e_x(y)$.
- Step 3: *Aggregation of Values*
  Once we obtain a list of values, several standard operations can be added to the list. Given a list of values, we can take the summation (*Sum*), average (*Avg*), maximum (*Max*), and minimum (*Min*). For example, if we apply *Sum* aggregation to a value list (1,0,1), we obtain a value of 2. We can write the aggregation as e.g., $Sum \circ s^{(1)} \circ$

N. Although other operations can be performed, such as taking the variance or taking the mean, we limit the operations to the four described above. The value obtained here results in the network-based feature for node x. Additionally, we can take the difference or the ratio of two obtained values. For example, if we obtain 2 by $Sum \circ s^{(1)} \circ C_x^{(1)}$ and 1 by $Sum \circ s^{(1)} \circ C_x^{(k)}$, the ratio is 2/1 = 2.0.

We can thereby generate a feature by subsequently defining a nodeset, applying an operator, and aggregating the values. The number of possible combinations is enormous. Therefore, we apply some constraints on the combinations. First, when defining a nodeset, k is an arbitrary integer theoretically; however, we limit k to be 1 for a nodeset of neighbors, k to be 3 for a nodeset of reachable nodes simplicity. Operator $s^{(k)}$ is used only as $s^{(1)}$. We also limit taking the ratio only to those two values with neighbor nodeset $C_x^{(1)}$ and reachable nodeset $C_x^{(\infty)}$. The nodesets, operators, and aggregations are presented in Table 1. We have 2(nodesets) × 5(operators) × 4(aggregations) = 40 combinations. There are ratios for $C_x^{(1)}$ to $C_x^{(k)}$ if we consider the ratio. In all, there are 4 × 5 more combinations: there are 60 in all. Each combination corresponds to a feature of node x. Some combinations produce the same value. One example is that $Sum \circ t_x \circ C_x^1$ is the same as $Sum \circ s \circ C_x^{(\infty)}$, representing the degree of node x.

Notation	Input	Output	Description
$C_x^{(1)}$	node x	a nodeset	adjacent nodes to x
$C_x^{(k)}$	node x	a nodeset	nodes within distance k from x
$s^{(1)}$	a nodeset	a list of values	1 if connected, 0 otherwise
t	a nodeset		distance between a pair of nodes
t_x	a nodeset	a list of values	distance between node x and other nodes
γ	a nodeset		number of links in each node
u_x	a nodeset	a list of values	1 if the shortest path includes node x, 0 otherwise
		a list of values	
		a list of values	
Avg	a list of values	a value	average of values
Sum		a value	summation of values
Min	a list of values	a value	minimum of values
Max		a value	maximum of values
	a list of values		
	a list of values		
Ratio	Two values	value	ratio of value on neighbor nodeset $C_x^{(1)}$ by reachable nodeset $C_x^{(\infty)}$

Table 1. Operator list

The resultant value sometimes corresponds to a well-known index, as we intended in the design of the operators. For example, the network density can be denoted as $Avg \circ s^{(1)} \circ N$. It represents the average of edge existence among all nodes; it therefore corresponds to the network density. These features represent some possible combinations. Some lesser-known features might actually be effective.

4.1.2 Network-based features with SNAs indices

It is readily apparent that centralities described in baseline approach are also a particular case of this model because our network-base feature include those centrality measures and other SNAs indices for each node. Below, we describe other examples that are used in the social network analysis literature.

- diameter of the network: $Min \circ t \circ N$
- characteristic path length: $Avg \circ t \circ N$
- degree centrality: $Sum \circ s_x^{(1)} \circ C_x^{(1)}$
- node clustering: $Avg \circ s^{(1)} \circ C_x^{(1)}$
- closeness centrality: $Avg \circ t_x \circ C_x^{(\infty)}$
- betweenness centrality: $Sum \circ u_x \circ C_x^{(\infty)}$,
- structural holes: $Avg \circ t \circ C_x^{(1)}$

When we set the element $Sum \circ s_x^{(1)} \circ N_x^{(1)}$ in a feature vector equal to 1, and all others to 0, we can elucidate the effect of degree centrality for predicting target ranking.

4.1.3 Network-based feature Integration

Next, generated network-based features to learn rankings are used for entities. The goal of learning is to integrate all features from networks into a single ranking of individuals. Combined, they are expected to be useful to interpret a given target ranking most accurately. After we generate various network-based features for individual nodes, we integrate them to learn ranking. This integration is accomplished through regression of features. We introduce an *f*-dimensional feature vector *F*, in which each element represents a network-based feature for each node. We identify the *f*-dimensional combination vector $\mathbf{u} = [u_1, \ldots, u_f]^T$ to combine network-based features for each node. The inter-product $\mathbf{u}^T\mathbf{F}$ for each node produces *n*-dimensional ranking. For relational networks of *m* kinds, the feature vector can be expanded to $m \times 56$-dimensions. In this case, the purpose is finding out whether optimal combination weight $\hat{\mathbf{u}}$ to $\mathbf{u}^T \cdot \mathbf{F}$ maximally explains the target ranking:

$$\hat{\mathbf{u}} = \arg\max_{\mathbf{u}} \boldsymbol{Cor}(\hat{\mathbf{u}}^{\mathrm{T}} \cdot \mathbf{A}, \mathbf{r}^*) \tag{9}$$

This model can be extended easily to add attributes (or profiles) of entities as features such as Sales, Assets, or number of employees of a company. We can use any technique, such as SVM, boosting and neural network, to implement the optimization problem. In this study, we consider using the Ranking SVM technique. Ranking SVM utilizes instance pairs and

their preference labels in training. The optimization formulation of Ranking SVM is the following:

$$\min \frac{1}{2}\mathbf{w}^T\mathbf{w} + C\sum_{i,j,q}\zeta_{i,j,q}. \quad (10)$$
$$s.t.\ \forall (d_i, d_j) \in r_q^* : w\phi(q, d_i) \geq w\phi(q, d_j) + 1 - \zeta_{i,j,q}$$

where **w** is a weight vector that is adjusted by learning to minimize the upper bound $\sum \xi_{i,j,q}$. In addition, *C* is a parameter that enables trading-off of the margin size against training error. The result is a ranking function that has few discordant pairs with respect to the observed of the target ranking. For multi-relational networks, we can generate features for each single-relational network. Subsequently, we can compare the performance among them to understand which relational network produces more reasonable features. Thereby, we can see which relation(s) is important for the target ranking. Generating Network-based Features for nodes

5. Experimental Results

5.1 Datasets

We extract social networks for companies from 312 electrical product-related industry companies that are listed on the Tokyo Stock Exchange. All financial information about these companies is published in Yahoo! Finance (http://profile.yahoo.co.jp/industry/electrical/electrical1.html). For these companies, we extract social networks of seven kinds (Fig. 1) from the Web using a search engine Yahoo! Search Boss (http://developer.yahoo.com/search/boss/) and information from Toyo Keizai Inc. (http://www.toyokeizai.co.jp) i.e. a Japanese book and magazine publisher: the cooc network (G_{cooc}) and overlap network ($G_{overlap}$) network are extracted using the co-occurrence-based approach described in Section 3.1; the business-alliance network ($G_{business}$) and capital-alliance network ($G_{capital}$) are extracted using the relation-identification approach described in Section 3.3; same-market network (G_{market}) includes links that connect two companies listed on the same stock market; shareholding network ($G_{shareholder}$) connects shareholding relations among companies; similar-age network (G_{age}) connects two companies if their average age is similar (age-gap is less than two years); Each extraction method and corresponding figure of networks is listed in Table 2.

G_i	Network name	Extraction Method	Fig.
G_{cooc}	cooc network	Section 3.1	Fig. 1(a)
$G_{overlap}$	overlap network	Section 3.1	Fig. 1(b)
$G_{business}$	business-alliance network	Section 3.2	Fig. 1(c)
$G_{capital}$	capital-alliance network}	Section 3.2	Fig. 1(d)
G_{market}	same-market network	connect companies listed on the same stock market	Fig. 1(e)

$G_{shareholder}$	shareholding network	connect shareholding relations	Fig. 1(f)
G_{age}	similar-age network	connect similar average-age companies	Fig. 1(g)

Table 2. Constructed networks of electrical industry companies.

For our experiments, we set the target ranking of the companies by market capitalization (designated as Market-Cap), ranking of average annual income (designated as Avg-In), and the ranking of excellent accounts (designated as Excellent). The target ranking of Avg-In is collected from quarterly corporate reports from Toyo Keizai Inc. Market-Cap represents the market's valuation of all the equity in a corporation. From Yahoo! Finance we can obtain all Market-Cap information for listed companies in Japan. The ranking of Excellent is published by Nihon Keizai Shimbun Inc.(http://www.nikkei.co.jp/) every year in March. They rank companies based on evaluating factors of flexibility & sociality, earning & growth ability, development & research, age of employees, etc. The top 300 excellent companies include 22 electrical industry companies used in our experiments. Table 3 shows the top 20 companies ranked by Avg-In, Market-Cap, and Excellent in the electrical industry.
In our experiments, we conducted three-fold cross-validation. In each trial, two folds of actors are used for training, and one fold for prediction. The results we report in this section are those averaged over three trials. We use Spearman's rank correlation coefficient (ρ) (Spearman, 1904) to measure the pairwise ranking correlation.

5.2 Ranking Results

First, we rank companies on different networks according to their network rankings. Table 4 and Table 5 show the top 20 companies ranked by degree centrality and betweenness centrality, respectively, on different types of networks in the electrical industry field. Results show that *Hitachi*, *NIEC*, and *Fujitsu* have good degree centrality in different networks. In addition, *Hitachi* has good betweenness centrality in the networks: we can implicitly understand that *Hitachi* has good network embeddedness in the electrical industry.

r*	Avg-In	Market-Cap	Excellent
1:	Keyence	Canon	Canon
2:	Advantest	Sony	Fanuc Ltd.
3:	AXELL	Panasonic	TDK
4:	Lasertec	Toshiba	Omron
5:	Fanuc Ltd.	Hitachi	Kyocera
6:	TEL	Mitsubishi	Sysmex
7:	Sony	Fanuc Ltd.	Ricoh
8:	Screen	Sharp	Toshiba
9:	Yokogawa	Kyocera	Ibiden
10:	Elpida	Fujitsu	Rohm
11:	Canon	Ricoh	Sharp
12:	Nihon Kohden	Murata	Sony
13:	Panasonic	Keyence	Eizo Nanao
14:	Megachips	Ibiden	Fujitsu
15:	Ricoh	TEL	Optex

16:	Nippon Signal	Nidec	Cosel
17:	Ulvac	Rohm	Daihen
18:	Hirose Elec.	Konica Minolta	SMK
19:	SK Elec.	TDK	Yamatake
20:	Panasonic Elec.	NEC	Ulvac

Table 3. Top 25 companies ranked by target rankings i.e. Avg-In, Market-Cap, and Excellent in an electrical industry field.

Additionally, these results reflect that companies have different centrality rankings even if they are in the same type of relational network. For instance, *Phoenix Elec.* and *SanRex* have good degree rankings in G_{market} and G_{age} networks respectively, but do not have good betweenness rankings in those networks. We also use seven carefully chosen fundamental indices as attributes of companies for comparison of our proposed network indices: Capital, Emplyee Number, Sales, return on equity (ROE), return on assets (ROA), the price earnings ratio (PER), and the price to book value ratio (PBR). Each of them has been used traditionally for company valuation. Additionally, we use the number of hits of names (HitNum) on the Web as another attribute (i.e. popularity on the Web) of a company. Table 6 shows the top 20 companies ranked by each attribute in the electrical industry field.

$\mathbf{r}_{i,Cd}$	$\mathbf{r}_{cooc,Cd}$	$\mathbf{r}_{overlap,Cd}$	$\mathbf{r}_{business,Cd}$	$\mathbf{r}_{capital,Cd}$	$\mathbf{r}_{market,Cd}$	$\mathbf{r}_{shareholder,Cd}$	$\mathbf{r}_{age,Cd}$
1:	NIEC	Keyence	Hitachi	Hitachi	Phoenix Elec.	Hitachi	SanRex
2:	JEM	Shindengen	Fujitsu	Suzuki	NIEC	Fujitsu	ALOKA
3:	Toshiba	HDK	Suzuki	Fujitsu	Shibaura	Mitsubishi	Koito
4:	JAE	Casio	Panasonic	Toshiba	Hamamatsu	Panasonic	TOA
5:	Pioneer	JAE	NEC	Mitsubishi	Nihon Kohden	Toshiba	Hitachi Medical
6:	JDL	Murata	Mitsubishi	Panasonic	Kenwood	Panasonic Elec.	Maxell
7:	Sony	Pulstec	Sharp	Nidec	Pixela	Sharp	Ichikoh
8:	Nippon Antenna	Clarion	Toshiba	Sony	ALOKA	ALOKA	Noble
9:	Chuo Seisakusho	Real Vision	Kenwood	NEC	Iwasaki	Nidec	Lasertec
10:	Panasonic	Kenwood	Oki	Sharp	JRC	Japan Radio	Soshin Elec.
11:	Shindengen	Hitachi Medical	Pioneer	Canons	JAE	Hitachi Medical	HitachiKokusaiElec
12:	Leader	Kikusui Elec.	Sony	Sanyo	Mutoh	NIEC	Minebea
13:	Fujitsu	Ikegami	Sanyo	Kenwood	Ikegami	Oki	Twinbird
14:	Canon Elec.	Toshiba	Omron	Yokogawa	Shinko	Fuji Elec.	Daido Signal
15:	Nagoya	Fujitsu Component	Canon	Takaoka Elec.	Optex	Fanuc Ltd.	Omron
16:	ADTEC	Sony	Nidec	Victor	ENPLAS	Elpida	Toyo Denki

17:	Murata	Noda	Screen	Victor	Ricoh	D&M	Canon	Shindengen
18:	HDK	JRC	Tietech	Oki	Casio	Koito	SPC	
19:	NEC	SPC	Kyocera	D&M	Shindengen	JEOL	Meidensha	
20:	Victor	Epson Toyocom	Casio	Keyence	FB	Clarion	ETA Elec.	

Table 4. Top 20 companies ranked by degree centrality on different social networks in the electrical industry.

$\mathbf{r}_{i,Cb}$	$\mathbf{r}_{cooc,Cb}$	$\mathbf{r}_{overlap,Cb}$	$\mathbf{r}_{business,Cb}$	$\mathbf{r}_{capital,Cb}$	$\mathbf{r}_{market,Cb}$	$\mathbf{r}_{shareholder,Cb}$	$\mathbf{r}_{age,Cb}$
1:	NIEC	Shindengen	Hitachi	Hitachi	Shinko	Hitachi	Konica Minolta
2:	JEOL	Keyence	Fujitsu	Suzuki	Eneserve	Fujitsu	Brother
3:	Toshiba	Casio	Mitsubishi	Mitsubishi	Konica Minolta	Mitsubishi	NetIndex
4:	Sony	HDK	Omron	Fujitsu	Hitachi	Panasonic	Sanyo Denki
5:	Fujitsu	JAE	Sharp	Nidec	Ibiden	Panasonic Elec.	Minebea
6:	ADTEC	JEOL	Panasonic	Toshiba	Nishishiba Elec.	Elpida	Hitachi
7:	Mitsubishi	Murata	Suzuki	NEC	Brother	Clarion	Mitsubishi
8:	Chuo Seisakusho	Toshiba	Oki	Takaoka Elec.	Noda Screen	ALOKA	Daiichi Seiko
9:	JEM	Sony	Nidec	Canon	Energy Support	Japan Radio	Shinko
10:	NEC	Mitsubishi	NEC	Sanyo	Showa KDE	JEOL	Ibiden
11:	Panasonic	Pulstec	Sony	Panasonic Elec.	Toyo Elec.	Toshiba	Morio Denki
12:	Pioneer	Kenwood	Toshiba	Kenwood	Tabuchi Elec.	Sharp	Nidec
13:	Panasonic Elec.	Real Vision	Sanyo	Oki	Sophia	Koito	Showa KDE
14:	JDL	NEC	Kenwood	Sharp	NIEC	Hitachi Medical	Syswave
15:	Nagoya	Hitachi Medical	Pioneer	Yokogawa	Ferrotec	Nidec	MCJ
16:	Sharp	Fujitsu	Keyence	Ricoh	Shibaura	Tabuchi Elec.	Origin Elec.
17:	Japan Radio	Suzuki	Panasonic Elec.	Panasonic	Santec	Canon	Sophia
18:	Canon Elec.	SEIWA	Toko.	Casio	Hamamatsu	NIEC	NIEC
19:	I-O Data	ADTEC	Maxell	Brother	Mimaki	Oki	Ferrotec
20:	Canon	JEM	Japan Radio	Omron	Enomoto	TDK	Shibaura

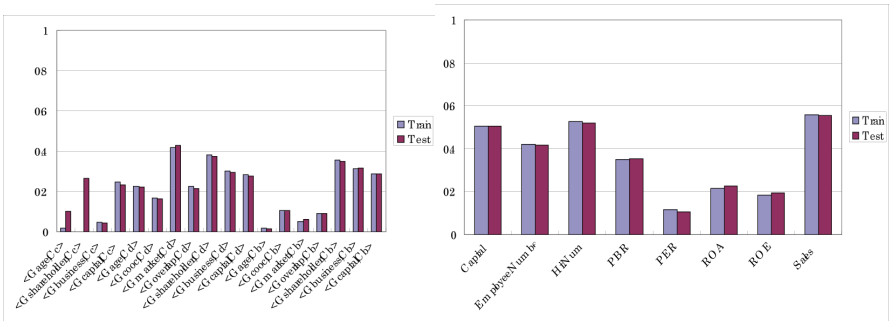
Table 5. Top 20 companies ranked by betweenness centrality on different social networks in the electrical industry.

$\mathbf{r}_A$	Capital	Employee Number	Sales	PER	PBR	ROA	ROE	HitNum
1:	Sony	Hitachi	Panasonic	ENPLAS	Sanyo	AXELL	Nagano JRC	NEC
2:	NEC	Panasonic	Sony	Santec	Meisei	Keyence	KKDI-Nikko Eng.	Sony
3:	Fujitsu	Toshiba	Toshiba	FDK	Tokki	OptexFA	TEAC	Suzuki
4:	Sanyo	Sony	Fujitsu	SK Elec.	TEAC	Canon Elec.	AXELL	Toshiba
5:	Hitachi	Fujitsu	Canon	NEC	Wacom	TEL	Yaskawa	Sharp
6:	Toshiba	NEC	Sharp	Sanko	Ibiden	Lasertec	Tabuchi Elec.	Fujitsu
7:	Panasonic	Canon	Hitachi	Fujitsu General	SPC	Roland DG	Fujitsu Component	Pioneer
8:	Sharp	Mitsubishi	Mitsubishi	Seiko Giken	Japan Servo	Hioki E.E.	Canon Elec.	Canon
9:	Mitsubishi	Sanyo	NEC	ALPS	AXELL	Wacom	Shinko	Mitsubishi
10:	Canon	Nidec	Sanyo	Maxell	Roland DG	Cosel	Konica Minolta	Ricoh
11:	Elpida	Seiko Epson	Ricoh	Sony	Yaskawa	Ibiden	TEL	Hitachi
12:	Panasonic Elec.	Ricoh	Panasonic Elec.	Anritsu	Nidec	Nidec-READ	Epson Toyocom	Panasonic
13:	Ricoh	Kyocera	TEL	Hosiden	Nagano JRC	Fanuc Ltd.	NEC	Kyocera
14:	Kyocera	TDK	Seiko Epson	UNIPULSE	Tabuchi Elec.	Optex	Lasertec	Sanyo
15:	Rohm	Panasonic Elec.	NEC Elec.	Raytex	Sysmex	Syswave	Ibiden	Panasonic Elec.
16:	NEC Elec.	Minebea	Pioneer	Iwasaki	Mimaki	JEM	Wacom	Omron
17:	Oki	Sharp	Kyocera	Miyakoshi	Keyence	Canon	Elpida	AXELL
18:	Murata	Mabuchi Motor	Murata	Wacom	Foster Elec.	CCS	Nidec-READ	Yamatake
19:	Fanuc Ltd.	Mitsumi Elec.	Casio	ETA Elec.	Micronics Japan	Noda Screen	Terasaki	TDK
20:	Minebea	Pioneer	Elpida	Nishishiba Elec.	Hamamatsu	Techno Medica	Mimaki	KEL

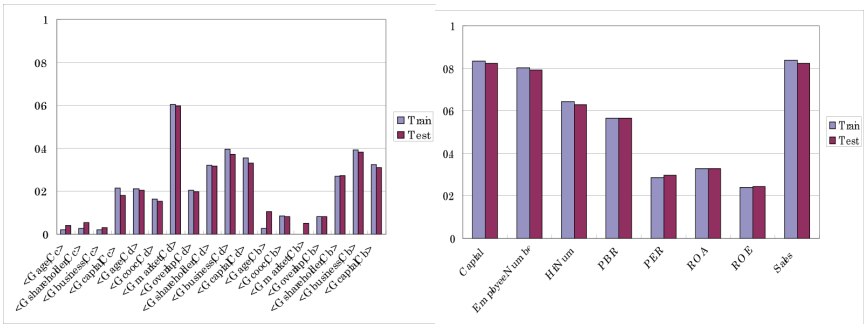
Table 6. Top 20 companies ranked by attributes of companies in the electrical industry.

As a baseline model, we use three centrality indices (i.e., degree centrality C_d, closeness centrality C_c, and betweenness centrality C_b) on different networks (G_{cooc}, $G_{overlap}$, $G_{capital}$, $G_{business}$, $G_{shareholder}$, G_{age}, G_{market}) as network rankings, and calculate the correlation between network rankings with each target ranking: Avg-In, Excellent, and Market-Cap. For comparison, we also rank companies according to previously described attributes (i.e., seven fundamental indices and hit number of names on the Web), and calculate the correlation with target rankings. Fig. 2 presents correlations (mean of three tries) of each network ranking as well as each attribute-based ranking with different target rankings on training

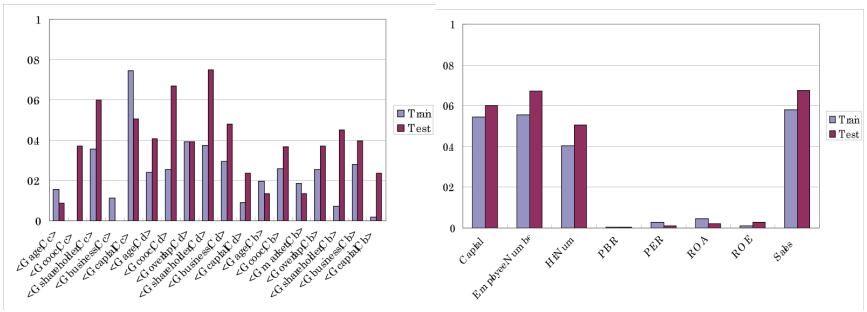
and testing data in the electrical industry. These results demonstrate that rankings of betweenness centrality in same-market network ($\mathbf{r}_{G_{market},\ C_b}$) and in shareholding relational network ($\mathbf{r}_{G_{shareholder},\ C_b}$) have good correlation with the target ranking of Avg-In. Betweenness centralities in the cooc network ($\mathbf{r}_{G_{cooc},\ C_b}$), betweenness centralities and degree centralities in the business-alliance network as well as the capital-alliance network ($\mathbf{r}_{G_{business},\ C_b}$, $\mathbf{r}_{G_{capital},\ C_b}$, $\mathbf{r}_{G_{business},\ C_d}$,, $\mathbf{r}_{G_{capital},\ C_d}$) all show good correlation with the target ranking of Market-Cap. Betweenness centralities in the capital-alliance network and shareholding relational network correlate well with the target ranking of Excellent.



(a) Centrality-based rankings with Avg-In (b) Attribution-based rankings with Avg-In



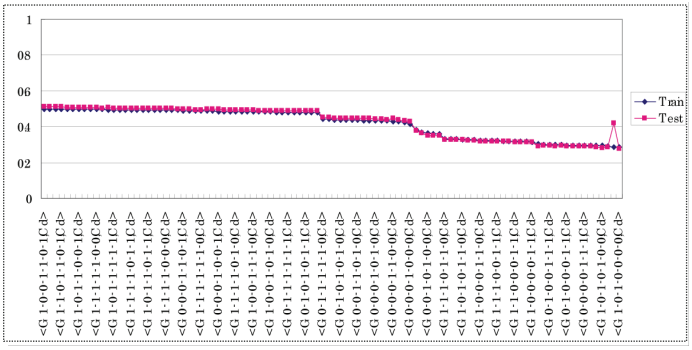
(c) Centrality-based rankings with Market-Cap (d) Attribution-based rankings with Market-Cap



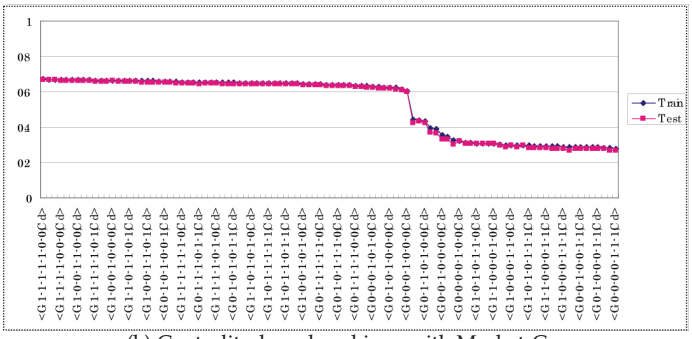
(e) Centrality-based rankings with Excellent (f) Attribution-based rankings with Excellent

Fig. 2. Evaluation for each centrality-based ranking, along with a attribute-based ranking with different target rankings in the electrical industry.

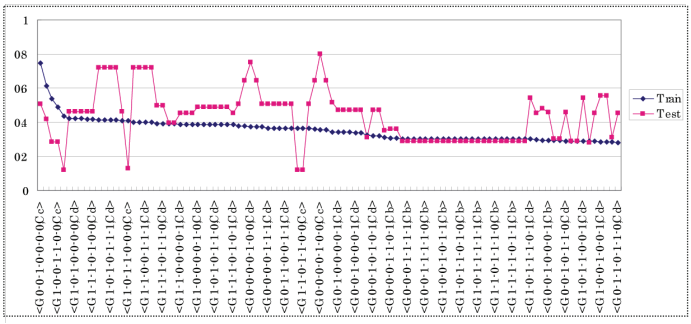
In the combination model, we simply use Boolean type ($w_i \in \{1, 0\}$) to combine relations. Using relations of seven types to combine a network $G_{overlap\text{-}business\text{-}capital\text{-}market\text{-}shareholder\text{-}age\text{-}cooc}$, we can create 2^7-1 (=127) types of combination-relational networks (in which at least one type of relation exists). We obtain network rankings in these combined networks to learn and predict the target rankings. The top 50 correlations between network rankings in combined-relational network and target rankings are presented in Fig. 3. Results demonstrate that degree centralities on combined-relational network produce good correlation with target rankings. For the target ranking of Avg-In, a network ($G_{1\text{-}0\text{-}0\text{-}1\text{-}1\text{-}0\text{-}1}$) comprising overlap relations, same-market relations, shareholding relations, and cooc relations shows good correlation. They outperform the baseline approach. For the target ranking of Market-Cap, the combined-relational networks which combined by overlap relation, capital-alliance relation, same-market relation, and shareholding relation ($G_{1\text{-}1\text{-}1\text{-}1\text{-}1\text{-}0\text{-}0}$, $G_{1\text{-}0\text{-}1\text{-}1\text{-}1\text{-}0\text{-}0}$) show good correlation. For the target ranking of Excellent, closeness centralities in the capital-alliance network outperform other combinations. Future work on how to choose parameter values will yield results that will be especially helpful to practitioners.



(a) Centrality-based rankings with Avg-In



(b) Centrality-based rankings with Market-Cap



(c) Centrality-based rankings with Excellent

Fig. 3. Evaluation for network rankings in a combined-relational network with different target rankings in the electrical industry.

We execute our feature integration ranking model (with several varies) to single and multi-relational social networks to train and predict three different targets rankings: Avg-In, Excellent, and Market-Cap. We use Ranking SVM to learn the ranking model which minimize pairwise training error in the training data; then we apply the model to predict rankings on training data (again) and on testing data. Comparable results for several varieties of model are presented in Table 7. Below we will explain a trial of each and interpret the results. First, we integrate the attributes of companies (i.e., several fundamental indices plus hit number of names on the Web) as features, and treat it as a baseline of feature-integration models to learn and predict the rankings. We can obtain 0.389 correlation for Avg-In, 0.571 correlation for Excellent, and 0.718 correlation for Market-Cap using these attribute-based features. This means that fundamental indices are quite good features for explaining target rankings, and are especially good for Market-Cap. Then, we integrate proposed network-based features obtained from each type of single network as well as multi-relational networks to train and predict the rankings. These results show that integrating the features in the network of G_{market}, G_{age}, $G_{capital}$ yields good performance for explaining the ranking of Avg-In, features in the G_{cooc}, $G_{shareholder}$ explain ranking of Excellent, and features in the G_{market}, $G_{business}$, and $G_{capital}$ have good performance for explaining the ranking of Market-Cap. These results reflect that relations and networks of different types produce different impacts on different target of rankings. Some examples are the following.
Listing on the same stock market and connection with similar average-age companies are related to higher average incomes of companies. Co-occurence with many other companies on the Web, shareholding relations with big companies are associated with a company being more well-known; consequently, the company has an excellent ranking. Active collaboration with other companies through business and capital alliances are associated with higher market value company. Using the features from multi-relational networks G_{ALL}, the prediction results are higher than those of any other single-relational network. This conforms to the intuition that multi-relational networks have more information than single networks to explain real-world phenomena. Furthermore, we combine network-based features with attribute-based features to train the model. The prediction results for any target ranking outperform each of the use of attribute-based features alone or network-based features alone. The correlation with target ranking of Market-Cap improved little from 0.718 (attribute only), 0.645 (network only) to 0.756 (both); the correlation with Avg-In shows

remarkable changes from 0.389 (attribute only), to 0.584 (network only) and 0.601 (both), which means that market values are explained more by fundamental attributes than relations among companies, although average incomes for companies are more understandable according to relations among companies than fundamental indices. The overall results demonstrate that, even thought the attribute-based features have good performance for explaining Market-Cap than network-based features, by combining network-based features with attribute-based features, the prediction results are improved. The target rankings of Avg-In and Excellent are more explainable by integrating network-based features than attribute-based features. Demonstrably combining both network and attribute-based features yields further improved prediction results.

Electrical	Feature	Avg-In		Excellent		Market-Cap	
		Train	Test	Train	Test	Train	Test
Network	G_{age}	0.357	0.341	0.443	-0.107	0.361	0.233
	G_{cooc}	0.247	0.120	0.364	0.619	0.346	0.197
	G_{market}	0.535	0.475	0.425	0.357	0.761	0.651
	$G_{overlap}$	0.409	0.284	0.423	0.381	0.519	0.295
	$G_{shareholder}$	0.397	0.190	0.771	0.400	0.514	0.117
	$G_{business}$	0.501	0.182	0.699	-0.500	0.590	0.421
	$G_{capital}$	0.641	0.329	0.818	0.300	0.643	0.350
	G_{ALL}	0.758	**0.584**	0.912	**0.574**	0.685	**0.645**
Attributes	ALL	0.559	**0.389**	0.811	**0.571**	0.735	**0.718**
Network + Attributes	G_{age}+A	0.681	0.573	0.762	0.429	0.791	0.710
	G_{cooc}+A	0.572	0.396	0.804	0.429	0.725	0.700
	G_{market}+A	0.643	0.555	0.746	0.595	0.808	0.754
	$G_{overlap}$+A	0.604	0.418	0.631	0.452	0.745	0.655
	$G_{shareholder}$+A	0.580	0.438	0.739	0.456	0.764	0.625
	$G_{business}$+A	0.596	0.396	0.873	0.619	0.747	0.692
	$G_{capital}$+A	0.592	0.470	0.811	0.524	0.752	0.705
	G_{ALL}+A	0.812	**0.601**	0.947	**0.580**	0.811	**0.756**

Table 7. Results of feature integration in the electrical industry.

5.3 Detailed Analysis of Useful Features

We use network-based features separately to train and expect the target rankings to clarify their usefulness. Leaving out one feature, the others are used to train and predict the rankings to evaluate network-based features. In fact, k -th feature is a useful feature for explaining the target ranking if the result worsens much when leaving out the feature k from the feature set. Table 8 presents the effective features for the different target rankings of Market-Cap, and Excellent, respectively, in company networks. For example, the maximum number of links in the neighbor nodeset of x from overlap network $Max \circ \gamma \circ C_x^{(1)} \circ G_{overlap}$ is effective for the target ranking of Avg-In, which means that if a famous company is reachable from a company, the company's income can be more high. The ratio of the sum of paths through x among neighbors to the sum of paths through x among reachable nodes from overlap network $Ratio \circ (Sum \circ u_x \circ C_x^{(1)}, Sum \circ u_x \circ C_x^{(\infty)}) \circ G_{overlap}$ is effective for the

target ranking of Market-Cap, which means that maintaining high betweenness among neighbors from all of reachable nodes in the Web makes the company' market value higher. The minimum number of edges among reachable companies from the business-alliance network $Min \circ s^{(1)} \circ C_x^{(\infty)} \circ G_{business}$ is effective for the target ranking of Excellent, which means that x will be more excellent when the reachable companies have little business-alliance among them.

Top	Features for Avg-In	Features for Market-Cap	Features for Excellent
1	$Max \circ \gamma \circ C_x^{(1)} \circ G_{overlap}$	$Ratio \circ (Sum \circ u_x \circ C_x^{(1)}, Sum \circ u_x \circ C_x^{(\infty)}) \circ G_{overlap}$	$Min \circ s^{(1)} \circ C_x^{(\infty)} \circ G_{business}$
2	$Min \circ s^{(1)} \circ C_x^{(\infty)} \circ G_{business}$	$Min \circ s^{(1)} \circ C_x^{(\infty)} \circ G_{shareholder}$	$Max \circ s^{(1)} \circ C_x^{(1)} \circ G_{business}$
3	$Avg \circ u_x \circ C_x^{(1)} \circ G_{capital}$	$Avg \circ \gamma \circ C_x^{(\infty)} \circ G_{business}$	$Ratio \circ (Max \circ s^{(1)} \circ C_x^{(1)}, Max \circ s^{(1)} \circ C_x^{(\infty)}) \circ G_{business}$
4	$Max \circ \gamma \circ C_x^{(\infty)} \circ G_{age}$	$Max \circ \gamma \circ C_x^{(\infty)} \circ G_{business}$	$Avg \circ t_x \circ C_x^{(1)} \circ G_{capital}$
5	$Avg \circ \gamma \circ C_x^{(\infty)} \circ G_{capital}$	$Min \circ \gamma \circ C_x^{(\infty)} \circ G_{business}$	$Max \circ t_x \circ C_x^{(1)} \circ G_{capital}$
6	$Ratio \circ (Sum \circ u_x \circ C_x^{(1)}, Sum \circ u_x \circ C_x^{(\infty)}) \circ G_{age}$	$Ave \circ s^{(1)} \circ C_x^{(1)} \circ G_{cooc}$	$Min \circ t_x \circ C_x^{(1)} \circ G_{capital}$
7	$Max \circ \gamma \circ C_x^{(\infty)} \circ G_{market}$	$Max \circ t \circ C_x^{(1)} \circ G_{market}$	$Min \circ t_x \circ C_x^{(\infty)} \circ G_{capital}$
8	$Ave \circ s^{(1)} \circ C_x^{(1)} \circ G_{business}$	$Max \circ \gamma \circ C_x^{(\infty)} \circ G_{market}$	$Ratio \circ (Min \circ t_x \circ C_x^{(1)}, Min \circ t_x \circ C_x^{(\infty)}) \circ G_{capital}$
9	$Avg \circ u_x \circ C_x^{(\infty)} \circ G_{capital}$	$Avg \circ \gamma \circ C_x^{(\infty)} \circ G_{shareholder}$	$Max \circ t_x \circ C_x^{(\infty)} \circ G_{capital}$
10	$Avg \circ u_x \circ C_x^{(\infty)} \circ G_{age}$	$Sum \circ t \circ C_x^{(\infty)} \circ G_{shareholder}$	$Max \circ s^{(1)} \circ C_x^{(\infty)} \circ G_{capital}$
11	$Min \circ \gamma \circ C_x^{(1)} \circ G_{cooc}$	$Avg \circ \gamma \circ C_x^{(\infty)} \circ G_{capital}$	$Avg \circ t_x \circ C_x^{(1)} \circ G_{cooc}$
12	$Sum \circ \gamma \circ C_x^{(1)} \circ G_{cooc}$	$Max \circ t \circ C_x^{(\infty)} \circ G_{capital}$	$Max \circ t_x \circ C_x^{(1)} \circ G_{cooc}$
13	$Min \circ \gamma \circ C_x^{(\infty)} \circ G_{business}$	$Avg \circ u_x \circ C_x^{(\infty)} \circ G_{age}$	$Max \circ s^{(1)} \circ C_x^{(\infty)} \circ G_{cooc}$
14	$Ratio \circ (Avg \circ s^{(1)} \circ C_x^{(1)}, Avg \circ s^{(1)} \circ C_x^{(\infty)}) \circ G_{business}$	$Min \circ s^{(1)} \circ C_x^{(1)} \circ G_{age}$	$Max \circ \gamma \circ C_x^{(1)} \circ G_{cooc}$
15	$Max \circ t \circ C_x^{(1)} \circ G_{age}$	$Min \circ \gamma \circ C_x^{(\infty)} \circ G_{age}$	$Max \circ \gamma \circ C_x^{(\infty)} \circ G_{cooc}$

Table 8. Effective features in various networks for Avg-In, Market-Cap, and Excellent, respectively, among companies.

We understand that various features have been shown to be important for real-world rankings (i.e. target ranking). Some of them correspond to well-known indices in social network analysis. Some indices seem new, but their meanings resemble those of the existing indices. The results support the usefulness of the indices that are commonly used in the social network literature, and underscore the potential for additional composition of useful features.

Summary:

Several conclusions are suggested by the experimental results presented above: Social networks vary according to different relational indices or types even though they contain the same list of companies; Companies have different centrality rankings even though they are in the same type of relational networks: Relations and networks of different types differently impact on different targets of rankings: Multi-relational networks have more information than single networks to explain target rankings. Well-chosen attribute-based features have good performance for explaining target rankings. However, by combining proposed network-based features, the prediction results are further improved: various network-based features have been shown to be important for real-world rankings (i.e., target ranking), some of which correspond to well-known indices in social network analysis such as degree centrality, closeness centrality, and betweenness centrality. Some indices seem new, but their meanings resemble those of the existing indices.

6. Related Works

Recently, many studies deal with social networks among various online resources such as social network services (SNSs) (Zhou et al. 2008), online Instance Messengers (IM) (Singla & Richardson, 2008), as well as Friend-of-a-Friend (FOAF) instances (Ding et al., 2005; Finin et al., 2005). Unfortunately, these resources are not specifically applicable to relations among companies or other organization structures. However, many relations among companies are published on the Web in news articles or news releases. Our work emphasizes the investigation of such published relations on the Web. A news site might deal little with information related to small companies and foreign corporations. Therefore, we use a search engine to extract more coverable relations among any given set of companies.

The location of actors in multi-relational networks and the structure of networks composed of multiple relations are interesting areas of SNAs. Recent efforts to address this problem adopt consideration of multi-modal networks---a network composed of a set of different kind of nodes---and mainly consider the relations among these nodes (Nie et al., 2005; Rodriguez, 2007; Zhou et al., 2008). They usually use papers, authors, and conferences (or journals) as different types of nodes, and considering the relational impact from different models (or layers) paper-paper, paper-author, as well as paper-conference (or journal) relations to calculate document similarity for document recommendation as well as support the scholarly communication process. This paper presents different views of multi-relational networks comprising multiple different kinds of relations (ties) among the same set of social actors (nodes) to elucidate what kinds of relations are important, as well as what kinds of relational combinations are important.

In the context of information retrieval, PageRank (Page et al., 1998) and HITS (Kleinberg, 1998) algorithms can be considered as well known examples for ranking Web pages based on the link structure. Recently, more advanced algorithms have been proposed for ranking

entities. Several studies have examined learning certain relational weights as conductance of Markovian walks on a network, given preference orders over nodes using gradient descent (Chang et al., 2000), error back-propagation (Diligenti et al., 2005), and approximate Newton method (Chakrabarti & Agarwal, 2006). Our networks are social networks with connections among nodes according to relations. Therefore, we neither give assumptions that the network must be a Markov network nor that the weight is positive only (because negative relations such as a lawsuit relation might damage the company ranking). Furthermore, our model is target-dependent: the important features of relations and structural embeddedness vary among different tasks.

Relations and structural embeddedness influence behavior of individuals and growth and change of the group (Singla & Richardson, 2008). Several researchers use network-based features for analyses. L. Backstrom et al. (Backstrom et al., 2006) describe analyses of community evolution, and show some structural features characterizing individuals'positions in the network. D. Liben-Nowell et al. (Liben-Nowell & Kleinberg, 2003) elucidate features using network structures for link prediction in the link prediction problem. We specifically examine relations and structural features for individuals and deal with various structural features from multi-relational networks systematically. Our generated features include those described in works from Backstrom and Liben-Nowell. Our approaches are similar to text classification given the document features and correct categories. Features are designed beforehand. Similarly, the relation is defined beforehand. The classifier learns the model to predict the given categories. Similarly, the ranking is given and is used for learning. Specifically regarding feature weights, we can understand which features are important for categorization, thereby yielding a better classification model. Furthermore, examining the weights of each relation, we can understand which relations are important for ranking. Cai et al. (Cai et al., 2005) regarded a similar idea with this approach: They try to identify the best combination of relations (i.e., relations as features) which makes the relation between the intra-community examples as tight as possible. Simultaneously, the relation between the inter-community examples is as loose as possible when a user provides multiple community examples (e.g., two groups of researchers). However, our purpose is learning of a ranking function (e.g.,, ranking of companies) based on social networks, which has a different optimization task. Moreover, we propose innovative features for entities based on the combination or integration of structural importance generated from social networks. However, our purpose is learn the ranking function (e.g. ranking of companies) based on social networks, which has different optimization task. Moreover, we propose innovative features for entities based on combination or integration of structural importance generated from social networks.

7. Conclusion

This chapter described methods of learning the ranking of entities from multiple social networks mined from the Web. Various relations and relational embeddedness pertain to our lives: their combinations and their aggregate impacts are influential to predict features of entities. Based on that intuition, we constructed our ranking learning model from social networks to predict the ranking of other actors. We first extracted social networks of different kinds from the Web. Subsequently, we used these networks and a given target ranking to learn the model. We proposed three approaches to obtaining the ranking model.

Results of experiments using two domains (i.e., companies in the electrical industry in Japan and researchers in The University of Tokyo) reveal that effectiveness of our models for explaining target rankings of actors using multiple social networks mined from the Web. Our models provide an example of advanced utilization of a social network mined from the Web. The results underscore the usefulness of our approach, by which we can understand the important relations as well as important structural embeddedness to predict the rankings. We use multiple social networks extracted from the Web, which are more realistic than a single relational network. In addition, the model can be combined with a conventional attribute-based approach. Our model provides an example of advanced utilization of a social network mined from the Web. More kinds of networks and attributes for various target rankings in different domains can be designated for improving the usefulness of our models in the future.

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7

Considering Culture in Designing Web Based E-commerce

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1. Introduction

E-commerce is design for users in different physical locations, and web based e-commerce sites intend to attract users from international as well as local regions (Callahan, 2008; Chen et al., 2004). There are increasing numbers of e-commerce sites that provide links to different country sites, however most of the sites are in English and not all sites provide languages other than English for web users from different countries (Internetworldstats, 2007). It has also been found in earlier studies, that the presentation of information through different languages and web design elements such as navigation, images and color can provide diverse reactions from people in different cultures (Kang & Corbitt, 2002; Nguyen et al., 2006). Usually, presentation of business information and services offered through the web is not only conveyed with designers' ideas but are also possible with web users' perception of choices. In short, information on the web relies on both groups - designers and users, forming a common perception. In a global context, many web interfaces do not support effective usage due to application of unsuitable tools for conveying information in a global context, since most of the information is presented on the web by icons, metaphors, shapes, colors of text and background, frame/ text locations on screen, etc., which, may be relevant to some culture groups but may be misinterpreted by the global audience.

E-commerce businesses are targeting business expansion into other countries, and to facilitate this, international users need to get appropriate support through web design features to use the site as an active business platform (Kang & Corbitt, 2002; Nguyen et al., 2006). Also providing appropriate language for international users on the site is important, not only just translation, but also delivering information in a local nous (Ford & Gelderblm, 2003; Piller, 2003).

This chapter presents investigation of global e-commerce sites, describing methods for understanding cultural issues in designing web based e-commerce sites. The author attempted to show how culture affected the features of the sites, and how these features might be adapted other cultures, through examples presented in the chapter. The chapter focuses on popular design features in web interfaces of global e-commerce sites and differences arising from design in different country sites.

2. Understanding Users and Culture

In recent years, e-commerce has made it possible for users to feel connected and have closer contacts, in turn impacting on the mode of commercial transactions (Chen et al., 2004; Horton, 2006; Statistics, 2007). Therefore cultural boundaries are of lesser importance in business, and the market place is not dependant on the physical store alone (Chen et al., 2004; Sudweeks & Ess, 1998). Products and services can be easily presented through the e-commerce, and business transactions are easy to carry out in the Business to Consumer (B2C) setting. This phenomenon has changed the cultural boundaries. Nevertheless, without a clear understanding of cultural differences as applied to e-commerce, specifically web interface design, the potential of e-commerce is difficult to realise (Ford & Gelderblm, 2003; Horton, 2006; Zhang, 2000). To improve this, interface design of web based e-commerce sites for a global context needs to have an emphasis on an enhanced cultural context for the interface (del Galdo & Nielsen, 1996; Kang & Corbitt, 2002). Consequently study of a usable web interface design for different culture background users and designers is being acknowledged as an important aspect of e-commerce.

In e-commerce, culture has a strong influence on the customers' (or users') responses, feeling and trust or satisfaction (Chau et al., 2002; Rose et al., 2003). Users feel and act on web sites within the culture. Users' negative or positive react to e-commerce web sites and they are being understood and identified in the e-commerce practice. In Chau et al's (2002) study on user behaviour in relation to culture in e-commerce, it was argue that e-commerce users are different in nature as they are surrounded by different cultures, and the emphasis on local user preferences. This is the key issue to support e-commerce practices. Even though the Chau et al's study has not fully investigated users' responses from the same ecommerce web site in different cultures, it shows user responses in e-commerce sites and important implications in improving user responses. Rose et al (2003) also emphasised that culture has a major impact on user responses to e-commerce sites. Rose et al's (2003) study shows that, users understanding of information on the web will be different to users from different cultures. Therefore presenting information on e-commerce sites can be an essential issue for users and providers. Barber and Badre's (2000) study about merging culture and usability work is a helpful guideline for attracting potential international users (Barber & Badre, 2000).

Considering culture in presenting colour on the screen is that it has different psychological and social associations in different cultures (Badre, 2002; Nielsen, 2000). Barber and Badre's (2000) study shows that various user interpretations of icons and graphical components, colours, fonts, shapes, icons and metaphors, geography, language, flags and sounds directly affects the user interaction with a site. More importantly, different users have different concepts of screen usage. Del Galdo and Nielsen (1997) for example have demonstrated that the right-to left writing direction of the Arabic language is the common way of design of screens in Arabic countries and users start reading from the top right-hand to the bottom left-hand side even in English language (del Galdo & Nielsen, 1996). Therefore culture influences certain methods of performing tasks, even common everyday jobs in certain ways (Fernandes, 1995). Design practices result from life long training of humans and set rules and circumstances. History and values can also impact on a web site user's perception. Hence, cultural understanding deals with how differences between people from different culture impact on their behaviour in particular circumstances, as in web based e-commerce.

Users in different cultures portray different meanings to web based e-commerce interface

elements in usage (del Galdo & Nielsen, 1996; Fernandes, 1995). The challenge of web interface design for e-commerce is to create a good design for the target users based in different cultural contexts. Therefore it is necessary to study web design practices focusing on target users and interface design issues by considering practices used by designers for the provision of a platform for web based B2C e-commerce. This can be done by providing either a single global site designed for users from all cultural backgrounds, or separate local sites for users from specific nations or cultures. Many researchers have proposed web interface design for e-commerce through distinct approaches for global and local users to provide effective user interaction. They have suggested changes for improving user activities to improve effectiveness in e-commerce (Kim & Moon, 1998; Nielsen, 2000; Shneiderman, 2000). However, there are no holistic studies examining the designers' approaches in different cultures.

3. E-commerce Type and Business Model

The intention of creating web based e-commerce is that, business can significantly reduce its operating costs, expand market without geographical restrictions, provide global exposure to the business, deliver effective customer services remotely, and increase overall product value (Afuah & Tucci, 2003; Elliot & Keen, 2002). In this way, the web based e-commerce model enables small to medium business to compete with a larger business on an even playing field; sometimes even providing advantages to the smaller business because it usually has lower cost structures and is more agile (Elliot & Keen, 2002). Table 1 presents a brief description of business models and identifies B2C and B2B business models that are relevant in the current e-commerce environment.

Business model	Description	E-commerce type
e-shops	Selling of products and services over the e-commerce sites	B2C
e-malls	Incorporates utilises that enables individual transaction processes under a single name, and consists of a collection of e-shops	B2C
e-procurements	Electronic tendering and procurement of goods and services from suppliers where a dedicated procurement system exist that is share with suppliers and e-commerce business	B2B
e-auctions	Intermediary services being provided to buyers and sellers who use the services to	B2C

	trade in an auction format. Invoicing is provided by the e-auction business and processes to resolve dispute are also provided through the web	
virtual communities	Contribute additional value in e-commerce site, and raise feedback from community members	B2C
collaboration platforms	Collaboration between enterprises through a set of tools	B2C
third-party marketplaces	Represents creation of a market through customers' requests and response by suppliers	B2C
value-chain integrators	Represents a function of a particular business within the value chain, such as payment and management services	B2B
value-chain service providers	Specialise on a specific function for the value chain	B2B
information brokerage & trust services	Use open networks to provide the huge amount of data from integrated business operations	B2B

Table 1. Description of business models and e-commerce based on Timmers' model (1998, 2000)

The business models broadly cover e-shops, e-procurement, e-malls, e-auctions, virtual communities, collaboration platforms, third-party marketplaces, value chain integrators, value-chain service providers, information brokerage and trust services (Timmers, 1998, 2000). These models broadly cover all business functions in e-commerce implemented on the web but not necessarily only for web based B2C e-commerce. As in any business, the models listed above can be present in a B2C web site depending on its business goals. Elliot and Keen (2002) refined the broad ten categories for simplicity into four primary business models, which are e-shops, e-malls, value-chain service provider and third-party market place (Elliot & Keen, 2002).

From the author's point of view, B2C business models can solely be represented as e-shops, e-procurements, e-malls, e-auctions, virtual communities, collaboration platforms and third party market places out of the ten models described by Timmers (1998 and 2000). For example, Airline industries are truly global due to the nature of their business and they have so far utilised web design and technology to promote their business to an international market quite actively. Therefore, airline sites are suitable for investigating how web design feature are used for facilitating business in a global market. Further, according to Timmers' (1998 and 2000) e-commerce business model 'e-shops', retailers replace their physical stores entirely with online operations (Timmers, 1998, 2000). Airline businesses aspire to have a similar business model where customers can directly do business online or use travel agents who perform transactions online. If travel agents are also considered as customers of airline

businesses, then including direct customers, all customer access and the pertinent business information is delivered to customers without prominent physical shopfronts. Therefore, airline global sites are selected as an example of global business as airlines come closest to one of Timmers' (1998 and 2000) e-commerce models.

4. Research Approach

As the literature review describes in Section 2, there are important issues in web design of e-commerce that are not clearly understood by the e-commerce community to effectively use global web based e-commerce. For supporting interactive web sites in e-commerce, the user's trust in using web sites for conducting business and designer's attitudes in supporting services provided by a business. Also cultural issues impacting on design of successful e-commerce sites were found to be issues relevant to the research community (Gefen & Devine, 2001; Kim & Moon, 1998). This research was through observations of design features in global e-commerce sites, analysing design features and the reasons for it.

As Yin (1994) suggested, evidence of case studies may come from six sources such as documents, archival records, interviews, direct observation, participant observation and physical artifacts (Yin, 1994). In this example, observations and documents were used in the process of conducting the case study. Firstly, the author focused on design features and information presentation differences in large global corporation web sites. Understanding how color, image presentations and facilities for data entry in different sites, and how the page included different regions. The author also considered complexity of a page including text density, site structure, frame and global links. This approach sought to confirm the generalizations and to test the impact of cultural differences on web design. This exploratory investigation attempted to formulate more precise objectives for further researching the problem.

Firstly, the author selected airline sites based on Timmers' business model (in section 3), and identified information web design styles; page layout, visual design elements and language options. Secondary, this research was conducted on pre-selected global sites, and compared country pages which are based in Australia, UK, Korea and Japan. The research questions were "what are design characteristics in different country web sites?" and "what are popular design features in Western and Eastern country sites?". The study attempted to find out the characteristics of design features. For the second research question, observations were conducted to determine the different design categories in four different countries. The author then investigated design features, where some design effects were taken into consideration, such as color, images, menu layout, etc. The data collection and research methods are similar to many studies, where exploratory research method is used to examine the web design of sites (Huberman, 1994; Jarvenpaa et al., 1999). This approach was found to be beneficial to confirm generalizations made in relation to test the impact of cultural differences on web design. This research is then used to formulate more precisely objectives for the final stage of the research.

5. Investigation Design Categories

Taxonomy of design feature categories is important in facilitating research in a systematic and meaningful fashion (see Table 2). The taxonomy presented in table 2 is based on leading

researchers in HCI and E-commerce (Horton, 2006; John et al., 2000; Lazar, 2006; Nielsen, 2000; Norman, 2004) and used to categories observed features in global airline sites.

	Categories	Details
Design feature	Page structure	Linear, hierarchical, network or multiple access links to product info
	Menu frame	Horizontal, vertical, or both
	Image	Image map, cartoon, moving or stationary, country logo, or picture with person/people
	Density of text	Low, medium or large on the home page
	High tech feature	Number, size, location
	Content	News, search or links for promotion
	Form	Search engine, booking from
	Global Links	Country, language options,
Information presentation	Style of presentation	Introduction, tailored information in different countries

Table 2. Categories of design feature and information presentation

These issues are then investigated through different country sites in as many culture groups as relevant for the study, in this case two - Eastern and Western. The purpose of this investigation was to find the design characteristics and information presentation styles that are distinct to a culture. An exploratory approach is then taken to examine multi-linguistic sites. This enables understanding of typical design styles in different language sites.
The global airline sites presented in this example were observed in relation to web design features and target users. Common and popular features on all sites were identified and classified after which four countries' airline sites were selected for further detailed comparisons, two each in different country sites based in USA, Australia, Japan and Korea (South). The design features within the same airline site were examined for the purpose of comparing culture differences.
Twenty-four airlines were selected for the sake of this example to identify the common elements of web design features, and the airline sites examined were based in twelve countries. Only the home country sites were used for this portion of the study, which helped in forming an idea of common web design features in these sites.

6. Findings

Research findings are then summarised into the headings of design characteristics and comparative features. These are described in a greater detail in the following two subsections.

6.1 Design Characteristics in Global SitesLanguage, Style Spelling

From the investigation for the airline sites' example, hierarchical structure was found to be the most popular information layout for the airline sites. A flat hierarchy of information presentation structure is important for a successful web site design because it facilitates user

understanding. It was apparent that airline sites considered user control in design and navigation features suitable for local sites and extended similar facilities to their global sites.
Most sites observed in the study provided menu at the top and second levels in a hierarchical information format, following the hierarchy for a selected product group and brought up to the index or a text box for the search engine. Also the horizontal layout was observed to be the most popular form. Most of sites had top-down and left to right arrangement for the menu layout.
Images on airline sites were not a major feature of the site and mainly contained stationary images. Most of the sites contained more than three images per page. Cartoons and moving images were not popular, and only one airline site (Japan Airline) had some cartoon images on the site. All the sites in the study also contained the business logo except one site, and were mainly located on the top-left corner of the cover page. Some of sites had more prominent use of images such as on Eastern country sites, where images of people and big welcome signs were used to promote friendliness.

It was also confirmed that attractive features such as animations, video clips, or graphics may attract user's eyes, but static information on the web provides much easier comprehension and navigation. This investigation confirmed that the global sites were providing easy to look at images on the sites that promoted comprehension. However, the size of images was different in some country's sites and is described in more detail later in the chapter.
The prominent colors on airline sites were found to be 'blue' images on a 'white' background. The text density was also very high, with 'black' text delivering information mainly through functional form and menu. Generally, each site contained between three to five different colors for each site including text and images.
Unlike other popular e-commerce sites, none of the airline sites used pop up windows. Some sites contained rollover features, and many sites had moving images. Most sites did not provide multiple access links for product information, and same page features for other country's pages on the main home page. Some of the sites had the same design with different colors and pictures for other countries, but the theme color and images were the same as the home page providing an image of consistency. Though, some Eastern country sites did not follow this norm. They also generally had more moving images and bigger pictures than Western country sites.
Fourteen airline sites provided global sites through links. Furthermore, around 10 sites had different design features as on the home sites. Only 8 airline sites had different design pages for different countries as compared to the home site. Rest of the airline sites presented cover pages with different photos or menu frames as on the main home site, with the same information contents as the main home page. Over 14 sites had different page designs for different country sites, but presented the same type of cover pages with links to other languages/countries as the main home site. Thirteen sites provided different menu frame and colors on local pages.
From the twenty-four airline sites researched, most of airline sites provided English sites only, and they focused on English speaking users, mainly based in the USA. As for providing global links and sites for users from other countries, almost all airlines provided links to other country or regional sites, and only one business provided local sites for different countries. In fact, many global sites provided links to multilingual sites or other

country sites from the main page. Most of the airline sites presented information in English on the cover page, except sites for Dutch, Japanese and Chinese airlines. Some country sites focused only on local users rather than other country users and provided local language on the cover page.
Most of airline sites required a user login facility to access service features, and the login form was located on the top of the sites. All airline sites provided multiple text boxes and drop-down selections for the booking forms. Mainly, these forms were located in the middle of the page. The popular design features of global airline sites in terms of position of the menu which is located on the top layout of the main sections for information presentation, which is oriented vertically; login located under the menu; form located in the middle of the page.

6.2 Comparisons

This section summarises the comparisons of different websites for the airline web sites' example. Table 3 shows in summary, the categories of design features clustered in selected groups of home page, and country pages in Korea (South)/Japan and Australia/UK. There are many design features that are different for other country sites for the same airline such as image links, overlapped images, number of persons in the picture, dominant page/text color and high-tech features.

Categories	Airline Home page	Country pages directed for Korean/ Japan	Country pages directed for Australia /UK
Image	Image links are popular but no cartoon images.	Business organisation logo and images are large. Mostly, the human and female faces on the picture. Many images with links	Smaller images are popular
Color	Dominant color is blue in text and image. More than three colors of text	Multiple colored images, text and backgrounds	Use limited numbers of color for text and images
Density of text	Mainly with text information on the page	Less text than the home page	Less text than the home page
High tech feature	More rollover features and search tools available than other country sites	Pop up windows and rollover features are popular. The animations are larger and located in the middle or top. The animations are mainly for other businesses' advertisements	Moving images and animations are uncommon, and usually located on the right corner and small
Particular feature	High density text on the page	The black text color is common	The animation is small and own business organisation's advertisement
Common feature	Business organisation logo was the strongest image on the cover page. Overall, blue color was commonly used. Multiple frames are in vogue.		

Table 3. Characteristics of design feature in Western and Eastern county

From analysis, it seems designers for airline sites have different impressions of target markets, and tended to provide less text and more images. Designers often provided similar structure and design features on other country sites as home pages. All airline home sites

provided search tools and links for finding more information. Particularly, Korean (South)/Japanese sites provided more than two languages including "Native" English and their own language for home sites. Most of the Korean (South)/Japanese sites provided alternative designs for local users. However Australian/ UK site rarely provided alternative design features (e.g. menu bar, multiple links, inter-linkages, etc), other than those on their home site. It was also observed that use of text, images, color and new high tech features in design for Korean (South)/Japan and Australian/UK sites were distinctly different. Australian/UK users were considered as equal to "Native" English site users on the Korean (South)/Japanese home site. Some Korean (South)/Japanese sites provided different designs for "Native" English and "non-Native" English users, and also provided different favourites for different language background users.

A typical page structure for Western country sites provided menu on the top and bottom, and main sections located in the middle of page. The pictures on the page are simple and not more than two were used. On the other hand, Eastern country sites show multi-layers of menu on the top and several pictures spread out in the main sections. The Eastern sites also tended to provide video clips, news and promotional links.

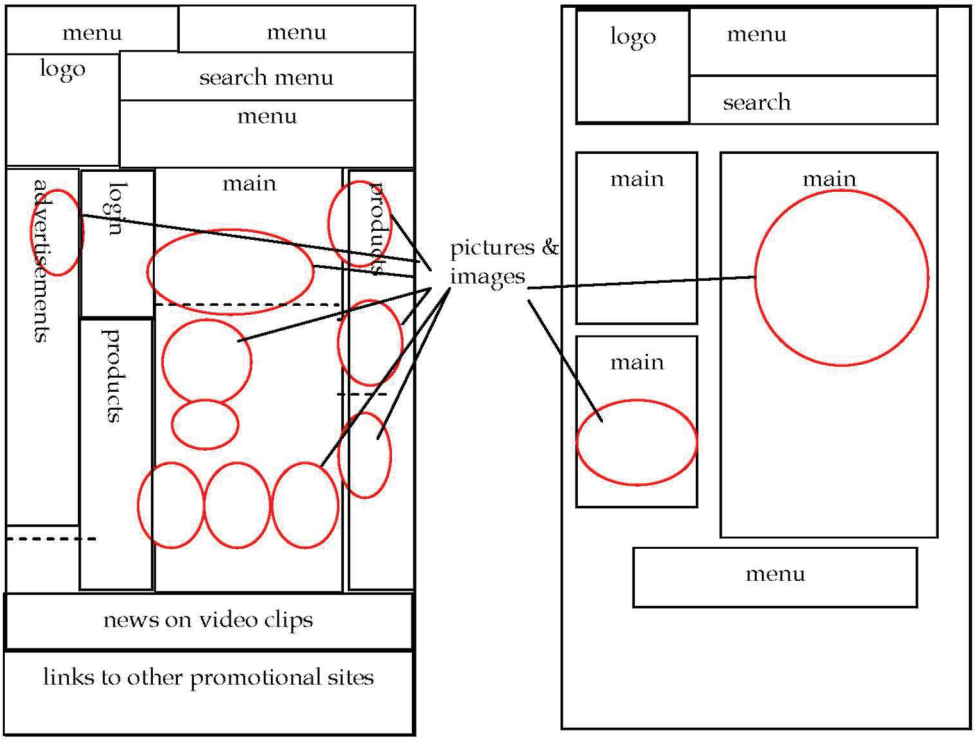

Fig 1. Popular design features in global sites: East (left) vs. West

The Western sites usually had an introduction page, which provided information about the business organisation, its market and then the product information could be accessed through links on the main page. In comparison Korean (South)/Japanese sites provided no introduction and took the user directly to links for selection of services and products. By looking at different design features, there was a clear connection between design features and pages aimed at or originating from certain cultures.

7. Summary and Conclusion

The investigation on airline sites based in Eastern and Western country confirms that there are certain ways to localise web sites based on cultural differences of target users. These suggestions were made to plan ahead, as all languages are not created equal and have their own nuances. The suggestions encourage a designer to be aware of cultural differences, present a clear choice, know the target users, avoid slang, and keep information current on the site. However not many airline sites seemed to be aware of how cultural difference impact on local users' preferences. Even though a global site provided links to other country sites, the site was in English and only three sites provided languages other than English for other country users. However the investigation provides an important framework for evaluating characteristics of web design features, and identifying culture differences that will help improve ease of use and satisfaction for international users. It was observed during the study that global airline sites mainly focused on English users rather than on other language users. In general, global e-commerce sites provided links to regions or country pages, which were partially customised. The customisation goes some way in providing access to international users. This convenience does break a language barrier but most of the global sites only provided essentially the same design features as on the home page. Perhaps this common practice aligns with providers' business goals or other reasons for creating awareness amongst customers, but does not deliver the full potential of a B2C e-commerce business. However it is necessary to understand users in different countries and their experiences in global sites to be effectively involved with e-commerce because customers are more comfortable with doing business in a familiar environment. This implies that, it is necessary to elicit how the web design features appeal to users in different cultures, and how designers in different countries approach the creation of usable design features for local and international users.

The investigation was targeted on finding commonalities and differences in design features related to different countries based on global airline sites. The reason for studying global airline sites was that airlines provide similar services following similar business practices, so the design features were more likely to be linked to target users' and designers' country of origin and typical choices of preferred web design features. The fact that airlines provide global services, covering multiple cultural groups also makes it logical to derive such conclusions. The key conclusion of this investigation was that the different country users have different favourites and reasons to use global sites. Hence the e-commerce providers and designers need to be prepared to make a distinction in design of sites for international users. It is important that the international users have different ways of adopting culture in e-commerce especially in a global context. In global sites, adopting culture in e-commerce

will accelerate creation of a new form of design of sites for international users which would address customers' concerns placed in a particular cultural setting.

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8

Consumer Responses to Colors of E-Commerce Websites: An Empirical Investigation

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1. Introduction

During the past 15 years, one of the most important influences on business has been the rapid development of the Internet and e-business technology. In a relatively short space of time, the Internet, or more specifically, the world wide web, has evolved from being a novelty used purely as an entertainment and communication device by a handful of technology aficionados into a transforming concept that is now seen as an essential business tool (Simeon, 1999; Poon & Swatman, 1999; Aldridge et al., 1997; Herbig & Hale, 1997; Cotter, 2002). The design of e-commerce websites interface is thus receiving increasing managerial and research attention in online retail context.

E-commerce websites are trying to increase their sales through a personalized merchandising mainly based on the *theatralization* of the interface. However, if online personalization has been extensively studied in information systems research, web users reactions to such personalization are not known yet (Ho, 2006).

From a cognitive point of view, the simple fact of getting lost on a webpage for example, seems to be the consequence of user's difficulties to manage simultaneously two cognitive activities: processing and locating (Tricot, 1995). Unfortunately, it changes the affective states and factors such as aesthetically pleasing color combinations can play an important role in generating positive affect, which may be particularly relevant for e-commerce website. Indeed, in this retail context, companies try to encourage users to associate a given brand with positive affective states. A few studies have been conducted on this topic. Norman (2002) worked on aesthetics and emotion in design, Eroglu et al., (2001, 2003) investigated the effects of atmospheric cues of the online store on shoppers' emotional and cognitive states, showing that they affected their shopping outcomes. Nonetheless, none research can be found on the effects of colors on the memorization and buying intention, by considering the impact of affective states as a mediating variable of the "colors-memorization/buying intention" link. Similar to traditional in store stimuli, online colors can provide information about the retailer (e.g., the quality or type or retailer, the target audience of the retailer) as well as influence shopper responses during the site visit (Eroglu et al., 2003). The consumers affective states can directly affect the website visit duration. It is

then possible to presume that consumer's emotion and mood affect the website visit duration, a domain already investigated (see Danaher et al., 2006).
This duration can help maintaining user interest in a site (Bucklin & Sismeiro, 2003, Hanson, 2000) and give users more time to consider and complete purchase transactions (Bucklin & Sismeiro, 2003). Enhancing user's interest helps to generate repeat visits, which lead to greater long-term sales according to Moe & Fader (2004). From a business investment point of view, Demers & Lev (2001) show that sites with longer visit duration also have higher monthly stock returns. Therefore, one can undoubtedly think that the visit duration is directly related to the buying intention in an e-commerce website: the more you stay if you feel in a good mood and emotion, the higher your intention to buy will be. A possibility for enhancing the visit duration comes from the design of the e-commerce website. Web designers have to *"continually weigh how visual elements affect audience perceptions and uses of online information. Such factors can be complex when designing materials for a particular group […] designers must now think in terms of global audiences"* (del Galdo, 1996; Nielsen, 2001).
In their effort to spur Internet users to buy, brands do not seem to focus systematically on color choice when conceiving or updating websites. However, when consulting a website, Internet users browse web pages designed to arouse their attention based on factors such as colors, sound animation, texts, animations, pictures, textures, graphic design and advertising. Aware of the significant and widely known impact of the atmosphere inside stores on the prospective buyers' behavior in a traditional buying situation (Kotler, 1973; Donovan & Rossiter, 1982; Filser, 1994, 2003a, 2003b; Lemoine, 2003), there is need to understand the effects of colors, as an atmospheric variable and as a component of e-commerce interfaces, on online consumer behavior. Although the color variable is a widely researched topic in various fields (Divard and Urien, 2001), there is a lack of studies focusing on color in the online context. As such, our knowledge regarding how the colors of e-commerce websites can influence online consumer behavior is scarce.
In an attempt to address this gap, the aim of this paper is to examine how the colors of an e-commerce website can help consumers to memorize information so as to end up buying on the website. The paper presents an empirical study of the effects of e-commerce website color on the memorization of product information and buying intention. Unlike most empirical studies dealing with color by comparing warm and cold colors, we examine color by focusing on its hues, brightness and saturation so as to demonstrate that its influence varies according to the intensity of each of these three components. Our findings show that the colors used on an Internet website have a positive effect on memorization of product information and buying intention, which is also mediated by the affective states. They emphasize the role of affect – mainly composed of emotions and moods (Derbaix & Poncin, 2005) – as a mediating variable.

2. Background

Readability represents the reaction time required to find a target word when searching on a website (Hall & Hanna, 2004). Although readability is informative with respect to basic processing, it does not address higher-level outcomes of processing such as retention, which is based on the cognitive architecture. The term "cognitive architecture" refers to the manner in which cognitive structures are organized. The two most important aspects of human cognitive architecture relevant to visually based instructional design and around which

there is broad agreement are the *working memory* and the *long term memory* (Sweller, 2002). While considerable work by many researchers over several decades has been devoted to the organization of human cognitive architecture (Sweller, 2002), far less effort has gone into investigating the memorization of the information presented on websites. De Groot (1965) work on chess (first published in 1946) demonstrated the critical importance of long-term memory to higher cognitive functioning. He demonstrated that memory of board configurations taken from real games was critical to the performance of chess masters who were capable of visualising enormous numbers of board configuration. The skills depended on schemas held in long-term memory, thanks to the retention of information.

Retention is a very important factor for the large number of information-based websites that exist. It is an important factor for e-learning applications, since the user's goal is usually to retain the information beyond the time the page is being read. This also applies to information included in e-commerce sites, since the users tasks are often facilitated when they can retain information from page to page. Thus, measures of higher level processing, such as retention, remain an important topic in examining the effects of text-background color combinations, for the success of e-commerce, e-learning and e-government websites.

2.1 Color

Although color is a widely researched topic (Divard & Urien, 2001), to this day very few studies focus on this variable within the online context. Research is limited to several studies about the impact of colors on Internet site readability providing advice about how to choose the most harmonious colors (Hill & Scharff, 1997; Hall & Hanna, 2004), while usability research experts, such as Nielsen (2001), make managerial recommendations. Yet color is omnipresent in e-commerce websites. Generally speaking, it affects consumer behavior in compliance with Mehrabian and Russell's (1974) Stimulus Organism Response (SOR) psycho environmental model.

E-commerce website interfaces seek to place consumers in a particular context by activating the sensory system (hearing or sight) and enable one to perceive their emotional, cognitive, psychological, physiological and behavioral responses through their being altered. The perception of a website's atmosphere lies almost exclusively in its visual aspect since 80% of the information processed by the Internet user's brain comes from sight (Mattelart, 1996). Among the behavioral reactions caused by website atmospherics, the visit frequency of a website depends on colors, which are considered as factors of positive influence; on the contrary, a limited use of colors in e-commerce websites is considered as a factor of negative influence (Lemoine, 2008).

The color contains three principal components (Trouvé, 1999):

- *Hue* (or chromatic tonality) is the attribute of the visual sensation defined according to the colors denominations such as blue, green, red…;
- *Saturation* provides the proportion of chromatically pure color contained in the total sensation;
- *Brightness* corresponds to the component according to a surface illuminated by a source that seems to emit more or less light.

Unlike most empirical studies dealing with color by comparing warm and cold colors, we have decided to focus on its hue, brightness and saturation so as to demonstrate that its influence varies according to each one of those components' intensity. In color literature, Bellizzi & Hite (1992), Dunn (1992), Drugeon-Lichtlé (1996) and Pantin-Sohier (2004) chose

hue as the main variable in their experiments and showed that brightness and saturation should be taken into consideration when conducting experiments about color. As Valdez (1993), Drugeon-Lichtlé (2002), Gorn et al. (2004) and Camgöz et al. (2002) had shown regarding the brightness component of color, it seems more interesting to compare hue and brightness than to compare warm and cold colors when trying to determine what consumers recall and what spurs them to buy. Indeed, in everyday life there is no support helping consumers to recall the content of an e-commerce website they visited or to compare it with another offer. The feeling of aggressiveness felt by consumers when visiting an e-commerce website – partly due to the use of rather bright colors – does not result in a more efficient memorization of information, nor to a stronger buying intention.

2.2 Color perception within interfaces

Color perception is a complex process in that it is more than a mere physiological or psychological fact. It is also formed by consumer's national culture, general education and socio-professional background. According to general psychological data (Fleury & Imbert, 1996), every individual is endowed with a physiological ability to perceive colors (Wright & Rainwater, 1962; Nakshian, 1964; Wilson, 1966; Jacobs & Suess, 1975; Kwallek et al., 1988).

On a website the interface represents the graphic chart, a set of rules composed of two colors: the foreground color also called "tonic" or "dynamic" color and the background color, labeled "dominant color" by webmasters. These colors reveal the contrast, which correspond to a strong opposition between the foreground and the background colors, as defined by W3C[1] (Accessiweb, 2008). Its main function consists in favorising the readability of the displayed information, and *a fortiori* the memorization process.

Kiritani & Shirai (2003) show that the effects of screen background colors on time perception vary according to the tasks performed by Internet users. When reading a text written on a white, blue or green screen background users have the feeling that time passes more slowly. When users are merely conducting a simple search and only need to understand the meaning of a sentence, then the screen background color does not have any impact on how they perceive time duration.

Hill & Scharff (1997) have demonstrated the importance of contrast (dynamic color vs. dominant color) when searching for information within a page. They obtained better readability scores when resorting to chromatic colors (green dynamic color on yellow dominant color).

The results of Corah & Gross (1967) suggest that recognition between colors was made when the differences of contrasts between the various forms and the standard forms were larger.

During an experiment where colored labels had been stuck to screen backgrounds, Camgöz et al. (2002) observed that brightness, saturation and hue had a specific impact on each colored screen background.

Biers & Richards (2002) have studied the impact of dominant color on the perception of promoted products and found that backgrounds with cold hues, such as blue, increased product value and reduced the risk of purchase postponement, especially with regards to regular Internet users.

Hall & Hanna (2004) studied the impact of dominant and dynamic colors on how readability was perceived and aesthetic aspect experienced, as well as on memorization of information

[1] http://www.w3.org/

and on intentions. According to them, sites promoting knowledge transfer must display black texts on white backgrounds, achromatic colors with maximum contrast. In parallel, e-commerce websites should merely use chromatic colors due to the higher aesthetic appreciation score which is correlated with higher purchase intention. Blue is the favorite hue when it comes to buying intention. These results underline the importance of taking into consideration the impact of the color's components (hue, brightness and saturation), as well as the contrasts occasioned by the foreground and background colors.
Moss et al. (2006) demonstrated that the impact of colors varied according to gender. According to them, differentiation mechanisms have an impact on how an e-commerce website is perceived, not based on price but based on website ease-of-use and the pleasure felt by users.

3. Research model

The model explains how the colors of an e-commerce website and their components - hue, brightness and saturation - can have an impact on the buyer's affective state of emotions and mood and cognitive states of memorization and buying intention (Figure 1).

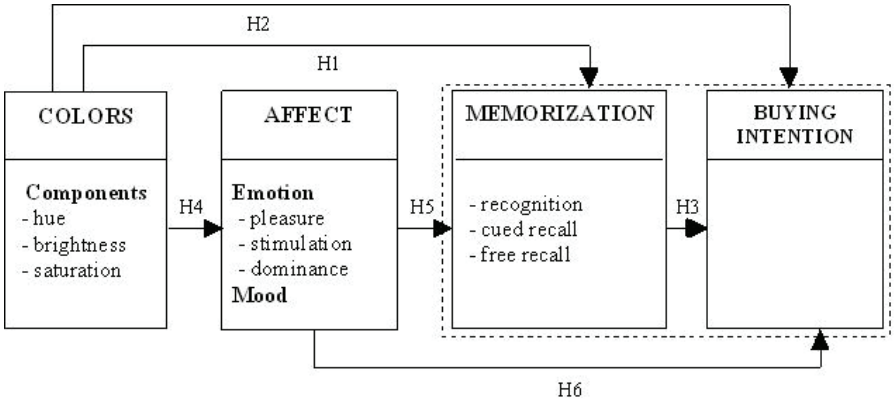


Fig. 1. Conceptual model of the research

3.1 Memorization

Memorization is a very important factor for the large number of information-based websites that currently exist. It is important for e-learning applications, since the user goal is usually to retain the information beyond the time the page is being read. This also applies to information included in e-commerce websites, since consumer tasks are often facilitated by memorizing information while navigating. Drawing on offline setting, memorization can be influenced by the colors of an e-commerce website.
In order to understand the effects of color on consumer memorization we have to take into account the quality and quantity of information a consumer has memorized while visiting an e-commerce website. We posit that memorization varies according to the colors of the website, and especially according to the contrast between the dominant and dynamic colors, in agreement with the work of Hall & Hanna (2004).

In general, information is stored according to an encoding process enabling one to sort out information thanks to criteria which will then allow one to retrieve this information. The role of these criteria is to connect a piece of information to other similar information already stored (Ladwein, 1999). In order to examine the information memorized by each participant, we resort to recognition and recall, two procedures belonging to a method of information retrieval based on overall stimulus in long-term memory. Be it free or cued, recall enables individuals to mimic mentally a stimulus to which they are not exposed during the evocation, for instance, their past reaction to a promotional action (Filser, 1994). Thus, we can hypothesize:

H1: The colors of an e-commerce website will have a positive effect on memorization

3.2 Buying Intention

Intention is activated by a desire or a need (Darpy, 1997) and desire is viewed as an active process (O'Shaughnessy, 1992). Although buying intention is more than a mere desire, it is not a promise to buy (O'Shaughnessy, 1992), it is the outcome of a cognitively handled desire. According to Darpy (1997), echoing the studies of O'Shaughnessy (1992), Howard (1994) and Belk (1985) "*Intention results from a desire or a need handled on the cognitive level and leading to purchase planification*".

Among the environmental factors recognized to produce important emotional and behavioral reactions on the consumer, color seems to play a big role. It serves to retain consumers longer on the e-commerce website according to certain criteria related to their perception of the interface. In particular, pleasure is increased with use of colors whereas the boredom can result from a weak use of them (Lemoine, 2008). This duration can help maintaining user interest in a site (Bucklin & Sismeiro, 2003; Hanson, 2000) and give users more time to consider and complete purchase transactions (Bucklin & Sismeiro, 2003). By enhancing consumer interest, it helps to generate repeat visits, which lead to greater long-term sales (Moe & Fader, 2004b). From a business investment point of view, Demers & Lev (2001) show that sites with longer visit duration also have higher monthly stock returns. Therefore, it can be assumed that e-commerce website colors are likely to have an impact on buying intention, as they can prolong the visit duration. Therefore, we propose:

H2: The colors of an e-commerce website will have a positive effect on consumer buying intention

There are many entries which are available in the memory and in the external environment. They can potentially be considered in decision making, but only a few will be used to make a choice in a given situation. Tactical choices effectively originate from decision made regarding the products we buy, including:

- considerations linked to the price (cheaper, use less of it, costs cheaper);
- considerations linked to the performance (the product functions in these conditions, it owns these qualities);
- considerations linked to the affect (I like the product, I love the product);
- normative considerations (my father advised me to buy it, my mother always uses this product);

It is important to understand the procedures which determine which small sample from the entry among all possibilities can be used as a base to make a choice. For these reasons, we propose:

H3: The memorization of e-commerce commercial information will have a positive effect on consumer buying intention

3.3 Emotion

We wish to bring to the fore the effects of colors on affect, which includes the emotions and moods experienced when visiting e-commerce websites. Emotions are short-lived but extremely intense. Their cause is unknown but their cognitive content obvious (joy, sadness, anger, fear, disgust). Their most obvious features are brevity and intensity. While emotions imply some kind of awareness of the information about the background and consequences of actions, moods refer to affective states of mind less likely to reach our consciousness. Moreover they last longer than emotions but are less intense (Forgeas, 1999).

To interpret colors one must go through a cognitive process which, in turn, arouses emotions in the Internet user. These emotions can fill users with a desire to buy, lead them to make a purchase or make them abandon the website. Perceived differently by each Internet user depending on his or her own way of perceiving colors, emotions involve a shift in his or her behavior.

3.4 Mood

Mood is generally is considered as a mild affective state that may influence cognitive processes such as evaluation, memory and decision strategies (Gardner, 1985). However, the observed effects of negative moods have been less consistent than those of positive moods. For example, Cialdini et al.'s (1973) negative state relief model of helping asserts that people in a negative mood will behave more charitably than others if the opportunity has potential for direct social or egoistic approval, suggesting that helping behavior may be quite a complex phenomenon not fully addressed by simpler explanations such as mood states (Swinyard, 1993). Gardner (1985) observed that the effects of mood may have special impact in retail or service encounters because of their interpersonal or dyadic nature, a view also supported by others (Isen et al., 1978; Westbrook, 1980).

According to Odom & Sholtz (2004), different colors tend to incur different moods. Studies have demonstrated the association of colors and mood by using diverse methods such as the objective impressions (printings), the clinical observations, the introspection and the experimental investigations (Wexner, 1954). Chebat & Morrin (2006) measured the effects of cold vs warm colors of a mall decoration on consumers. They showed that these were mostly guided by affective mechanisms, such as mood, or by other cognitive states, such as the evaluation of the mall environment quality. We believe that same mechanisms can exist in an online context.

Hence, we suggest the following hypotheses:

H4: The colors of an e-commerce website will have a positive effect on consumer affective states
H5: Consumer affective states will have a positive effect on consumer memorization
H6: Consumer affective states will have a positive effect on consumer buying intention

4. Research method

Our research method includes both a qualitative and a quantitative study. An exploratory qualitative study was conducted first to allow for verifying the importance of the research variables and the necessity of including them in our model to be tested. The proposed research hypotheses were then empirically tested through a quantitative study conducted in a laboratory setting.

4.1 Qualitative study

The main objective of the exploratory phase was to investigate the empirical knowledge gained by consumers and webmasters when browsing e-commerce websites. It mainly sought to confirm that colors have an impact on their perception, so as to prepare our quantitative study for data collection. The study was based on semi-structured interviews conducted with usual consumers and web designers, where we asked interviewees to speak about past visits to websites of their choice. From these interviews, topics referring to the affective states lived by the consumer in an online shopping situation emerged. These topics relate to the emotions and moods and show the importance attached by the consumers to the ease-of–use of a website. They also reinforce the proposed effects of variables such as color, as well as the quality of the images perceived by the consumers.

Participants

Participants were chosen according to their expertise with web sites (webmaster/simple user), their age, their sex and their social background. A participant is selected as an expert or not based on the answer in qualitative criteria of people selection, regarding the research objective. In our case, this selection was based on the answer to the question “have you already conceived or built a website?”.

Method

The criterion of saturation of the data being retained (Mucchielli, 1991, p. 114), we interviewed 21 persons. The interview guide was structured and opened. It allowed us to obtain interviews related to the subjects purchase experience in e-commerce websites. We adopted a neutral attitude with regard to them so as not to influence them in the way they answered. Participants were questioned without being able to face a computer screen, in order to answer only by using their memory to restore the information evocating their navigation on the e-commerce website of their choice. Once every interview was re-transcribed, the duration of which ranged from 13 to 47 minutes in average, we obtained a verbatim of hundreds of pages.

Results

The exploratory qualitative analysis enabled us to note that color was actually an integral part of the atmosphere on e-commerce websites. This variable even seems to hold a more important role than we thought prior to the analysis: color was mentioned more than 79 times during the interviews carried out. Some elements which appear essential to the interface are:

- elements related to usage - putting the organization of the site as a main factor, thanks to its clarity and the readability of its tree structure,

- elements allowing a rapid navigation within the site, by the provision of search engines in particular.

Color was actually mentioned by all the interviewees as a means of principal location within the interface of the site. It is perceived as an aid for consumer moves and sometimes caused aggravation if it appeared too violent.

" times you feel aggravated, irritated, because it does not function well, because there are bugs or because it attacks you, yes it can attack you, when it is too "violent" at the level of the colors " (respondent 14).

Not only is color part of the website design, but when soft, it also seems to comfort consumers thus filling them with enough self-confidence to buy an item in an environment to be "tamed": *" What I like in the site Boursorama website, it is a site initially on the general level that is comfortable. Comfortable visually speaking I would say." (respondent 16)*

It serves the organization of the information by highlighting useful zones systematically sought by the surveyed Internet users: *"it remains practical, therefore with doors, really accessible, or in any case visible, where I am able to make my reference marks easily. By zones possibly defined by executives, and then zones of text in fact. A regrouping of texts on certain places." (respondent 5).*

When used in compliance with the contrasts advocated by Itten (1970), color can prove very timesaving, a major asset in the relationship between consumers and websites. *"I will spend more time on a site which will have a large catalog, or products similar to what I seek, therefore always containing contents."*

As we mentioned, making information search easier by implementing rules specific to ergonomics and human computer interaction, the colors encountered when browsing an e-commerce website enable Internet users to navigate it more easily, according to its layout.

"Thus there is the speed already, it is important but it can be more due to the material with ADSL or not,… I do not know if one can control this, and if not, colors help to locate a little bit what one wants, how to explain that… if it is clear and neat if the screen by far were looked at, one knows what the various parts of the site contain more or less. But it is true that most important are the links for me."

Usability seems to play an important role in the consumer's perception of the e-commerce website's services and information provided. The content analysis pursued during this exploratory phase allowed us to verify that the color played an important role on the affective states lived in an online shopping situation. It also permitted us to determine certain characteristics appropriate for online purchase which differentiate it from purchase in traditional context. The respondent of interview 19 confirms this by saying that *"…the more readable the site, the more one wants to spend time on it"*. He further reinforces his assertion about the factors which discourage him to revisit a particular website: *"… if the site is complicated to access, has a complicated address in the address bar which is completely unmemorizable in order to revisit the same page, a difficult readability, too many animations… "*. This testimony corresponds to the one of the respondent of interview 3 who is more direct about the appearance of the e-commerce website: *"… its brightness encourages me to go and consult a commercial website, if it is clear and convivial. And what discourages me is, if it is all the reverse"*.

Discussion

Besides being pleasant to look at, information must be structured so that the visitors can easily distinguish the main thing from the accessories (principle of pregnancy) and that

available information is treated on a hierarchical basis (Ladwein, 2001). Among this essential information which is likely to be of interest to the consumer, we can distinguish the links or the interactive and informational zones, providing access to a particular zone of the website that the company wishes to put to the fore front. These links permit transitions from one page to another or provide access to "higher level" information. They need to be easily located. Their recognition can be facilitated by color, which constitutes one of the characteristics of information systems: to make any zone of the page more easily interactive by the creation of a feature which changes the state of a textual link or a button when the mouse is over it. Independently of the graphic style of the link, it is important that the visitor can discriminate very quickly which links are important and understand where they lead (Spool et al., 1999).
The non-recognition of these links can quickly become tiring and frustrating. Their recognition, which corresponds to fast identification of the possible actions on the website, is crucial for the consumer to get the impression that he is in control of the website. The use of color is thus pivotal in making links easily recognizable.
A quantitative analysis follows, showing that the effects of the colors of an e-commerce website on the Internet user, and, in particular, on his affective states, are not neutral.

4.2 Quantitative analysis

A laboratory experiment was conducted with 440 participants in order to test the proposed hypotheses. An e-commerce website selling music CDs was especially designed for the experiment. For each CD, participants could see the CD cover, the album title, the artist name, and seven pieces of information: music style, online store price, music company price, sale percentage, delivery time, state (new or used) and delivery charge. In addition, there was a CD description of 160 characters (around 20 words), next to the CD cover.
Each respondent visited the website with a graphic chart which was randomly selected among the eight charts prepared for the experiment, explained in the next section. A balanced distribution of the graphic charts among all respondents was ensured. After viewing two CDs, an easy to see link appeared on the participants screen. The respondents were asked to complete a questionnaire with questions about memorized information, emotion and mood states and buying intention. Demographic data were also collected. Then each participant was asked to go to another room to pass the Ishihara's test. This last stage was the only reliable way to know if the respondent was color blind or not. This guaranteed the validity of our sample, by keeping people with a perfect vision of colors. After discarding questionnaires that were incomplete or filled by colorblind people (8% of the males), 296 valid responses were used for the analysis, with each graphic chart being visited by 37 respondents.

Experiment design

Carrying out this experiment under laboratory conditions allows us to draw valid conclusions about the groups surveyed (Jolibert and Jourdan, 2006). Internet enables one to conduct non-intrusive studies, meaning that Internet users are not even aware that their behavior is being analyzed (Dreze and Zufryden, 1997). However, when conducting a study focusing on color, one has to control and neutralize three major elements: screens, ambient light, and, above all, the participants' color perception (Fernandez-Maloigne, 2004). Since, these elements cannot be controlled in a distance study carried out over Internet, a

controlled laboratory setting had to be used for our study. Table 1 explains how each of the three elements was controlled, while further, detailed information can be found in Appendix 4.

 Fig. 2. The screen adjustment (calibration) of screens is possible with a probe	We can make sure that the colors featuring in the different charts framing our experiment appear just as we have defined them on the screens of our participants.
 Fig. 3. The luxmeter enables to set up the brightness of the room at 1000 lux	By carefully defining the color of the walls and the brightness of the environment in which participants stay we can make sure that the colored appearance of the websites used for the experiment will not be altered by a too dim lighting or, on the contrary, by a too brightly lit room.
 Fig. 4. Sample of the Ishihara test	One must make sure that participants do not have any color vision deficiency, which is extremely hard to check. Only two solutions can be resorted to: one can either rely on the good faith of the participant's statement, or ask an eye specialist to provide a certificate stating the participant's vision is not impaired[2].

Table 1. Conditions of the experiment

Design

The experiment design included 8 treatments (4 x 2) related to the 8 graphic charts devised for the website dedicated to the experiment. In order to measure the differences in color perception, we created 8 different graphic charts with varied hues, brightness and saturation. The color stimuli were modified in accordance with Munsell's system (Munsell, 1969), which enabled us to precisely define several levels of brightness and saturation for each hue. Besides, this is considered to be the most accurate system (Aumont, 1994). We observed the results related to brightness and saturation, the variations of which depended on the hues carefully selected beforehand.

To implement our first experimental design we employed the graphic chart used by Hill & Scharff (1997) which set the best readability rate in relation to contrast and we chose as chromatic colors a yellow dominant named Magnolia Yellow and a green dynamic named

[2] Asking a participant for such a certificate would assuredly have let him/her guess that our experiment was focused on color, which would have biased the experiment. Following recommendations from eye specialist Professor Lanthony, we decided to have each participant take the Ishihara test in a room separate from the one where the experiment was conducted.

Newsvine Green. Starting from this chart, we reduced the brightness level of the two colors so as to obtain the second experimental design (Table 2). For experimental designs 3 and 4 we kept the same colors but switched dynamic and dominant colors. Experimental designs 5, 6, 7 and 8 are based on black and white (achromatic colors), the ones most frequently used on e-commerce websites, with different brightness and saturation levels, like those chosen for the experimental designs relying on green and yellow hues.

Graphic charts	Plan	**Background (Dominant)**				**Foreground (Dynamic)**				*Plans explanations*
		Name	H	B	S	Name	H	B	S	
Chart 1 – chromatic colors- Green and Yellow	1	Magnolia Yellow	60	100	20	Newsvine Green	120	40	100	(Hill and Scharff, 1997) showed that the sharp contrasts of his chart offered users the fastest reading speed possible.
	2	Magnolia Yellow	60	100	20	Granny Apple Green	90	80	100	Same chart as in the **Plan 1** with increased dynamic color brightness (from 40 to 80).
	3	Newsvine Green	120	40	100	Magnolia Yellow	60	100	20	Same colors as in **Plan 1.** Dynamic and dominant colors were switched.

	4	Newsvine Green	120	40	100	Sunflower Yellow	60	100	60[3]	Same color's chart as in **Plan 3** with a decrease in dynamic color brightness (from 80 to 40).
Chart 2 – Achromatic colors - Black & White	5	White	0	100	0	Black	0	0	0	This chart is the most widely used one on e-commerce websites.
	6	White	0	100	0	Grey	0	60	0	Same color's chart as **Plan 5** with increased dynamic color brightness (from 0 to 60).
	7	Black	0	0	0	White	0	100	0	Same colors as in **Plan 5**. Dynamic and dominant colors have been switched.
	8	Black	0	0	0	Grey	0	60	0	Same chart as in **Plan 7** with a decrease in dynamic color brightness (from 100 to 60).

Table 2. Factorial design of the experiment

[3] The color which should have been used for the text of the experimental plan 4, in order to preserve rates of luminosity and saturation in relation to the background color, could not be preserved. Indeed, this chart cannot be used given the lack of contrast between the two colors (foreground/background) which makes the reading impossible on a more or less old or difficult screen, for an individual presenting deficiencies with color's vision we refer to the directives of the w3c. We thus varied its degree of saturation.

Procedure
Respondents were asked to enter a room where all conditions cited above had been controlled before they started the procedure. The scenario of their entire participation to the experiment is presented in Table 3.

Stages	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Room	Laboratory – Prepared room for the experimentation (screens, light, walls)				Welcome room of school
Action	Presentation of respondents and topic of study	Sign up on the experimental *e-commerce* website	Visit of the experimental *e-commerce* website	Questionnaire	Ishihara's Test (color blind test)

Table 3. Scenario of the participation to the experiment

5. Measures

5.1 Memorization

Memorization was measured by recognition, cued recall and free recall.
To measure recognition, participants were asked to recognize two CD covers, each among two other covers of different albums by the same artist. Recognition scores ranged from 0 to 2, one for each CD cover they could recognize. Measuring recognition was not deemed useful since the participants answered to the questionnaires a few minutes after visiting the e-commerce website and 100% of them recognized both CD covers at least. Thus, we decided not to include recognition further in our analysis.
Cued recall was measured by asking the respondents to recall information about CDs they visited. A question with 3 alternative values (correct, wrong and "I don't know") was posed for each of the seven pieces of information related to a CD. Scores could thus be graded from 0 to 7 for each CD visited. Since participants were required to check out two CD covers, scores for cued recall ranged from 0 to 14.
In order to measure free recall, participants were asked to answer to an open-ended question related to a CD cover they had just seen. The question was "What do you remember from the information associated with this CD cover?". Free recall was measured by counting the number of items that participants could recall from those used in the CD description. Since participants could see two CD covers, each having a 20-element description, free recall value ranged from 0 to 40.
The score of commercial information memorization was the sum of the recognition score, cued recall score and free recall score, ranging from 0 to 56 (Table 4).

	Right answer	Wrong answer	Neutral answer (if applicable)
Recognition	[0 – 2]	0	0
Cued recall	[0 – 14]	0	0
Free recall	[0 – 40]	0	0
Total	[0 – 56]	0	0

Table 4. Synthetic table summing up the measurement of the memorization of commercial information

5.2 Buying intention

Buying intention was measured using a four-item scale developed by Yoo & Donthu (2001). The items were measured on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Already used in a similar context, its internal consistency was good, as presented in Appendix 1.

5.3 Emotions

Mehrabian and Russell (1974) pointed out two sets of methodological issues related to colors and emotions. The first one has to do with the lack of control or specification over the color stimulus, for instance, the lack of control over saturation and brightness when focusing on hues. We endeavored to control this aspect by resorting to Munsell's system (Munsell, 1969) to define the colors selected for our experiment's chart. The second has to do with the lack of liability and validity of the tools used to measure emotional responses to color stimuli.

To measure the emotions of participants visiting an e-commerce website, we will use Mehrabian and Russell's PAD scale (Pleasure Arousal Dominance) (Mehrabian and Russell, 1974).

- Pleasure: pleasure/displeasure, assessing the well being experienced by the individual;
- Arousal (stimulation): arousal/non-arousal, assessing the consumer's level of awareness (of the item) and activation;
- Dominance (domination): dominance/submission, assessing the feeling of freedom pervading the consumer when buying something on a website.

Since the reliability of the PAD scale remained continuously high and satisfactory throughout the experiments conducted by Valdez & Mehrabian (1994), we decided to use this method. Originating in the studies of Osgood et al. (1957) already centered on the "evaluation, activation and potency" triptych, this scale is still the most widely used to measure the consumer's affective states (Derbaix & Poncin, 2005). The scale is presented in Appendix 2.

5.4 Mood

To measure moods we resorted to Mayer & Gaschke's (1988) Brief Mood Introspection Scale (BMIS). It includes 16 items rated on a 5-point Likert scale ranging from definitely do not feel (1) to definitely feel (5). We selected it because it provides a quite exhaustive range of moods and is easy to supervise. It is presented in Appendix 3.

6. Data analysis and results

We followed both the General Linear Model (GLM) to test the impact of the colors of the graphic chart and variance analyses (ANOVA) to test the significance of the links between variables and the validity of the scales. We also examined interaction effects between hue and brightness with a series of regressions on each of the dependent variables.

6.1 Direct effects of the colors of the graphic chart on memorization

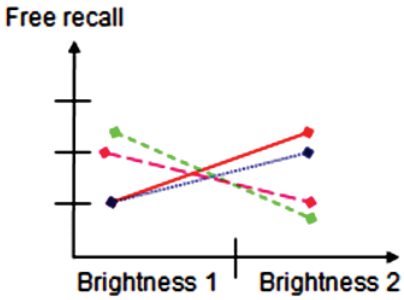
The colors did not show a significant impact on cued recall, according to the GLM analysis. However, an interaction effect on free recall exists ($F = 2.484$; $p \leq 0.061$*) (Table 5).

Effects of graphic chart colors upon cued recall			
	DF	F	p-value
Hue	3	0.404	0.750
Brightness	1	0.771	0.381
Hue x Brightness	3	0.616	0.616
Effects of graphic chart colors upon free recall			
	DF	F	p-value
Hue	3	0.288	0.834
Brightness	1	0.049	0.835
Hue x Brightness	3	2.484	0.061*

Table 5. Effects of graphic chart colors upon cued and free recalls

Participants provided equivalent answers to closed questions about the content of the website, no matter which colors were featured in the graphic chart (cued recall). These questions actually helped participants to memorize information in that they accurately added up the information that could be easily memorized. When no help was provided and participants had to remember what they saw on the website (free recall), colors proved very helpful to them. This is significant in that it shows that color needs to be taken into consideration when conceiving usable graphic charts. Indeed memorization seems helpful to evaluate the e-commerce's website usability.

After studying the ANOVAs carried out, we noted that the effect of brightness on free recall is most significant when hue 2 (green dominant color, yellow dynamic color) was employed. With a low level of brightness (brightness 1) participants remember the content of the website better than with a high level of brightness (brightness 2) (Figure 5).



Hue 1	Newsvine Green (dynamic) / Magnolia Yellow (dominant) & Granny Apple Green (dynamic) / Magnolia Yellow (dominant)
Hue 2	Magnolia Yellow (dynamic) / Newsvine Green (dominant) & Sunflower Yellow (dynamic) / Newsvine Green (dominant)
Hue 3	Black (dynamic) / White (dominant) & Grey (dynamic) / White (dominant)
Hue 4	Black (dynamic) / White (dominant) & Black (dynamic) / Grey (dominant)

Fig. 5. Effects of brightness on free recall

From this result, we understand that a lower contrast between dominant color and dynamic color enhances the memorization of the commercial information given on the website.

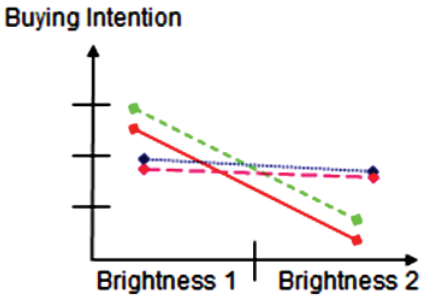
6.2 Direct effects of the colors of the graphic chart on buying intention

The results of the GLM analysis demonstrate that a graphic chart of an Internet website is very influential on buying intention (Table 6). Brightness has a significant positive effect on buying intention ($F = 15.201$, $p \leq 0.000$). In line with our results for memorization, we note that when the dominant and dynamic colors' brightness is not too strong, buying intentions are the highest.

	DF	F	p-value
Hue	3	0.349	0.790
Brightness	**1**	**15.201**	**0.000*** **
Hue x Brightness	**3**	**3.732**	**0.012***

Table 6. Effects of graphic chart colors on buying intention

The GLM analysis shows that hue and brightness have a positive effect on buying intention ($F = 3.732$; $p \leq 0.012$). The results of the ANOVA show that the effect of brightness on buying intention is only significant for hues n°1 (yellow = dominant color, and green = dynamic color) and n°2 (green = dominant color and yellow = dynamic color), with a chromatic color hue, but has no particular effect with a black and white hue chart. When contrast is higher and brightness increases, memorization decreases (Figure 6).



Hue 1	Newsvine Green (dynamic) / Magnolia Yellow (dominant) & Granny Apple Green (dynamic) / Magnolia Yellow (dominant)
Hue 2	Magnolia Yellow (dynamic) / Newsvine Green (dominant) & Sunflower Yellow (dynamic) / Newsvine Green (dominant)
Hue 3	Black (dynamic) / White (dominant) & Grey (dynamic) / White (dominant)
Hue 4	Black (dynamic) / White (dominant) & Black (dynamic) / Grey (dominant)

Fig. 6. Effects of brightness upon buying intention

6.3 Relationship between memorization and buying intention

A simple regression enables us to observe that free recall has a positive effect on buying intentions ($F = 3.824$; $p \leq 0.051$). The more information an individual memorizes about a product, the stronger his or her buying intention will be (Table 7).

	Buying intentions
Memorization	0.113*
Constant	2.096**
$F = 3.824$; $R^2 = 0.013$	

* $p < 0.1$ ** $p < 0.01$

Table 7. Regression between memorization and buying intention

6.4 Mediating effect of emotions

The GLM analysis demonstrates that the colors of the graphic chart affect emotions in a negative way as a low brightness enhances stimulation ($F = 3.167$; $p \leq 0.076$). However, the colors of the graphic chart do not affect pleasure or domination in any way (Table 8).

Effects of graphic chart colors on pleasure			
	DF	F	p-value
Hue	3	1.606	0.188
Brightness	1	0.330	0.566
Hue x Brightness	3	0.567	0.637
Effects of graphic chart colors on stimulation			
Hue	3	1.243	0.294
Brightness	**1**	**3.167**	**0.076***
Hue x Brightness	3	0.154	0.927
Effects of graphic chart colors on domination			
Hue	3	0.105	0.957
Brightness	1	0.705	0.402
Hue x Brightness	3	0.338	0.798

Table 8. Effects of graphic chart colors on emotions

Since stimulation was the only emotion dimension affected by the graphic chart colors, the effect of emotion on memorization and buying intention was tested by examining the effect of stimulation on these variables. Two simple regressions showed that stimulation does not affect memorization in a significant way (free recall) but does have a significant effect on buying intention ($b=0.143$; $p \leq 0.01$) , as shown in Table 9.

	Buying intention
Stimulation	**0.143****
Constant	0.001
$F = 5.526$; $R^2 = 0.013$	
* $p < 0.1$ ** $p < 0.01$	

Table 9. Regression between stimulation and buying intention

6.5 Mediating effect of mood

GLM analyses show that hue and brightness have a significant interaction effect on negative mood ($F = 3.042$; $p \leq 0.029$) (Table 10).

Effects of graphic chart colors on positive mood factor			
	DF	F	p-value
Hue	3	0.374	0.772
Brightness	1	0.041	0.840
Hue x Brightness	3	0.916	0.434

Effects of graphic chart colors on negative mood factor			
	DF	F	p-value
Hue	3	1.159	0.326
Brightness	1	0.334	0.564
Hue x Brightness	**3**	**3.042**	**0.029***

Table 10. Effects of graphic chart colors on mood

ANOVAs show that graphic charts based on hues n°1 (dynamic = Newsvine Green / dominant = Magnolia yellow and dynamic = Granny Apple Green / dominant = Magnolia yellow) and n°4 (dominant = black and dynamic = white) offer an interaction effect between hue and brightness. When hue n°1 (Newsvine Green/Magnolia yellow and Granny Apple Green/Magnolia yellow) is used, an increase of the brightness level entails a significant increase of negative mood ($F = 3.066$; $p \leq 0.084$), while with hue n°4 (White/Black - Grey/Black), an increase of the brightness level contributes to toning down negative mood ($F = 3.815$; $p \leq 0.055$). Two simple regressions give evidence that negative mood has a significant and negative impact on buying intention ($b = -0.129$; $p \leq 0.01$), but does not have any effect on memorization (free recall) (Table 11).

	Buying intention
Negative mood	**-0.129****
Constant	- 8.215E-17
$F = 4.901$; $R^2 = 0.017$	
* $p < 0.1$ ** $p < 0.01$	

Table 11. Regression between negative mood and buying intention

7. Discussion and Implications

Our research enabled us to bring to the fore the effects of the colors used on e-commerce websites on consumer memorization and buying intention. Two mediating variables – stimulation and negative mood – helped us to explain how they reinforce these effects.

Chromatic colors are more likely to enhance the memorization of the displayed information than black and white (achromatic colors) are. These results must be related to the studies conducted by Silverstein (1987) who noticed that monochrome screens entailed more eyestrain and overall tiredness. Therefore, e-merchants should be aware of this and choose carefully the hues of the dynamic and dominant colors that they will use on their site so as to adjust them to their target. They should also take into account the aesthetic and functional impact of those colors: their contrast makes it easier to find the information on a webpage. Moreover, low brightness fosters better memorization scores and stronger buying intention. We also noticed that consumers recalled more easily information that they had trouble to read on an e-commerce website. However, let us note that they did not necessarily feel like buying a product from this type of website afterwards.

The possibility offered in certain e-commerce websites to see quality representations of the products contributes to the consumer feeling in a favorable state to buy. A representation of quality relies on an image being able to be magnified so that the product appears larger. This is the case with the material of music's websites or data processing websites, like the Apple one for example. An image makes it possible for the consumer to see the product in another color, another pattern or another texture like on clothes and cars websites such as Smart, for example.

As Camgöz et al. (2002), Gorn, et al. (2004) and Valdez (1993) had shown about the brightness component of color, it seems more interesting to compare hue and brightness than to compare warm and cold colors when trying to examine what consumers recall and what leads them in purchasing. Indeed, in everyday life there is no support helping consumers to recall the content of an e-commerce website they visited or to compare it with another offer.

The web designer of a commercial website is thus faced with the difficulty of conceiving and juxtaposing on the same surface: visuality (Nel, 2001) - an object equipped with practical functionalities - and visibility - i.e. readable contents, with the aim to make him progress quickly to the webpage. To enable consumers to acquire the tools which will help them during a later visit move more easily in order to make their shopping experience even simpler, more pleasant and quicker could thus constitute one of the major stakes of actors wishing to develop their sales volume online.

It is important to maintain a graphic chart which helps the visitor to learn in an incremental way the organization of the information. For a longer duration of time spent in an e-commerce website, it is also important to surf easily from one page to another (Ladwein, 2001). Moreover, the ease of seeking information or comparing prices or products is more satisfying for the individuals in their purchases on the Internet and helps them to better memorize the commercial website structure (Lynch and Ariely, 2000). By enabling memorization of the e-commerce website structure, website designers are able to evoke the mental image that the consumers can have about the website. This may be presented as a set of pages with particular characteristics related to ergonomics, navigation, a general structure, a graphic composition describing products, including photographs and textual descriptions. The graphic composition of the website can thus affect the representation that

the consumer retains when shopping. It thus exploits the perception of the interface and the memorizing of the whole website and commercial information that are available on its pages.
In addition, if the new appearance does not please the consumer, the questioning of a group that the consumer memorizes with each visit to a website can involve a specific or total disaffection of the website as a whole. It is perhaps this type of reason, which encourages electronic merchants to offer consumers the possibility of modifying the appearance of the pages of the website. This possibility of modifying the colors when there is much reading can thus seem an obvious competitive advantage for the commercial website.

7.1 Limitations

The experiment carried out revealed some limitations such as the difficulty of retaining a large number of participants in an experiment without any exchange: motivation is difficult to find in these kinds of cases, whereas an incentive would make it possible to arouse people interest with regard to participation. Moreover, the conditions of experimentation require the installation of particular light sources, screens calibrated thanks to a probe and tests of the vision like the test of Ishihara, which implies expenditure. It then appears indispensable to put into practice the conditions under which we conducted our experiment – conditions complying with the criteria used to evaluate the color quality of digital interfaces – which enable one to benefit from an accurate and easy to implement tool (Fernandez-Maloigne, 2004; Munsell, 1969). The design and the realization of the experiment site require professional skills in terms of programming to guarantee the reliability of the system and its longevity.

7.2 For future experiments

For future experiments related to the measurement of consumer memorization or buying intention in an e-commerce website, one should undoubtedly take into consideration brightness and saturation rates. When focusing on textures, matt and glossy aspects, "an essential parameter of Japanese sensitivity that is all too often overlooked by Western standards" (Pastoureau, 1999), researchers can obtain more accurate outcomes in their studies dealing with screen colors in a business-driven context. Coupled with the use of sound in e-commerce websites, these analyses would enable us to reach a better understanding of the effects of the atmosphere pervading an e-commerce website on consumers, especially according to a holistic rather than an atomized approach to the phenomenon. The three-dimensional textures used on billboards or virtual worlds such as Second Life question the merely three-dimensional aspect of color as measured under those conditions.
For the reasons mentioned above, such a project would benefit from the provision of features guaranteeing reliability and longevity, such as the use of tools found in numerous e-commerce websites enabling accessibility for people with disabilities, in the same way that the traditional stores are encouraged to allow the visit of their products and services by disabled people. Products and services are thus visible and accessible by most users, with respect to principles of accessibility. This seems very important for the Web Accessibility

Initiative (WAI - department of the W3C specializing in accessibility) that explained what happened in case of color blindness troubles[4]:

Online shopper with color blindness

Mr. Lee wants to buy some new clothes, appliances, and music. As he frequently does, he is spending an evening shopping online. He has one of the most common visual disabilities for men: color blindness, which in his case means an inability to distinguish between green and red.

He has difficulty reading the text on many Web sites. When he first starting using the Web, it seemed to him that the text and images on many sites used poor color contrast, since they appeared to use similar shades of brown. He realized that many sites were using colors that were indistinguishable to him because of his red/green color blindness. In some cases the site instructions explained that discounted prices were indicated by red text, but all of the text looked brown to him. In other cases, the required fields on forms were indicated by red text, but again he could not tell which fields had red text.

Mr. Lee found that he preferred sites that used sufficient color contrast, and redundant information for color. The sites did this by including names of the colors of clothes as well as by showing a sample of the color and by placing an asterisk (*) in front of the required fields in addition to indicating them by color.

After additional experimentation, Mr. Lee discovered that in most new sites the colors were controlled by style sheets and that he could turn these style sheets off with his browser or override them with his own style sheets. But in sites that did not use style sheets he couldn't override the colors.

Eventually Mr. Lee bookmarked a series of online shopping sites where he could get reliable information on product colors, and did not have to guess which items were discounted.

Our knowledge about people with this disability is now sufficient so that web designers take them into account before designing the website. Among these principles, let us not forget the regulation related to public service sites which forces them to respect a minimum level of accessibility. Within a framework of sustainable development, the e-commerce websites sensitive to the problem of disabled people show a willingness to address their needs and as such serve as examples for other sites. To arrive at this level of accessibility, making it possible for most people to discover the contents of a web page, a certain number of principles of construction must be taken into account.

Accessibility is not solely intended to help the partially-sighted persons. Deaf people as well as physically handicapped persons must also be able to reach and use the web. Among the various criteria of accessibility set up by W3C consortium and WAI, we propose to retain:

- a simple HTML code,
- the use of cascade style sheets (CSS) functioning on HTML pages,
- a separation between content and form,
- the use of alternatives for content elements, such as graphic, audio and video

It can be seen that accessibility is not only related to ergonomics, the usability or the "playability" and that it does not prevent the creators from being creative. It is a question above all of indicating to the consumer the solutions which give access to information and services on the site. In addition to serving a greater number, accessibility, which is based on the use of a well structured HTML code which separates the contents (commercial information) from the form (the style sheet), allows a site to be easier to develop and

[4] http://www.w3.org/WAI/EO/Drafts/PWD-Use-Web/#shopper

maintain, load more rapidly and be better referenced by search engines than a conventional one. These characteristics, related to the loading time of webpages and the referencing of websites, constitute imperative reasons to take accessibility into account in a systematic manner in the design phase.

8. Appendices

A1: Buying intention scale (from Yoo & Donthu, 2001)

- I will certainly buy products coming from this website in a near future.
- I intend to buy on this website in a near future.
- It is likely that I buy on this website in a near future.
- I plan to buy on this website in a near future.

1 - Definitely agree	2 - Slightly agree	3 - Neither agree nor disagree	4- Slightly agree	5 - Definitely agree

A2: Pleasure, Arousal, Dominance (PAD) - Mehrabian & Russell (1974)

These PAD (pleasure, arousal, and dominance) scales include:

* A 4-item State Pleasure-Displeasure Scale
* A 4-item State Arousal-Nonarousal Scale
* A 4-item State Dominance-Submissiveness Scale

1 - Definitely agree	2 - Slightly agree	3 - Neither agree nor disagree	4- Slightly agree	5 - Definitely agree

A3: Brief Mood Introspection Scale (BMIS)- Mayer J. D. & Gaschke Y. N. (1988)

Grouchy, Tired (in general), Gloomy, Happy, Loving, Calm, Active, Jittery, Fed up, Drowsy, Sad, Lively, Caring, Content, Peppy

1 - Definitely do not feel	2 - Slightly do not feel	3 - Neither do not feel nor feel	4- Slightly feel	5 - Definitely feel

A4: Devices and installation required to conduct the experiment properly

Experiment Room (Fernandez-Maloigne, 2004)

Measurements were taken at different intervals thanks to a luxmeter:

- Keep a distance of about one meter between the back of the room and the screen,
- A relationship between idle screen luminance and peak luminance (luminance is the Y coordinate of the XYZ model),
- Peak luminance of the screen,
- Room lighting (ambient illumination),
- Background chromaticity related to the D65 illuminant,
- Maximum observation angle (CRT5 screen) of 30°,
- High-quality assessment monitor, size 50-60 cm (22" - 26").

Participants (Lanthony, 2005)

[5] CRT screens or old generation screens

- An Ishihara test for determining color blindness was conducted in another room than the experiment's one room so as to check that participants were not color-blind and thus in a position to provide valid answers.

Screens

All the screens used during the experiment were calibrated
- The screens must warm up for an hour before calibration;
- Hue, Brightness, Saturation as well as the R, G, B channels for each screen used must be possible to modulate;
- A CRT display must be used rather than a plasma screen;
- The target to be taken into account by the probe must be a 2.2 - 6500 Kelvin (Gamma, color temperature);
- Ambient light compensation must be disabled;
- The BLACK point must have a light level of 0.8° while that of the WHITE must reach 90°. If the weakest screen is no higher than 80°, you must calibrate all the screens to this level°. This might very likely be the case with old screens;
- The luminance of the WHITE for the contrast must be set so that four more or less WHITE squares are visible to the naked eye;
- The luminance of the BLACK, for brightness, must be set so that four more or less BLACK squares are visible to the naked eye,
- Identification of color controls: press the radio button on "RGB slider",
- Place the probe which will then provide the test patterns on the screen using the suction pads enabling it to stay stuck;
- The measurements mentioned above can be taken again two weeks afterwards, but normally they should not be altered if no one changed the screen settings;
- The probe allows to generate the ICC profile ;
- Save the ICC profile which will be set automatically afterwards.

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9

A Framework for Quality Assurance of Electronic Commerce Websites

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1. Introduction

In the last decade, electronic commerce has significantly contributed to national economic growth. This is evident in that "according to Forrester Research, the United States (US) online retail reached $175 billion in 2007 and is projected to grow to $335 billion by 2012". (Source: http://www.sescommerce.com/ecommerce-growth.asp; accessed 9 May 2009) And yet, although the electronic commerce market value is growing fast, there are many electronic commerce Websites that are failing and disappearing from the market (Pather et al., 2003). The success of online business will for the large part depend on the quality of electronic commerce Websites. In keeping up with the expectations of online consumers, electronic commerce retailers will continue to face to the challenges of ensuring the quality of electronic commerce Websites. Although there have been intense discussions about quality in the literature, quality dimensions of electronic commerce are not well established and recent studies indicate that more research is needed (Mohanty et al. 2007). Lohse and Spiller (1998) stated that "the nature of electronic commerce is diverse". Due to this nature, the quality of electronic commerce Websites can be viewed from several perspectives i.e. product quality, systems as product, service quality of provider, software product quality, system design, quality of the human-computer interaction (HCI) etc. (Balfagih et al, 2008). Further in analyzing the complexity of electronic commerce quality, one can apply various bodies of knowledge i.e. information systems, marketing, human-computer interaction and design (Balfagih et al, 2008). Hence, the evaluation of quality of electronic commerce Websites depends on the perspective and role of the assessor. The assessor may be an online shopper, repeat purchaser, potential consumer, electronic commerce business owner, service provider to the business owner, Web developer etc.

This chapter proposes a framework that synthesizes previous multiple perspectives. Its aim is to aid research and practice in assuring quality of electronic commerce Websites. In this section, we have presented an overview the research background. In the following section, we discuss our review of literature on models for quality of electronic commerce Websites. Subsequently, we discuss the critiques of the literature and present the gaps that emerge out of our analysis of the literature. The gaps will be the basis for our recommendation on a framework to aid research and practice in assuring quality of electronic commerce Websites. Following that, we present the concept of software quality and software quality assurance.

Consequently, we conclude with a recommendation and the significance of proposed framework as well as future directions for research and practice.

2. E-commerce quality models

Much discussion in the literature has taken the view of online consumers when evaluating the quality of electronic commerce Websites (Balfagih et al, 2008). In this regard, the online consumers may evaluate the quality of the product purchased, service quality of provider, electronic commerce systems as product quality and quality of the Human-Computer Interaction (HCI) design. The concern of this section, however, is on the electronic commerce systems as product quality and quality of the Human-Computer Interaction (HCI) design that make up quality of electronic commerce Websites.

In design, the term *usability* is commonly used. Usability concerns with ease of use and ease of learning. Bad usability could turn-off users or customers. It has been cited that the interface design is crucial because the user will experience usability first before deciding to conduct a transaction such as buying the product (Nielsen, 1999; Nielsen, 1993). Usability is also a critical factor for a user to re-visit or to recommend an electronic commerce Website to another customer; which is critical to the overall performance of electronic commerce. Usability may also influence users in their decision to buy the product. Several elements are important for consideration in the design process of electronic commerce Websites: selection of design features, visualization of content, navigation and control, accessibility and attractiveness. Besides, attractiveness has been cited as critical in ensuring users are attracted to a particular Website and continue to transact at the Web site (Sutcliffe, 2001; Sutcliffe, 2002).

Recognizing the importance of electronic commerce systems as product quality and quality of design, several researchers grouped critical elements that make up quality of electronic commerce design into a framework or a model. In the ensuing discussion, we will discuss Rayport and Jaworski 7Cs Framework, DeLone and McLean Electronic Commerce Model, The ISO 9126 Quality Model, WebQual 4.0 Model, Palmer's Model and Stefani and Xenos Quality Model.

2.1 Rayport and Jaworski 7Cs Framework

Rayport and Jaworski (2001, pp. 115-117) developed the 7Cs framework in defining the quality of electronic commerce Website design from the online consumers' perspective.

- *Context* – The context of an electronic commerce Website defines its aesthetic and functional look-and-feel which encompasses interesting graphics, colors, design features, goals and ease of navigation.
- *Content* – The content in an electronic commerce Website defines all digital subject matter including text, video, audio and graphics to convey the message of the site.
- *Community* – This aspect refers to the communication that occurs between two users such as through e-mails or chat. This element, however, does not cover a user's experience when interacting with the Website.
- *Customization* – Customization refers to the electronic commerce Website's ability to tailor itself or to be tailored by each user such that a user is provided with a

function or functions that enables him to enter personal details or customize the look of a banner.

- *Communication* – Communication is defined as the dialogue that occurs between the site and its users through e-mail notification, customer service request or customer messaging.
- *Connection* – This aspect defines the extent of formal linkages between the electronic commerce Website and other sites.
- *Commerce* – This covers the functions that the online consumer may use such as "shopping basket", check-out process etc.

2.2 DeLone and McLean Electronic Commerce Model

The DeLone and McLean Electronic Commerce Model was an updated and extended model of information systems success (DeLone and McLean, 2003). The authors argued that there were six major dimensions of electronic commerce model: system quality, information quality, service quality, use, user satisfaction, and net benefit.

- *System quality* – this aspect refers to the desired characteristics of an electronic commerce system. Usability, availability, reliability, adaptability and response time (e.g., download time) are examples of qualities that are valued by users of an electronic commerce system.
- *Information quality* – this captures the e-commerce content issue.
- *Service quality* – measures the overall support delivered by the service provider.
- *Usage* – measures everything from a visit to a Website, to navigation within the site, to information retrieval and to execution of a transaction.
- *User satisfaction* – this is the affective attitude towards the electronic commerce Website which can be measured by re-purchasing or re-visiting.
- *Net benefits* – this captures the balance of positive and negative impacts of the electronic commerce on customers, suppliers, employees, organizations, markets, industries, economies and even our societies.

Figure 1 shows the DeLone and McLean Electronic Commerce Model.

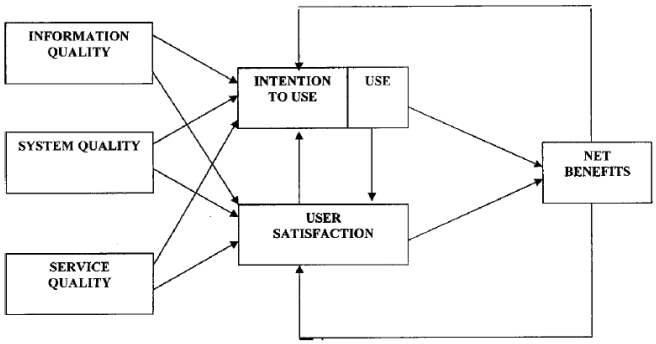

Fig. 1. DeLone and McLean Electronic Commerce Model

For each of the dimensions, DeLone and McLean (2003) suggested measures for operationalization (see Table 1).

Dimensions	Measures
Systems quality	Adaptability, availability, reliability, response time, usability
Information quality	Completeness, ease of understanding, personalization, relevance, security, service quality, assurance, empathy, responsiveness
Use	Nature of use, navigation patterns, number of site visits, number of transactions executed
User satisfaction	Repeat purchases, repeat visits, user surveys
Net benefits	Cost savings, expanded markets, incremental additional sales, reduced search costs, time savings

Table 1. DeLone and McLean Electronic Commerce Model Metrics

2.3 The ISO 9126 Quality Model

The ISO/IEC 9126:2001 (ISO/IEC, 2001a) is the latest revision to the international software product quality standard (Figure 2). The ISO 9126 defines quality as a set of six features and/or characteristics of a product or service that bear on its ability to satisfy stated or implied needs: functionality, reliability, usability, efficiency, maintainability and portability (ISO 9126, 2001).

- *Functionality* – refers to the essential purpose of the software functions.
- *Reliability* – reliability is defined as the capability of the system to maintain its service provision under defined conditions for defined periods of time.
- *Usability* – this is the set of attributes that bear on the effort needed for use, and on the individual evaluation of such use, by a stated or implied set of users. Usability comprises four quality sub-characteristic: attractiveness, learnability, understandability and operability.
- *Efficiency* – this defines the capability of the system to provide appropriate performance, relative to the amount of resources used and under stated conditions. Efficiency entails both conceptual and implementation difficulties.
- *Reliability* – the quality characteristics that refer to a set of attributes that bear on the capability of software to maintain its level of performance under stated conditions for a stated period of time.
- *Maintainability and portability* – also referred to as the internal factors of the ISO 9126 model that measure the quality of the backend of the system.

It has been suggested that adopting and adapting ISO 9126 for specific domains is not new and not foreign to the standard itself (Cody and Kishore, 2006). The ISO 9126 can be used as the basis for electronic commerce quality evaluation but further analysis and mapping of its characteristics and sub-characteristics to system functions/services is required (Stefani, 2008). Past researches have shown that different models that follow the ISO 9126 software standard quality model were used to assess the quality of electronic commerce Websites (ISO 9126, 2001) and (Olsina et al, 2000).

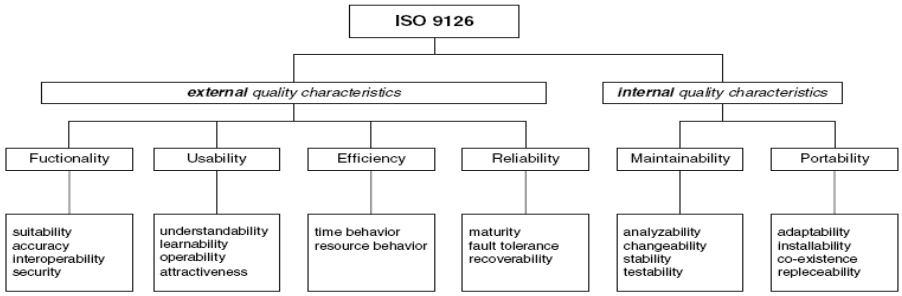

Fig. 2. ISO 9126 Quality Model

2.4 SERVQUAL Model

One dominant theoretical model that has emerged from the information systems and marketing literature and that perhaps can be used to assess the quality of electronic commerce Websites is the Service Quality (SERVQUAL) model (Parasuraman et al., 1988). The SERVQUAL model is an instrument that comprises 22 statements which measure the performance across five dimensions. For each statement, the expectation and the experience of a customer are determined.

- *Reliability* – refers to the ability to perform the promised service dependably and accurately.
- *Assurance* – includes competence, courtesy, credibility and security.
- *Responsiveness* – means the willingness to help customers and provide prompt service.
- *Tangibles* – includes physical facilities, equipment and appearance of personnel.
- *Empathy* – refers to access, communication, understanding the customer; in short the demonstration of care and individualized attention that a firm provides its customers.

Since 1988, many research efforts utilizing the SERVQUAL framework have proliferated the literature (Iwaarden and Wiele, 2003) and (Sinnapan & Carlson, 2004). All five SERVQUAL dimensions i.e. reliability, responsiveness, assurance, empathy, and tangibles have been cited as relevant and important in Web-based environment (Cao et al, 2005).

It has been cited, however, that the SERVQUAL model has posed different problems as a measure for quality (Myerscough, 2008). The problems have been classified into conceptual and empirical (Myerscough, 2008). Conceptual problems refer to the definition of service quality as a difference or gap score between a customer's perceptions and expectations, the ambiguity of the expectation constructs, and the generality of SERVQUAL as a single measure of service quality across different industries and settings (Myerscough, 2008). Empirical problems can encompass issues like overestimated reliability, poor convergent validity, poor predictive validity, and unstable dimensionality caused by different or gap scores of each dimension in the SERVQUAL model (Park and Baek, 2007).

2.5 WebQual 4.0

WebQual 4.0 draws on research from three core areas: information quality, interaction and service quality, and usability (Barnes and Vidgen, 2003). WebQual is based on quality

function deployment (QFD). The application of QFD starts with capturing the voice of "customers" using words that are meaningful to the customers. These qualities are then fed back to the customers and form the basis of an evaluation of the quality of product or a service (Barnes and Vidgen, 2003).
In WebQual, users are asked to rate target sites against each of a range of qualities using a seven-point scale. Thereafter, users will be asked to rate each of the qualities for the importance that are considered by the user to be most important in any given situation (Barnes and Vidgen, 2003). The standard WebQual 4.0 instrument contains 23 questions (see Table 2).

Category	Questions
Usability:	1- I find the site easy to learn to operate 2- My interaction with the site is clear and understandable 3- I find the site easy to navigate 4- I find the site easy to use 5- The site has an attractive appearance 6- The design is appropriate to the type of site 7- The site conveys a sense of competency 8- The site creates a positive experience for me
Information Quality:	9- Provides accurate information 10- Provides believable information 11- Provides timely information 12- Provides relevant information 13- Provides easy to understand information 14- Provides information at the right level of detail 15- presents information in appropriate format
Service Interaction:	16- has a good reputation 17- It feels safe to complete transactions 18- My personal information feels secure. 19- Creates a sense of personalization 20- Conveys a sense of community 21- Makes it easy to communicate with the organization 22- I feel confident that goods/services will be delivered as promised 23-Overall view of the Web site

Table 2. WebQual 4.0 instruments

2.6 The Palmer's Model

The Palmer's quality model is based on the close association between usability and Website design quality (see Table 3). Design quality covers easy-to-use navigation, frequent updating, minimal download times, relevance to users, high quality contents, response time and credibility (Palmer, 2002). It has been suggested that high levels of media richness is reflected in its results, with interactivity and responsiveness constructs related to Website success.

Constructs	Measures
Content Quality	Amount of information, Variety of information
Navigation	Arrangement, sequence, Links, Layout
Download Delay	Initial Access Speed, Speed of Display Between Pages
Responsiveness	Feedback, FAQ
Interactivity	Customization Interactivity

Table 3. Palmer's Metrics

2.7 The Stefani and Xenos QualityModel

User-centred design has continuously been the focal attention for quality of electronic commerce Websites (Stefani and Xenos, 2001; Stefani, 2008). The Stefani and Xenos Quality Model provides another such evidence (see Table 4).

The model is built upon three levels and four factors. The levels were defined as high, middle and low. The high level comprises basic characteristics of electronic commerce systems such as the search engine service, ease of navigation, security and reliable transaction etc. The middle level includes services such as site map services, multilingualism, and attractive interface. The low level includes additional services and facilities aimed at improvements of user perceived usability and efficiency such as cross selling, variety of colors and graphics, etc. The four factors have been defined as functionality, reliability, usability and efficiency. Functionality covers suitability, accuracy, interoperability and security. Reliability has sub-characteristics like maturity, fault tolerance and recoverability. Usability refers to understandability, learnability and operability. Efficiency encompasses time-behavior and resource behavior.

Characteristics of electronic commerce systems	Related quality factors
Easy access to the web pages of the e-commerce system	Functionality Usability Efficiency
Easy navigation	Functionality Usability
Adaptation to user profile	Functionality Usability Efficiency
Search engine service	Functionality Usability Reliability
Easy exit − undo functions	Functionality

Useful help service	Functionality Usability Efficiency
Electronic shopping cart	Functionality Usability
Electronic shopping list	Functionality Usability
Secure and reliable transactions	Functionality Reliability
Secure protocols SET, SSL	Reliability
Correct and accurate information about the products	Reliability
Direct delivery of the products	Usability Efficiency
Indisputable financial transactions	Reliability
Recoverability of products and services	Usability Functionality
Legitimate Website	Reliability

Table 4. Stefani and Xenos Quality Model

3. Critiques of the Literature

In the previous section, we have discussed various electronic commerce quality models such as Rayport and Jaworski 7Cs Framework, DeLone and McLean Electronic Commerce Model, The ISO 9126 Quality Model, WebQual 4.0 Model, Palmer's Model, and Stefani and Xenos Quality Model. These models were drawn from the fields of information systems, marketing, human-computer interaction and design. The researchers' focus has been on online consumers' perspective.

As evident, the literature discussed has not covered the integration between the developer's perspective and the online consumer's perspective. In ensuring all possible alternatives are taken care of during implementation of an electronic commerce system, there is a need for such integration.

Quality design of electronic commerce system does not happen by chance. Rather, it needs to be planned. The planning takes place during the software development process of the electronic commerce project between the developer and the users including potential online consumers. As an electronic commerce Website could be regarded as a piece of software, software quality and software quality assurance practices could be a reference point in ensuring the quality of electronic commerce Website. Hence, researchers and practitioners in electronic commerce would benefit from the synthesis of knowledge in software quality and software quality assurance.

4. Software Quality and Software Quality Assurance

Software quality is one important factor that could determine the success or failure of the software. Software quality calls for critical attention that covers the functionality of the software to be built, cost of developing the software, schedule it takes to build the software and cost evaluation on building, implementing and maintaining it. Essentially, ensuring quality during software development process reduces the overall cost by reducing the defect correction costs which can be inherently complex especially in the late stages of the development process. The cost of low quality can amount to more than 50% of total costs of software development (Tian, 2005). Correcting defects in early stages imposes less cost than correcting them in later stages. Preventing defects from the beginning by applying appropriate quality assurance system is even more cost effective that just correcting them when they occur. In the electronic commerce context, ensuring the quality of electronic commerce Websites could help business owners to gain customers' loyalty and attract more customers. It has been stated that the quality of electronic commerce Websites plays a crucial role in customers' re-purchase intention (Zamzuri et al., 2008). Hence, in achieving repeated "winning" in the electronic commerce market, it may be worthwhile to ensure software quality of the electronic commerce systems.

Pressman and Ince (2000) defined software quality as "conformance to explicitly stated functional and performance requirements, explicitly documented development standard and implicit characteristics that are expected from the professionally developed software." Software quality concerns are on three main factors. The first factor is the functionality and performance requirements which are usually identified during planning and analysis phase of the software life cycle. The second factor is the conformance of the software to the industry or field standards. The third factor is the professionalism in developing the software by implementing good practices of software development even if it is not specified in the requirements or standards. The definition implies that software quality does not necessarily entail error-free application while it satisfies users' requirements and expectations. On the other hand, Godbole (2005) referred to software quality as meeting users' requirements in time and within budget. It has also been highlighted that user satisfaction is important in software quality (Chen, 2005).

The Institute of Electrical and Electronics Engineers (acronym: IEEE) recommends conformance to Software Quality Assurance (SQA) framework when developing a software. It defines SQA as "a planned and systematic pattern of all actions necessary to provide adequate confidence that an item or product conforms to established technical requirements. It includes a set of actions designed to evaluate the process by which the product is developed or manufactured" (IEEE, 1990). This definition indicates the different phases of quality assurance (QA) practices during a software development life cycle. However, it has been cited that the definition lacks non-technical requirements from SQA process that includes information quality, budget and time (Galin, 2003).

There are several definitions of software quality and software quality assurance in the literature. However, most of them consider testing with developing and implementing SQA plans for the software projects (Dromey, 1995; Giance, 1998). This task includes all the activities needed to ensure software quality from the beginning to the end of the project life cycle. This includes both technical and non technical activities. SWEBOK (2004) defined software quality assurance as processes that provide assurance to the software products and processes in project life cycle so that they conform to the specified requirements by

planning, enacting and performing a set of activities that provide adequate confidence that quality is being built into the software. This definition suggests that the first part of software quality assurance is the development of SQA plan. Software quality assurance plan defines the means that will be used to ensure that the software developed for a specific product satisfies the users' requirements and is of the highest quality possible within project constraints. The major tasks included in the SQA plan are:

- Identifying quality assurance project objectives.
- Developing quality factors, quality criteria and quality metrics.
- Identifying list of the standards, practices, and conventions.
- Developing guidelines for every step of the quality assurance processes.
- Specifying the responsibilities of SQA group with the schedule of the different quality assurance activities.
- Developing reviews (design reviews and peer reviews), walkthroughs and checklists.

Another main part of the SQA is the implementation of the SQA plan. The main tasks included in this part are:

- Conducting reviews includes management reviews, design reviews, peer reviews, walkthroughs and checklists. These reviews provide early detection for analysis and design defects in the early stages before it becomes inherent in the software and more complex to be corrected in late stages.
- Conducting testing and evaluation. The IEEE (1990) defines testing as "(1) The process of operating a system or component under specified conditions, observing or recording the results and making an evaluation of some aspect of system or component. (2) The process of analyzing a software item to detect the differences between existing and required conditions (that is, bugs) and to evaluate the features of the software item." We will discuss the different types of software testing in the electronic commerce quality assurance framework section.
- Conducting verification and validation. Verification is the process that determines whether the product fulfills the project requirements or not while validation is the process of evaluating the software to ensure the compliance with software requirements.
- Conducting maintenance and monitoring for the software after production.

Laudon and Traver (2007) built upon the systems development life cycle to define the electronic commerce Website development process. They defined five phases in the process: systems analysis/planning, systems design, building the system, testing and implementation service delivery.

- *Systems analysis/planning* – refers to defining business objectives of the electronic commerce, system functionality and information requirements.
- *Systems design* – this phase describes the main components of the system and their relationships to one another.
- *Building the system* – this phase calls for the decisions on development of the system and implementation. Outsourcing or development in-house could be the options.
- *Testing* – Regardless the decision made on building the system, testing is required. Laudon and Traver (2007) defined three levels of required testing i.e. unit test that involves program modules, system test that covers testing the site as a whole and acceptance test that involves users of the system.

- *Implementation and maintenance* – this phase covers the monitoring, adapting the site for change, improvement and correction.

Bidgoli (2002) suggested that the electronic commerce life cycle comprises problem definition and requirement analysis, feasibility study, formation of the task force, analysis, design, simulation prototyping, implementation, post-implementation audit and monitoring, site marketing and management.

4.1 Software engineering practice in electronic commerce development

Acknowledging the contributions of (Bidology, 2002) and (Laudon and Traver, 2007), we will apply the phases in software engineering practice recommended in sommervelli (2007) to ease the discussion on quality assurance process for electronic commerce Websites. The phases are planning, designing, implementation, testing and post-implementation. Each of the phases covers a discussion on the different quality assurance activities required for successful delivery of the electronic commerce Website.

4.2 The planning phase

Planning serves as a guide on how quality is to be built in and how it is to be evaluated. Quality cannot be added at the end of an electronic commerce project. Quality must be included from the early steps of a project and continuously evaluated to ensure that it is satisfactory. This is also the reason that a quality plan should be produced very early in the life of an electronic commerce project. Quality assurance plan helps to schedule quality assurance activities and define the factors that will lead to the successful completion of an electronic commerce project. A quality assurance plan is a document that contains all quality assurance activities throughout the project lifecycle including processes, procedures, standards, reviews and audits, checklists, tests, quality factors and quality metrics. The quality assurance activities in the planning phase consist of the following steps:

General information

In this step, we identify the purpose and scope of the quality assurance plan. In addition, this step provides a general system overview which includes responsible organization, system title, system environment etc. Also, the plan must identify the functional requirements and evaluation criteria of the electronic commerce project. The project goals might include marketing campaign, supporting sales activities, providing new channels of communication with the customers etc. Tasks and responsibilities are also identified in this step where the project leader, electronic commerce application development groups and the quality assurance sub-committee and their responsibilities are assigned.

Standards, practices and conventions

This section of the electronic commerce quality assurance plan identifies the standards, practices and conventions to be applied. It states how compliance with these items is to be monitored and assured. It specifies documentation standards, security standards, coding standards, payment standards etc.

Specification of requirements

In this step, we describe the entire requirements for the electronic commerce system behavior. It includes a set of use cases to represent the functional requirements of the system and specifications for the non-functional requirements. These requirements must be clear,

complete and measurable. Considerations of non-functional requirements include among others usability, reliability, trust, interface satisfaction and information quality.

- *Usability* – Many prior works concerning electronic commerce systems consider usability as an important factor in electronic commerce quality (Stefani and Xenos, 2001; Palmer, 2002). Usability is achieved when all functions of an electronic commerce system are developed in a way that seeks to help the end-users by simplifying their actions (Stefani, 2008). High usability means an electronic commerce system is easy to learn and remember, efficient, visually pleasing and fun to use, and quick to recover from errors (Shaikh et al, 2001). However, electronic commerce Website usability is not easily achievable because there is no unified view on how to build a usable Website despite the number of frameworks and guidelines already advocated by industry experts and consultants (Kuan et al., 2005).
- *Understandability* – Feedback and Help features as well as interface and aesthetic features mark the characteristics of promoting ease in understandability of electronic commerce Website.
- *Reliability* – Reliability could be assessed on the basis of the electronic commerce system. In this sense, reliability encompasses security of electronic financial transactions (Stefani and Xenos, 2001). Besides, reliability in the ISO 9126 document specifies maturity, fault tolerance and recoverability. Shaikh et al. (2001) defined reliability as the ability of a system to consistently produce the same result and be able to meet or exceed the set specifications.
  Reliability may also be assessed from the users' perspective of the electronic commerce services' provider. Based on SERVQUAL, reliability defines the ability of personnel rendering electronic commerce services to perform promised services dependably and accurately.
- *Trust* – The risks and their associated levels inherent in electronic commerce makes trust a critical consideration in quality assurance of electronic commerce Websites. Trust reduces the uncertainty and risks perceived by users. Consequently, trust enhances users' perception about the Website and this should lead to higher users' satisfaction with the Website (Chen, 2005). Trust is defined as the subjective probability that customers believe that an organization's underlying technology infrastructure and control mechanisms are capable of supporting transactions (Cao, et al., 2005). This definition is however, confined to trust in general and hence, may not necessarily refer to electronic commerce per se. However, perhaps, the most succinct definition of trust in relation to electronic business could be "a consumer's willingness to accept vulnerability in an online transaction based on [his] their positive expectations regarding an e-retailer's future behaviors" (Cody and Kishore, 2006).
- *Interface satisfaction* – Interface satisfaction measures consumers' evaluation of the Website interface design in terms of information presentation, webpage navigability, ease of use and efficiency of interaction with the Website. Chen (2005) states that interface satisfaction includes ease of use, information presentation and information time. It has been stated however, that the term structural awareness of an interface implies that the interface makes the users aware of the larger structure of the information content in the web pages in an electronic business application

(Cody and Kishore, 2006). On the technical side, interface satisfaction may include graphics, help system, support of a foreign language and customer service (Shaikh et al., 2001; and Cox and Dale, 2002).

- *Information quality* – Three commonly used metrics to evaluate information quality are information accuracy, relevance, and completeness (Cao et al., 2005; Cody and Kishore, 2006). Information accuracy is the extent to which the information is accurate and the extent that it determines, among others, whether the promise is fulfilled. Information relevance refers to the extent to which the information on the Website is related to the information needs of the customers. Information completeness means that the information on the web page is available to the extent that the online consumers need it. DeLone and Mclean (2003) suggests five sub-characteristics for information quality: completeness, ease of understanding, personalization, relevance and security.

Creating test plans

After identifying the electronic commerce project requirements, we need to start planning for the testing process. A test plan is a document that describes the approach of testing activities and identifies the items to be tested, the types of tests to be performed, test schedules, reports that are to be produced, evaluation criteria, etc. (Lewis, 2004). The general outline of the test plan includes an introduction, business function, testing requirements, testing software and hardware, personnel and testing schedule. This plan will be the basis for accomplishing the testing process. At the same time, the test plan will be refined and expanded throughout the phase until we reach to the testing phase. The main objective for the testing process is to reveal the existing errors as much as possible and to ensure that the delivered electronic commerce Website meets the functional and non-functional requirements.

4.3 The design phase

In the electronic commerce project life cycle, this stage contains detailed definition for the system inputs, outputs, procedures, data structure, databases, Website map and structure, Website interface components etc. The design phase translates the business requirements into electronic commerce system specifications that can be used by programmers during coding (Implementation) phase. A lack of quality in the design phase can invalidate the requirement specifications identified earlier and can make the correction process difficult and costly. The major tasks of electronic commerce quality assurance in this phase include:

Design

This step defines the designers' selection of a set of design attributes that should be measured at the end of the phase. There should also be procedures to evaluate the overall quality of the design process. The electronic commerce quality assurance would have a specification for approval of design standards and a guideline to ensure that they are followed and that all the electronic commerce project requirements are allocated to the project components. A checklist during the design phase is recommended in helping designers improve design quality. The general principles of electronic commerce Website design practice should cover at least the following but not limited to:

- The Website is easy to navigate and easy to learn.
- It is compatible with the different Web browsers, screen resolutions and color settings.

- There is "About us" section in the Website.
- All the pages are not too lengthy.
- There are easy ways to get customers comments and feedbacks.
- There is a date stamp with the Website information.
- There is a search facility in the Website.
- There are no broken links, missing images or graphics.
- There are no scripting and HTML coding errors that may cause a page to not display.
- There are no slow page downloads due to excessive use of graphics or long pages.
- There is no sound "auto play".

Verification and validation

Validation is the set of quality assurance activities that ensures that the right functions are performed while verification is the set of quality assurance activities that ensures the correct performance of these specified functions. In other words, validation checks whether a function needed by the customers are present in the electronic commerce system while verification checks the conformance of the electronic commerce system to its specifications that we identified earlier in the planning phase. Among the activities included in verification and validation process are acceptance testing, ensuring the traceability of identified requirements in the planning phase, ensuring the feasibility of achieving functional and performance requirements, ensuring the feasibility of user requirements etc. Verification and validation are continuous processes to ensure that requirements identified in the previous phase are accomplished in the current phase. Therefore, this step is required in all the phases except the very early phase.

Expansion of the testing plan

In this step, test plans are explained in more detail. Test cases for the electronic commerce system are created in this phase. The test cases include test data, test script or guidelines, test input and the expected results from each test case. In this step, we need to conduct a system test for the resulted design to demonstrate whether the system meets the original requirements of the project or not. Regardless, this step may not require the complete preparation of test plans, test procedures, test tools, types of required tests etc.

4.4 The implementation (coding) phase

In this phase, developers implement the outcomes of the design phase by building the electronic commerce Website and other applications associated to it. Generally, the basis of good programming entails the application of defined set programming standards. The assumption is that development is done in-house provided resources are abundance.

However, where resources could be a significant constraint, an alternative to in-house development is outsourcing. Outsourcing the development of electronic commerce Website could be faster and cheaper. On the other hand, outsourcing limits flexibility in handling changes and diminishes ownership and control. It has been cited however that most of medium and large-size organizations prefer to build their Websites from scratch using commercial site-building software with some opting for hard coding (Cassidy, 2001).

Coding

In this step, quality assurance team checks whether developers have followed a proper use of programming language and defined standards or not. They have to ensure that the codes comply to coding standards of the language style. Checks are performed to determine

whether the codes fulfil the design specification for the functionality, data structures and user interface.

Verification and validation

In this step, we verify the fulfilment of the design specification developed in the design phase using code walkthroughs, peer code review, checklists, inspections and formal verifications.

Completing the testing plans

By the end of this phase, all the components of the testing plans should be completed. All the test cases must be described in detail including the objectives, inputs, expected outputs, and testing procedure. Also, the testing tasks must be assigned to the respective testing team members by the end of this phase including other details such as test time and required resources.

4.5 The testing phase

This phase implements the test plans generated so far. The testing process itself is one of the main activities of quality assurance in electronic commerce development life cycle. The priority of this phase is to have all tests run according to test plans and procedures. Other priority is ensuring that test reports are complete and correct and that test results are documented properly. The essential tasks of quality assurance in this phase include:

Testing

During this phase, tests are carried out by running the test cases according to the already established test procedures.

- *Usability evaluation* – This activity characterizes the conduct to determine the extent to which the electronic commerce Website is understood, easy to learn, easy to operate, easy to navigate and is attractive to the online consumers.
- *Unit testing* – This is the process of testing each part of the electronic commerce Website individually to ensure that it performs its assigned function accordingly.
- *Acceptance testing* – This refers to the testing of the electronic commerce Website with respect to users' defined needs, requirements and expectations. The aim is to determine whether or not the electronic commerce Website satisfies the acceptance criteria.
- *Compatibility testing* – It measures how well the electronic commerce Website pages could be displayed on different browsers, different browser version, different resolutions, different operating systems and different machines.
- *Integration testing* – This test is performed to find defects in the interfaces and in the interactions between different components of the electronic commerce Website.
- *Regression testing* – This refers to a re-testing of a previously tested Website after a modification is performed on the Website to ensure that defects have not been introduced or uncovered in unchanged areas of the electronic commerce Website.
- *System testing* – This is the process of testing the whole Website after completing all of the components to verify that it meets specified requirements.
- *Stress testing* – This set of tests evaluates the electronic commerce Website or its associated components at or beyond the limits of its specified requirements.
- *Testability Testing* – This measures the ease of testing a component in the electronic commerce Website or a specific functionality so that test plans and scripts could be executed properly.

- *Validation testing* – Validation is the term used to refer to the act of verifying that the HTML code in a file meets the DTD (Document Type Definition) for any particular version of HTML.

Evaluation and Re-testing

This process entails that every error discovered during the test process ought to be documented in detail for evaluation and correction. These documents will be used again in the regression testing to compare the results before and after correcting the defects. In addition, we need to evaluate the testing process itself at the end of this phase. This evaluation will help to improve the testing process in future. Metrics that can be used in evaluating the testing process are number of the test cases, detected errors, number of defects uncovered in the testing, cost of testing, and average cost of locating a defect.

4.6 Development and post-deployment phase

Although the main objective of electronic commerce quality assurance practice is to detect defects before publishing the Website, it is practically impossible to create an error-free electronic commerce Website and system. Therefore, we need continuous quality improvement standards to keep up with the changes of the electronic commerce Website. The basis for changes would typically emerge out of customers' inputs and feedbacks.

Monitoring

In this step, we first collect the run time data about the successes and failures in electronic commerce Website operations. The data should represent the functionality, performance, usability, reliability, and other quality factors of the operations. Then, we analyze the collected data in order to detect any available defects in the Website. Another great source for the defects is customers' feedback about; in particular their experiences in browsing the Website. The availability of channels to be in contact with the customers in any electronic commerce Website as a customer support service is highly recommended. After this, the developers should start to analyze and correct the failures that had occurred or been reported.

Upgrade

The electronic commerce Website components can be improved to provide better performance, more functionality, higher in content quality, or greater usability. Most of the electronic commerce Websites would expand with additional services to their original Websites from time to time in fulfilling and exceeding customers' satisfaction, needs and expectations.

5. Recommendation and Conclusion

The success of online business will, for the large part, depend on the quality of electronic commerce Websites. Our review of past researches suggests models of quality assurance of electronic commerce Websites that are fragmented and distinct in that they were confined to the respective perspectives of assessors and specific concerns.

This work has been built based on our earlier work that had been drawn from the fields of information systems, marketing, human-computer interaction and design. The limitation of the prior work was that the literature in these fields confined discussions within the online consumers' perspective as evaluators. The assessment is made on electronic commerce Website with the view of systems as a product.

This chapter extends our previous work with a proposal of a framework that synthesizes these previous multiple perspectives with the developers' perspective. In particular, our emphasis in this chapter is that, in order to arrive at quality electronic commerce Website as a final system product, one must adhere to a set of quality assurance processes during the electronic commerce life cycle. This form the basic building blocks for the end product. In this regard, we adopt the view of software quality, software quality assurance and software engineering. Figure 3 shows our proposed synthesis as a framework for quality assurance of electronic commerce Websites.

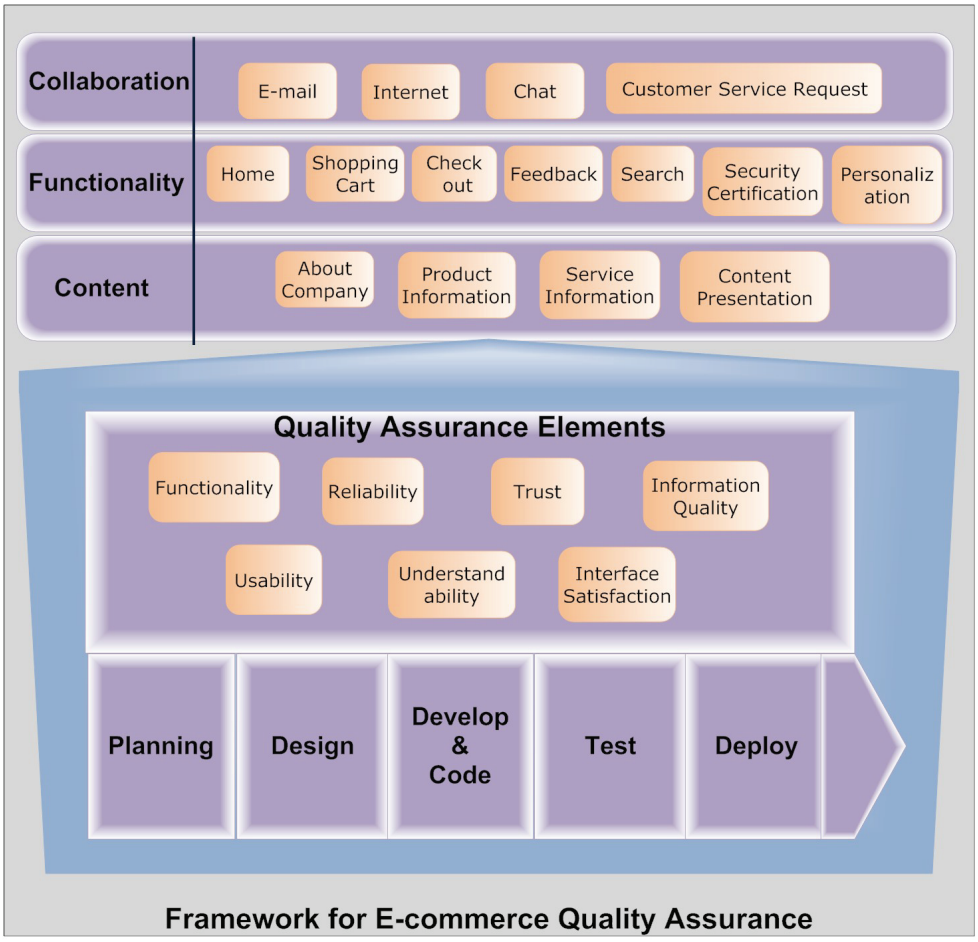

Fig. 3. A Framework for Quality Assurance of Electronic Commerce Websites

Quality of electronic commerce Websites is an important factor in attracting potential consumers, encouraging first-time purchases and retaining repeat purchases. It has been emphasized that the quality of electronic commerce Websites is an important factor for consumers in selecting the most preferred Website that ultimately results in more revenue

for the Websites (Lohse and Spiller, 1999; Ngai, 2003 and Carnero, 2005). The proposed framework provides a bird's eye view to aid discussions in research practice toward ensuring the quality of electronic commerce Websites. One consideration for future research areas could be to validate the elements of quality from the various perspectives.

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10

Improving performance in recommender system: collaborative filtering algorithm and user's rating pattern

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1. Introduction

With the advance of IT technologies, a recommender system in online commerce environment has been introduced as personalized services (Schafer et al., 2006). The recommender system is used in E-commerce for recommending a product, an item or even any web service to each customer based on customer's preference.

Since a recommender system can predict customers' preference and forecast the future degree of customer's fondness for a certain item and services, it is used as a conspicuous service which distinguishes an on-line commerce service from an off-line commerce service. In predicting each user's preference, a recommender system essentially provides enough information of items and users because it is able to predict the specific user's preference for a target item and suggest the result to users.

One of the classic recommender systems is a content-based filtering system which uses textual contents. In the recommender system for an on-line movie rental process, two types of profiles are usually used; movie profile and customer profile. The movie profile describes a movie category, main actors, and performance movie. The customer profile is created with the historical experienced textual information, which is stored in the system, of items or users for seeking the best fits.

This type of approach works well in initial systems, but there are some drawbacks for expanding the scales of recommender systems due to the following reasons. First, there are difficulties in converting features of all traded items into textual data. Additionally, if the number of traded items extremely increases, it is not easy to automatically convert all items' information into textual forms. Second, since content-based systems only recommend items based on the past experience of user, it cannot help the user choose items for specific cases. This problem is called over-specification for recommendations.

Such drawbacks can be eliminated by collaborative filtering recommender systems, which use relationships between users and items that can be represented on numerical scales (i.e. preference rating). This preference rating information can be collected from tracks of clients who surf web and purchase items. Typically, such types of recommender systems utilize neighbour users' data, using a set of data that has similar characteristics for

recommendations of a target item. This concept used for users or item is called user-based or item-based respectively.
Collaborative filtering recommender systems are successfully used in commercial web sites such as Amazon.com, E-bay and Netflix. The item-based approach is generally adapted to commercial web sites because the speed and the range of expansion of user are much higher than items and also the problem of data scarcity is willing to occur in user-based (Linden et al., 2003; popescul et al., 2001).

2. Collaborative Filtering

To make up for shortcomings of content based approach, collaborative filtering approach is adopted in the recommender system. Collaborative filtering approach is the method using only related data between users and items like explicit numerical ratings, and the detailed attributes of both users and items are intentionally ignored. Collaborative filtering can be said that the most popular item is recommended for every user. It is known as the most commercially successful recommender technique and is the base of the studies on the recommender systems algorithms.
Collaborative filtering approach can be grouped into two classes according to algorithms for prediction users' preferences. One is memory-based and the other is model-based. Memory-based algorithms predict the rating of users using the previously rated items by the users and other users who have similar tastes. In contrast to memory-based algorithms, model-based algorithms use the probabilistic approach, such as, cluster models, Bayesian network, and machine learning approach (Adomavicius & Tuzhilin, 2005 ; popescul et al., 2001).
In memory-based collaborative filtering algorithms, to show the similarity of the preferences between the active users and others, the Pearson's correlation coefficient was used in the GroupLens first. Breese et al. researched the ways of improving the prediction accuracy, using the Pearson's correlation coefficient, the Vector similarity, the default voting, the inverse user frequency, and the case amplification (Breese et al., 1998). Also, they researched the collaborative filtering with the use of the Bayesian probability model. Herlocker et al. studied about making the prediction accuracy improved with using both the Pearson's correlation coefficients as the similarity weight and the effect of the number of co-rated items (Herlocker et al., 2004). Memory-based collaborative filtering algorithms can be divided into user-based method using the relations among users and item-based method using the relations between items as the method of algorithm application.
Collaborative filtering system also has some limitations like content-based system have.

→ • New user problem
• New item problem
• Scarcity

New user problem is the same problem as content-based system has. To predict more accurate recommendations, collaborative filtering system has many ratings that users give, because the more ratings are given to the system, the better the user's preferences can be understood. If a new item enters into the system, there are no users who give rating to item. Therefore, this item can not be recommended to users in the system. To solve this problem, it will be possible to make ratings from system manager or some groups of panel users.

In many recommender systems, the numbers of ratings already rated by users are very small to make prediction for recommendation.The success of the collaborative filtering system depends on the available users. Well established system like MovieLens dataset also has the scarcity, 95.8% in 1 million dataset and 93.7% in 100K dataset.
To overcome these problems, diverse approaches are proposed. For example, it is possible to use other information like demographical information and users' behaviour in the web and dimensionality reduction techniques (Adomavicius & Tuzhilin, 2005).

3. Algorithm

To predict the preference of a target user about specific items, the neighbor selection process is firstly carried out. Figure 1 shows the neighbor selection step for predicting the preference of the active user 4 about the specific item 4. The user 1 and the user 3 are selected as the neighbour users of the because they have already rated the item 4. For calculating the prediction value about the preference rating of the user 4 about the item 4, the preference ratings of neighbors are needed and in this figure, the user 1 and the user 4 have already rated about the item 4.

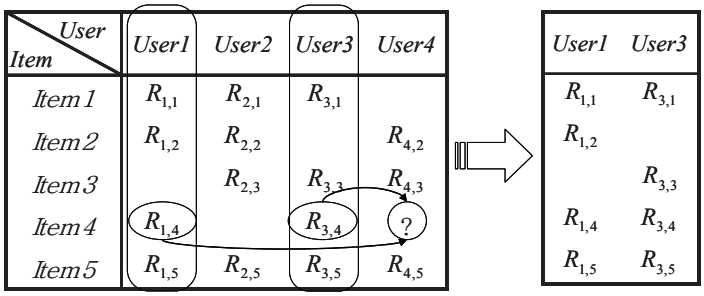


Fig. 1. Neighbour selection step

Before applying algorithms, a preference similarity weight for items between a target user and his neighbors must be defined. Pearson's correlation coefficient is used for the similarity weight between them and equation 1is the similarity weight used in this study.

$$r_{uj} = \frac{\sum_{i=1}^{m}\left(R_{u,i} - \overline{R}_u\right)\left(R_{j,i} - \overline{R}_j\right)}{\sqrt{\sum_{i=1}^{m}\left(R_{u,i} - \overline{R}_u\right)^2 \cdot \sum_{i=1}^{m}\left(R_{j,i} - \overline{R}_j\right)^2}} \tag{1}$$

r_{uj} is the similarity weight between the target user u and neighbor user j and $R_{u,i}$ denotes preference ratings of the target user u for the items i which are already rated by the target user. $R_{j,i}$ denotes preference ratings of neighbor user j, $\overline{R}_u$ and $\overline{R}_j$ are the mean of ratings of user u and j. In this equation, all ratings R must be co-rated by user u and j.

3.1 Neighborhood Based Collaborative Filtering Algorithm

One of the most famous and well known algorithm is neighborhood based collaborative filtering algorithm(NBCFA) proposed by GroupLens (Resnick et al., 1994).

$$\hat{U}_x = \overline{U} + \frac{\sum_{J \in Raters} (J_x - \bar{J}) r_{uj}}{\sum_{J \in Raters} |r_{uj}|}, \quad where \ \bar{J} = \frac{\sum_{i}^{n} J_i}{n}, i \neq x \tag{2}$$

The $\hat{U}_x$ is the prediction value of the preference of the target user u over the target item x, the $\overline{U}$ is the mean of the all preference ratings of the user u, the J_x is the preference rating of the neighbor user j over the target item x, and the $\bar{J}$ is the mean of the all preference ratings of the neighbor user j except the rating of target item x. Raters are users who rate the preference of the item in the data set. r_{uj} is the similarity weight of both the user u and the neighbor user j and the Pearson's correlation coefficient and the vector similarity are usually used for this but the performance of the Pearson's correlation coefficient is usually better than the vector similarity.

Figure 2 shows the prediction step for the item 4 of the user 4 using the NBCFA. First, the similarity weights between the user 1 and the user 4, the user 1 and the user 3 are calculated. The similarity weight indicates the preference relationship of the two users, and the more similar user 1 and neighbor users are, the more weight will increase in the prediction step. The two most commonly used similarity weights will be described below. Usually the Pearson's correlation coefficient is used for similarity weight of two users but any types of measures, cosine vector and Euclidean distance as similarity weight, are possible if the preference of two users are explained.vector and Euclidean distance as similarity weight. In this chapter we use the Pearson's correlation coefficient as the similarity weight of two users.

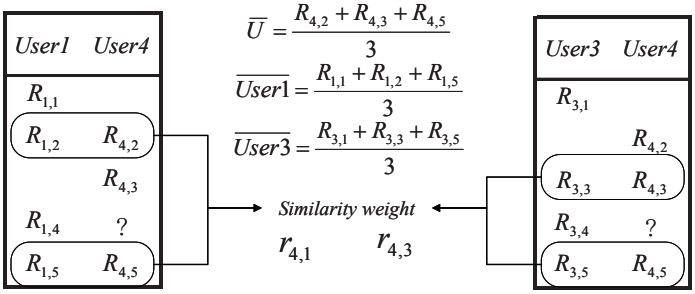


Fig. 2. Neighbourhood Based Collaborative Filtering

3.2 Correspondence Mean Algorithm

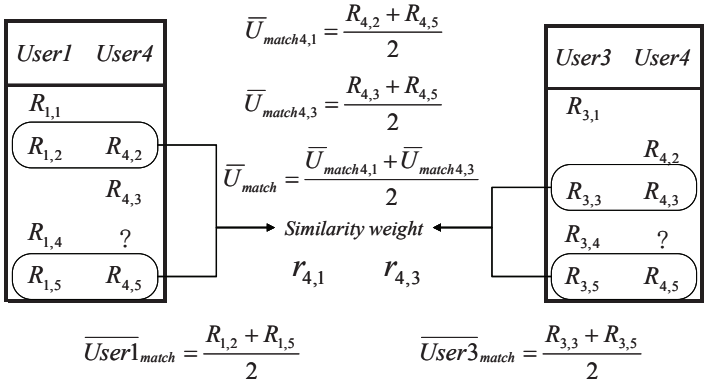
In the NBCFA, $\overline{U}$ is the mean of the preferences of the target user u who will take prediction value for the specific item which the target user has never experienced. In this case of calculating $\overline{U}$ with the entire ratings of the target user, the preference of the target user is overestimated, which leads to a possibility that the preference of the target user might be insufficiently or excessively reflected if the numbers of co-rated items with his or her neighbour are small. So, some tuning is needed for alleviating insufficient reflection of target user and his or her neighbour.

This is why $\overline{U}_{match}$ and $\overline{J}_{match}$ are used in the CMA. $\overline{U}_{match}$ is the mean of all the means of the preferences that are rated by both the user u and the neighbour user j.

Equation 3 is the correspondence mean algorithm (Lee et al., 2007a; Lee et al., 2007b)...

$$\hat{U}_x = \overline{U}_{match} + \frac{\sum_{J \in Raters} (J_x - \overline{J}_{match}) r_{uj}}{\sum_{J \in Raters} |r_{uj}|} \tag{3}$$

$\overline{J}_{match}$, the mean of the preferences rated by both the user u and the neighbour user j, and it is calculated by the same way of calculating the Pearson's correlation coefficient. For example, if the user u has 10 ratings and one of the neighbour user j has 20 ratings and the other user j has 10 ratings, the preference of the user u must be calculated with the relationship of each neighbour. In the case of this example, if the first user j and user u have only 5 co-rated items and the second user j and user u have 10 co-rated items, it is reasonable to use the only co-rated items to calculate the preferences user u and user j not using all ratings of them. Also, $\overline{U}_{match}$ must be the mean of $\overline{U}_{sub\_match}$ s of the user u and user j.



$$\overline{U}_{match4,1} = \frac{R_{4,2} + R_{4,5}}{2}$$

$$\overline{U}_{match4,3} = \frac{R_{4,3} + R_{4,5}}{2}$$

$$\overline{U}_{match} = \frac{\overline{U}_{match4,1} + \overline{U}_{match4,3}}{2}$$

$$\overline{User1}_{match} = \frac{R_{1,2} + R_{1,5}}{2} \qquad \overline{User3}_{match} = \frac{R_{3,3} + R_{3,5}}{2}$$

Fig. 3. Correspondence Mean Algorithm

Figure 4 shows the prediction step for item 4 of user 4 using CMA. First, the similarity weights of user 1 and user 4, user 1 and user 3 are calculated. In this step, we calculate the $\overline{U}_{match}$ as the preference of user 4. To compute $\overline{U}_{match}$, $\overline{U}_{match4,1}$ and $\overline{U}_{match4,3}$ are calculated before, which uses the ratings of co-rated by two users.

3.3 Significance Weight and Evaluation Metric

The similarity weight of the target user with the neighbour explains their relationship of preference to items. This similarity weight of both users' preference of items must be considered, so it will be computed with ratings which are rated by both users. If the similarity weight of both users is computed only with small portion of their ratings, it is doubtful of their real relationship of preference to items. For example, the similarity weight using only two pairs of ratings is just 1 or -1, and even it is impossible to compute their relationship of preference. Herlocker et al. adopted the significance weight to devalue the overestimated similarity weight. They showed the improvement of prediction accuracy by reducing the overestimated Pearson's correlation coefficient under the number of co-rated movies as 50 (Herlocker et al., 2004).

To devalue the overestimated similarity of active user and their neighbours' preference, the significance weight is set to consider the effect of the number of co-rated movies from both active user and his or her neighbour user and applied as equation 4.

$$\hat{U}_x = \overline{U} + \frac{\sum_{J \in Raters} (J_x - \bar{J}) r'_{uj}}{\sum_{J \in Raters} \left| r'_{uj} \right|} \qquad (4)$$

$$where, \qquad r'_{uj} = r_{uj} \cdot sw$$

The significance weight(sw) gains the weight according to the number of co-rated items as shown below.

$$sw = \frac{\min(n(I_u \cap I_j), C)}{C} \qquad (5)$$

In equation 5, the $n(I_u \cap I_j)$ is the number of movies that are rated by both the target user u and neighbor user j, and the C is the number of co-rated movies that are for setting the application range of the significance weight. To get the prediction accuracy more improved, we extend the range of the significance weight according to the number of co-rated movies as the set C below .

$$C = \begin{Bmatrix} 3,5,710,15,\cdots 50,60,\cdots,100,120,150,180,200, \\ 300,\cdots,500,700,1000,2000,4000,7000,10000 \end{Bmatrix} \qquad (6)$$

Several techniques have been used to evaluate recommender systems. Those techniques are divided into three categories; predictive accuracy metrics, classification accuracy metrics and rank accuracy metrics. The predictive accuracy metrics measure how close the predicted ratings by algorithm are to the true ratings in the test dataset. In this study, Mean Absolute Error (MAE), one of the predictive accuracy metrics, is used to evaluate the performance of each algorithm, especially measuring each user's MAE, to test the performance of two algorithms and other experimental results.

$$MAE = \frac{1}{N}\sum_{j=1}^{N}\left|R_{uj} - \hat{R}_{uj}\right| \tag{7}$$

In equation 7, R_{uj} is the true rating of user u given to the item j and $\hat{R}_{uj}$ is the prediction value of user u to the item j.

4. Pre-evaluation

4.1 Error Fence

To find the relationship of the prediction accuracy of users' preference with the pre-evaluation approach, the prediction error fences are set on the each user's MAE by using exploratory data analysis (EDA) technique. To set the prediction error fence, we use the concept of the hinge as proposed by Tukey to set the fence (Tukey, 1977). For classifying the users' groups, we set the range of the normal errors as the H-spread, and the range of abnormal errors is set as the adjacent values and the outside values divided by the inner fence. Figure 4 shows the H-spread and the fences for classifying the normal errors range and the abnormal errors range of MAEs and standard deviations of each user's ratings in the training dataset (Han et al., 2008).

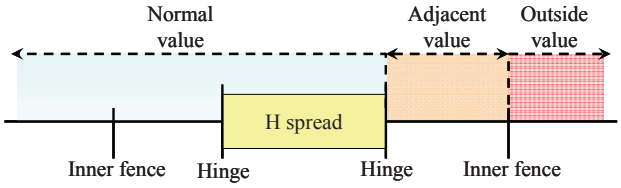


Fig. 4. Error bound divided by EDA

After classifying process, we classify the users' groups according to the classified MAEs and standard deviations and we run the statistical test on the groups to find their relationships.

4.2 Classification Function

According to our previous study, the prediction accuracy of user's preference on the item has a close relationship with the generative probability of specific ratings which have been already rated by the user before prediction process. The generative probabilities of specific ratings denoted as δ_{u1}, δ_{u2}, δ_{u3} will be used to define the classification functions that select users whose MAE is lower than non-selected users' MAE from the next equations presented by Lee (Lee et al., 2007).

$$\delta_{u1}=\begin{cases}1, & f_u(R_5)\geq f_u(R_2)\\ 0, & elsewhere\end{cases}\qquad \delta_{u2}=\begin{cases}1, & f_u(R_1)\geq f_u(R_4)\\ 0, & elsewhere\end{cases}$$

$$\delta_{u3}=\begin{cases}1, & f_u(\{R_1\}\cup\{R_5\})\geq f_u(\{R_2\}\cup\{R_3\}\cup\{R_4\})\\ 0, & elsewhere\end{cases} \tag{7}$$

$$where,\quad R_i=i,\quad i=\{1,2,3,4,5\}$$

δ_{u1}, δ_{u2}, δ_{u3} are the conditions for defining the classification functions and showed in the equation 8. It has only the values of 1 or 0.

$$L(\delta_{u1},\delta_{u2},\delta_{u3})=\delta_{u1}\cdot\delta_{u2}\cdot\delta_{u3} \tag{8}$$

To classify users who have higher prediction accuracy than non-selected users, we propose another classification function in this study. We also define the generative probabilities of specific ratings as θ_{u1}, θ_{u2}, θ_{u3}. Each condition and function is showed in equation 9 and 10.

$$\theta_{u1}=\begin{cases}1, & f_u(R_2)\geq f_u(R_1)\\ 0, & elsewhere\end{cases}\qquad \theta_{u2}=\begin{cases}1, & f_u(R_4)\geq f_u(R_5)\\ 0, & elsewhere\end{cases}$$

$$\theta_{u3}=\begin{cases}1, & f_u(R_3)\geq f_u(\{R_2\}\cup\{R_4\})\\ 0, & elsewhere\end{cases} \tag{9}$$

$$where,\quad R_i=i,\quad i=\{1,2,3,4,5\}$$

θ_{u1}, θ_{u2}, θ_{u3} are the conditions that classify users who have high prediction accuracy for defining the classification functions and showed in the equation 10. It also has only the values of 1 or 0.

$$H(\theta_{u1},\theta_{u2},\theta_{u3})=\theta_{u1}\cdot\theta_{u2}\cdot\theta_{u3} \tag{10}$$

5. Experiments

5.1 Experimental Dataset

To evaluate the performance of each algorithm and pre-evaluation function, our experiment uses the MovieLens datasets which have been made public by GroupLens for experiment. The GroupLens presents 2 types of the MovieLens dataset. One is a 100K dataset and the other is a 1 million dataset. We use both datasets for our research analysis.

100K dataset was rated by 943 users over 1682 movies and the total ratings are 100,000 while 1 million dataset was rated by 6040 users over 3952 movies and the total ratings are more than 1,000,000.

To test performance of two algorithms and classfication function, we divide each dataset into 80% of training dataset and 20% of test dataset. Generally, training and test datasets are

divided randomly regardless of the number of ratings each user has. In this case, there are biased ratios of ratings belonging to training dataset and test dataset for each user. To balance this discrepancy of the 80% of training and the 20% of test dataset, we divide off training dataset and test dataset from each user's ratings randomly. We then predict the 20% of test dataset through NBCFA and CMA using 80% of training dataset(Han et al., 2008).Figure 5 shows the concept of composing the experimental dataset.
Generally, the prediction accuracy will be evaluated by the MAE which is calculated by the average of the absolute errors of all the real ratings between predicted values in test dataset. But our study uses the each user's MAE which is calculated by using ratings of each user in the test dataset instead of using all the ratings in the test dataset. This study shows the possibility of the pre-evaluation approach using previously possessed preference information of users as ratings on the items before the prediction process for each user's preference.

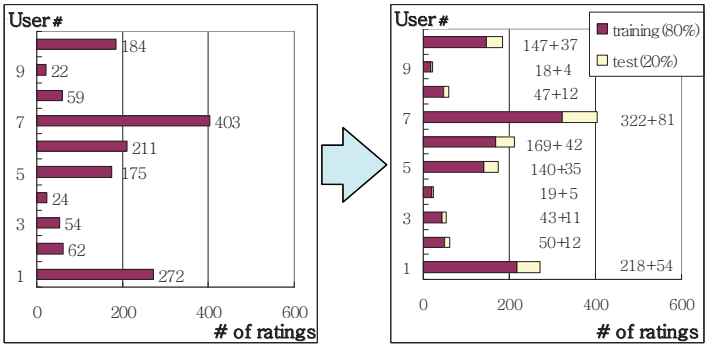


Fig. 5. Experimental dataset formation

5.2 Experimental Design

To compare the prediction accuracy of the result of NBCFA and CMA, the followings are conducted.
First, the Pearson's correlation coefficient is applied to NBCFA and CMA as the similarity weight, to present the preference relation of target users and their neighbours, and the prediction results of that are compared according to the user-based method and the item-based method. The user-based prediction is the way that uses the relations of users to compute the similarity weight and applies them to each algorithm for predicting the test set. And item-based prediction is the way that utilizes the relations of items or goods to compute the similarity weight and applies them. And then we analyze the prediction accuracy statistically in the view of each user's MAE, not using the MAE of all predicted ratings, to confirm the improvement of prediction accuracy using the CMA.
Second, we analyze the effect of the significance weight to the result of each prediction method and prediction algorithm. The similarity weight, which presents the relation of preference between users, might be overestimated if the numbers of co-rated movies are small. To get the prediction accuracy more improved, we extend the range of the significance weight according to the equation 6.

Figure 6 shows the steps for our study and flow of the experiment. Step 1 shows the division of our experiment into user-based and item-based according to the prediction method explained. Step 2 classifies each prediction method by prediction algorithm applied to each dataset. Step 3 divides the prediction algorithm according to similarity weight applied to the each algorithm. To know how much the numbers of co-rated items affect the accuracy of prediction, step 4 is divided according to the significance weight.

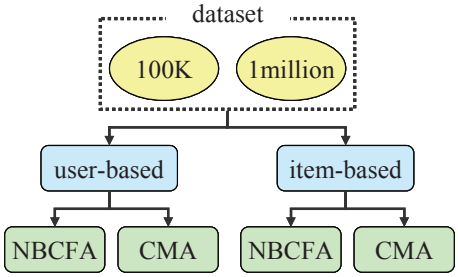


Fig. 6. Experimental flow diagram for algorithm

Figure 7. shows the experiment flow diagram for proposing the possibility of the pre-evaluation for the preference prediction errors before the prediction process.

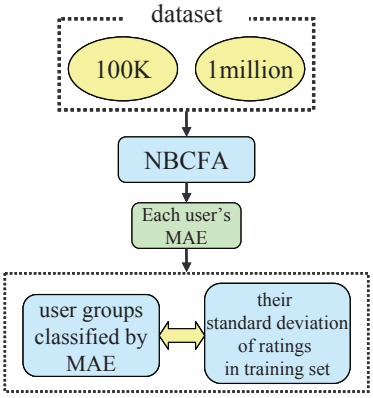


Fig. 7. Experimental flow diagram for error bound

We evaluate the prediction errors of each user's ratings in the test dataset after the prediction process by using NBCFA. And then, we run statistical tests for analyzing the relationship of prediction error of the user's preferred items between information of users before prediction.

First, we classify 3 groups into normal, adjacent, and abnormal users group according to the each user's MAE by applying the exploratory data analysis approach. And then, the analysis of variance test is applied to comparing the means of each user's standard deviation derived from the training dataset. According to the results, users are classified into groups.

Figure 8. shows the experiment flow diagram evaluating the performance of classification functions of the pre-evaluation for the preference prediction errors before the prediction process.

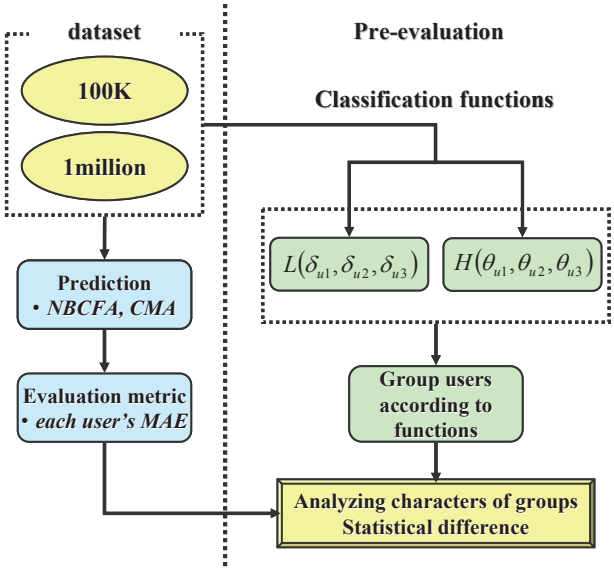


Fig. 8. Experimental flow diagram for classification function

The left side of the vertical dotted line on figure 8 shows the process of prediction domain and two MovieLens datasets which are predicted through NBCFA and CMA, and then the prediction results are evaluated by each user's MAE.
The right side of the line shows the pre-evaluation process using $L(\delta_{u1},\delta_{u2},\delta_{u3})$ and $H(\theta_{u1},\theta_{u2},\theta_{u3})$ function for classifying users who have low prediction performances or high prediction performances. These functions classify users into three groups; lower performance group, higher performance group and non-selected group. Non-selected group has normal performance. In order to analyze characters of users for each group, we show their rating pattern graphically and their statistical features through statistical tests.

6. Experimental Results

6.1 Prediction Accuracy

The followings are the results of the NBCFA and the CMA that don't consider the number of co-rated items in the user-based method.
Figure 9 shows the prediction results of 100K dataset and 1 million dataset in the user-based according to similarity weight as the Pearson's correlation coefficient. In the results of experiment, the results of prediction accuracy predicted by the CMA are more accurate than those of the NBCFA. The results of 1 million dataset are more accurate than those of 100K dataset and the improvements of the prediction accuracy are similar to all cases.

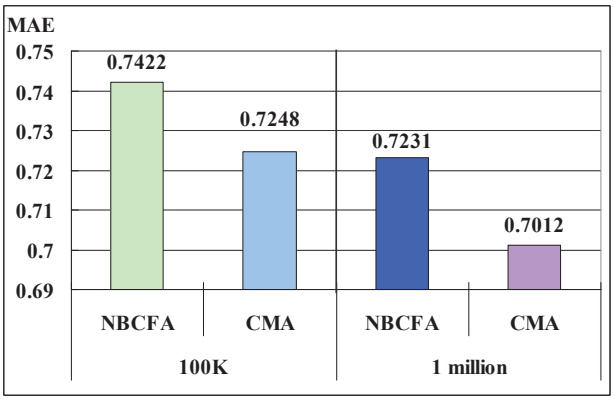


Fig. 9. Prediction results of 100K and 1 million dataset in the user-based

Figure 10 shows the prediction results of 100K dataset and 1 million dataset in the item-based according to similarity weight as the Pearson's correlation coefficient. In the results of experiment, the results of the prediction accuracy predicted by the CMA are more accurate than those of the NBCFA, but the improvements degree of prediction accuracy is less than that of the user-based.

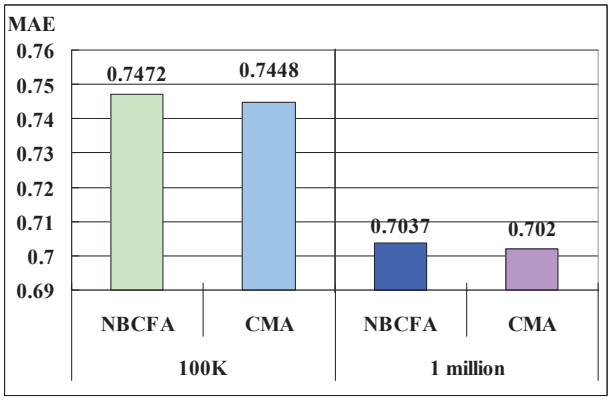


Fig. 10. Prediction results of 100K and 1 million dataset in the item-based

For more analysis, we classify the prediction errors by each user and calculate their MAE. Usually, the MAE measures the accuracy of algorithms used to predict user's preference to items, so the MAE using all predicted ratings means the systematic accuracy. But in our experiment, we take statistical approach for more analysis, so we classify 943 users' prediction values in 100K dataset and 6040 users' prediction values in 1 million dataset and then compute their each MAE. We compare the means of each user's MAE by the result of each algorithm with paired-samples t-test. Table 1 shows the result of paired
Table 1 shows the result of paired-samples t-test of two algorithms with 100K dataset and 1 million dataset.

From the table 1, it is found that the results of user-based have significant differences in the mean statistically, and t-value of the 1 million dataset is bigger than that of 100K dataset, As a result, the prediction accuracy of the CMA is better than that of NBCFA, especially in 1 million dataset. In case of item-based, the result of each algorithm has not statistically significant difference.

Method	dataset	Algorithm	Mean	t-value	Sig.
user-based	100K	NBCFA	0.7691	5.6	0.000**
		CMA	0.7562		
	1million	NBCFA	0.7465	22.417	0.000**
		CMA	0.7285		
item-based	100K	NBCFA	0.761	1.34	0.18
		CMA	0.759		
	1million	NBCFA	0.7171	1.868	0.062
		CMA	0.7164		

* : p<0.05, ** : p<0.01

Table 1. Results of paired-samples t-test

Below shows the degrees of the changes depending on the number of co-rated items in two datasets.

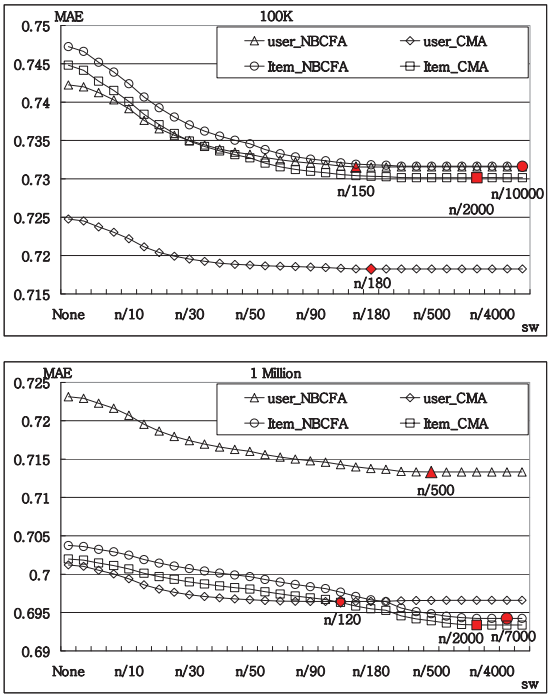


Fig. 11. The accuracy of 100K (above) and 1 million(below) dataset is changing according to the significance weight

Figure 11 shows decreasing curves of MAE according to the significance weight of 100K dataset and 1 million dataset using correlation coefficient as the similarity weight. In the results, it is found that all the results of CMA are better than those of NBCFA. In case of user-based, the decreasing width of MAE is bigger than the result of item-based. The results of user-based are more accurate than those of item-based in 100K dataset, but the results of 1 million dataset show vice versa.

6.2 Relationship between MAE and SD

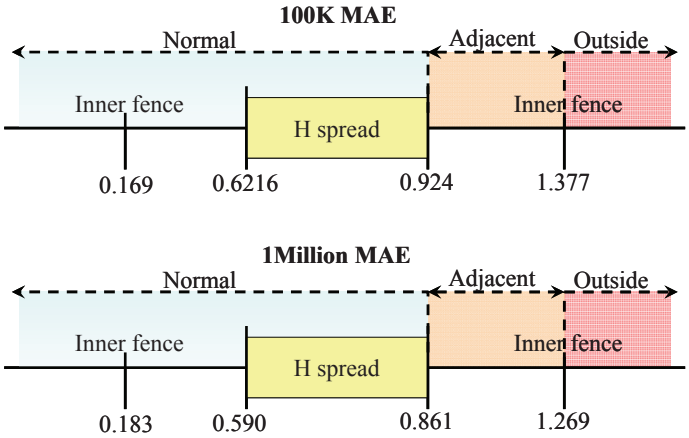


Fig. 12. Error bound of 100K and 1million dataset

To classify users who have low prediction accuracy, the EDA approach is applied. We define the users who have low prediction accuracy as outside values, adjacent values, and H-spread who have superior prediction accuracy as normal user groups. And then, abnormal user group is divided into two groups, one is an adjacent values group within inner fence, and the other is an outside values group beyond the inner fence (Fig. 12). Table 2 and table 3 show the results of ANOVA test to compare the prediction accuracy of each group in 100K and 1 million_MovieLens dataset.

dataset	Group	N	Mean	Std. Deviation	Min	Max
100K	Normal	707	0.954	0.176	0.314	1.541
	Adjacent	213	1.138	0.212	0.492	1.723
	Outside	23	1.304	0.227	0.681	1.561
	Total	943	1.004	0.207	0.314	1.723
1million	Normal	4380	0.943	0.172	0.139	1.726
	Adjacent	1453	1.134	0.200	0.484	1.719
	Outside	205	1.269	0.247	0.687	1.823
	Total	6038	1.000	0.206	0.139	1.823

Table2. Basic statistics of each group

dataset	-	Sum of Squares	df	Mean Square	F	Duncan
100K	Between	7.670	2	3.835	110.555**	{1}{2}{3}
	Within	32.608	940	0.035		
	Total	40.278	942			
1million	Between	55.319	2	27.660	833.505**	{1}{2}{3}
	Within	200.270	6035	0.033		
	Total	255.589	6037			

*: p<0.05, **: p<0.01
Table 3. The result of ANOVA test

Table 2 shows the result of the basic statistics of each user group classified by the each user's MAE as the prediction accuracy using the prediction results of 100K and 1million MovieLens dataset. Table 3 shows the result of ANOVA test to compare the means of users' MAE of each group. From the result of the statistical test, it shows that each group has the difference in the means of standard deviations and they are clearly grouped by the multiple comparison with their means of SD as Duncan test. So, it will be possible to use the standard deviations from training dataset for classification criterion of the users who have low prediction performance.

6.3 Rating Pattern

Figure 13 and 14 show rating patterns of users who are classified by $L(\delta_{u1}, \delta_{u2}, \delta_{u3})$ function applied to 100K and 1 million experimental dataset modified MovieLens dataset.

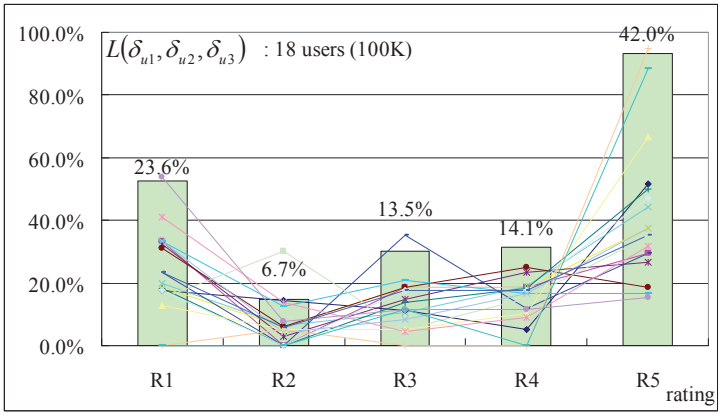


Fig. 13. Rating patterns of classified users by $L(\delta_{u1}, \delta_{u2}, \delta_{u3})$ function in 100K dataset

The function $L(\delta_{u1}, \delta_{u2}, \delta_{u3})$ classifies 18 users with 100K dataset and 90 users classified with 1 million dataset. Lines on each chart represent the ratio of each rating rated by every selected user, and bars represent the average ratio of each rating.
As shown in Figure 13 and Figure 14, both rating patterns show that the average ratio of rating forms 'W' in shape. In other words, the number of users classified by R1 and R5 is more than R2, R3, and R4. Users who have lower prediction performance are generally apt

to rate either R1 or R2. As a result, they have bigger deviations of their ratings to items than non selected users.

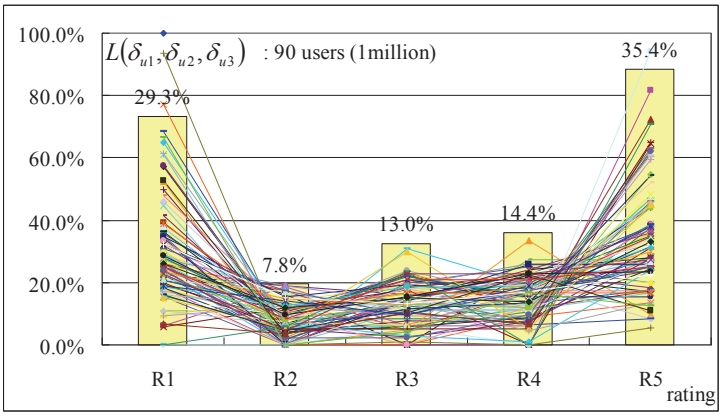


Fig. 14. Rating patterns of classified users by $H(\theta_{u1},\theta_{u2},\theta_{u3})$ function in 100K dataset

Figure 15 and 16 show rating patterns of users classified by $H(\theta_{u1},\theta_{u2},\theta_{u3})$ applied to 100K and 1 million experimental dataset modified MovieLens dataset. The function $H(\theta_{u1},\theta_{u2},\theta_{u3})$ classifies 63 users with 100K dataset and 260 users classified with 1 million dataset.

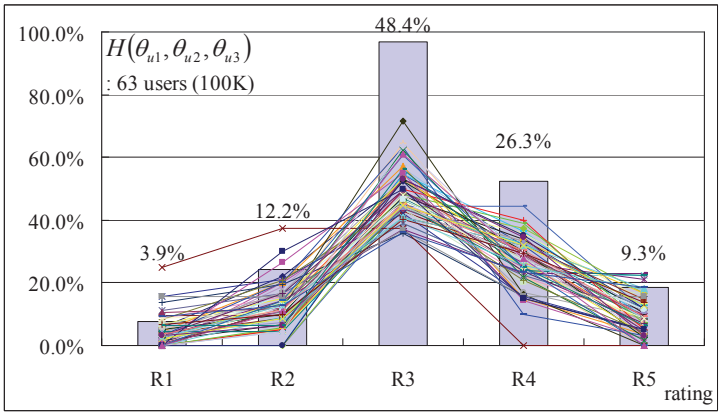


Fig. 15. Rating patterns of classified users by $H(\theta_{u1},\theta_{u2},\theta_{u3})$ function in 100K dataset

As shown in Figure 15 and Figure 16, both rating patterns show that the average ratio of rating forms 'hat' in shape. In other words, the number of users classified by R3 and R4 is more than R1 and R5. Users who have higher prediction performance are generally apt to rate one of R2, R3 and R4. As a result, they have smaller deviations of their ratings to items than non-selected users.

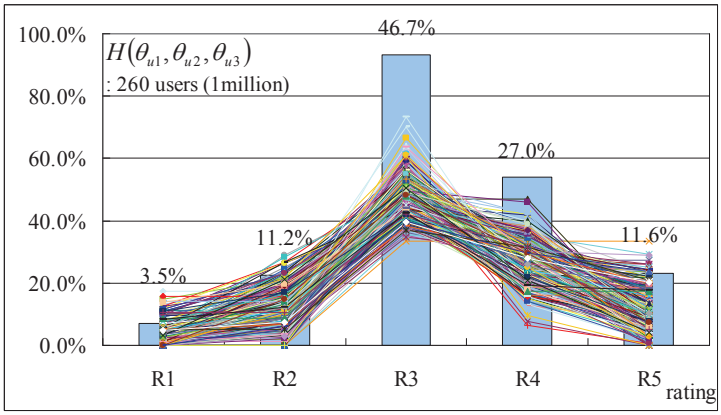


Fig. 16. Rating patterns of classified users by $H(\theta_{u1},\theta_{u2},\theta_{u3})$ function in 1million dataset

Table 4 shows the result of ANOVA test over the each user's MAE grouped by two classification functions and non-classified users' group. From Table 4, F values show a meaningful significance statistically. Thus, the means MAE of three groups (H, Non, L) have some differences, but their variances are not so big. As the result of Duncan's Multiple Range Test, we have some difficulties in discriminating the means of users' MAE between group H and group Non, but we can easily distinguish group L from other groups

100K	Group	N	mean	SD	F value	Duncan.
NBCFA	H	63	0.710	0.234	15.99**	{H,Non}{L}
	Non	862	0.780	0.247		
	L	18	1.082	0.283		
	total	943	0.781	0.251		
CMA	H	63	0.707	0.241	12.60**	{H,Non}{L}
	Non	862	0.763	0.242		
	L	18	1.031	0.322		
	total	943	0.764	0.246		

*: $p<0.05$, **: $p<0.01$

Table 4. The result of ANOVA over 100K dataset

Similarly, Table 5 shows that three groups are well distinguished statistically than the result of 100K dataset. This result shows that our classification functions can be used as useful tools for detecting or pre-evaluating before prediction process.

1million	Group	N	mean	SD	F value	Duncan.
NBCFA	H	260	0.693	0.187	218.59**	{H}{Non}{L}
	Non	5690	0.744	0.222		
	L	90	1.228	0.314		
	total	6040	0.749	0.231		
CMA	H	260	0.674	0.190	201.20**	{H}{Non}{L}
	Non	5690	0.727	0.218		
	L	90	1.182	0.347		
	total	6040	0.731	0.226		

*: $p<0.05$, **: $p<0.01$

Table 5. The result of ANOVA over 1million dataset

7. Conclusion

As the extensive use of e-commerce through web-site increases, the need for other marketing approach is also increasing more than ever before. Increased concern by on-line company and academia has led to the development of numerous method and techniques that improve the performance of recommender system and promote customers' interests.

In this work we presented our research results in the area of collaborative filtering algorithm and other techniques to improve the performance of recommender systems which are one of the most important tools for the on-line marketing.

From our experimental results, it can be summarized as two main parts. One is algorithmic improvements for prediction accuracy and the other is possibilities of pre-evaluation methods using each user's rating pattern which is already collected in the system.

In the view point of algorithmic improvements, the followings are the results of this study.

First, the prediction performance of CMA on the view of accuracy is superior to that of NBCFA compared to all the results of user-based and item-based approaches. Second, the significance weight which makes up for overestimated preference relationships between target user and his or her neighbours, where the number of co-ratings is so small, contributes greatly to the accuracy of prediction. Also it is necessary to set the extended weighted range rather than existing N/50 ratings. Third, under the extending scale of recommender system, it is more efficient to run the recommender system controlling the increasing numbers of items than to control the increasing numbers of customers. Item-based approach which controls the numbers of items has the more accurate prediction results than those of user-based approach, but our another research which isn't presented on this work shows that the rank correlations between predicted values and real values of user-based approach are more accurate than those of item-based approach. This means that it would be needed to decide one of the two approaches between accurate prediction for rating and customer's preference rank for trade-off. It will be needed that the further research on this topic follows.

In the view point of pre-evaluation, the followings are the results of this study.

This work presents experimental results about setting the error bound for classifying the users who have lower prediction performance before prediction process using collaborative filtering algorithm in the recommender system. Through the statistical analysis, we have

significant results from the prediction result of the error bound. This result is not the approach of improving the prediction performance of algorithm, nor is the method of decreasing the prediction error, but it will be a useful basis for improving algorithms and also understand users' rating pattern better only by using already-existing ratings as pre-information before the prediction of users preferences about items.

Also, we show the evaluation performances of classification functions which classify users with lower or higher prediction accuracy before prediction processes using collaborative filtering algorithm in the Recommender System. With our statistical analysis, we show that applying classification functions before prediction process to the users' preference data would get meaningful results for pre-evaluating users' prediction accuracy. This is especially useful to detect users who have lower prediction accuracy before time consuming prediction process. Additionally, it would be helpful to protect recommender system from malicious attacker. However, this result also does not suggest the way to improve the users who have been classified by proposed classification functions or make clear the reason why these results are produced. It will be expected that further studies must be made in the near future.

In conclusion, it seems that in the near future, the field of recommender systems in e-business will attract even more interest from the research community. The increasing adoption of recommender system as a main tool for on-line marketing by prominent company and diverse field denotes its strategic role in on-line shopping environment.

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11

Attacks on Two Buyer-Seller Watermarking Protocols and an Improvement for Revocable Anonymity

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1. Introduction

The recent success of the Internet and the rapid development of information technology facilitate the proliferation of e-commerce, where all types of multimedia information can easily be stored, traded, replicated, and distributed in digital form without a loss of quality. As a main advantage over traditional commercial means, e-commerce brings convenience and efficiency for trading activities between sellers and buyers. However, it also enables illegal replications and distributions of digital products at a low cost. In this regard, there are many multimedia content providers still hesitating to sell and distribute their products over the Internet. Therefore, digital copyright protection is a main concern that needs to be addressed. On the other hand, how to protect the rights and provide security for both the seller and the buyer is another challenge for e-commerce.

In the realm of security, encryption and digital watermarking are recognized as promising techniques for copyright protection. *Encryption* is to prevent unauthorized access to a digital content. The limitation is that once the content is decrypted, it doesn't prevent illegal replications by an authorized user. *Digital watermarking* (Cox et al., 2001, 1997), (Hartung & Kutter, 1999), complementing encryption techniques, provides provable copyright ownership by imperceptibly embedding the seller's information in the distributed content. Similarly, *digital fingerprinting* is to trace and identify copyright violators by embedding the buyer's information in the distributed content.

The literature of fingerprinting research can be categorized as fingerprinting for generic data, e.g. c-secure fingerprinting code (Boneh & Shaw, 1995), fingerprinting for multimedia data (Wang et al., 2005), (Trappe et al., 2003), (Liu et al., 2005), and fingerprinting protocols, e.g. the ones based on secure two-party computations (Pittzmann & Schunter, 1996), (Pfitzmann & Waidner, 1997) or based on coin-based constructions (Pfitzmann & Sadeghi, 1999, 2000), (Camenisch, 2000).The shortcoming of these fingerprinting schemes lies in the inefficiency of the implementations (Ju et al., 2002). On the other hand, the literature can also be categorized as symmetric schemes, asymmetric schemes, and anonymous schemes. In *symmetric schemes* (Blakley et al., 1986), (Boneh & Shaw, 1995), (Cox et al., 1997), both the seller and the buyer know the watermark and the watermarked content.

Problem solved	(Memon& Wong)	(Ju et al.)	(Choi et al.)	(Goi et al.)	(Lei et al.)	(Zhang et al.)	(Shao)	(Ibrahim et al.)	Ours
Piracy tracing	√	√	√	√	√	√	√	√	√
Customer's rights	√	√	√	√	√	√	√	√	√
Unbinding					√	√	√	√	√
Conspiracy				√		√			√
Dispute resolution		√			√		√	√	√
Anonymity/unlinkability									√

Table 1. Comparison of some existing buyer-seller watermarking protocols with our protocol

As a consequence, it is possible for a malicious seller to frame an innocent buyer, or for an accused buyer to repudiate the guilt. This *customer's rights problem* in symmetric schemes was first pointed out (Qiao & Nahrstedt, 1998), and the problem can be solved by *asymmetric schemes* (Pittzmann & Schunter, 1996), (Pfitzmann & Waidner, 1997), (Biehl & Meyer, 1997) where only the buyer can obtain the exact watermarked or fingerprinted copy, and hence the buyer cannot claim that an pirated copy was originated from the seller. When a pirated copy is found, the seller is able to obtain a means to identify and prove the copyright violation to a trusted third party. Moreover, in order to provide the buyer's anonymity, *anonymous schemes* (Pfitzmann & Sadeghi, 1999, 2000) further make use of a registration service to eliminate the need of exposing the buyer's identity to the seller.

A *buyer-seller watermarking protocol* is one that combines encryption, digital watermarking, and other techniques to ensure rights protection for both the buyer and the seller in e-commerce. A complete and sound buyer-seller watermarking protocol is expected to solve the following problems.

1. **The piracy tracing problem:** once a pirated copy is found, the seller should be able to trace and identify the copyright violator.
2. **The customer's rights problem:** when a watermark is inserted solely by the seller, the seller may benefit from framing attacks to an innocent buyer or it causes unsettled disputes. On the other hand, the accused buyer of distributing an unauthorized copy may claim that the copy originated from the seller or there existed a security breach in the seller's system.
3. **The unbinding problem:** upon discovering a pirated copy, the seller can fabricate piracy by transplanting the buyer's watermark into another digital content. Therefore, it is necessary to bind a chosen watermark with a specific transaction.
4. **The anonymity problem:** the identity of a buyer should remain unexposed during transactions unless he is proven to be guilty.
5. **The conspiracy problem:** malicious parties may collude with each other and mount attacks to frame an innocent buyer or to confound the tracing by removing the watermark from the digital content.
6. **The dispute problem:** the arbitrator should be able to resolve disputes, without the buyer revealing his identity or private key.

Accordingly, a buyer-seller watermarking protocol should provide the following security properties as the strategic design principle.

1. **Traceability:** a copyright violator should be able to be traced and identified.

2. **Non-framing:** nobody can accuse an honest buyer.
3. **Non-repudiation:** a guilty buyer cannot deny his responsibility for a copyright violation caused by him.
4. **Dispute resolution:** the copyright violator should be identified and adjudicated without him revealing his private information, e.g. private keys or watermark.
5. **Conspiracy resistance:** no colluded parties should be able to frame an innocent buyer or to confound the tracing by removing the watermark from the digital content.
6. **Anonymity:** a buyer's identity is undisclosed until he is judged to be guilty.
7. **Unlinkability:** nobody can determine whether the different watermarked contents are purchased by the same buyer or not.

1.1 Analysis of the Existing Work

The literature is rich of relevant buyer-seller watermarking protocols. Qiao and Nahrstedt (Qiao & Nahrstedt, 1998), first pointed out the *customer's rights problem* in the watermarking protocols for piracy tracing. However, their scheme is symmetric and doesn't guarantee the buyer's security. The first known asymmetric buyer-seller watermark protocol was introduced by Memon and Wong (Memon & Wong, 2001), and it was improved by Ju et al. (Ju et al., 2002). Since the first introduction of the concept, several alternative design solutions have been proposed. Due to the space limit, instead of a full security analysis, we summarize the analysis and point out the shortcomings of each previous protocols (Choi et al., 2003), (Goi et al., 2004), (Lei et al., 2004), (Zhang et al., 2006), (Shao, 2007), and (Ibrahim et al., 2007). Except that the piracy tracing problem and the customer's rights problem are solved in the early schemes, the existing solutions to the other problems are either impractical or incomplete, as depicted in Table 1. Comparison of some existing buyer-seller watermarking protocols with our protocol

1. **The piracy tracing problem.** All of these protocols are able to resolve the piracy tracing problem, and provide a mechanism for the seller to trace and recover the identity of a guilty buyer.
2. **The customer's rights problem.** All these protocols can solve the customer's rights problem, since the protocols are designed asymmetric, i.e., the seller doesn't know the exact value of the buyer's watermark, neither does she know the final watermarked digital content that the buyer gets. Therefore, the accused buyer for a illegal replication or distribution cannot claim that the copy is originated from the seller or a security breach in the seller's system.
3. **The unbinding problem.** Lei et al. (Lei et al., 2004) addressed *the unbinding problem* in (Memon & Wong, 2001), (Ju et al., 2002), (Choi et al., 2003), (Goi et al., 2004) and provided a mechanism to bind a specific transaction of a digital content to a specific buyer, such that a malicious seller cannot transplant the watermark embedded in a digital content to another higher-priced content. The similar design principle is applied in (Zhang et al., 2006) and (Shao, 2007).
4. **The conspiracy problem.** Choi et al. (Choi et al., 2003) pointed out the *conspiracy problem* of (Memon & Wong, 2001), (Ju et al., 2002) where a malicious seller can collude with an untrustworthy third party to fabricate piracy to frame an innocent buyer. Goi et al. (Goi et al., 2004) found the conspiracy problem couldn't be solved through commutative cryptosystems of (Choi et al., 2003), and further point out that the schemes of (Memon & Wong, 2001), (Ju et al., 2002), (Choi et al., 2003) are vulnerable

against *conspiracy attacks*, and show that the protocol's security shouldn't rely on any third party. Zhang et al. (Zhang et al., 2006) apply the idea of (Goi et al., 2004)and ensure that the buyer's watermark is generated by the buyer, instead of a watermark certificate authority (*WCA*). According to our analysis, we conclude that the protocols of (Lei et al., 2004), (Shao, 2007), and (Ibrahim et al., 2007) cannot resist the conspiracy attack, where a malicious seller can collude with a third party, such that the seller can discover the buyer's watermark.

5. **The anonymity problem.** Memon and Wong's protocol (Memon & Wong, 2001) requires the seller to know the buyer's identity to carry out a transaction. Protocols of (Ju et al., 2002), (Choi et al., 2003) improve (Memon & Wong, 2001) by applying an anonymous key pair in each transaction. However, both protocols require the *WCA* to know the buyer's identity, which means that the buyer's anonymity is not preserved against conspiracy attacks. In (Goi et al., 2004), the buyer is required to request a signature from the certification authority (*CA*) of the public key infrastructure (*PKI*) to generate a watermark. However, (Goi et al., 2004) cannot solve the anonymity problem efficiently, since before each transaction, the buyer has to contact the *CA* for a new signature. (Lei et al., 2004), (Zhang et al., 2006), (Shao, 2007) apply anonymous certificates, i.e., digital certificates without real identities of applicants. Unfortunately, transaction unlinkability is not provided: during all transactions, the anonymous certificate stays the same, unless the buyer contacts the *CA* before each transaction for a new certificate, which is impractical for real life applications.
6. **The dispute problem.** Zhang et al. (Zhang et al., 2006) presented a scheme, derived from (Lei et al., 2004), where no trusted third party (*TTP*) is required in the watermark generation phase and the conspiracy problem is solved. Unfortunately, we find the existence of *dispute resolution problem* in (Zhang et al., 2006), in order to resolve disputes the buyer is required to cooperate and reveal his secret key or his secret watermark to the judge or to the *CA*, which is unrealistic in real-life applications. Similarly, schemes of (Memon & Wong, 2001), (Choi et al., 2003), (Goi et al., 2004) all require the accused but possible innocent buyer to disclose his identity or private key. Moreover, these protocols don't operate properly if the underlying cryptosystem is probabilistic, because the data encrypted by the judge or the *CA* may not be equal to the data provided by the seller. In (Ju et al., 2002), the buyer creates a key escrow cipher to escrow his anonymous private key at the judge. The problem is that the buyer's secrecy would not be protected against conspiracy attacks if the judge was malicious. In (Lei et al., 2004), the judge requests the buyer's watermark from the *WCA*, and hence the security depends on the trustworthiness of the *WCA*.

1.2 Our Approach

From the above analysis, we show that none of the existing protocols fulfils the design requirements. Our contribution of this paper is twofold: first, we analyze the security and present attacks on the protocols by Lei et al. (Lei et al., 2004), and Ibrahim et al. (Ibrahim et al., 2007), and prove that neither of them is able to provide security for the buyer and/or the seller as claimed. Further, both protocols require to employ deterministic cryptosystems. Unfortunately, all efficient privacy homomorphic cryptosystems are probabilistic (Fontaine & Galand, 2007), and both protocols require a privacy homomorphism for watermark insertion in the encrypted domain. In this regard, we can prove that both protocols are not

able to work properly as designed to be. Next, we point out that the buyer's anonymity or the transaction unlinkability is not provided by these two protocols. Second, we propose an anonymous buyer-seller watermarking protocol, which is secure and fair for both the seller and the buyer. Our protocol employs privacy homomorphic cryptosystems to protect the buyer's secret watermark, and group signature schemes to provide revocable anonymity of the buyer. The proposed protocol is an improvement of the early work (Deng & Preneel, 2008), (Zhang et al., 2006).

The rest of the paper is organized as follows. The security of the protocol by Lei et al. is analyzed in Sec. 0. The security of the protocol by Ibrahim et al. is analyzed in Sec. 0. Some cryptographic primitives are reviewed in Sec. 0. A generalized model of anonymous buyer-seller watermarking protocol is defined in Sec. 0. The proposed protocol is explained in Sec. 0. Finally, the security analysis is provided in Sec. 0 and the conclusion is drawn in Sec. 0.

2. Attacks on the Protocol of Lei et al.

In the protocol of (Lei et al., 2004), the players are the seller Alice *A*, the buyer Bob *B*, the certificate authority *CA*, the watermark certificate authority *WCA*, and the arbitrator *J*. The protocol comprises three phases, namely the registration protocol, the watermark generation and insertion protocol, and the identification and arbitration protocol. We provide an overview of the protocol in Fig. 1, Fig. 2, and Fig. 3. Notations are explained in Table 2. Notations and abbreviations

2.1 Attack on the Buyer's Security

Collusion of the seller and the *WCA*. In the protocol, Alice generates her watermark V and embeds V to the original content X, $X' = X \oplus V$. The *WCA* generates Bob's watermark W, and sends Alice the two encrypted values of W with Bob's encryption key pk_{B^*} and *WCA*'s encryption key pk_{WCA}, respectively. Alice embeds the encrypted watermarked, $E_{pk_{B^*}}(X'') = E_{pk_{B^*}}(X') \oplus E_{pk_{B^*}}(W)$. When malicious Alice colludes with an untrustworthy *WCA*, Alice sends $E_{pk_{B^*}}(W)$ back to the *WCA*. The *WCA* recovers W via decryption, and sends W to Alice. After Alice obtains W, she knows all the necessary information X, V, W to reproduce the watermarked content X'' for Bob.

Lei et al. assume that the *WCA* will not reveal Bob's information to Alice. However, the assumption is unrealistic. Because there is no technical enforcement for the *WCA* not to reveal any private information to Alice, the conspiracy attack is effective. Once Alice gets Bob's watermark, any important features of the protocol would end up getting compromised. First, the piracy traceability won't be achieved, since both the buyer and the seller might be the traitor. Second, non-framing fails, even though the unbinding problem is solved in the protocol. Alice is able to frame an innocent Bob by reproducing and redistributing the watermarked content X''. Third, non-repudiation fails, even though *B* doesn't know W and cannot remove W from X''. A malicious Bob can deny his guilt by claiming that the pirated copy was created by Alice or a security breach in Alice's computing system. In fact, this attack weakens the security for both the buyer and the seller.

$\mathcal{A}$	Alice, the seller and the copyright holder
$\mathcal{B}$	Bob, the buyer who purchases the desired digital contents from the seller
CA	A trustworthy certificate authority in the *PKI*
$\mathcal{J}$	An arbiter who adjudicates lawsuits against the infringement of copyright and intellectual property
WCA	A watermark certificate authority to generate or approve the watermark of the buyer
$E_{pk_i}(\cdot), D_{sk_i}(\cdot)$	Encryption and decryption operation
$sign_{sk_i}(m), \mathtt{Vf}(pk_i, m, sig)$	The signature creation and verification operation
$H(\cdot)$	A collision resistant hash function
UKg	The user key generation algorithm applied by a user i to obtain a personal public and private key pair
GSig	The group signing algorithm applied by a group member i to a message m
GVf	The group signature verification algorithm to verify the signature on m with the group public key gpk
Open	The opening algorithm applied by the opener to claim the identity of the group member who has produced the signature of m, and generate a proof of the claim
Judge	The judge algorithm which aims to verify that certain group member i produced a signature of m with a proof
ARG	An agreement between the buyer and the seller that uniquely binds the particular transaction to X
$Cert_{CA}(pk_B)$	Bob's anonymous certificate for pk_B issued by the CA
$Cert_{pk_B}(pk_B{}^*)$	Bob's anonymous certificate for $pk_B{}^*$ issued by Bob on the honer of pk_B
$Cert_C A(B)$	Bob's public key certificate issued the CA
$Cert_B$	Bob's certificate issued by CA in the group signature registration phase
B	The identity of Bob
X, X', X''	The original content, the watermarked content after the first embedding, the final watermarked content for Bob
$\oplus$	Watermark embedding operation
$det(X, Y)$	Non-blind watermark extraction operation with inputs as the watermarked content and the original content
$gpk, gmsk, gsk_B$	The group public key, group manager's secret key, and Bob's group signature key.
$(pk_B, sk_B), (upk_B, usk_B)$	Bob's key pairs used in the group joining phase
(pk_B^*, sk_B^*)	Bob's one-time anonymous public private key pair for each transaction
$reg[B]$	The registration table populated by the CA to store the group registration information of Bob
sig_B	Bob's signature to pk_B signed with usk_B
μ	Bob's group signature to pk_B^* signed with gsk_B
$e_{csc}, pf_{sk_B^*}$	Bob's key escrow cipher $E_{pk_{GA}}(sk_B^*)$ and its proof
V, W_A, W_B	V, W_A are the seller's watermarks, W_B is the buyer's watermark, generated in each transaction
1^k	If $k \in \mathbb{N}$, then 1^k denotes the string of k ones.

Table 2. Notations and abbreviations

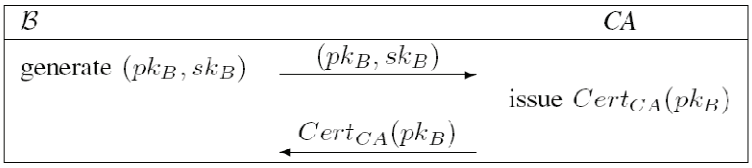


Fig. 1. The registration protocol in Lei et al.'s protocol (Lei et al., 2004).

2.2 Attack on the Seller's Security

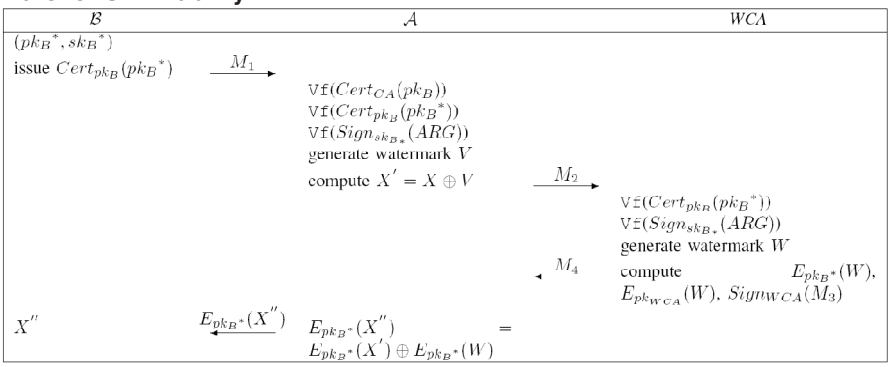
Collusion of the buyer and the *WCA*. Besides the conspiracy attack explained above, a malicious buyer and the untrustworthy *WCA* can also collude. In this case, the *WCA* informs Bob the actual value of W directly, so that it is possible for Bob to remove his watermark from the watermarked digital content. Therefore, non-repudiation won't hold, and the protocol fails to provide security for the seller.

2.3 Failure for Probabilistic Cryptosystems

In the arbitration and identification protocol, the WCA is required by the arbitrator J to decrypt $E_{pk_{WCA}}(W)$ and obtain the Bob's watermark W. Then J performs a validation on the correctness of the value $E_{pk_{WCA}}(W)$ sent by Alice, by computing the encryption of W obtained from the WCA with the buyer's public key pk_{B^*} as $E_{pk_{WCA}}(W)$. If $E_{pk_{B^*}}(W)$ is not

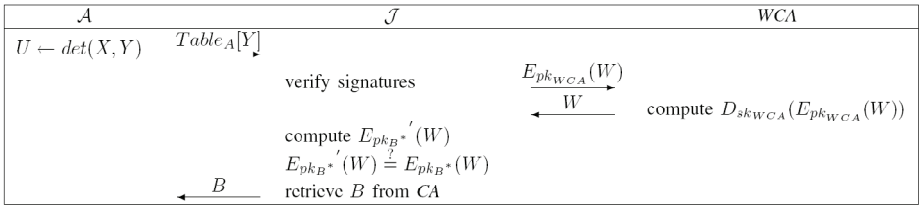
the same as $E_{pk_{B^*}}{}'(W)$, then J rejects the case and the protocol halts. It is obvious that this verification won't work using probabilistic cryptosystems. As explained in Sec. The buyer-seller watermarking protocol requires watermarking insertion to be performed in the encrypted domain, and it should be achieved by employing privacy homomorphic cryptosystems. However, all efficient privacy homomorphic cryptosystems are probabilistic (Fontaine & Galand, 2007). As a result, the protocol fails to function properly as claimed.

2.4 Failure for Unlinkability



Note: $M_1 = \{Cert_{CA}(pk_B), Cert_{pk_B}(pk_B{}^*), ARG, Sign_{sk_{B^*}}(ARG)\}$
$M_2 = \{Cert_{pk_B}(pk_B{}^*, ARG, Sign_{sk_{B^*}}(ARG), X'\}$
$M_3 = \{E_{pk_B{}^*}(W), pk_B{}^*, Sign_{sk_{B^*}}(ARG)\}$
$M_4 = \{E_{pk_B{}^*}(W), E_{pk_{WCA}}(W), Sign_{WCA}(M_3)\}$

Fig. 2. The watermark generation and insertion protocol in Lei et al.'s protocol (Lei et al., 2004).



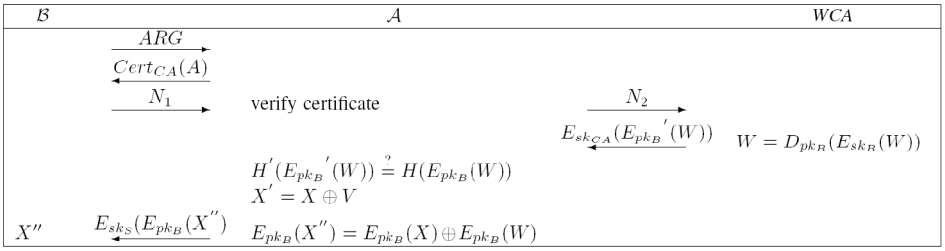
Note: $Table_A[Y] = \{Y, X' = X \oplus V, M_1, M_4\}$

Fig. 3. The identification and arbitration protocol in Lei et al.'s protocol (Lei et al., 2004).

In the protocol, Bob first obtains an anonymous certificate $Cert_{CA}(pk_B)$ from the *CA*, i.e., a digital certificate without the real identity of the applicant, in order to provide the buyer's anonymity. As Lei et al. claimed, by issuing the anonymous certificate to Bob, the *CA* is responsible for binding this anonymous certificate to Bob's identity. In each transaction with Alice, Bob generates an one-time key pair (pk_{B^*}, sk_{B^*}), and creates a certificate of pk_{B^*} on the honour of the certified public key pk_B. Unfortunately, the protocol fails to provide transaction unlinkability: during all transactions from the seller to the buyer, the public key anonymous certificate $Cert_{CA}(pk_B)$ stays the same, unless the buyer contacts the *CA* before each transaction to acquire a new certificate, which is impractical for real-life applications.

3. Attacks on the Protocol of Ibrahim et al.

The players involved in the protocol (Ibrahim et al., 2007), are the seller A, the buyer B, the certificate authority CA, and the arbitrator J. The protocol comprises two phases, namely the watermark generation and insertion protocol and the identification and arbitration protocol. The watermark generation and insertion protocol is reviewed in Fig. 4.



Note: $N_1 = \{E_{pk_B}(W), E_{sk_B}(H(ARG)), E_{pk_{CA}}(E_{sk_B}(W)), E_{sk_B}(H(H(ARG)) + H(W)), Cert_CA(B)\}$
$N_2 = \{E_{pk_{CA}}(E_{sk_B}(W)), Cert_CA(B)\}$

Fig. 4. The watermark generation and insertion protocol in Ibrahim et al.'s protocol (Ibrahim et al., 2007).

3.1 Attack on the Seller's Security

In the protocol, Bob generates his secret watermark W, and W is approved by the CA. The watermarked content is $X'' = X \oplus V \oplus W$, V is Alice's watermark. Since Bob knows W, it is possible for Bob to remove his watermark W from the watermarked content X''. Hence, the protocol fails to provide non-repudiation and traitor traceability.

Ibrahim et al. assume that it is impossible for Bob to remove W from X'', because Bob doesn't have access of the original content X nor the watermark embedding algorithm. Unfortunately, the assumption is unrealistic, and it can be combated by employing a blind watermarking scheme (Kutter & Petitcolas, 1999), (Eggers et al., 2000), where the original content is not required to remove the watermark. On the other hand, there is no technical enforcement to ensure that Bob can't get the knowledge of the watermarking algorithm employed in the protocol. In fact, according to Kerckhoffs' principle in cryptography, "a cryptosystem should be secure even if everything about the system, except the key, is public knowledge." "The system must not require secrecy and can be stolen by the enemy without causing trouble" (Kerckhoffs, 1883). Therefore, the attack is effective and non-repudiation fails. The protocol fails to provide both the basic requirement of traitor traceability and the seller's security.

3.2 Failure for Probabilistic Cryptosystems

In the watermark generation and insertion protocol, after Alice receives the encrypted value $E_{SK_{CA}}(E_{PK_B}'(W))$ from the CA, Alice decrypts $E_{SK_{CA}}(E_{PK_B}'(W))$ using the CA's public key pk_{CA}, and then computes the message digest of the result $E_{PK_B}'(W)$, as $H'(E_{PK_B}'(W))$. Next, Alice computes the message digest of $E_{PK_B}(W)$ sent earlier by Bob, as $H(E_{PK_B}(W))$. Alice compares $H'(E_{PK_B}'(W))$ and $H(E_{PK_B}(W))$. The protocol continues if they equal, else the

protocol halts. Therefore, the protocol fails with probabilistic cryptosystems, because $E_{PK_B}{}'(W)$ computed by the CA and $E_{PK_B}(W)$ provided by Bob would be different. Then Alice would consider the protocol failed, and halt the protocol. Following the same reasoning of the similar attack on the Lei et al.'s protocol, we can prove that the protocol fails to employ privacy homomorphic probabilistic cryptosystems.

3.3 Failure for Anonymity and Unlinkability

The protocol doesn't specify the registration subprotocol. In each transaction with Alice, Bob provides Alice his PKI certificate $Cert_{CA}(B)$ issued by a trustworthy CA. Since $Cert_{CA}(B)$ is not an anonymous certificate, Alice can identify Bob. Therefore, Bob's anonymity is not preserved whatsoever. It is clear that the protocol fails to provide anonymity and unlinkability for the buyer.

4. Cryptographic Primitives

4.1 Privacy Homomorphism

A privacy homomorphism refers to a cryptosystem E which is homomorphic with respect to some binary operators $\circ_M$ in the plaintext space M and $\circ_C$ in the ciphertext space C, such that

$$\forall m_1, m_2 \in M : E(m_1 \circ_M m_2) = E(m_1) \circ_C E(m_2)$$

Homomorphic cryptosystems can be classified as two groups, namely those security relies on the "*decisional composite residuosity assumption" (DCRA)*, and those of the *ElGamal* class based on "*decisional Diffie-Hellman assumption" (DDH)*. The strongest security level a privacy homomorphism can reach is *IND-CPA*, instead of *IND-CCA2*. The state of the art of privacy homomorphic cryptosystems is presented in (Fontaine & Galand, 2007). For instance, the deterministic *RSA cryptosystem* (Rivest et al., 1978) and the *ElGamal cryptosystem* (ElGamal, 1985) are multiplicative privacy homomorphism. In contrast to deterministic *RSA*, *ElGamal* is *IND-CPA*. The *Goldwasser-Micali cryptosystem* (Goldwasser & Micali, 1982), the *Paillier cryptosystem* (Paillier, 1999), and *Paillier's* generalization the *Damgård-Jurik cryptosystem* (Damgåard & Jurik, 2001) are additive privacy homomorphism.

4.2 Group Signature

Group signatures (Chaum & van Heyst, 1991), (Camenisch & Stadler, 1997) enable group members, each with its own private signature key to produce signatures on behalf of the group. Group signature schemes can either be for static groups, where the identities of group members are fixed in the group setup phase; or for dynamic groups, which allow to update group members with time. Dynamic schemes have the advantage that instead of assigning a high level of trust to a single group manager, the group manager is separated as an issuer, to issue private signature keys to the group members, and an opener, to open signatures. This provides more security with a lower level of trust. The security properties of static and dynamic group signature schemes are formalized in (Bellare et al., 2003, 2005) as follows:

1) **Anonymity** allows group members to create signatures anonymously, such that it is hard for an adversary, not in possession of the group manager's opening key to recover the identity of the signer.
2) **Traceability** permits the signer's anonymity to be revoked by the group manager in case of misuse, and ensures that no colluded group members can create unverifiable signatures, or signatures that can't be traced back to some member of the coalition.
3) **Non-frameability** requires that no adversary can produce a signature in the name of a user unless the latter indeed produced it.

4.3 Verifiable Encryption

Verifiable encryption schemes enable the encrypter to ensure that the plaintext satisfies certain application-dependent properties without compromising secrecy. It can be employed in numerous applications including escrow schemes (Young & Yung, 1998), (Poupard & Stern, 2000), group signature and identity escrow schemes (Ateniese et al., 2000), (Kilian & Petrank, 1998), and digital payment with revocable anonymity (Frankel et al., 1996), (Camenisch et al., 1996). Specific schemes are proposed in (Camenisch & Shoup, 2003) for both discrete-log based and factoring based schemes. In our proposed scheme, verifiable encryption is used for key escrow, such that the buyer can prove to the seller that the plaintext is valid without revealing any private information, and hence the buyer's privacy is preserved.

5. Model of Anonymous Buyer-Seller Watermarking Protocols

Let $X_0 \in \{0,1\}^*$ be the cover data, X be the set of all watermarked copies of X_0, and k be a security parameter as a common input for all algorithms. An anonymous buyer-seller watermarking protocol involves four parties: a seller Alice A that is the copyright holder, a buyer Bob B, a certificate authority CA that functions as a group manager, and a judge J that adjudicates lawsuits against the infringement of copyrights. The protocol consists of the following three subprotocols.

1. *Reg*: the registration protocol consists of an algorithm *Set-CA* and a protocol *Reg-CAB*. *Set-CA* is a probabilistic key setup algorithm to generate group manager's public key gpk and private keys (ok, ik) of the *CA*. *Reg-CAB* is a probabilistic two-party protocol (*Reg-CA, Reg-B*) between the *CA* and the buyer *B*. Their common input are *B*'s identity B and gpk. The *CA*'s secret input is (ok, ik). *B*'s output is his private group signature key gsk_B. The *CA* stores *B*'s group certificate $Cert_B$ and the buyer's identity B in a registration table as $reg[B]$.
2. *WK*: a two-party protocol (*WK-A,WK-B*) between the seller *A* and the buyer *B*. Their common input is gpk. *A*'s secret input are the cover data X_0 and a transaction number ϕ, and *A*'s output is a transaction record in $Table_A$. *B*'s secret input is *B*'s group signature key gsk_B, and *B*'s output is a watermarked copy $X' \in \mathrm{X}$.

3. *Arb*: a three-party protocol (*Arb-A, Arb-J, Arb-CA*) among *A*, *J*, and the *CA*. *A* and *J* 's input are a pirated copy $Y \in \mathrm{X}$, the cover data X_0, and a record in $Table_A$. The *CA*'s input are (gpk, ok, ik) and the list of buyer's certificates in the registration table reg. The *CA*'s output is the identity id of a guilty buyer with a proof τ. *J* verifies τ and provides *A* the output as id or an empty string ε in case of failure.

Note that the registration protocol *Reg* is required to be performed once in the setup-phase by the *CA* for each new buyer. The watermarking protocol WK should be executed multiple times for multiple transactions between the buyer and the seller. The arbitration protocol *Arb* is executed for dispute resolution.

6. Proposed Protocol

The proposed buyer-seller watermarking protocol involves four players: the seller Alice, the buyer Bob, the trustworthy *CA* that functions as a group manager, and an arbitrator. The protocol consists of three phases. First, Bob registers at the *CA* before the purchase in the registration protocol. Second, Bob only needs to contact Alice during transactions in the watermark generation and insertion protocol. Third, in case Alice found a pirated copy, the identification and arbitration protocol enables her to identify the copyright violator, with the help of the judge and the *CA*.

The following assumptions should hold in the protocol, otherwise, the security properties cannot be guaranteed. We assume a public key infrastructure *PKI* is well deployed, such that each entity has a *PKI* certificate issued by the *CA*. The *CA* is assumed to be trustworthy, because the *PKI* should be secure. For consistency, we assume that the digital content is a still image, although the protocol can be applied to other multimedia formats such as audio or video. Note that the security of the protocol depends on the security of the underlying watermarking and cryptographic building blocks. Hence, the watermarking scheme employed should be collusion resistant. In particular, nobody is able to detect and delete the embedded watermark from a content without knowing the watermark. Our scheme employs the privacy homomorphism of the Paillier cryptosystem (Paillier, 1999) and Cox et al.'s robust collusion resistant watermarking scheme (Cox et al., 1997). Camenisch et al.'s verifiable encryption scheme (Camenisch & Shoup, 2003) is employed for the key escrow of the buyer's private key at the *CA*, such that the buyer can prove to the seller that the plaintext is valid without revealing the secrecy. We choose to employ the dynamic group signature proposed by Bellare et al. (Bellare et al., 2005) as an example.

6.1 Registration Protocol

The registration protocol, performed between the buyer Bob and the *CA*, is depicted in Fig. **5**.

1) In the group key generation phase, the CA generates a tuple $(gpk, gmsk)$. The group public key gpk consists of a public encryption key pk_e, a certificate verification key pk_s, and some security parameters. The manager secret key $gmsk$ is the decryption key sk_e corresponding to pk_e. The certificate creation key is sk_s, corresponding to pk_s.

CA		$\mathcal{B}$
1. group key generation $gpk \leftarrow (pk_e, pk_s), gmsk \leftarrow sk_e$	$\xleftrightarrow{Secure}$	
		2. user key generation $(upk_B, usk_B) \leftarrow \mathtt{UKg}(\mathbf{1}^k)$
3. group joining		$(pk_B, sk_B) \leftarrow K_s(1^k)$
	$\xleftarrow{pk_B, sig_B}$	$sig_B \leftarrow \mathtt{Sign}_{usk_B}(pk_B)$
$\mathtt{if\ Vf}(upk_B, pk_B, sig_B) = 1\ \mathtt{then}$ $Cert_B \leftarrow Cert(sk_s, (B, pk_B))$ $reg[B] \leftarrow (pk_B, sig_B)$		
$\mathtt{else}\ cert_B \leftarrow \varepsilon$	$\xrightarrow{Cert_B}$	
		$gsk_B \leftarrow (B, pk_B, sk_B, Cert_B)$

Fig. 5. The registration protocol performed between the buyer *B* and the *CA*.

$\mathcal{A}$		$\mathcal{B}$
	$\xleftarrow{ARG}$	$(pk^*_B, sk^*_B) \leftarrow K_B(1^n)$ $\mu = \mathtt{GSig}(gsk_B, pk^*_B)$ $e_{esc} = E_{pk_{CA}}(sk^*_B)$, proof $pf_{sk^*_B}$ for e_{esc}
group signature verification $GVf(gpk, (pk^*_B, \mu))$ $\mathtt{Vf}(pk^*_B, sign_{sk^*_B}(m))$ $\mathtt{Vf}(pf_{sk^*_B}, E_{esc})$ generate VW_A $X' = X \oplus V, W \leftarrow (W_A, W_B)$ $E_{pk_B{}^*}(X'') = E_{pk_B{}^*}(X') \oplus E_{pk_B{}^*}(W)$	$\xleftarrow{m_1}$	generate $W_B, ew_B = E_{pk^*_B}(W_B)$
$Table_A[B] \leftarrow (V, W_A, m_1)$	$\xrightarrow{E_{pk^*_B}(X'')}$	obtain X'' with sk^*_B

Note: $m = \{pk^*_B, \mu, ARG, ew_B, pf_{sk^*_B}, e_{esc}\}, m_1 = \{m, sign_{sk^*_B}(m)\}$

Fig. 6. The watermark generation and embedding protocol performed between the seller *A* and the buyer *B*.

$\mathcal{A}$		$\mathcal{J}$		$\mathcal{CA}$
$U \leftarrow \mathtt{Det}(X, Y)$	$\xleftrightarrow{Table_A[Y], X'}$			
		$\mathtt{Vf}(pk^*_B, sign_{sk^*_B}(m))$	$\xrightarrow{e_{esc}}$	
			$\xleftarrow{E_{pk_J}(sk^*_B)}$	$sk^*_B = D_{sk_{CA}}(e_{esc})$
		$W_B = D_{sk^*_B}(ew_B)$ $sk^*_B = D_{sk_J}(E_{pk_J}(sk^*_B))$ $W \leftarrow (W_A, W_B)$ $W' \leftarrow \mathtt{Det}(X, Y)$		
		$W' \stackrel{?}{=} W$	$\xrightarrow{\mu, pk^*_B}$	$(B, \tau) \leftarrow \mathtt{Open}(gmsk, reg[], pk^*_B, \mu)$
	$\xleftarrow{B}$	$\mathtt{Judge}(gpk, B, upk_B, pk^*_B, \mu, \tau)$	$\xleftarrow{B, \tau}$	

Note: $\mu = \mathtt{GSig}(gsk_B, pk^*_B)$

Fig. 7. The copyright violator identification and arbitration protocol performed among the seller *A*, the judge *J*, and the *CA*.

2) To join the group, Bob generates a public and private key pair (upk_B, usk_B), and a signing and verifiction key pair (pk_B, sk_B). Bob sends to the CA his signature sig_B on pk_B with the key usk_B.
3) After the signature is verified, the CA issues the group membership to Bob by issuing a certificate of pk_B and Bob's identity B. Then the CA stores Bob's public key and Bob's signature (pk_B, sig_B) in the registration table reg.
4) Bob receives the certificate $Cert_B$ and derives his group signature key gsk_B from the tuple $(B, pk_B, sk_{B,} Cert_B)$.

6.2 Watermark Generation and Embedding Protocol

The watermark generation and insertion protocol, as depicted in Fig. **6**, can be executed multiple times for multiple transactions between the seller Alice and the buyer Bob. In order to uniquely bind a particular transaction to the item of interest X, Alice and Bob first negotiate a purchase agreement *ARG* on transaction specifications.

1) Bob generates a one-time anonymous public and private key pair (pk_{B^*}, sk_{B^*}), and signs the public key pk_{B^*} with his group signature key gsk_B. For key escrow, Bob encrypts the secret key sk_{B^*} with the *CA*'s encryption key pk_{CA}, and computes a verifiable proof $pf_{sk_{B^*}}$ for the escrow cipher e_{esc}, in order to assure Alice that the encrypted message is valid without compromising sk_{B^*}. For each transaction, Bob generates a unique watermark W_B, in compliance with the features of the content X for robustness, and transfers the encrypted watermark and all the other public information m to Alice.
2) Alice verifies Bob's signature and verifiable proof, as well as Bob's group signature on his anonymous public key. Similarly, Alice generates two unique watermarks V and W_A for each transaction. The first round of watermark insertion is performed as:

$$X' = X \oplus V \tag{1}$$

Note that the sole purpose of V, is to be used as a key to search the sales record in case Alice finds a pirated copy of her products (Memon & Wong, 2001), (Lei et al., 2004).

3) Alice computes the composite watermark W in the encrypted domain by employing privacy homomorphism:

$$E_{pk_{B^*}}(W) = E_{pk_{B^*}}(W_A) \times E_{pk_{B^*}}(W_B) = E_{pk_{B^*}}(W_A + W_B) \tag{2}$$

4) Alice performs the second round of watermark insertion:

$$E_{pk_{B^*}}(X'') = E_{pk_{B^*}}(X') \otimes E_{pk_{B^*}}(W) = E_{pk_{B^*}}(X' \oplus W) \quad (3)$$

Where $\oplus$ denotes the watermark insertion operation in the message space, and $\otimes$ denotes the corresponding operation in the encrypted domain. Note that the computation is possible because we assume the encryption $E_{pk_{B^*}}(\bullet)$ is privacy homomorphic with respect to $\oplus$. Alice stores W_A, V, W_A and Bob's information in $Table_A$, and delivers the encrypted content X'' to Bob.

5) After decryption $D_{sk_{B^*}}(E_{pk_{B^*}}(W))$, Bob obtains the watermarked content X'' from Alice.

6.3 Identification and Arbitration Protocol

The identification and arbitration protocol is executed among the seller Alice *A*, an judge *J*, and the *CA*, as depicted in Fig. **7**.

1) In case Alice finds a pirated copy Y of X, she extracts the watermark U from Y, and searches the sales record by correlating U with every V in $Table_A$. Then she provides all relevant information together with the intermediate watermarked content X' to *J*.
2) If the signature provided by Alice is verified, *J* accepts the case and forwards the seller's key escrow cipher to the *CA* to recover the private key of the buyer.
3) The *CA* decrypts the cipher, recovers the key, and returns the encrypted value $E_{pk_J}(sk_{B^*})$ to *J*.
4) After *J* obtains the buyer's key by decryption $D_{sk_J}(E_{pk_J}(sk_{B^*}))$, he further obtains the buyer's secret watermark $W = D_{sk_{B^*}}(ew)$. Then *J* compares the extracted watermark from X' and Y provided by Alice, with the one that is derived from the recovered watermarks (W_A, W_B) from the buyer and the seller. If they match with a high correlation, the suspected buyer is proven to be guilty. Otherwise, the buyer is innocent. Note that until now, the buyer's identity is unexposed.
5) To recover the buyer's identity, *J* orders the *CA* to open the buyer's group signature, with the group manager's secret key $gmsk$.
6) Upon receiving the recovered identity B and a claim proof τ, *J* verifies the *CA*'s claim.
7) If verified, *J* closes the case and announces that the buyer with identity B is guilty.

7. Security Analysis

In this section, we analyze the security properties of the proposed scheme. The soundness and completeness of the protocol rely on the security and robustness of the underlying cryptographic and watermarking primitives.

1. **Non-framing (buyer's security).** Alice only knows the encrypted content $E_{pk_{B^*}}(X'')$, but she doesn't know the watermarked content delivered to Bob X'', neither does she know Bob's secret watermark W_B. Therefore, Alice cannot accuse Bob by distributing replicas of X'' herself. That is, the customer's rights problem is solved. On the other hand, Bob is able to generate his watermark and there is no third party involved in the watermark generation phase. Therefore, Alice cannot recover Bob's watermark via conspiracy attacks. Further, the unbinding problem is solved because Alice can't forge Bob's signature that explicitly binds $E_{pk_{B^*}}(W_B)$, pk_{B^*} to *ARG*, which in turn binds to a particular transaction of X. In this regard, it is infeasible for Alice to transplant Bob's watermark to another content to fabricate piracy.
2. **Non repudiation (seller's security).** Bob only knows his watermark W_B, but not the composite watermark W generated from the watermarks of Alice and Bob. On the other hand, there is no third party involved in the protocol, so Bob cannot obtain any secret information via conspiracy attacks. Therefore, it is infeasible for Bob to remove his watermark W_B from the watermarked content X'', neither can he claim that the copy was created by Alice or a security breach of Alice's system. Because only Bob knows sk_{B^*} and W_B, no one can forge Bob's copy.
3. **Traceability.** The protocol provides a mechanism that, once a pirated copy is found, Alice can provide the judge with sufficient information related to the particular transaction. The judge is able to identify the privacy violator with the help of the *CA*, due to the traceability property of the underlying group signature scheme.
4. **Dispute resolution.** When a dispute occurs, even without Bob providing his secret key sk_{B^*} or his secret watermark W_B, the judge can still recover sk_{B^*} from the *CA*, with the help of the key escrow cipher e_{esc} and the proof $pf_{sk_{B^*}}$. Once sk_{B^*} is recovered, the judge knows W and can further arbitrate if the suspected Bob is guilty or not.
5. **Conspiracy resistance.** Bob is able to generate his own wat ermark and there is no third party involved in the watermark generation and insertion protocol. It enables the scheme to be conspiracy resistant.
6. **Revocable anonymity.** The essential protection of the buyer's privacy is by taking advantage of the group signature scheme and the one-time anonymous public and private key pair. Before the purchase, Bob requests a group signature key gsk_B from the trustworthy *CA*, which in turn takes responsibility to bind Bob's signature key to Bob's identity. In each transaction with Alice, Bob uses an anonymous public and private key pair (pk_{B^*}, sk_{B^*}) and generates a signature μ to pk_{B^*} with the group signature key gsk_B. By the anonymity property introduced by the underlying group signature scheme (Bellare et al., 2005), it is computationally infeasible for an adversary, not in possession of the opener's opening key ok, to recover the identity of the signer from its signature. Note that the *CA* is trustworthy, otherwise the group signature

scheme would not be secure. In case of disputes, Alice collects the transaction information and sends μ, pk_{B^*}, *ARG*, ew_B, $pf_{sk_{B^*}}$ and e_{esc} to the judge for arbitration. The information can only prove someone with an anonymous key pk_{B^*} has bought the product X, but it doesn't disclose the identity of Bob. Only when Bob is adjudicated to be guilty, the judge can send a legal order for the *CA* to recover Bob's identity. Therefore, Bob's anonymity is not revoked by the *CA* only until he is adjudicated to be guilty.

7. **Unlinkability.** Unlinkability is provided in the proposed protocol because of the unlinkability property introduced by the underlying group signature and Bob's one-time key pair (pk_{B^*}, sk_{B^*}). Given the list of sales information, no one can relate two transactions together as if they were from the same buyer.
8. **Mutual authentication.** Man-in-the-middle attacks on the protocol are infeasible. First, the *PKI* is well deployed to ensure mutual authentication between entities, as the basic requirement of a secure protocol. Second, all messages are transferred in a secure communication channel, such that eavesdropping is infeasible.

8. Conclusion

In this paper, we present attacks on two buyer-seller watermarking protocols proposed by Lei et al. (Lei et al., 2004) and Ibrahim et al. (Ibrahim et al., 2007), and prove that neither of these protocols is able to provide security for the buyer or the seller as claimed. Further, we point out that both protocols are not able to work properly when employing homomorphic probabilistic cryptosystems. We also address the anonymity and unlinkability problem in these protocols. We propose an improved protocol, which is secure and fair for both the seller and the buyer. Our protocol employs privacy homomorphic cryptosystems and group signature schemes, in order to protect the secrecy of the buyer and the seller, and to preserve revocable anonymity of the buyer. Comparing with early work, our scheme is able to provide all the required security properties of a secure and anonymous buyer-seller watermarking protocol, namely non-framing, non-repudiation, traceability, mutual authentication, dispute resolution, anonymity and unlinkability.

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Electronic Commerce Readiness in Developing Countries: The Case of the Chinese Grocery Industry

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1. Introduction

Electronic Commerce (e-Commerce) offers many potential benefits particularly in productivity gains and transaction cost reductions, mainly by enabling organisations to conduct business transactions electronically, facilitating efficient information sharing between organisations within and across industries and allowing automatic product identification. The rapid dissemination of information, the digitisation of record keeping and the networking capability of the Internet has improved flexibility and responsiveness and encouraged new and more efficient intermediaries. It has increased the use of outsourcing, expanded market access, reduced time to market by linking orders to production and improved internal coordination. Because of its potential in this era of globalisation, many countries have rapidly adopted e-Commerce (Andersen et al. 2003; Bean 2006; Gibbs and Kraemer 2004).

E-Commerce is also seen to play a significant role in bridging the digital gap between developed and developing worlds through improving developing countries' access to information, knowledge and expertise and enabling organisations around the world to extend their supply chain and to engage in global trading efficiently and effectively regardless of their geographical locations. Consequently, e-Commerce has the potential to enhance developing countries' competitiveness and reduce poverty (Qureshi 2005; Qureshi and Davis 2007). Nevertheless, contradictory findings have been discovered in several studies which highlight that e-Commerce further marginalises developing nations and widens the digital divide (Odera-Straub 2003).

At this stage, the e-Commerce adoption has been concentrated in developed countries. According to The United Nations Conference on Trade and Development (UNCTAD), 95% of e-Commerce takes place in developed countries, with Africa and Latin America combined accounting for less than 1% of the total (UNCTAD 2005). In 2008, only 3% of the developing countries had access to Broadband Internet, in sharp contrast to the 28% penetration rate enjoyed by developed nations (AGENCIES 2008). These figures demystify the digital divide that exists between developed and developing nations.

The fact that developing countries have lagged behind developed countries in the adoption of e-Commerce technology and those e-Commerce-enabled applications to support

Business-to-Business transactions (B2B e-Commerce) has created significant challenges to achieving global advanced supply chain management. B2B e-Commerce technologies are by nature inter-organisational systems and as such, they cannot be adopted in isolation from other trading partners. In addition, B2B e-Commerce technologies and applications were generally developed in Western countries that have very different national environmental backgrounds to those of developing countries, in areas such as legislation, technology infrastructure, competition, financial resources, labour rates and regional ways of doing business. As a result, differences in the readiness between developed and developing nations in adopting e-Commerce have been observed in many studies (Gibbs et al. 2003; Molla 2004) and, therefore, developing countries are facing a uniquely challenging environment in the course of e-Commerce adoption (Bean 2006).

This chapter presents the current situation in China and its readiness in e-Commerce adoption. China is used as an example of a developing country in the chapter because it is one of the major trading partners of many developed countries. The chapter specifically explores the Chinese grocery industry to illustrate the relevance of B2B e-Commerce, the current level of adoption and challenges faced. The grocery industry has been chosen because the industry has been pioneering the use of technologies to improve efficiency. This is due to the nature of the industry, which involves high-volume transactions with low profit margins. By systematically assessing the Chinese grocery industry's readiness on the organisational, industrial and national level, this chapter highlights the unique challenges faced by organisations in China in adopting e-Commerce and the opportunities offered through the adoption of e-Commerce. Lessons learned and the implications of the study are discussed to conclude the chapter.

2. E-Commerce in China

In contrast to western countries, China is one of the late adopters of e-Commerce, since the majority of the IT/e-Commerce infrastructure was not established until the late 1990s (Tan and Wu 2004). However, China was able to catch up with the rest of the world in the adoption of e-Commerce technologies including email, websites, intranets, extranets and mobile technologies (Tan and Wu 2004; Xu et al. 2004). On the other hand, the leapfrog approach to adoption has caused the deficient deployment of traditional e-Commerce technologies such as Electronic Data Interchange (EDI) and Electronic Funds Transfer (EFT). This has severely restricted China's e-Commerce development despite the widespread adoption of other e-Commerce technologies (Dedrick and Kraemer 2001; Tan and Wu 2004; Trappey and Trappey 2001; Xu et al. 2004).

The overall e-Commerce development and diffusion in China varies widely according to different geographic locations, industrial fields and firm sizes. Large cities and economically-advanced provinces along the coastline generally have access to better IT infrastructures and more Internet users than remote and poorer provinces. Information-intensive industries such as banking and insurance are better at adopting any information-related technologies. The current e-Commerce activities in China are concentrated in large cities, coastal provinces, certain industries, large enterprises and among well-educated young people (Tan and Wu 2004). According to International Data Corporation estimates, e-Commerce revenues in China totalled US$2.2 billion in 2000 with B2B accounting for

US$1.68 billion and Business-to-Consumer (B2C) accounting for US$522 million (Dedrick and Kraemer 2001).

As identified by the survey carried out by Tan and Wu (2004), the top 4 drivers for e-Commerce adoption in China are: market expansion for existing products, customer demand, entering new markets and cost reduction. In general, wholesale and retail firms consider "customer demand" as the most important driver. Small firms are also subject to stronger pressure from customer demand than large firms, while large corporations benefit from stronger government incentives than small firms. In addition, global firms also face heavier pressure to use e-Commerce due to increased international competition and hence the need to coordinate their operations more effectively across national borders has been recognised (Kraemer et al. 2005).

E-Commerce development in China is also influenced by the unique characteristics of the state. As an authoritarian state, the Chinese government plays an extremely prominent role in influencing e-Commerce adoption. The nature of the state has both positive and negative impacts on the progress of e-Commerce development in the country. On the positive side, in order to attract foreign investment to rebuild the ravaged economy under the strict Communist rule, the Chinese government has endeavoured to build an attractive investment environment. This includes an effective IT infrastructure and an e-Commerce-friendly government policy (Chen et al. 2005; Gibbs and Kraemer ; Xu et al. 2004).

Government efforts to promote IT began in 1986 through the establishment of the 863 plan, a technology development scheme that includes promotion of IT production and use. The most significant projects were the series of Golden projects, including the Golden Bridge National Data Network and other projects aimed at developing IT infrastructure and applications. IT moved further to the forefront in the tenth Five-Year Plan, 2001-2005. The plan states that "*information technology should be used extensively in all circles of society and use of computers and Internet should be wide-spread*". In addition, the plan calls for the development of Electronic Commerce and the use of information technology in commercial sectors. The tenth Five-Year plan earmarks 1.7 trillion Yuan (US$200 billion) for spending on information and communication technologies. Of this amount, about 1.2 trillion goes into telecommunications while 400 billion goes into electronic manufacturing. In order to coordinate its efforts to improve telecommunication and promote IT, the government is allegedly setting up a new high-level telecommunications commission directly under that State Council.

On the negative side, the Chinese government still seeks to control the flow of information and restricts foreign participation in telecommunication, Internet and information content provision. In fact, there are still some powerful and privileged interests in China that are resisting the transition to e-Commerce as the Internet has already undermined the Chinese Communist Party's monopoly on "public" information (Martinsons 2001). As a result, encryption regulations have been established, forbidding Chinese firms from using any foreign-made standalone encryption products. The only legitimate encryption products are the ones made in China and registered with the new State Encryption Management Commission, which consequently gives the state a means of monitoring computer traffic. Therefore, safeguarding privacy, security and encryption have become major concerns for many Chinese organisations in relation to e-Commerce adoption.

Overall, the e-Commerce development in China is still at its very early stage. With strong support from the Chinese government and increasing customer demand, a significant

growth in e-Commerce activities has been experienced in the past decade. However, its future development is not without obstacles. As the degree of e-Commerce sophistication increases, along with the need to share information, a range of technical and non-technical barriers is expected to come into effect, hindering further development.

3. The Chinese Grocery Industry

Because of the changes in the political, social and economic environments, the Chinese grocery industry has evolved over time, developing numerous retail formats from wet markets, retail-cooperatives to supermarkets. Table 1 summarises the evolution of the Chinese grocery industry.

Year	Format	Description
Before 1949	Wet markets, street markets, small shops	These were private retail sectors. Distribution system was virtually nonexistent. Grocery needs were fulfilled locally.
1953-1958	Retail co-operatives, State-owned enterprises (SOE)	Chinese Communist Party (CCP) dictated a state-controlled economy. Private retailers were either formed into retail co-operatives or bought out to establish SOEs to sell basic food at low prices.
1959-1980	State-owned enterprises (SOE)	CCP expanded the control on China's economic activities and extended SOE retail sector to urban areas
1981-1990	Wet markets, provisional shops, staple food stores, supermarkets (marginal-player)	Economic liberalisation began. Wet markets and small shops that sell grocery items in the urban areas started to flourish again. In March 1981 the first supermarket in China catering for foreign tourists was established in Guangzhou.
1990s	Supermarkets, wet markets street markets, staple food stores	The supermarket format experienced an exponential growth in the large cities and special economic zones due to their consumers' high purchasing power.
Late 1990s – now	Supermarkets, wet markets, street markets	Supermarkets started to move into other cities in the eastern region and extended into large cities in the central region.

Table 1. The Evolution of the Chinese Grocery Industry

Before the Chinese Communist Party (CCP) became the ruling party, small shops and wet markets dominated China's retail sector. These store formats were later taken over by the retail-cooperatives and state-owned enterprises (SOE) when the CCP became the ruling party. The distribution of grocery items remained under strict state control until the

economic liberalisation, which happened in the early 1980s. Economic liberalisation allowed private ownership of retail and wholesale operations. The supermarket format was first introduced during this period, but its growth was hampered by a lack of appropriate suppliers and the high prices charged (Lo et al. 2001). However, the supermarket experienced an exponential growth during the 1990s to the 2000s. The popularity of supermarkets among Chinese consumers has increased due to the arrival of western culture and growing consumer purchasing power. Supermarkets have grown into a US$55 billion industry by 2004, consisting of approximately 53,000 units and occupying a share of 30% of urban food market (Hu et al. 2004; Lo et al. 2001).

3.1 Chinese Consumer Behaviour

While cultural, political and economical forces are shaping the grocery industry over time, Chinese consumers have also developed a set of unique behaviours, which has fundamental impacts on the characteristics of China's supermarkets. Being raised in a collective society under the influence of Confucian philosophy, Chinese consumers are extremely price conscious and tend to be very informed and disloyal shoppers. They are willing to search extensively for a better deal and consider it to be a leisure-activity (Ackerman and Tellis 2001). Meanwhile, vast geographical coverage and sophisticated local cultures have also caused Chinese consumers to have significantly different product preferences and value systems, varying from city to city (Ackerman and Tellis 2001).

In order to address such consumer behaviour, China's supermarkets are under constant pressure to offer low prices and a wide range of products to facilitate the Chinese consumer habit of comparing prices and seeking bargains. Commonly used sales generation techniques such as the loss-leaders strategy, are usually unable to generate expected results due to Chinese consumers' preference for frequent grocery shopping in small volumes (Goldman 1996; Goldman January 2001; Mai and Zhao 2004). In addition, differences in local product preferences make it impossible to centralise inventory management among chain stores and, as a result, local sourcing and direct-store delivery distribution strategies are common among China's supermarket chains. These Chinese consumer characteristics and behaviours pose unique challenges to the supermarkets and consequently require different strategies compared to supermarkets in developed countries, which are summarised in Table 2. These unique market characteristics have caused unexpected problems among the first wave of foreign investors. After rushing into the Chinese market, foreign chains frequently fail to replicate the successes in their home countries (Goldman 1996; Goldman January 2001; Mai and Zhao 2004).

Furthermore, Chinese consumers' obsession over price has made the competition within the supermarket sector especially furious. New entrants can easily attract a large number of customers from established chains by offering lower prices and it is a constant struggle to retain market share among the existing players. Continuous price and promotion wars are raging among the major chains, thinning their profits. The intrusion of foreign supermarket chains armed with modern management concepts and technologies has further increased the intensity of the competition. To stay competitive, Chinese chains have frequently consolidated to form retail giants such as the Bailian group. Consequently, as Mousteraski (2001) estimates, a total of 350,000 small shops have had to go out of business (Mousteraski 2001).

Consumer Characteristics	Consumer Behaviour	Supermarket Challenges	Supermarket Strategy
Price conscious	Extensive product search	Under constant pressure to offer low prices	Frequent sales and price wars among supermarkets
Disloyal	Shop from a number of supermarkets, based on price and product offerings.	Hard to maintain a stable customer base, under constant pressure to attract and retain customers.	Offer huge range of products from white goods to cosmetics.
View grocery shopping as leisure activity	Frequent, small shopping trips	Sales generating strategies fail to have spill-over effect on normally priced products	Extensive sales range, heavy advertising and frequent promotional activities
Local preferences	Distinct product preferences in different regions.	Different inventory requirements in different regions, which makes it difficult to manage inventory centrally.	Inventory is managed on a store-by-store basis. Direct-store delivery and local sourcing are common practices.

Table 2. Consumer behaviour and its impact on China's supermarkets

3.2 Major players and their operations

In the last few decades, the Chinese grocery industry has seen a significant shift of power in favour of the retailers (Luk 1997). The demolition of the state-controlled grocery distribution system has catalysed the development in the retail sector with powerful players such as Lianhua, Suguo and Carrefour dominating the market, with enormous buying power.

Meanwhile, the former state-owned distribution system was left behind, with no significant growth over the past years. Coupled with the Chinese economy's transformation from a seller's market to a buyer's market, retailers gained a dominant position in the marketing channel (Bean 2006; Luk 1997). There are currently no major players in the distribution sector that can compete with the power of retail giants such as Carrefour or Bailian. The majority of the sector remains extremely fragmented. These distributors remain small in size and usually specialise in a specific area or product category (Bean 2006). As a result, products that go through the conventional distribution channels typically have to be handled by various parties before reaching their destination.

The underdevelopment of the distribution sector has created significant difficulties for the supermarkets in inventory management. Smaller supermarkets usually procure supplies directly from the wholesalers, with limited direct-supply relationships for certain products (Hu et al. 2004). Large chains, on the other hand, may use a combination of a pick-and-pack approach and direct-store delivery (e.g. Suguo and Carrefour) or a third-party logistics (Wal-Mart) system depending on their focus and size. Limited e-Commerce technologies such as B2B portals are used among these major chains to enable information exchange

between the supply chain partners, while the smaller chains still deploy manual procurement procedures.

3.3 The Potential of E-Commerce for the Chinese Grocery Industry

Based on the characteristics of the Chinese grocery industry and its consumers, e-Commerce offers great potential. It is able to enhance the organisational performance in several ways. Firstly, e-Commerce can have a strong impact on administration and daily operations. Administration and transaction processing is extremely demanding, due to the labour-intensive nature of the grocery industry and the enormous volume of transactions made. E-Commerce's ability to automate day-to-day document exchange and communications within and between organisations can significantly enhance operational efficiency as well as reduce administration costs. Operational efficiency will enable the industry to offer low costs to the consumers (Kurt Salmon Associates 1993).

Secondly, inventory management and supply chain coordination is crucial to the performance of the firms. Retailers are expected to offer a wide range of products to suit the Chinese consumer habit of product search and price comparison. The ability to manage inventory efficiently and effectively can therefore generate significant advantage for the firms in an industry where low-prices are merely a point of competitive parity. E-Commerce, therefore, has a great deal to offer to the industry in streamlining the product and information flow within the supply chains so that the inventory level can be kept to a minimum, while product range can be increased. Advanced supply chain management practices such as Vendor Managed Inventory (VMI) and cross-docking, which are enabled by various e-Commerce technologies, will not only enhance product replenishment efficiencies but also improve product quality and availability (Kurnia and Johnston 2001; Simchi-Levi 2003).

Lastly, Chinese consumers' ever-changing preferences and demands have made it especially important for firms to respond quickly to the changing market needs. By facilitating real-time market demand sharing among supply chain participants, e-Commerce is able to provide better information to assist decision making process within firms. It consequently enhances firms' responsiveness to the market and environment.

3.4 Current Use of Information Technologies

Firms in the grocery industry introduced stand-alone computers to their stores and offices in the 1990s. However, the build-up of hardware and software for Enterprise Resource Planning (ERP) and other decision supporting functions only began two to three years ago. In the wake of the liberalisation of the Chinese economy, the grocery industry has been quick to adopt Internet-based applications. Enterprise applications and other applications such as Electronic Data Interchange (EDI) were, however, generally left behind, leaving a large gap in a firm's IT infrastructure.

The most commonly used technologies are Point-of-Sales (POS) systems and bar-coding, which can be found in almost any supermarket. However, given the limited EDI and data analysis capabilities, the POS system is mainly used for checkout purposes only. The data collected through the system are rarely utilised for sales analysis or inventory management purposes (Sinclair et al. 1998). With plenty of low cost labour working in the supermarket stores, it is apparent that computerised systems are not typically required for labour saving

purposes. Sinclair et al. (1998) argue that many supermarkets in China have installed computerised applications systems under the assumption that these applications' full potential benefits will eventually be realised.

Major supermarket players have taken the first step towards adopting e-Commerce technologies. In order to effectively coordinate a large number of suppliers, Internet-based Business-to-Business portals were established as a means to communicate with the suppliers electronically without worrying about the system compatibility or the hardware and software investment at the supplier's end. By logging into the retailer's B2B portal through the Internet, a supplier is able to obtain information about their products and hence make replenishment decisions accordingly. This approach has allowed the supermarkets to bypass the inadequate information technology infrastructure and realise some degree of VMI without significant investments.

The Warehouse Management System (WMS) is another application that has been adopted by major chains to improve their operational efficiency. It is usually a standalone system that tracks and coordinates the inventory movement within the distribution centre by assisting warehouse staff to accurately store incoming inventory and prepare outgoing orders. All incoming stock is first entered into the WMS manually upon arrival to update the inventory record and generate a storage slip. It is then placed onto the inventory transportation terminal, which automatically stores the inventory into the appropriate place in the warehouse. Upon receiving store orders, WMS generates an outgoing inventory slip to list stocks required and their locations in the warehouse to assist the manual pick-and-pack process. Although this system seems to be primitive compared to western standards, it is one major step forward for the Chinese supermarket chains to achieve automatic inventory control.

4. The e-Commerce Readiness Framework

Adopting e-Commerce offers organisations a new way of conducting business, due to the technology's ability to revolutionise modern business operations. E-Commerce's impact transcends organisational boundaries. The consequent complexity of adopting and using e-Commerce is immense. As a result, in order to ensure the success of e-Commerce adoption, e-Commerce readiness has to be achieved. E-Commerce readiness refers to an institution's ability to fully support the adoption, use and diffusion of e-Commerce. In this paper, the term institution encompasses the organisations under study, the industry and the country to which the organisations belong. Consequently, as depicted in figure 1, E-Commerce readiness has dimensions, organisational readiness, industrial readiness and national readiness. Achieving E-Commerce readiness at all three levels forms the basic conditions of e-Commerce adoption by any organisation.

Organisational readiness refers to the organisation's internal capability to support the adoption and use of e-Commerce technologies. Four main factors are commonly regarded as important in determining an organisation's e-Commerce readiness. These are organisational structure, organisational culture, organisational size and slack resources as well as skills and knowledge. The industry represents the immediate business environment in which organisations operate. Given the different industrial affiliations, structures and operating norms of different commercial sectors, different industries can have very different levels of e-Commerce readiness. Industrial readiness is concerned with the conditions within the

industry that are conducive to e-Commerce adoption. It can be measured through factors including the existence of industrial e-Commerce standards and coordinating bodies, the industrial structure and the power relationships among the participants within the industry.

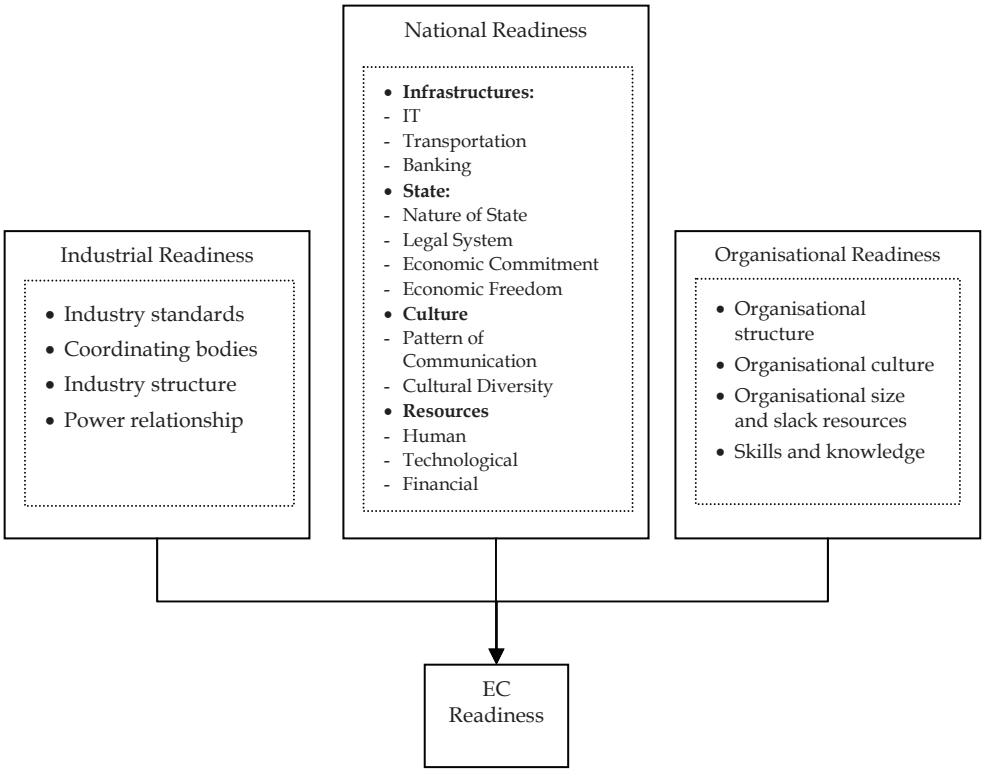

Fig. 1. The e-Commerce Readiness Framework

National readiness indicates the maturity of a country's macro environment for supporting e-Commerce activities. The common national factors can be classified into four main categories, namely infrastructures, state, culture, and resources. The *Infrastructures* category refers to the maturity of a nation's IT, banking and transportation infrastructure. The *State* category includes factors such as the nature of the state, policy and legal framework, economic freedom and economic commitment which determines the national environment for business operations. The *Culture* category consists of factors that influence the behaviour of the businesses and consumers in a certain country such as the pattern of communication and cultural diversity. The *Resources* category examines the availability of the adequate financial, technological and human resources required to support e-Commerce activities in the country.

Based on the E-Commerce readiness framework presented above, an assessment of the Chinese grocery industry's e-Commerce readiness is discussed in the next section. The framework helps reveal the advantages and challenges faced by Chinese organisations

within the grocery industry in the adoption of e-Commerce, and consequently it enables the establishment of more effective practices and strategies to promote e-Commerce growth in the industry.

5. E-Commerce Readiness in the Chinese Grocery Industry

For the purpose of this study, a multiple case study was conducted with six organisations within the Chinese grocery industry. Interviews and a review of business documentation and other relevant secondary data were used as the data collection techniques. A semi structured interview protocol was developed based on the various e-Commerce readiness factors shown in Figure 1. Each interview lasted around one hour and was recorded for later analysis. At the end of each interview, the information obtained was checked against the prepared questions to ensure that all questions had been answered. Interviews were tape-recorded and later transcribed into written-up field notes. A qualitative data analysis technique was used to identify and categorise themes/concepts of interest through close examination of data in the written-up field notes. Cross case analyses were also conducted to compare the findings from different interviews. Through the cross case comparison, various emerging concepts were then refined (Neuman 2006). Table 3 summarises the profile of the participating organisations in this study.

Company	Type	Full-time employees	Interviewee	Ownership
A	Manufacturer	350	Regional Manager	Local with foreign ownership
B	Broker	25	Chief Executive Officer	Local
C	Retailer	80	Marketing Manager	Local with foreign ownership
D	Retailer	500+	General Manager	Local
E	Retailer	65	General Manager	Local
F	Distributor	15	General Manager	Multi-national Chain

Table 3. Participant Profiles

Company A is a major manufacturer of instant noodles in China. Employing around 350 full-time employees, it is a typical well-established traditional grocery manufacturer in China. Despite its mixed ownership, Company A's operation largely remains unchanged, with the limited addition of stand-alone computers and the Internet used at management level. With virtually no dedicated IT investment, business is carried out through conventional means, including face-to-face interactions and telephone conversations. The interviewee (Regional Manager) demonstrated little understanding of e-Commerce and was not enthusiastic about the prospects of future adoption within the organisation, since the traditional way had been working well.

Company B is a small broker of grocery items with twenty-five full-time employees. As most of other similar sized grocery distributors in China, it is independent and locally owned. Given its recent establishment, its operation is unsurprisingly supported by IT, which gives all employees direct access to computers, Internet and e-mail. Since most of company B's employees have a tertiary degree, the interviewee (Chief Executive Officer) showed a comprehensive understanding of e-Commerce and indicated willingness in its future investment because of the organisation's positive experience with IT.

Company C is a medium sized grocery retailer with foreign ownership. Like other grocery retailers in China, it is equipped with standard information technology such as scanner/bar-coding, Internet and a website to attract customers and facilitate its day-to-day operation. The majority of staff members at management level hold a tertiary degree. The interviewee (Marketing Manager) also demonstrated adequate e-Commerce knowledge and expressed a commitment to maintain the current level of IT investment, but with a limited willingness to further increase e-Commerce adoption in the near future.

Company D is one of the major retailers in China. It was a State-Owned Enterprise (SOE) until the recent privatisation. As the largest player in the region, it is very well funded and has a team of highly educated managers. Compared to the other locally owned retailers, Company D is relatively more advanced in the e-Commerce adoption. It does not only possess basic technology such as scanner/bar-coding and the Internet, but it also has taken one step forward in adopting B2B and B2C e-Commerce. It has set up a sophisticated transactional and interactive website which offers online shopping, after sale service for the customers and acts as a communication portal for their business partners. The interviewee (General Manager) demonstrated a keen interest in furthering their e-Commerce initiatives and was optimistic about e-Commerce's future in China's grocery industry.

Company E is a small, local grocery retailer with around sixty full-time employees. Because of its small size, it lacks the financial and technical resources to adopt any advanced technologies. It is equipped with the industry standard Scanner/Bar-coding system, E-mail, Internet, and it has an interactive website that accepts online payment. The interviewee (General Manager) completed a tertiary education and demonstrated a sound understanding of e-Commerce and its potential.

Company F is a part of a multinational grocery distribution chain. Its local office has only fifteen fulltime employees, but due to its foreign heritage, it invests heavily in information technologies and uses them extensively in its day-to-day operations. Although their financial resources are still limited, all of the employees have direct access to personal computers, the Internet and e-mail. During the interview, the General Manager demonstrated e-Commerce proficiency.

6. The Study Findings

The results of the data analysis are discussed in this section based on the three levels of e-Commerce readiness: national, industrial and organisational levels.

6.1 National Readiness

As the world's most populous nation, and as an authoritarian state, the national readiness of China has an important influence on e-Commerce development in the grocery industry. Given the recent focus on economic development, China has made significant strides toward establishing an e-Commerce friendly environment. However, due to the vastness of the country, a relatively underdeveloped economy, an inefficient bureaucratic system and the deep-rooted relationship-based culture, China still has long way to go before it is qualified as e-Commerce ready. A number of observations obtained from the interviews are discussed below in detail.

Infrastructure

Sound telecommunication and transportation infrastructure in developed regions, however national infrastructure remains fragmented

As the backbone to e-Commerce development, the availability and quality of national infrastructure such as the transportation, telecommunication and banking systems are vital to its growth. Although China's national infrastructures can still be characterised as fragmented and inefficient (Chang et al. 2003; Jiang and Prater 2002; Okamoto and Sjoholm 2001; Purbo 2001), China's recent efforts in economic advancement have brought infrastructure development to the top of the country's agenda. Accordingly, all Chinese respondents demonstrated great confidence in the country's basic telecommunication and transportation infrastructure and believed in the ability of the Chinese infrastructure to support their current e-Commerce applications. The Marketing Manager of Company D supports the view of the China infrastructure development as revealed below:

"In our region of operation, the basic infrastructure is very reliable. We have not encountered any significant problems so far. The government has invested heavily in infrastructure development in the past few years, and we are very happy with the result."

However, it is worth noting that given all our respondents are positioned on China's economically-advanced east coast, their experience may not be representative of the national condition. According to state statistics, significant disparities still exist within the country, especially between the advanced costal and isolated central regions. Realising the importance of a mature national infrastructure, the Chinese government has shifted its infrastructure development focus from cities to the country in an attempt to bridge the infrastructural divide that exists within the nation (GOV.cn 2005). With an estimated 496 billion USD investment required, the infrastructural disparities in China are not expected to be resolved in the near future.

Banking system inadequate in supporting e-Commerce development

Despite the recent economic boom, the Chinese banking system remains unsupportive of e-Commerce transactions. Its ability to facilitate credit card transactions and electronic funds transfer is extremely limited compared to western banking systems. Such an inadequate banking system is especially detrimental to the further development of e-Commerce. It effectively prevents e-Commerce from progressing to a more mature development stage characterised by routine electronic inter-organisational transactions and cooperation activities. Although such inadequacy is having little impact on the current development of e-Commerce in China because most of the e-Commerce applications are restricted to basic administration tasks, it poses a great risk for hampering the development of the general economy in the near future as e-Commerce is expected to play a more important role in the

modern business. A comment made by the Regional Manager of Company A below highlights the inadequacy of the current state of the Chinese banking system:

"No, we prefer to do our sales the traditional way. It is much more reliable and simpler for us to bill our customers the old way. The electronic banking is highly unreliable and very costly. We do not see any significant benefits in using it. "

Overall, the national infrastructure in China is currently capable of supporting basic e-Commerce activities. However, its current readiness for more advanced e-Commerce development is unsatisfactory. China's fragmented telecommunication and transportation infrastructure will obstruct the establishment of a nation-wide supply chain and cooperation networks, while the inadequate banking system prevents the widespread use of e-Commerce technologies and consequently the realisation of its full benefits. Taking the current economic and political conditions into consideration, China is well placed to improve its national infrastructure readiness to match e-Commerce development. The government's strong commitment on economic advancement has put infrastructure development projects on a fast track and as a result, the prospect for China's national infrastructure readiness is rather positive.

Culture

Relationship-based business practices hamper the development of e-Commerce

The interviews consistently revealed that relationship-based or "guanxi" business transactions are still symbolic of China's business practices. The majority of the respondents confirmed their reliance on personal social networks for obtaining new business opportunities and trading partners as previous studies indicated (Chen and Ning 2002; Dickson and Zhang 2004; Efendioglu and F.Yip 2004; Hansen April 2001; Jiang and Prater 2002; Malley 2004; Meng 2004; Millington et al. 2005; Tan et al. 2007).

Regardless of a company's industry sector, size, or nature of the business, the time-honoured practice of informal bargaining through socialising and entertaining clients is still widely used as a key approach to form new or maintain existing business relationships. This phenomenon is further reflected in the way e-Commerce technologies are used in the adopting companies. When asked about the detailed usage of e-Commerce technologies in the organisation, the majority of the respondents see e-Commerce as a tool for information dissemination, and communication within existing relationships. This is consistent with the findings in numerous other studies (Chae et al. 2005; Chen and Ning 2002; Kshetri and Dholakia 2002; Martinsons 2003). Only one respondent indicated a limited success in obtaining new trading partners through e-Commerce websites. The responses show that the businesses' heavy dependence on the traditional relationship-based communication and transactions severely limits the development of e-Commerce in both countries. For example, the Regional Manager of Company A reveals:

"Yes we have a website and e-mail systems, but we prefer to call our clients and suppliers for serious business matters. We have been doing it for ages and it works well for us."

The existence of the relationship-based economy and the reliance on personal relationship and face-to-face communication for business deal making can be largely attributed to China's complex pattern of communication and its geographical cultural diversity. The large numbers of local dialects, customs and consumer preferences forged the unique business

practices in different regions of the nation. Only through local knowledge and personal networking, can a deal be executed successfully between two different regions of a country. The complex communication pattern, including the high power distance and the rich, informal way of business communication also made it essential to carry out business through proper channels and in a face-to-face manner in order to negotiate successfully with the trading partners. This, in turn, reduces the relevance of e-Commerce technologies to the businesses.

Lack of trust among trading partners

After a decade of e-Commerce development and diffusion in China, it appears that some organisations finally started to develop a sense of trust within their business relationships. All respondents except one confirmed the existence of a trusting relationship with their trading partners. However, the level of trust is still considered to be low. When asked about the sharing of information with their partners, all IT capable organisations indicated reluctance in sharing important information. It appears that although businesses have made improvements in the trust level among trading partners, they are still largely cautious in cooperating with their partners, as highlighted in the following interview excerpt of the Marketing Manager of Company C:

"*We trust our trading partners as much as they can be trusted.*"

Furthermore, as revealed in our interviews, the concern that the suppliers will not hesitate to take advantage of the situation if they are not monitored carefully is still prevalent among the major grocery retailers. Conflicts between large retailers and their suppliers are widespread in China, which sometimes can escalate to violent confrontations between the two parties (Dickson and Zhang 2004; Liu and Wang 1999). As a result, lack of trust is believed to be one of the major impediments to B2B e-Commerce adoption.

In general, Chinese culture is currently not ready to fully support e-Commerce activities. The inherent mistrust between business partners and the demand for face-to-face interaction severely reduces the usefulness of e-Commerce technologies for Chinese organisations. Given the change-resistant nature of cultural values, e-Commerce adoption efforts in China will continue to face significant cultural barriers in the future.

State

Chinese government strongly drives e-Commerce adoption but its strict information oversight impedes future development

The influence of the state can be measured through respondents' reliance upon the government's support for their e-Commerce adoption efforts. It is clear that the respondents regard government support as one of the major drivers for adoption and the main reason for using such technologies in the first place. Such responses are reflective of the nature of the state. With China being ruled by the Central Communist Party, the effect of its heavy promotion of e-Commerce development has become apparent at the organisational level in the grocery industry. It is a testimonial to the influence an authoritarian state can have on e-Commerce adoption.

However, it was also noted that most of the respondents expressed their concern over the privacy and security of business data if they conducted business online, due to the strict oversight of the nation. In fact, the issue of data security is the second main institutional barrier to e-Commerce development, more so than the lack of a legal framework for Chinese businesses. The Chinese government's strict control over the information exchanged on

websites and the ban of any foreign encryption technology has prevented most businesses from taking their e-Commerce to the next level (Chvaja et al. 2001; Hynes et al. 2006; Jennex and Amoroso 2004), as revealed by the Marketing Manager of Company C:

"We adopted e-Commerce because we believe it is a good time to do so with all the support and guidance provided by the government. However, I do not think that we will take it any further than where it is now. I simply do not want to put all our information online and rely on e-Commerce to do our business."

Strong commitment to economic development is positively linked with e-Commerce development

In this era of globalisation, liberalising the markets and introducing "open door" policies are two of the key tools for the developing countries to promote their economic development. In order to take advantage of the financial resources and managerial expertise of the foreign investors, China has strived to attract foreign direct investments (FDI). Towards that end, China has modified its legal, tax and infrastructure systems to different degrees to create a more attractive investment environment for potential foreign investors.

The inflow of FDIs brought new and powerful competitors into the usually stagnant domestic markets. Consequently, this introduced significant competitive pressure into the economic environment. The interviews show that the respondents, especially the retailers, are experiencing a high degree of competitive pressure from major global players such as Carrefour, Wal-Mart and Metro. Their e-Commerce adoption and usage are directly a result of the increase in competition and demands from trading partners. Four respondents cited competition as one of the main reasons for them to use e-Commerce and two respondents were planning to invest significantly to expand their e-Commerce applications to improve their operations. Consequently, it is expected that increased foreign investment will promote economic growth and consequently encourage e-Commerce adoption.

Lack of rule of law impedes e-Commerce development

Lack of rule of law is one of the major barriers discovered through the study. All respondents expressed their concerns over the country's abilities to protect their rights. Due to China's authoritarian government control, its legal system is far from stable. Laws are interpreted arbitrarily and enforced depending on the government's political agenda and corruption remains rampant (EIU 2007; Malley 2004). As a result, most of the respondents hesitate to take their existing e-Commerce applications any further. Some respondents regarded the weak legal system of China as one of the major risks for their future e-Commerce investments. This finding echoes the results of previous research projects conducted in developing countries, in which the lack of rule of law is consistently identified as a key barrier to e-Commerce development (Chen and Ning 2002; Gibbs and Kraemer 2004; Martinsons 2003; Tan et al. 2007; Trappey and Trappey 2001).

China's authoritarian government has proven to be largely advantageous to the current development of e-Commerce. Its strong commitment to development and economic prosperity has allowed e-Commerce to enjoy a friendlier environment than other developing countries at its initial stage of development. However, the state's centralised control and the lack of rule of law will significantly impede future advancement of e-Commerce in the country as the demand for economic freedom and solid legal protection rises. The Chinese government will need to address these problems before China can be ready for further development of e-Commerce.

Resources

Sufficient IT investment, IT expertise and existence of technology standards promote e-Commerce development

After over three decades of market reform and explosive economic growth, China has amassed huge economic resources. The country has invested heavily in IT education and related technology standards. The consequent creation of a relatively favourable e-Commerce environment has allowed Chinese businesses to adopt and use e-Commerce more effectively. This is reflected in the general satisfaction expressed by the study respondents concerning the resource conditions of the country that support their efforts to adopt e-Commerce. None of the respondents have encountered significant difficulties in obtaining the required IT support and expertises. Thus, from a resource availability perspective, China is ready to support e-Commerce development.

6.2 Industrial Readiness

Through decades of evolution, the Chinese grocery industry developed a set of characteristics that are shaping the adoption and development of e-Commerce in the industry. Its unbalanced power structure, fragmented sector development and the overall lack of e-Commerce standards and coordination have prevented the effective diffusion of e-Commerce within the industry. While powerful players such as the supermarket chains are well-positioned to adopt e-Commerce, other sectors are generally not ready for it. Below are some important observations obtained from the study regarding the industrial readiness.

Unbalanced power relationship increases resistance to e-Commerce adoption

The current imbalance in industrial bargaining has created significant friction between grocery retailers and their suppliers and wholesalers. By controlling the access to the end consumer market, the grocery retailers, especially the large supermarket chains, command almost absolute power over their suppliers. They dictate payment terms, margins and even suppliers' business practices. The usually fragmented and small-sized suppliers are generally powerless in the face of giant retailers' demands.

E-Commerce has the ability to radically improve a supermarket's efficiency and profitability. As such, e-Commerce has been actively adopted and promoted by Chinese retailers, with some major chains introducing sophisticated supply chain management and inventory control systems. The grocery suppliers on the other hand, see e-Commerce in a less favorable light. Despite the supermarkets' strong demand for e-Commerce-facilitated B2B transactions, few distributors or manufacturers see the value in adopting e-Commerce systems. Their mistrust of retailers effectively prevents the healthy and widespread dissemination of e-Commerce within the industry. A positive attitude and active collaboration and information sharing is crucial for successful adoption and diffusion of e-Commerce (Kurnia and Johnston 2001; Grandon and Pearson 2004; Uzoka et al. 2007).

Fragmented sector development prevents industry wide e-Commerce adoption

In addition to the unbalanced power distribution among the industrial participants, the fragmented sector development also significantly hampers e-Commerce adoption and diffusion within the industry. As discussed above, the retailing sector has experienced significant growth since the economic reform, while the distribution and manufacturing sectors have remained fragmented and stagnant in their growth. As a result, the retailers are the only sector with adequate resources and scope to support e-Commerce adoption and development. The other sectors lack the capability to facilitate effective e-Commerce

adoption within the industry. The uneven adoption of e-Commerce severely restricts the realisation of promised e-Commerce benefits for adopting organisations, which further discourages e-Commerce diffusion within the industry.

Lack of industry standards and coordinating bodies hampers e-Commerce development

Finally, the Chinese grocery industry's poor e-Commerce readiness can also be attributed to the lack of e-Commerce standards and a lack of coordinating bodies within the industry. The current e-Commerce activities in the industry are largely unregulated, utilising a wide-range of e-Commerce standards depending on each organisation's own preferences. The fragmented nature of the e-Commerce systems used in the industry is detrimental to the future development of e-Commerce. It increases the risk of e-Commerce investments and consequently deters new e-Commerce adoption initiatives.

There is also virtually no industrial support to guide the adoption and implementation of new e-Commerce applications. The absence of an e-Commerce coordinating body to provide support for e-Commerce adoption efforts and oversee e-Commerce transactions has significantly increased the perceived difficulty of e-Commerce adoption and usage. The respondents frequently pointed out that the lack of industrial support and the general lack of confidence in their e-Commerce capability is the main deterrent to their e-Commerce adoption effort. This situation is especially prominent among the small distributors given their limited size and resources.

6.3 Organisational Readiness

The study conducted with a number of organisations within the Chinese grocery industry highlights the unilateral development of e-Commerce within the different sectors of the industry. Depending on the firm's supply chain position, specialty, size and resources, their organisational readiness varies. A number of important observations regarding the organisational readiness from this study are discussed below.

The firm's scope has a positive link to its e-Commerce readiness

From the interview analysis, a positive relationship has been identified between a firm's scope and the firm's enthusiasm for e-Commerce adoption. Retailers, as the dominant player within the industry in both business size and scope, have a more positive attitude towards e-Commerce adoption. They possess the required resources for supporting e-Commerce adoption and are the most optimistic about e-Commerce's potential to enhance their performance. The distributors on the other hand are able to maintain a broad business scope despite of its relative small size. Their extensive service offerings make e-Commerce an attractive tool for improving the coordination efficiencies of their business activities. As a result, they are also relatively willing to commit to future e-Commerce investments. However, due to their small size and limited financial resources, they may face some challenges in e-Commerce implementation. Finally, this study suggests that the manufacturers commonly lack the scope to make e-Commerce an appealing business investment. With their traditional mindset and well-established trading channels and procedures, the manufacturers generally see little need to change and thus are unwilling to commit investments in e-Commerce. Although there is only one manufacturer involved in the interview, the interviews with the retailers and distributors have confirmed the view expressed by the Regional Manager of Company A (manufacturer) regarding the negative attitude of manufacturers towards e-Commerce adoption.

Such cross-sectional comparison between different sectors of the industry effectively highlights the importance of business size and scope to e-Commerce readiness. Without sufficient business size and resources, organisations are unable to successfully support the adoption of e-Commerce through implementation and assimilation. The lack of business scope also restricts firm's ability to realise e-Commerce's potential benefits and consequently reduces its business relevance as demonstrated by the manufacturers interviewed.

An organisation's position in the supply chain affects e-Commerce adoption

The cross case comparison also suggests that the closer the organisation is to the consumer, the more information technologies are used as part of daily business procedures. With all interviewees confirming their IT and basic e-Commerce adoption situation as the industry standard practice, this study concludes that this phenomenon is relatively wide-spread within the grocery industry. The manufacturers, as being located furthest away from the consumer in the supply chain, repeatedly questioned the necessity of e-Commerce technologies in the manufacturing sector and expressed contentment regarding their traditional way of operation under the current situation. This is revealed in the following interview excerpt of the Regional Manager of Company A:

"…at the moment, our business is operating with the traditional approach and performing well, we are not really looking into any e-Commerce initiatives."

Other participating companies, on the other hand, demonstrated a much more advanced e-Commerce understanding and IT usage. Being able to meet consumer demand is considered by the majority of the participants to be one of the major reasons for adopting IT and introducing e-Commerce. The study shows that the retailers use information technology to a much greater extent than the distributors, which is consistent with an e-Commerce survey carried out in China by Tan and Wu (2004). As a result, depending on the firm's position on the grocery supply chain, their organisational e-Commerce readiness changes.

Strong support from the senior managers

Intriguingly, the interviews revealed that there exists strong top management support for IT implementation and upgrades within the Chinese grocery industry. This can be directly attributed to China's hierarchical decision-making structure where all important business decisions originate from the executive level. Given the amount of investments required for e-Commerce adoption, this study found that it is usually company executives who champion e-Commerce development initiatives instead of the IT managers. As the key decision-maker of the organisation, an executive's direct control over a company's business practices, personnel and resources guarantees adequate support for e-Commerce projects and maximises the chance of success. In addition, the collective nature of Chinese culture also contributes significantly to the smooth introduction of new technologies. It enables smooth execution of top management's orders while minimising change resistance in the lower level of the firm, as highlighted in the following interview excerpts:

"…of course we gave our full support for computerizing the workplace and putting up a website. We are the ones who proposed the idea and made the final call after all."(Marketing Manager, Company C)

"… once a decision was made, we all see it as our own goal to see the decision being carried through. We work as a single entity and resistance to the change is minimal. After all, we [senior managers] all agreed upon the necessity for introducing e-Commerce into our business." (General Manager, Company D)

Sound understanding of e-Commerce but limited e-Commerce expertise available

During the interviews, all respondents except one demonstrated a good understanding of e-Commerce and its potential benefits, threats and opportunities. However, when asked about the existence of IT expertise within the firm to support future advancement of e-Commerce, only two respondents provided an affirmative answer. Other respondents were unsure about the adequacy of their current internal e-Commerce expertise. However, companies with strong financial resources further explained their intention to recruit more technical personnel to rectify this problem in the near future. Despite the various responses regarding the availability of internal IT expertise, all respondents believed that there was plenty of IT expertise in the market given the yearly increase of IT graduates. As a result, Chinese grocery firms can be regarded to be ready in terms of their e-Commerce skills and understanding, given their relative ease in gaining these skills either internally or externally.

Supporting Conditions	Likely Barriers
National Readiness	
• Sound telecommunication and transportation infrastructure in developed region • Strong drives and supports for e-Commerce development from the government • Strong commitment of the government to economic development • Sufficient resources (IT and skills) and technology standards	• Overall infrastructure is still fragmented • Inadequate banking system • Relationship-based Chinese culture • Lack of trust among trading partners • Strict information oversight by the government • Weak legal framework
Industrial Readiness	
	• Unbalanced power relationship within the industry • Fragmented sector development • Lack of industry standards and coordinating bodies
Organisational Readiness	
• Sound understanding of e-Commerce • Strong support from senior managers in some organisations	• Varying firms' scope and size within the industry affect the resource availability • Varying firms' perception regarding the necessity of e-Commerce, depending on their position in the supply chain • Limited e-Commerce expertise available

Table 4. Summary of the Study Findings

Overall, the Chinese grocery firms' organisational readiness varies according to their particular size, scope and specialty. The retailers as the most powerful player in the industry can be generally regarded as being ready to adopt e-Commerce. Their immense business scope and constant pressure from the end consumers heightens e-Commerce's relevance. They are best positioned to reap the benefits promised by e-Commerce technologies. The retailers' significant size and abundant resources also have allowed them to fully support e-Commerce adoption and optimise its implementation and diffusion. The distributors on the other hand are moderately ready for e-Commerce adoption. Their large business scope makes e-Commerce technologies attractive. However, their lack of sufficient size and resources may present a problem during the process of e-Commerce adoption. Finally, the manufacturers lack the organisational readiness to adopt e-Commerce. Their relative isolation from the end-market and their deep-rooted traditional business practices severely dampen the attractiveness of e-Commerce technologies. Consequently, this reduces their willingness to adopt e-Commerce.

Table 4 summarises the supporting conditions and the likely barriers to e-Commerce adoption in the Chinese Grocery Industry based on the findings of this study. It shows that the current situation in the Chinese grocery industry is likely to present more barriers to e-Commerce development than supporting conditions. The findings are further discussed in the next section.

7. Discussion & Conclusion

Currently, e-Commerce has been used within the industry to various degrees, with retailers leading the way in incorporating e-Commerce technologies into the majority of their daily operations. Some of the major retailers have already introduced transactional and interactive websites to facilitate B2C and B2B e-Commerce. However the majority of the businesses within the grocery industry possess only standalone internal computer networks and websites. The e-Commerce readiness of the Chinese grocery industry is influenced by a multitude of factors from the national, industrial and organisational levels, each offering unique opportunities and challenges for e-Commerce adoption.

As summarised in Table 4, on the national level, the abundance of IT expertise and the state's strong commitment to the economic and e-Commerce development helps promote e-Commerce adoption in the country. On the other hand, the weak national legal framework, the relationship-based Chinese business culture, as well as the lack of trust within business relationships significantly reduce the attractiveness and relevance of e-Commerce. Unless rectified, these barriers will effectively confine future e-Commerce adoption to fragmented networks and standalone applications.

Significant weaknesses in China's industrial-level readiness have also been identified. The lack of industry standards and lack of a coordinating body to control the development and adoption of e-Commerce within the industry, the fragmented industrial structure and the severely imbalanced power relationship pose substantial challenges for the adoption and diffusion of e-Commerce. None of the industry current condition seems to support e-Commerce development.

Finally, the evaluation of the organisational level readiness shows some promises. Strong executive support and the overall sound understanding of e-Commerce demonstrate the existence of a viable foundation for future e-Commerce growth. The main challenge lies in

the unbalanced development of different organisations. The distributors lack the resources and business scale to make e-Commerce viable at the moment, while the manufacturers seem not ready for e-Commerce. Again, although there is only one manufacturer involved in this study, the view expressed by the interviewee has been confirmed indirectly in other interviews. In addition, since the participating manufacturer is one of the largest manufacturers in China, the lack of readiness identified in this study is also likely to be applicable for other manufacturers with similar or smaller scope and size.

Overall, the study indicates that the e-Commerce readiness in China, specifically the grocery industry is still relatively low. However, after recent substantial development and growth, the retailing sector of the grocery industry is better positioned to adopt e-Commerce with adequate business size, scope as well as significant resources. Retailers' more advanced e-Commerce readiness is directly reflected in their relatively more sophisticated e-Commerce development as observed in this study. Despite the e-Commerce advancements the retailing sector has made, without the cooperation of the manufacturing and distribution sectors, the Chinese grocery industry will not be capable of fully adopting e-Commerce and realising its promised benefits. In order to help the grocery industry to improve its e-Commerce readiness and consequently increase its chance for capitalising on the e-Commerce technologies in the future, some suggestions are proposed below.

In order to improve organisational readiness, the study findings suggest that the awareness and understanding of e-Commerce potential need to be improved within the manufacturing sector to further encourage adoption. This may require the involvement of an industry body that can improve the visibility of e-Commerce practices among the industry players and to demonstrate the benefits obtained. Through progressively increasing the awareness and understanding of e-Commerce business practices and procedures, an increasing number of organisations will be willing to consider e-Commerce as a means of organisational improvement.

In terms of the industrial readiness, the grocery industry as a whole lacks e-Commerce facilitating technologies such as EDI and other application standards. For e-Commerce to be introduced successfully within the industry, it is crucial not only to have a firm hardware backbone but also universal operational and communication standards and protocols. The national and industry governing bodies need to provide incentives and assistance to promote investments in the adoption of such technologies. Only by establishing a solid operation foundation are firms able to reap the full benefit of e-Commerce in the future. Based on the experience of western countries, this process may take several years as it is not easy to coordinate and streamline business processes to implement e-Commerce initiatives within an industry.

However, with the advancements in Internet-based e-Commerce applications, it is hoped that China and other developing countries can bypass some early problems faced by western organisations in implementing e-Commerce such as EDI high implementation costs and compatibility issues. To facilitate the future adoption of e-Commerce, national e-Commerce readiness also needs to be improved. Laws and regulations need to be put into place to protect vulnerable parties and rebuild the sense of trust between trading partners. Stronger legal frameworks will also help facilitate online activities and reassure organisations when conducting e-Commerce.

However, it is worth noting that sound e-Commerce readiness does not equate to e-Commerce adoption. E-Commerce readiness only assesses the organisation and its

environment's ability to support e-Commerce adoption. It underlies the condition of e-Commerce adoption and provides indications of the possible adoption difficulties. Successful e-Commerce adoption and development also depends on other factors rooted in the technology, the adopting organisation and the adoption environment. These factors impact on the adoption decision-making and the implementation, management and use of new technologies and systems.

This chapter systematically examines the reason why China as an example of a developing country lags behind developed countries in e-Commerce adoption from a readiness point of view. China is considered to be one of the fastest growing developing countries in the world. By using China as the research focus, this chapter does not only shed light into the unique e-Commerce adoption environment in the Chinese grocery industry but it also highlights the likely causes of the lack of e-Commerce readiness in the majority of developing countries. However, it is also worth noting that depending on the specific conditions of each country, the challenges faced in e-Commerce adoption may vary.

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13

Can a Recommender System induce serendipitous encounters?

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1. Introduction

Today recommenders are commonly used with various purposes, especially dealing with e-commerce and information filtering tools. Content-based recommenders rely on the concept of similarity between the bought/searched/visited item and all the items stored in a repository. It is a common belief that the user is interested in what is similar to what she has already bought/searched/visited. We believe that there are some contexts in which this assumption is wrong: it is the case of acquiring unsearched but still useful items or pieces of information. This is called serendipity. Our purpose is to stimulate users and facilitate these serendipitous encounters to happen.
This chapter presents the design and implementation of a hybrid recommender system that joins a content-based approach and serendipitous heuristics in order to mitigate the over-specialization problem with surprising suggestions.
The chapter is organized as follows: Section 2 presents background and motivation; Section 3 introduces the serendipity issue for information seeking; Section 4 covers strategies to provide serendipitous recommendations; Section 5 provides a description of our recommender system and how it discovers potentially serendipitous items in addition to content-based suggested ones; Section 6 provides the description of the experimental session carried out to evaluate the proposed ideas; finally, Section 7 draws conclusions and provides directions for future work.

2. Background and Motivation

Information overload is a common issue among the modern information society. Information Filtering (IF) is a kind of intelligent computing techniques that mitigates this problem by providing the user with the most relevant information with respect to her information needs.
Recommender systems (RSs) adopt IF techniques in order to provide customized information access for targeted domains.

They can be viewed as intelligent systems that take input directly or indirectly from users and, based on their needs, preferences and usage patterns, provide personalized advices about products or services and can help people to filter useful information.
Several definitions of RS have been given. According to (Burke, 2002): "*Recommender systems have the effect of guiding the user in a personalized way to interesting or useful objects in a large space of possible options*". This definition makes it clear that user oriented guidance is critical in a RS.
Among different recommendation techniques proposed in the literature, the content-based and the collaborative filtering approaches are the most widely adopted to date. Systems implementing the content-based recommendation approach analyze a set of documents, usually textual descriptions of the items previously rated by an individual user, and build a model or profile of user interests based on the features of the objects rated by that user (Mladenic, 1999). The profile is exploited to recommend new items of interest. Collaborative recommenders differ from content-based ones in that user opinions are used instead of content. They gather ratings about objects by users and store them in a centralized or distributed database. To provide the user *X* with recommendations, the system computes the neighborhood of that user, i.e. the subset of users that have a taste similar to *X*. Similarity in taste is computed based on the similarity of ratings for objects that were rated by both users. The system then recommends objects that users in *X*'s neighborhood indicated to like, provided that they have not yet been rated by *X*.
Each type of filtering methods has its own weaknesses and strengths. In particular, the content-based approach suffers from *over-specialization*. When the system can only recommend items that score highly against a user's profile, the user is limited to being recommended items similar to those already rated. Even a 'perfect' content-based technique would never find anything surprising, limiting the range of applications for which it would be useful. This shortcoming is called *serendipity problem*.
To give an example, a person with no experience with Greek cuisine would never receive a recommendation for even the greatest Greek restaurant in town.
In other words, over-specialized systems can prevent serendipitous discoveries to happen, according to Gup's theory (Gup, 1997).
It is useful to make a clear distinction between *novelty* and *serendipity*. As explained by Herlocker (Herlocker et al., 2004), novelty occurs when the system suggests to the user an unknown item that she might have autonomously discovered. A serendipitous recommendation helps the user to find a surprisingly interesting item that she might not have otherwise discovered (or it would have been really hard to discover). To provide a clear example of the difference between novelty and serendipity, consider a recommendation system that simply recommends movies that were directed by the user's favorite director. If the system recommends a movie that the user was not aware of, the movie will be novel, but probably not serendipitous. On the other hand, a recommender that recommends a movie by a new director is more likely to provide serendipitous recommendations. Recommendations that are serendipitous are by definition also novel.
Novelty is the main objective of a "classical" recommender. We agree with the theory proposed by McNee (McNee et al., 2006), that studies about improving precision and recall (or accuracy metrics in general) just do not get the point of what is useful for the user: a sensible recommendation (which is not always the most accurate one).

Our objective is to try to feed the user also with recommendations that could possibly be serendipitous. Thus, we enrich the architecture of content-based RS with a component devoted to introduce serendipity in the recommendation process.
The demonstrative scenario concerns with personalized museum tours where the serendipitous suggested items are selected exploiting the learned user profile and causing slight diversions on the personalized tour. Indeed content-base recommender module allows to infer the most interesting items for the active user and, therefore, to arrange them according the spatial layout, the user behavior and the time constraint. The resulting tour potentially suffers from over-specialization and, consequently, some items can be found no so interesting for the user. Therefore the user starts to divert from suggested path considering other items along the path with growing attention. On the other hand, also when the recommended items are actually interesting for the user, she does not move with blinkers, i.e. she does not stop from seeing artworks along the suggested path. These are opportunities for serendipitous encounters. These considerations suggest to perturb the optimal path with items that are programmatically supposed to be serendipitous for the active user.

3. Serendipity and information seeking

Horace Walpole coined the term "serendipity" in the 1754 explaining it as "*making discoveries by accident and sagacity of things which one is not on quest of*". The origin of the word "serendipity" (van Andel, 1994) is the persian fairy tale titled "The three princes of Serendip" that Cristoforo Armeno translated and published in the 1557. M. K. Stoskopf (Foster & Ford, 2003) was one of the first scientists to acknowledge the relevance that serendipity covers in scientific field, affirming that serendipitous discoveries are of significant value in the advancement of science and often presents the found for important intellectual leaps of understanding.
The history of science is full of serendipitous discoveries: the (re-)discovery of the Americas by Columbus, the Gelignite by Nobel, the Penicillin by Fleming, etc.
We agree with Roberts (Roberts, 1989) when he stresses that serendipitous encounters depend on the characteristic of the information seeker, her open minded attitude, her wide culture and her curiosity.
The idea of serendipity has a link with de Bono's "lateral thinking" (De Bono, 1990) which consists not to think in a selective and sequential way, but accepting accidental aspects, that seem not to have relevance or simply are not sought for. This kind of behavior surely helps the awareness of serendipitous events.
The subjective nature of serendipity is certainly quite a problem when trying to conceptualize, analyze and implement it. As Foster & Ford said: "*Serendipity is a difficult concept to research since it is by definition not particularly susceptible to systematic control and prediction. […] Despite the difficulties surrounding what is still a relatively fuzzy sensiting concept, serendipity would appear to be an important component of the complex phenomenon that is information seeking*" (Foster & Ford, 2003). Even though we agree with van Andel (van Andel, 1994) that we cannot program serendipity because of its nature, we share the concern of Campos and de Figueiredo (Campos & de Figueiredo, 2001a) of programming for serendipity. They also tried to suggest a formal definition of serendipity (Campos & de Figueiredo, 2001b) identifying different categories for serendipitous encounters.

By the way, the problem of programming for serendipity has not been deeply studied and there are really few theoretical and experimental studies.
The noble objective of allowing users expand their knowledge and preserve the opportunity of making serendipitous discoveries even in the digital libraries could push the development of useful tools that can facilitate important intellectual leaps of understanding.
Like Toms explains (Toms, 2000), there are three kind of information searching:

- seeking information about a well-defined object;
- seeking information about an object that cannot be fully described, but that will be recognized at first sight;
- acquiring information in an accidental, incidental, or serendipitous manner.

It is easy to realize that serendipitous happenings are quite useless for the first two ways of acquisition, but are extremely important for the third kind.
To accomplish the goal of implementing a serendipity–inducing module for a content-based recommender, the appropriate metaphor in a real-world situation could be one of a person visiting a museum (or going for shopping in a virtual space) who, while walking around, would find something completely new that she has never expected to find, that is definitely interesting for her.

4. Strategies to induce serendipity

Introducing serendipity in the recommendation process requires an operational strategy. Among different approaches which have been proposed, Toms suggests four strategies, from simplistic to more complex ones (Toms, 2000):

1) Role of chance or 'blind luck', implemented via a random information node generator.
2) Pasteur principle ("chance favors the prepared mind"), implemented via a user profile.
3) Anomalies and exceptions, partially implemented via poor similarity measures.
4) Reasoning by analogy, whose implementation is currently unknown.

In this chapter we propose an architecture for content-based RSs that implements the "Anomalies and exceptions" approach, in order to provide serendipitous recommendations alongside classical ones.
The basic assumption is that serendipity cannot happen if the user already knows what is recommended to her, because a serendipitous happening is by definition something new. Thus the lower is the probability that user knows an item, the higher is the probability that a specific item could result in a serendipitous recommendation. The probability that user knows something semantically near to what the system is confident she knows is higher than the probability of something semantically far. If we evaluate semantic distance with a similarity metric, like internal product which takes into account the item description to build a vector and compares it to other item vectors, it results that it is more probable to get a serendipitous recommendation providing the user with something less similar to her profile.
According to this idea, items should not be recommended if they are too similar to something the user has already seen, such as different news article describing the same event.

Therefore, some content-based RSs, such as DailyLearner (Billsus & Pazzani, 2000), filter out items not only if they are too different from the user preferences, but also if they are too similar to something the user has seen before. Following this principle, the basic idea underlying the proposed architecture is to ground the search for potentially "serendipitous" items on the similarity between the item descriptions and the user profile, as described in the next section.

5. Inducing serendipity in a content-based recommender

The starting point to provide serendipitous recommendations consists in a content-based recommender system developed at the University of Bari (Degemmis et al., 2007; Semeraro et al., 2007). The system is capable of providing recommendations for items in several domains (e.g., movies, music, books), provided that descriptions of items are available as text metadata (e.g. plot summaries, reviews, short abstracts). In the following, we will refer to documents as textual metadata about items to be recommended.
Fig. 1. shows the general architecture of the system evolved to provide also serendipitous suggestion within the museum scenario.

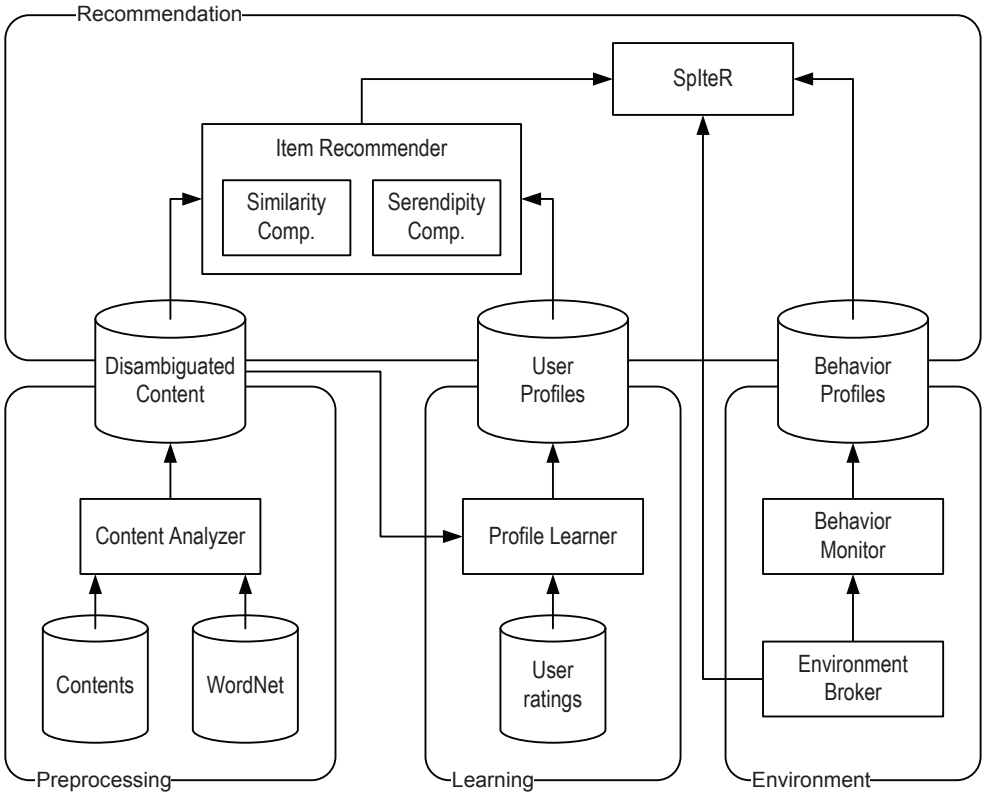

Fig. 1. General system architecture

The recommendation process is performed in several steps, each of which is handled by a separate component of the architecture shown in Fig. 1. First, given a collection of documents, a preprocessing step is performed by the *Content Analyzer*, which uses the WordNet lexical database to perform *Word Sense Disambiguation* (WSD) to identify correct senses, corresponding to concepts identified from words in the text.
Subsequently, a learning step is performed by the *Profile Learner* on the training set of documents, to generate a probabilistic model of the user interests. This model is the user profile including those concepts that turn out to be most indicative of the user's preferences.
Then, the *Item Recommender* component implements a naïve Bayes text categorization algorithm to classify documents as interesting or not for a specific user by exploiting the probabilistic model learned from training examples. In addition, the *Item Recommender* contains a sub-module implementing heuristics to provide *serendipity computation*.
Finally, the *SpIteR* (Spatial Item Recommender) module rearranges the suggested items in a personalized tour using information about environment and user behavior.

5.1. Content Analyzer

It allows introducing semantics in the recommendation process by analyzing documents in order to identify *relevant concepts* representing the content. This process selects, among all the possible meanings (senses) of each polysemous word, the correct one according to the context in which the word occurs. In this way, documents are represented using concepts instead of keywords, in an attempt to overcome the problems due to natural language ambiguity. The final outcome of the preprocessing step is a repository of disambiguated documents. This semantic indexing is strongly based on natural language processing techniques and heavily relies on linguistic knowledge stored in the WordNet lexical ontology (Miller, 1995).
The core of the Content Analyzer is a procedure for Word Sense Disambiguation (WSD), called JIGSAW (Basile et al., 2007). WSD is the task of determining which of the senses of an ambiguous word is invoked in a particular use of that word. The set of all possible senses for a word is called *sense inventory* that, in our system, is obtained from WordNet. The basic building block for WordNet is the *synset* (*syn*onym *set*), which contains a group of synonymous words that represents a concept. Since it is not the focus of the chapter, the procedure is not described here. What we would like to underline here is that the WSD procedure allows to obtain a synset-based vector space representation, called bag-of-synsets (BOS), that is an extension of the classical bag-of-words (BOW) model. In the BOS model a synset vector, rather than a word vector, corresponds to a document. Our idea is that BOS-indexed documents can be used in a content-based information filtering scenario for learning accurate, sense-based user profiles, as discussed in the following section.

5.2. Profile Learner

It implements a supervised learning technique for learning a probabilistic model of the interests of the active user from disambiguated documents rated according to her interests. This model represents the semantic profile, which includes those concepts that turn out to be most indicative of the user preferences.
We consider the problem of learning user profiles as a binary Text Categorization task (Sebastiani, 2002), since each document has to be classified as interesting or not with respect

to the user preferences. Therefore, the set of categories is restricted to POS, that represents the positive class (user-likes), and NEG the negative one (user-dislikes). The induced probabilistic model is used to estimate the *a-posteriori* probability, $P(X|d)$, of document d belonging to class X.
The algorithm adopted for inferring user profiles follows a Naïve Bayes text learning approach, widely used in content-based recommenders (Mladenic, 1999). More details are reported in (Semeraro et al., 2007). What we would like to point out here is that the final outcome of the learning process is a text classifier able to categorizes a specified item in two classes: POS (for the item the user should like) and NEG (for the item the user should not like). Given a new document d, the model computes the *a-posteriori* classification scores $P(\text{POS}|d)$ and $P(\text{NEG}|d)$ by using probabilities of synsets contained in the user profile and estimated in the training step. The classifier is inferred by exploiting items labeled with ratings from 0 to 5 (items rated from 0 to 2 are used as training examples for the class NEG, while items rated from 3 to 5 are used as training examples for POS).

5.3. Item Recommender

It exploits the user profile to suggest relevant documents, by matching concepts contained in the semantic profile against those contained in documents to be recommended. The module devoted to discover potentially serendipitous items has been included in this component, in addition to the module which is responsible for the similarity computation between items and profiles.
In order to integrate Toms' "poor similarity" within the recommender, a set of heuristics has been included in the module for *serendipity computation*.
The module devoted to compare items with profiles (*Similarity Computation*) produces a list of items ranked according to the a-posteriori probability for the class POS. That list will contain on the top the most similar items to the user profile, i.e. the items high classification score for the class POS. On the other hand, the items for which the a-posteriori probability for the class NEG is higher, will ranked lower in the list.
The items on which the system is more uncertain are the ones for which difference between the two classification scores for POS and NEG tends to zero. We could reasonably assume that those items are not known by the user, since the system was not able to clearly classify them as relevant or not. Therefore, one of the heuristics included in the serendipity module takes into account the absolute value of the difference of the probability of an item to belong to the two classes: $|P(\text{POS}|d)\text{-}P(\text{NEG}|d)|$. The items for which the lowest difference $|\text{P(POS}|\text{d)-P(NEG}|\text{d)}|$ is observed are the most uncertainly categorized, thus it might result to be the most serendipitous ones. Beside the most serendipitous function, serendipitous items can be also pseudo-ranked, i.e. the top most items are randomly arranged to avoid that the repeated requesting obtains the same result for the same un-updated user profile.

5.4. SpIteR

It dynamically arranges the suggested items to make the user experience more enthralling. Indeed, the Item Recommender is able to provide a static ordered list of items according to the user assessed interests, but it does not rely on the user interaction with environment. Besides, if the suggested tour simply consists of the enumeration of ranked items, the path is

too tortuous and with repetitive passages that make the user disoriented, especially under a time constraint. Finally, different users interact with environment in different manner, e.g. they travel with different speed, they spend different time to admire artworks, they divert from the suggested tour. Consequently, the suggested personalized tour must be dynamically updated and optimized according to contextual information on user interaction with environment.

The tour suggestion task requires knowledge about item layout. We propose to basically represent items as nodes of an Euclidean graph. Thus the museum tour is quite similar to the classical *Traveling Salesperson Problem* (TSP). TSP aims to find the shortest cycle visiting each node exactly once (Lawler et al., 1985). TSP is a well known combinatorial optimization problem and has been studies extensively in many variants. The problem is NP-hard, as shown by Papadimitriou (Papadimitriou, 1977), even if the weight of each edge satisfies the triangle inequality (in addition to nonnegative and symmetry properties) like in Euclidean graphs.

The TSP combinatorial complexity makes difficult to achieve a methodology to solve efficiently TSP of realistic size to global optimality. A number of different methods have been proposed for obtaining either optimal or near optimal solutions, ranging from classic methodologies based on linear programming (Wong, 1980) and branch-and-bound (Little et al., 1963; Bellmore & Malone, 1971) to artificial intelligence methods such as neural networks (Bhide et al., 1993), tabu search (Glover, 1990), and genetic algorithms (Goldberg & Lingle, 1985).

SpIteR does not uses only one method, but here some aspects of genetic one are shortly presented. Genetic algorithms (GAs) are search algorithms that work via the process of natural selection. They begin with a sample set of potential solutions which then evolves toward a set of more optimal solutions. A solution (i.e., a *chromosome* for GAs) for the museum tour is a sequence of suggested items. GAs require that a potential solution can be break into discrete parts, namely *genes*, that can vary independently. It's necessary to evaluate how "good" a potential solution is with respect to other potential solutions. The *fitness function* is responsible for performing this evaluation and the returned *fitness value* reflects how optimal the solution is: the higher the number, the better the solution. In the museum tour scenario, the fitness function relies on a user-sensitive time constraint, the user behavior (i.e., speed and stay times), the user learned preferences and the item layout.

Further information about museum tour items can be exploited to obtain the problem solution. Usually, few items are placed in rooms and each room is connected with some other rooms. A sample layout of rooms is shown in Fig. 2 with the schematic representation of Vatican Pinacoteca. Rooms provide a simpler perspective from combinatorial complexity point of view, but, while tour visits each item at most once (like in *k*-TPS), each room can be visited more times[1].

[1] a user should anyway cross each room access at most twice

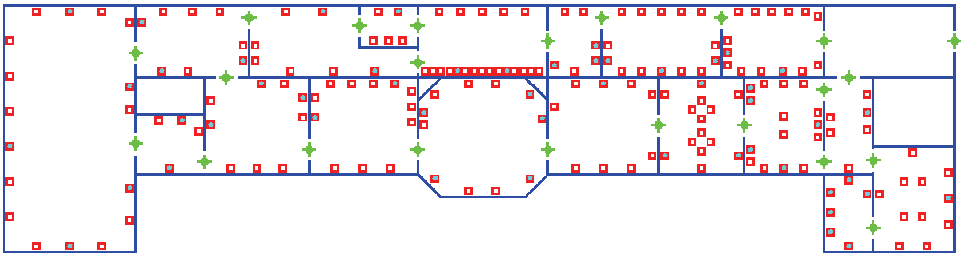

Fig. 2. Schematic representation of Vatican Pinacoteca layout

User profile can be exploited to further reduce nodes involved in the TSP for museum scenario. Indeed the suggested tour should consist of recommended items, i.e., the k most interesting items for the active user. The question about k value selection arises. Intuitively, the k value depends on how long should be the personalized tour, e.g., the preferred tour duration and the user behavior must be counted. Thus the estimate of k value mainly deals with the overall time constraint on expected time spent by the user to admire the supposed most interesting museum items. That estimate is allowed to be rough (i.e., the actual time spent to reach items can be disregarded) since the initial goal is to cut back the supposed less interesting nodes. Fig. 3 shows a sample tour consisting of the k most interesting items sorted according to the ranking provided by the Item Recommender: bend lines are only a graphical expedient to avoid hidden segments.

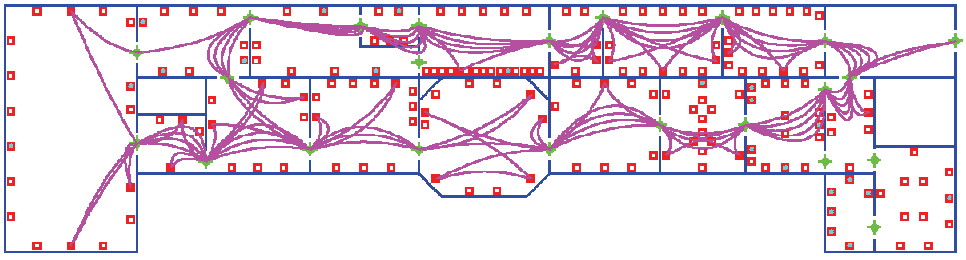

Fig. 3. A sample tour consisting of the ranked k most interesting items

Speed and stay times are parameters related to user behavior. At the beginning, they are estimated on the basis of a stereotypical user profile (Shapira et al., 1997) and then updated according to data collected during the tour from actual user behavior by the *Behavior Monitor* module. Hence the k value can change during the tour: that is not an issue, since the tour is constantly monitored to detect significant deviation from proposed one. When the user behavior requires too many significant updates to the behavior profile or the user skips a recommended item or she stays in front of un-recommended items, the tour is planned again taking into account the previous user behavior and the actual viewed items.

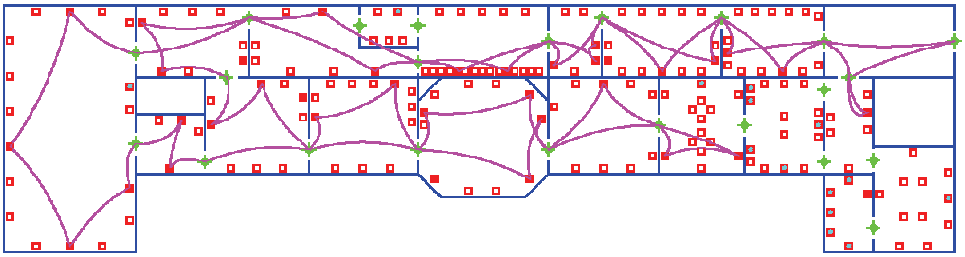

Fig. 4. The optimized version of personalized tour in Fig. 3

Once the personalized tour is achieved starting from the k most interesting items, as shown in Fig. 4, serendipitous disturbs are applied. Indeed, the ranked list of serendipitous items is obtained from the *Item Recommender* module and the previous personalized tour is augmented with some serendipitous items along the path. The resulting solution most likely has a worse fitness value and then a further optimization step is performed. However, the further optimization step should cut away exactly the disturbing serendipitous items, since they compete with items that are more similar with the user tastes. Therefore serendipitous items should be differently weighed from the fitness function, for instance changing their stay time. Indeed, the supposed serendipitous items should turn out not so serendipitous and the user should reduce her stay time in front of such items. Once again, this is not a problem since the user behavior is constantly monitored and tour dynamically updated. Fig. 5 shows an "good enough" personalized tour consisting of the most interesting items and the most serendipitous ones. It is amazing to note that some selected serendipitous items are placed in rooms otherwise unvisited.

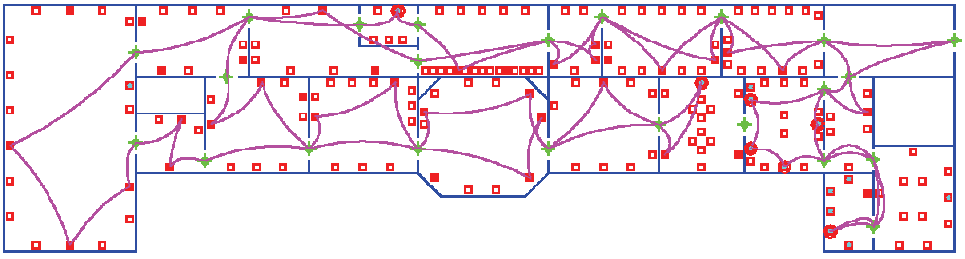

Fig. 5. The optimized version of personalized tour whit serendipitous items

6. Experimental Session

The goal of the experimental evaluation was twofold: to investigate different strategy for providing serendipitous recommendations and to evaluate the serendipity augmenting effects on personalized tours.

The experimentations we conducted was based over a corpus of 45 paintings chosen from the collection of the Vatican picture-gallery. The dataset was collected using screenscraping

bots, which captured information from the official website[2] of the Vatican picture-gallery. In particular, for each element in the dataset an image of the artefact and three textual metadata (title, artist, and description) were collected. Fig. 6 shows a sample of the resulting item. All artworks were laid in the schematic environment model of the Pinacoteca in order to deal with the spatial layout influence on recommending.

17) Raphael - Crowning of the Virgin

Painting Description

The Crowning of the Virgin was painted for the altar of the Oddi Chapel in the church of S. Francesco al Prato in Perugia. In 1797 it was confiscated by the French and transferred to Paris. When it was returned after 1815, Pius VII (pontiff from 1800 to 1823) had it placed, instead of in its original setting, in the new Vatican Art Gallery.
In the upper part of the composition, among angel musicians, Christ crowns the Virgin, while in the lower part the Apostles, among whom St Thomas with the girdle which he had received as a gift from the Virgin, are arranged around the tomb, in which there are flowers in place of the Virgin who has ascended to heaven.
The painting, which is an early work and usually dated between 1502 and 1504, has always been indicated as the work of Raphael that is closest to the style of his maestro Perugino.
The predella illustrates three episodes from Christ's infancy: the Annunciation, the Adoration of the Magi and the Presentation in the Temple.

Fig. 6. Sample of dataset item

We involved 30 users who voluntarily took part in the experiments. The average age of the users was in the middle of twenties. None of the users was an art critic or expert. Users were requested to express their preferences for collection items as a numerical vote on a 5-point scale (1=strongly dislike, 5=strongly like).
The ratings have been used for *K*-fold cross validation (Kohavi, 1995) that gave back an average degree of precision, recall and *F*-measure (Herlocker et al., 2004). We simulated the user interaction with the system using a small part of the ratings of each user for the training of the classifier. Then five iterations were performed, in which a serendipitous item was selected by the module, rated with the ratings already expressed and added to the training set. The ratings for 5 serendipitous items proposed to each one of the 30 users were collected. The whole process has been done with the most serendipitous function and for the random over most serendipitous function with a numeric threshold of 5%, 10% and 15% of the database.
Investigating different strategy to provide serendipitous recommendation, the rating interpretation issue comes out. Indeed, from a pragmatic point of view, ratings must be homogenous with other ratings in order to allow their subsequent exploitation in the profile learning step, but user rating motivations affect the meaning evaluation of finding unknown and possibly interesting things, and not simply interesting ones. For instance, a poorly rating for serendipitous suggested items should come from the experience of the user (the user already knows the item), from her lack of interest (the user already knows the item and is not interested in it), from her lack of interest in finding new things (the user does not know the item and has no interest in knowing something new), from the conscious expression of dislike (the user did not know the item before, now she knows it but she does

[2] http://mv.vatican.va/3_EN/pages/PIN/PIN_Main.html

not like it or is not interested in it) or from a serendipitous encounter (before-unknown item that results to be interesting for the user).
The results of the experimentation (Table 1) showed that the average percentage of POS items (ratings better than 3) were 40,67% for the most serendipitous function, 42,67% for the random over most serendipitous function with a threshold of 5% of the database size, 46,67% with a 10% threshold and 48,67% with a 15% threshold.
The results present a trend: with a larger threshold of randomness there are more good ratings. This could be interpreted as follows: the randomness of the selection over the most serendipitous item helps improving the ratings. So the best function would be the one with a more wide threshold of randomness. But, as the average POS ratings increase and better ratings means more similar items, we can hypothesize that suggested items are more semantically near to user tastes and knowledge so it is less probable that they are unknown. In this case the best function would be the most serendipitous one.

	Average POS
Most serendipitous	40.57%
Random over most serendipitous (5% threshold)	42.57%
Random over most serendipitous (10% threshold)	46.67%
Random over most serendipitous (15% threshold)	48.67%

Table 1. Four functions average results

In order to evaluate the serendipity augmenting effects on personalized tours, the learned profiles were used to obtain personalized tours with different time constraints and different serendipitous disturbs. Five time constraints were chosen so that tours consisted approximately of 10, 15, 20, 25, 30 items. Serendipitous items ranged from 0 to 7.
Table 2 reports the average of sums and means of POS values of tours. Fig. 7 helps in the data interpretation: the serendipitous item augmenting causes the exploiting of items less similar to the user tastes and this effect is particularly evident when there are too many serendipitous items. On the other hand, there is also a decrease when many items are selected according to the user profile, since they are progressively less interesting. When there are many items, the serendipitous item augmenting seems to have no effects over POS mean, but probably this comes from the not very large dataset used.

	T_1		T_2		T_3		T_4		T_5	
S0	7.18	0.711	10.69	0.714	14.02	0.705	17.21	0.679	19.94	0.671
S1	7.15	0.708	10.61	0.709	14.00	0.704	17.20	0.679	19.89	0.670
S2	7.12	0.705	10.59	0.708	13.98	0.702	17.20	0.679	19.88	0.669
S3	7.08	0.701	10.60	0.708	13.96	0.702	17.19	0.679	19.87	0.669
S4	7.03	0.696	10.58	0.707	13.96	0.701	17.19	0.678	19.87	0.669
S5	6.88	0.681	10.52	0.703	13.95	0.701	17.17	0.678	19.85	0.668
S6	6.54	0.647	10.42	0.696	13.90	0.698	17.11	0.676	19.75	0.665
S7	6.17	0.611	10.19	0.681	13.76	0.692	16.99	0.671	19.64	0.661
Items	*10.10*		*14.97*		*19.90*		*25.33*		*29.70*	

Table 2. Sums and means of POS values of tours

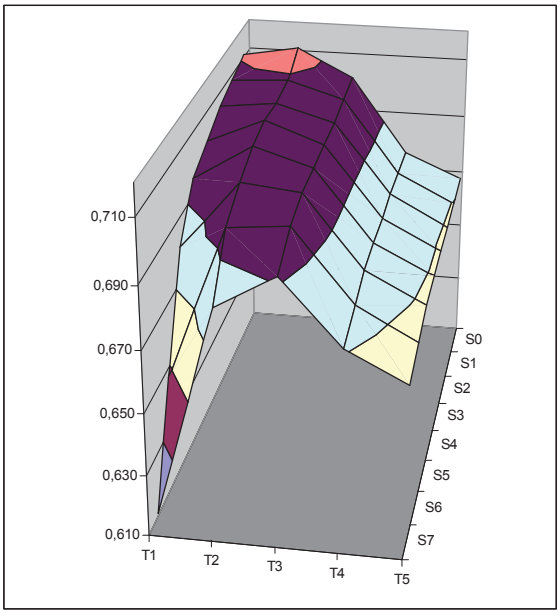

Fig. 7. Means of POS values of tours

Table 3 reports percentages of walking time over the tour. Data show that, increasing the time constraint, less time is spent to walk. Indeed, if few items are selected, they are scattered around (proportionally) many rooms and the user visits room with very few and even no one suggest item. The serendipitous item augmenting seems to increase the walking time. This result is quite amazing according to the selection serendipitous item strategy, i.e., items that are along to a previously optimized path. Actually, the walking time percentage mainly increases because serendipitous items are introduced as new genes of a "good enough" chromosome (solution). However, the augmented chromosome tends to evolve toward the previous one. Thus the new genes should be promoted with a benefit over the fitness function: the reduction in their supposed stay time. This approach is simple and intuitive, but it makes difficult the interpretation of expected walking time percentage.

Indeed the variation on walking time becomes from path variations, but the total tour time is also changed on account of the technical issue about the GA fitness function.

	T_1	T_2	T_3	T_4	T_5	
S0	39.9%	34.0%	34.6%	31.6%	30.2%	**34.1%**
S1	42.6%	36.3%	36.0%	32.8%	31.3%	**35.8%**
S2	45.0%	38.1%	37.4%	34.0%	32.2%	**37.4%**
S3	49.7%	40.1%	38.3%	34.5%	33.5%	**39.2%**
S4	52.7%	42.0%	39.9%	36.3%	34.6%	**41.1%**
S5	56.0%	45.5%	41.9%	37.8%	35.9%	**43.4%**
S6	60.0%	47.5%	43.7%	39.7%	37.2%	**45.6%**
S7	65.2%	51.7%	45.6%	41.7%	39.0%	**48.6%**

Table 3. Percentages of walking time

Moreover, the effects of serendipitous items on expected walking time are analyzed with respect to the starting optimized tours (S0), i.e. the previously discussed drawback is partially cut off. Table 4 and Fig. 8 show that few disturbs cause a quite uniform increase of the walking time: the ground becomes from the slight deviations on S0 tour. On the other hand, growing the number of serendipitous items, the deviations are amplified. This is more evident for the shortest S0 tours, since many serendipitous items can encourage the "exploration" of rooms untouched by S0, about Fig. 5.

	T_1	T_2	T_3	T_4	T_5
S1	106%	106%	104%	103%	103%
S2	112%	112%	108%	107%	107%
S3	124%	119%	112%	110%	111%
S4	131%	126%	117%	115%	115%
S5	141%	136%	123%	121%	120%
S6	150%	143%	130%	127%	125%
S7	164%	155%	135%	134%	131%

Table 4. Increment of walking time for tours with serendipitous items

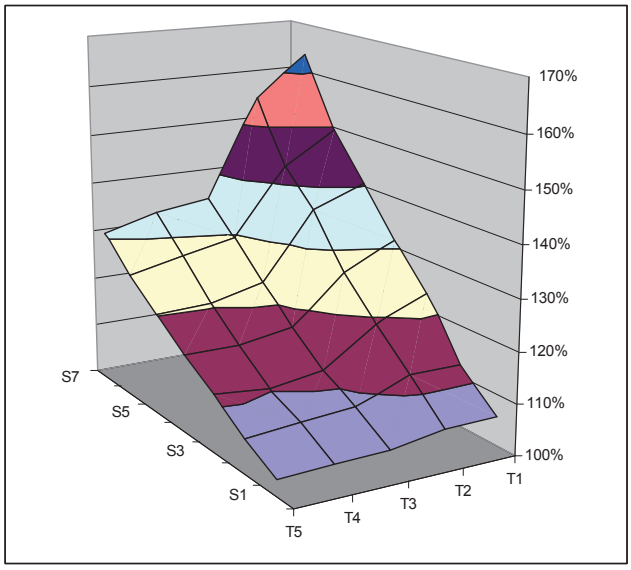

Fig. 8. Serendipitous effects on walking time

7. Conclusions and Future work

This chapter presents a beginning effort to apply some ideas about serendipity to information retrieval and information filtering systems, especially in recommenders, to mitigate the over-specialization issue. The museum scenario is particularly interesting because items are arranged in a physical space and users interact with the environment. Thus disregarding context facets makes useless recommendations. Similar remarks are still valid in domains (different from cultural heritage fruition) in witch a physical or virtual space is involved and it represents a pragmatic justification to explain (supposed) serendipitous recommendations.

As future work, we expect to carry out more extensive experimentation with more users and wider item collections. We plan also to gather user feedback and feeling by questionnaires focused on qualitative evaluation of the recommendations and the idea of getting suggestions that should surprise them. That is really important for the need to understand the effectiveness of the module in finding unknown items rather the ones that result best rated. Experimentation with users with different cultural levels and with different information seeking tasks are also important to find out which kind of user would like most serendipitous recommendations and to whom they are more useful.

We expect also to implement the other suggestions given by Toms (Toms, 2000) and to develop further the heuristic proposed (maybe padding a parameter factor that multiplies the probabilities in order to balance better between categories) or also introduce new heuristics and make an experimental comparison.

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A Mobile Commerce Model for Automobile Rescue Services

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1. Introduction

The automobile is usually composed by four components of automobile engines, chassis, body and the electrical equipments. The spare parts of it reach over ten thousand, the reason of the initiation breakdown is numerous, therefore the duty of automobile rescue services is not to repair automobiles, but to restore the ability of safe driving. Generally speaking, the content of automobile rescue services include: (1) some breakdown, which could be restored within half an hour and in the conditions of not-for-pieces and not to disintegrate ;(2) some ordinary rescue services such as sending oil, replacing spare tire and unlock services under the permission of law; (3) The specialized automobiles towing services in the condition that the automobiles' normal capacity cannot be restored at the scene (Liyi Zhang & Qihua Liu, 2008) .

With the rapid economy development of China, the total number of society vehicles has increased dramatically. From the information of the Ministry of Public Security of China, as the end of September 2007, the total number of personal vehicles is 118129662. It has increased by 7.22% comparing with the end of 2006. Among them, private automobiles are accounted for 61.25% of the total number of automobiles, private motorcycles are accounted for 97.08% of the total number of motorcycles; private trailers are accounted for 23.48%of the total number of trailers. The information demonstrated that business vehicles are accounted for 9.21% of the total number of vehicles. It has the growth of 8.82%comparing with the end of 2006.

With the rapid development of the automobile industry, the demand for automobile rescue services has also become increasingly strong. The CCTV reported the total number of China private automobiles are 13,000,000 in November 2005. According to the empirical statistics, 10% vehicles will need rescue services . So, we can estimate that the number of the automobile rescue services is 1.3 million every year. If an automobile rescue services will cost 150 Yuan by an average, the annual market share of automobile rescue services are 195,000,000 Yuan(Lin Deng, 2006).

But there are still many problems in China's automobile rescue services. The article firstly analyses and compares the models of automobile rescue services both at home and abroad, and then builds an e-commerce site of automobile rescue services—995 Automobiles Rescue Network.(995ARN), and analyze its mobile commerce solution. The article firstly analyses

and compares the models of automobile rescue services both at home and abroad, and then builds an e-commerce site of automobile rescue services—995 Automobiles Rescue Network.(995ARN), and at last analyze its mobile commerce solution. This article creatively integrates some technologies of mobile commerce such as LBS, SMS and Electronic Map and SNS in automobiles rescue service, reflecting a certain amount of advanced and innovative.

2. The analysis of automobile rescue market at home and abroad

2.1 The analysis of foreign automobile rescue market

Automobile rescue markets have highly developed in some western countries.

International Automobile Travel Alliance (AIT) already has 138 members club. Its headquarters locate in Switzerland, is an Automobile Club Organization, which is mainly engaged in rescue services. It is divided into North, South, Europe and Asia-Pacific, has 200 million members. It has a unified telephone number, membership-based chain brand and standard services (Liyi Zhang & Qihua Liu, 2008).

Germany's automobile maintenance club (ADAC), which is managed by ministry of communications, is responsible for the maintenance work of vehicles. It has set up some filiations in some Germany's cities, European countries and some Asian countries.

There are also a number of other departments actively involved in the automobile rescue services, such as Australian Automobile Association (NRMA), some foreign insurance companies, telecommunications operators (Nextel, Onstar and the SUNCOM companies of ATT), automobile manufacturing enterprises and highway departments. But, different organizations provide different services. For example, some insurance companies provide short-term Motorists travel insurance services; transnational automobile manufacturer enterprises are implementing the plan of automobile emergency rescue, to provide rescue services for new automobiles at appointed time or mileage.

Overall, foreign vehicle rescue and maintenance services have became a relatively perfect service system, and the efficiency of rescue services is more efficient. If the owner of automobile ask for help under steam, rescue vehicles can be arrived at the scene within half an hour, and provide rescue services for member. Foreign automobile rescue companies all pay high attention on rescue effect and user's satisfaction. They not only regularly launch market surveys and evaluation, but also seriously accept customer complaints. Each year, they all hire professional consultant firm to evaluate the effect of rescue, so that can constantly improve the service system and the level of services.

2.2 The analysis of domestic automobile rescue market

In recent years, some provinces and municipalities have been carrying out automobile rescue services. Among them, some offices also formed the network of automobile rescue. The work of automobile rescue services has achieved positive effects in general. There are four automobile rescue models in china. Those are Member model, bidding model, enterprises construction model .

2.2.1 Membership model

The Hebei province is the representation of member model. The Hebei Province Communications Department has launched the building work of automobile rescue

network in 1998. In 2006, the Hebei Province automobile rescue network (HARN) is formally established.

The HARN is constituted by Hebei Province and every city's automobile rescue center, some automobile rescue companies and owners of automobile under the circumstances of agreeing to fulfill a contractual obligation of the constitution of HARN and enjoying corresponding power. The network will use uniform operation model and corporate image to serve the overwhelming majority of automobile units and individuals. Among them, the companies are intituled as "net"; the individuals are intituled as "member".

Now, the HARN has used uniform telephone number. It is 1019122。It has produced good results.

2.2.2 Bidding model

The representation of bidding model is Liaoning province. Bidding model is that the local government adopt bidding scheme to fix on member so that to set up the rescue network. By the end of 2004, Liaoning Province have established municipal vehicle rescue service centers, and used uniform telephone number to provide service. In 2004, the total number of automobile rescue services is more than 75,000 times, and the rescue work achieves good benefit.

2.2.3 Enterprises construction model

Enterprises construction model is that some enterprises through a lot of business cooperation to set up a club such as Beijing Mainland Automobile Club, Shanghai Anji Automobile Club and SUyou Automobile Club. They all have rescue equipment and set up mobile rescue team. But they always focus on providing services for member; the item of services also is relatively simple. The representation of the model is UAA.

United Automobile Association (UAA), founded in March 2005 and headquartered in Beijing, is a foreign invested membership based company. By incorporating the successful experiences of international automobile service industry, as well as utilizing the Internet and CRM-integrated call center technology, the company provides automobile owners and drivers nationwide with efficient, flexible and competitive services, including full-range automobile and travel-related services such as automobile rescue, auto insurance, auto repairs, hotel accommodations, airline tickets and map guides, etc.

2.2.4 Problems

There are other model to provide automobile rescue service such as the intelligent traffic network patterns of Hubei and "11185 automobile rescue network" of Quanzhou city in Fujian province.

Overall, the three rescue model before all have the following problems (Liyi Zhang & Qihua Liu, 2009):

- Not building a transparent supply and demand platform of the rescue services;
- The three rescue models have a clear regional characteristics and different service model.
- In these models, service organizers always can obtain a majority of the rescue profits. So, it objectively has led to the lower customer satisfaction rate of automobile rescue service.

2.2.5 Solutions

In order to solve these problems, the author proposes a new model of the automobile rescue services: E-commerce model.

The so-called E-commerce model is building a transparent platform for the owners of automobile and the repairers. Firstly, the owners of automobile can contact with the system through three ways such as call telephone send messages and Internet. Secondly, the system chooses some suitable repairers to the owners. Thirdly, the repairers can contact the owners. According to the concept, the authors build the 995ARN.

3. The analysis of 995ARN's model

3.1. The framework of 995ARN

The 995ARN is developed by the authors in 2007, which is a third-party automobile rescue service platform. The platform locates in providing the nationwide "one-stop" service platform for the members, is for the purpose of establishing the scientific and standard automobile rescue network, and improving the level of rescue service so that to meet the growing demand of automobile rescue.

The 995ARN's framework is that the automobile rescue platform is the resources deployment center, automobile maintenance service providers is the crunodes, the automobile owners membership is main form, as shown in Fig.1.

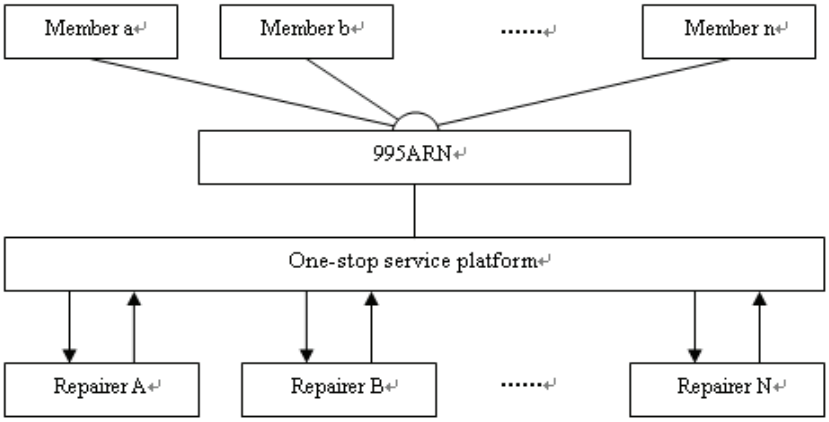

Fig. 1. The framework of 995ARN

3.2. The one-stop service platform in 995ARN

The one-stop service platform in 995ARN is that system through an entrance to provide resources integration services for all members, including automobile rescue, the Internet Shopping Mall, automobile news and forum, as shown in Figure 2.

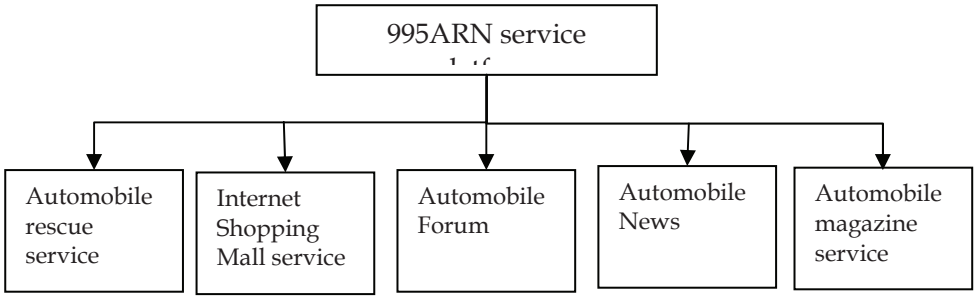

Fig. 2. The components of 995ARN service platform

3.2.1. Automobile rescue service

Automobile rescue service platform is a system using mobile commerce technologies (SMS and Location Based Servers) to provide reasonable match for the member, according to location, the degree of damaging and Rescue Company's rank.

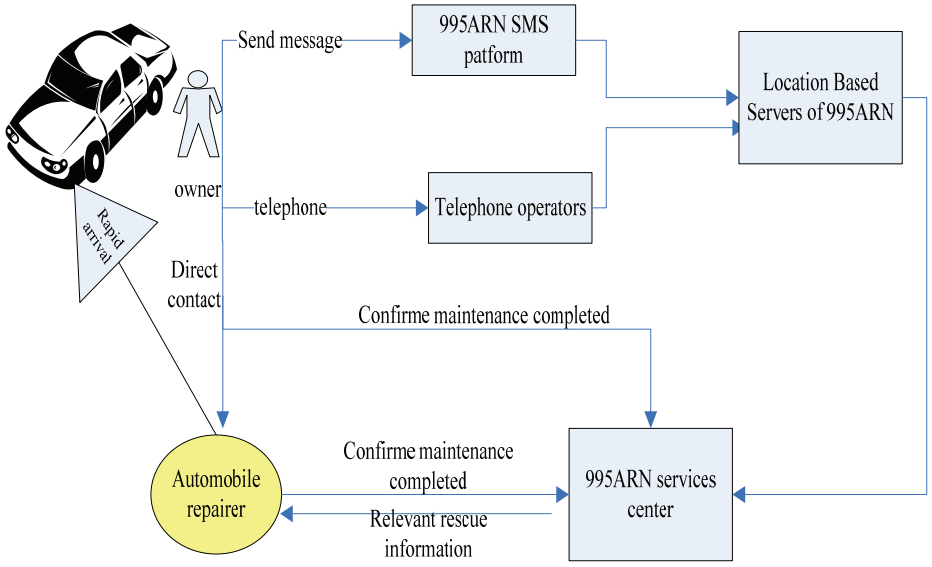

Fig. 3.The process of automobile rescue service in 995ARN

As Figure 3 shows, the process of 995ARN's rescue platform is composed by three ways: send message, call the telephone hot-line and direct contact. If the owner of automobile knows the address and telephone of rescue member, he or she can direct contact the company to obtain service. If he doesn't familiar with the situation of rescue member in the vicinity, he can send messages or call the telephone hot-line to 995ARN, and the system will

provide the information of reasonable rescue member for him. Of course, rescue member and the owners of automobile should feedback the new circumstances to the system after complete the rescue services.

3.2.2. Internet Shopping Mall service

The internet shopping mall service is that system provides a product or service transaction platform for relevant automobile companies such as automobile parts suppliers, automobile repairers, automobile manufacturers, sales of automobiles and automobile beauty service. It can provide the following services:

- Automobile parts transaction service
- Comparison service of new automobile's price
- The second-hand automobile transaction service
- Automobile maintenance service

3.2.3. Automobile Forum

Automobile Forum is a network community, which provides an immediate communication platform for paying members of 995ARN, as shown in Fig.4.

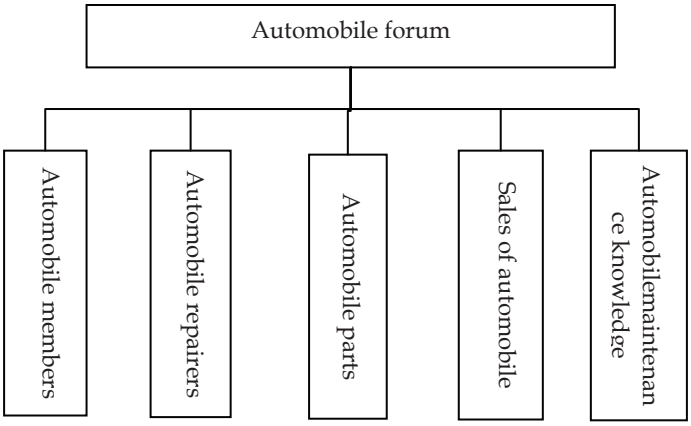

Fig. 4. The components of automobile forum

In addition, users can also establish their own circle of friends according to their own interest, so that can share and transmit information.

3.2.4. Automobile News

995RAN provides some news of new automobile, the second-hand automobile, the auto parts, automobile maintenance and so on for all customers. At the same time, it also provides automobile industry investigation reports, the practical guide service, rescue policies and regulations, correlation technique standard for members of 995RAN.

3.2.5 Automobile magazine service

There are some very exceiting rescue stories and automobile news in 995ARN. So, we use some technologies such as data-mining to obtain some useful knowledge of automobile industry from automobile news, rescue stories and automobile forum. Then, we will regularly publish some electronic magazine to members.

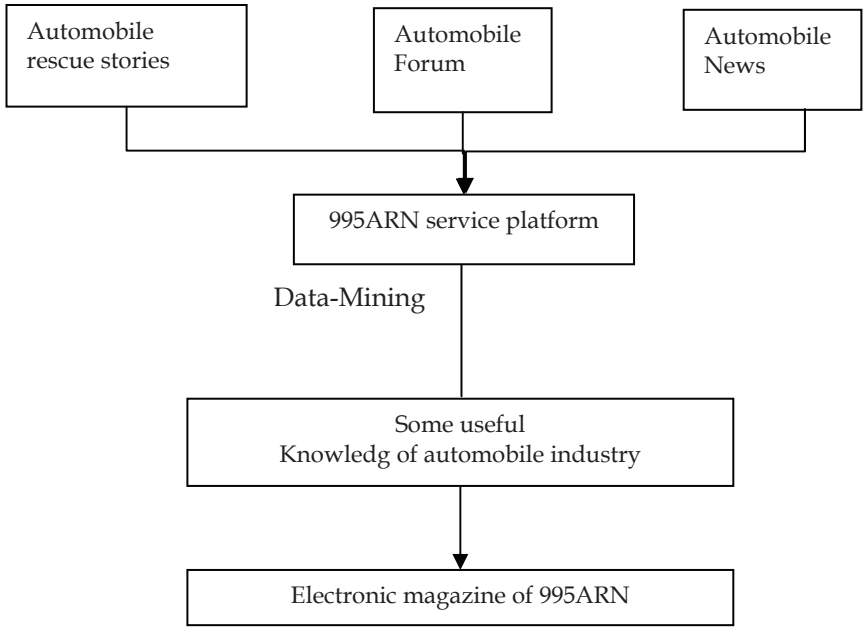

Fig. 5. Automobile magazine of 995ARN

3.3. The members'management of 995ARN

3.3.1 The types of members

995ARN mainly contains three types of Members: Ordinary Members, individual VIP members and industry VIP Members. In order to improve service levels, the system will provide different service permissions to different members types, as shown in Table.1.

Function directory	Ordinary members	Invidividual VIP members	Industry VIP members
Publish purchasing information	0	0	1
Publish selling information	0	0	1
My consumption points	1	1	0
automobile rescue services	0	1	0
My purchasing history	1	1	1
My selling history	0	0	1
My Collector	1	1	1
Change password	1	1	1
Individual/ Industry Information Maintenance	1	1	1
Integral query	1	1	1

Notes: '0' indicated that they had no authority; '1' indicated that they had authority.
Table 1. The types of members

3.3.2 Members registration

Users can use the following four ways to become the members of 995ARN: Online registration, service point registration, telephone registration and SMS registration.

3.4. Combination of 995ARN and SNS

The combination between 995ARN and SNS is to provide a convenient platform for making friends so that to strengthen communication and cooperation of members.

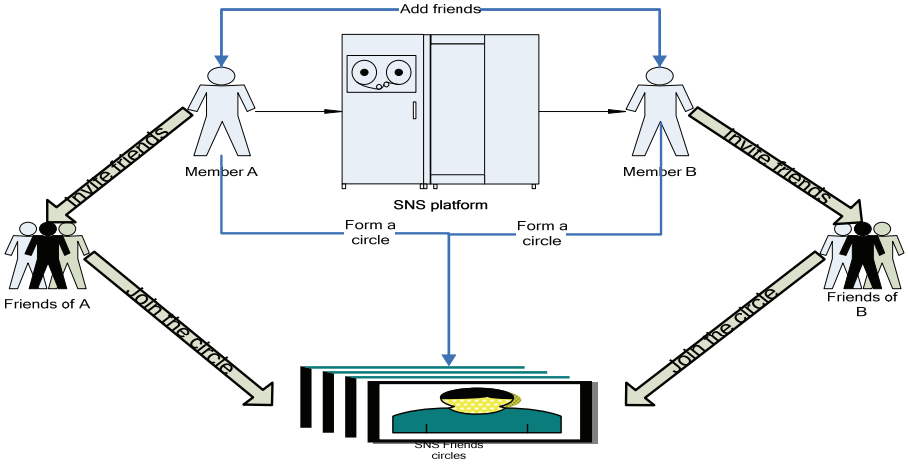

Fig. 6. SNS services model

4. The mobile commerce solution of 995ARN

The mobile commerce solution of 995ARN includes three aspects: GSM-Modem SMS platform, Location Based Servers platform and Electronic Map, as shown in Fig.7.(Liyi Zhang & Qihua Liu, 2009)

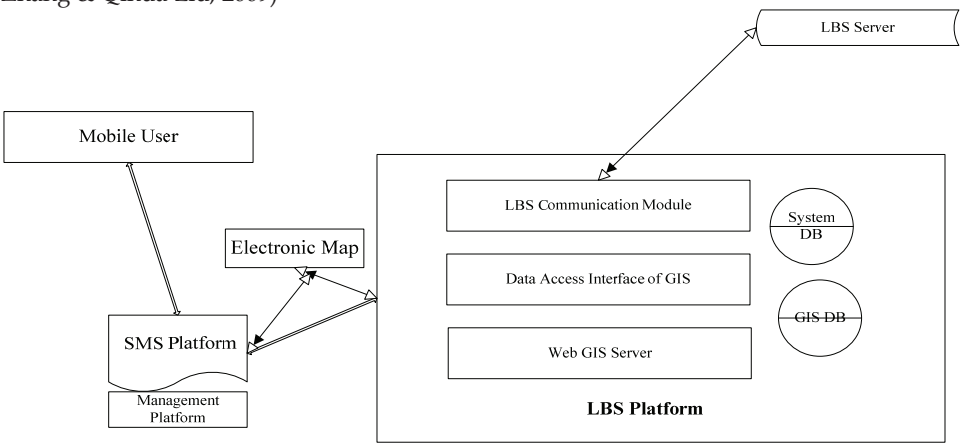

Fig. 7. The mobile commerce solution of 995ARN

4.1. GSM-Modem SMS platform of 995ARN

The Short Message Service (SMS) is based on outof-band message delivery, which permits users to send and receive text messages to/from their mobile phones.

SMS was introduced in 1992 and, since then, has experienced a remarkable success: by the end of 2002, 30 billion messages have been exchanged monthly, and the growth rate has been 0.5 billions per month. This makes SMS to represent about 10% of the revenue of mobile operators.

Considering the particularity of the users of the website, it is inconvenient for the drivers in the way to go online, so 995ARN provides its members with convenient message platform. A small cell phone can be used to send the information of the rescue, information about the member's number, and request of rescue and so on.

The internet can be connected with the SMS Network in three ways.

The first approach is that the internet cooperates with the mobile service operators (SO) directly, and gets a special-service number. Besides, we pay for the services according to a certain accounting method and can acquire some technical support from the mobile SO. This approach often has high stability and quality. However, the related costs are high. Moreover, a relatively high threshold may be set up by the mobile service operator. SP usually adopt this approach to connect with the mobile service operators.

And the second approach is to connect with the mobile SO with the help of the SP. That is the internet being connected to mobile service operators with SP as an intermediary. A SP can provide accesses for more than 100 users. It is bound to affect the communicating quality and the stability must be affected by the SP itself.

The final approach is connecting with the mobile SO with the help of their own SMS modem which supports GSM (Global System for Mobile Communications). With an SMS modem

and a mobile phone SIM card, we can send and receive text messages like using a common mobile phone and needn't any other procedures. Comparing with the above two approaches, this one is more convenient and its stability is relatively higher. The only disadvantage is the limited transmission capacity and speed.
Here, we use equipment named SMS Modem which supports GSM. It can get access to the SMS gateway which is a component of SMS server center through a wireless access.
Considering that 995ARN's requirement is not too high and is usually stabile, we choose the third one as the approach to access to the SMS network in our 995ARN's SMS Platform System.

4.1.1. The Framework of 995ARN's SMS Platform

As Fig.8 shows, the framework of 995ARN's SMS platform is composed by three tiers: R/S (Receive /Send) Protocol Control Tier, R/S Control Tier and Application Tier. The R/S Protocol Control Tier is responsible for using some SMPP Message gateway protocol such as CMPP, SGIP, SMGP, SMPP and producing a platform-crossed SMS service. So it can provide a SMS R/S interface for the above Tiers. Here we use the JSMSEngine 2.0.4, which is a popular open-source java package in the internet. The R/S Control Tier is responsible for packaging the messages which need to be sent and unpacking the received SMS formatted text messages from the SMS server centers and routing and choosing an appropriate application for the received messages. Text message package is to package the text messages which include the Cell Phone Numbers, Text Message, SMS Gateway Protocol, SMS Encoding, etc in accordance with the requirements of the R/S interface format and then send them to the R/S Protocol Control Tier whose duty is to send the text message to the SMS server center. The third Tier – the Application Tier has to analyze the messages and then choose a certain application unit to deal with and respond to them. The Application Tier is mainly dealing with the content of the text message and the operation of receiving and the sending of the text message means a black-box to the Application Tier (Yadong Lang & Juan Wu, 2004) .

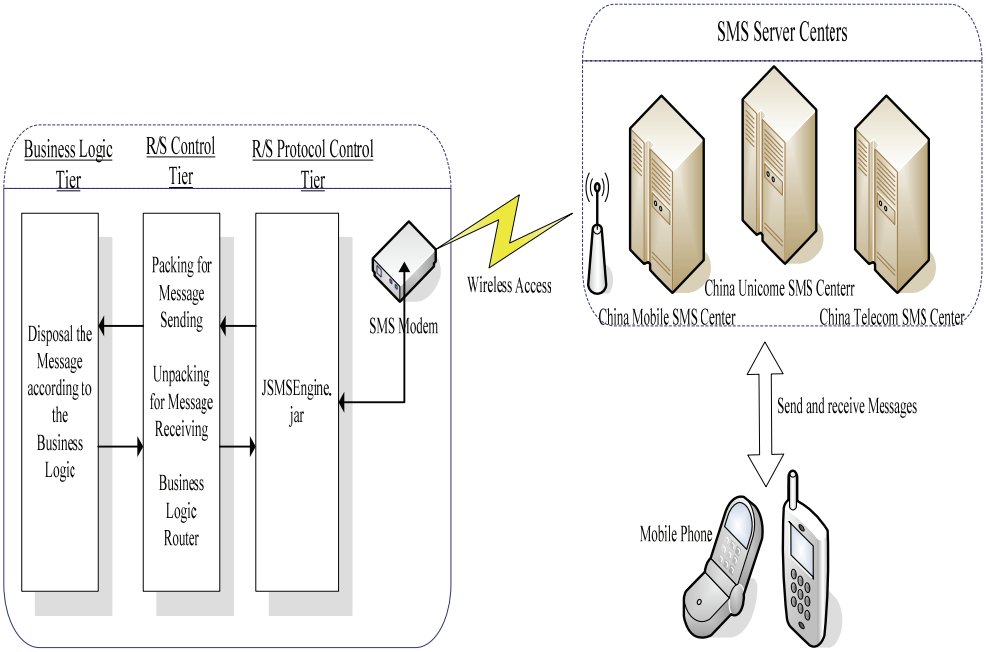

Fig. 8. the model of GSM-Modem

4.1.2. The Design of R/S Control Tier

R/S Control Tier has three tasks: sending text messages, receiving text messages and application routing. Moreover, necessary log document must be written in. Sending and receiving text messages are both communicating operations, while the writing of log is the database operation and the application routing is WEB operation. Three independent threads are designed to take charges of these three functional operations. And we have also set two text-message queues to manager the text messages. The structure of R/S Control Tier is shown as Fig.6.

R/S Control Tier is a gateway communication Tier which takes responsibility to maintain a connection to the gateway, send messages to the gateway, and receive messages from the gateway and send them to Message Receiver Queue.

Message Sender Queue and Message Receiver Queue are two Queues which see to the message management.

Application Router takes responsibility to send text messages to the related application.

Logger Thread is log-writing programs which fetches text messages from the message queues, and then write in the log.

Sender Thread is a thread program which submits text messages to R/S Control Tier. The SMS gateway protocol is asynchronous, however, in most of the time, a synchronous one is needed which means that we have to know whether the sending is successful. Therefore, Sender Thread always provides a method to keep synchronous. After sending a text

message, Sender Thread will waiter for the result until it is notice that the message has been send successfully or not.
Receiver Thread is a thread program which sees to receive the text messages. It fetches the text messages from Message Receiver Queue and then delivers the text messages to different application routers according to the contents of the text messages (Qi Zhu, 2005).

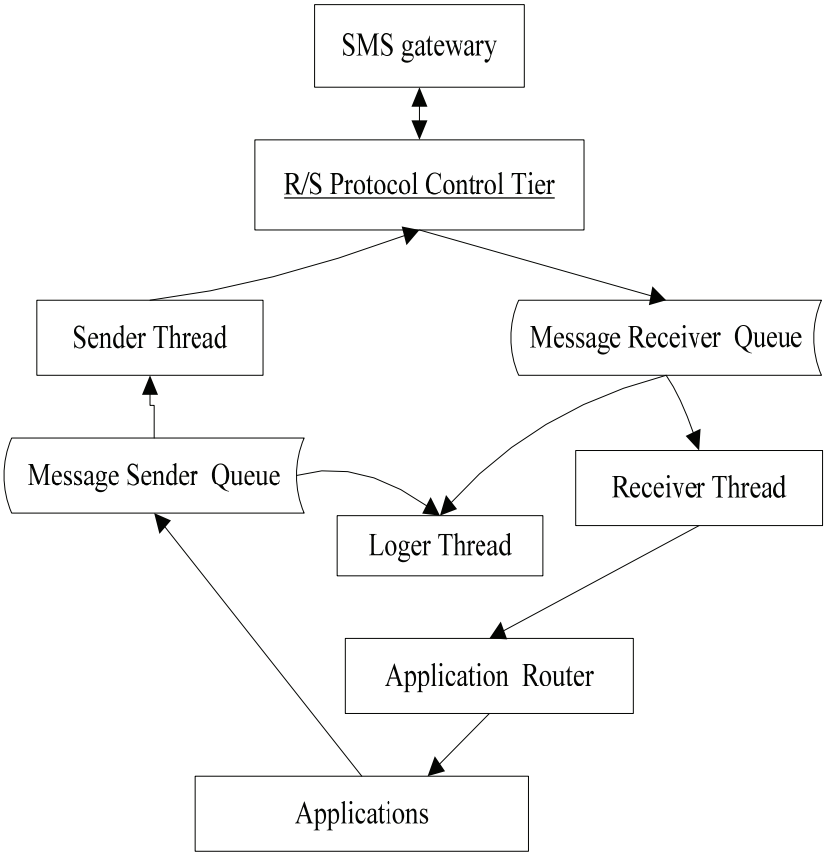

Fig. 9.Structure of the R/S Control Tier

The data structure of text message class and the queue algorithm are described as follows. The queue is designed as a linked list which uses "last Node" as a reference variable. (Qi Zhu, 2005)

```
class MessageBean
{
  //definition of MessageBean
  private String cellPhoneNumbers;
  private String textMessage;
  public MessageBean(String cellPhoneNumbers, String textMessage){
    this.cellPhoneNumbers = cellPhoneNumbers;
```

```
    this.textMessage = textMessage;
  }
 //get and set methods
} //end class MessageBean
class Node
{
//definition of Node
  private MessageBean item;
  private Node nextNode;
  public Node(MessageBean mewItem){
    item = newItem;
    nextNode=null;
  }
 public Node(MessageBean mewItem,Node next){
    item = newItem;
    nextNode=next;
  }
 //get and set methods
} //end class Node
public class MessageQueue{
 //definition of MessageQueue
 private Node lastNode;
 public MessageQueue(){
 lastNode=null;
 } //end structure method MessageQueue
 public isEmpty(){
  return lastNode==null; //determines whether a queue is empty
 }
 public enqueque(MessageBean newMessage){
 //insert a new node
} //end enqueque
public MessageBean dequeque throws QueueException(){
 //retrives and removes the front of the queue
} //end dequeue
public MessageBean peek throws QueueException(){
// retrives the item at the front of the queue
} //end peek
} //end class MessageQueue
```

4.2. Location Based Servers platform of 995ARN

With the development at full speed of mobile Internet and progress constantly, the demand for 4A (anytime, anywhere, anybody, anything) service of spatial information increase day by day, so LBS appears with the combination of wireless information service and spatial information service. LBS refer to offering information service based on geographical location for mobile terminal by utilizing GIS echnology, GPS technology, embedded technology and

wireless network communication technology under mobile environment. It is convenient for user to query present location, the nearby market and other information with the advantage of LBS.

Location-based services (LBS) are services that utilize their ability of location awareness to simplify user interactions and adapt to the specific context. With advances in automatic position sensing and wireless connectivity, the application range of mobile LBS is rapidly developing, particularly in the field of geographic, tourism, and logistic information systems.

In 995ARN, we use the Location Based Servers technology to quickly determine the location of members after SMS Modem received the members' messages.

LBS is an interface provided by China Mobile network operator. First, mobile operator develop a port to receive the SP location request in the form of XML package, and then send back the result in XML after they got the location information. To carry out the port of message platform and location service, we write a program to receive parsing request, send and revive location request package, return the results in SMS, and take it as a part of the message management platform , as shown in Fig.10.(Liyi zhang & Shitong Zhang, 2007)

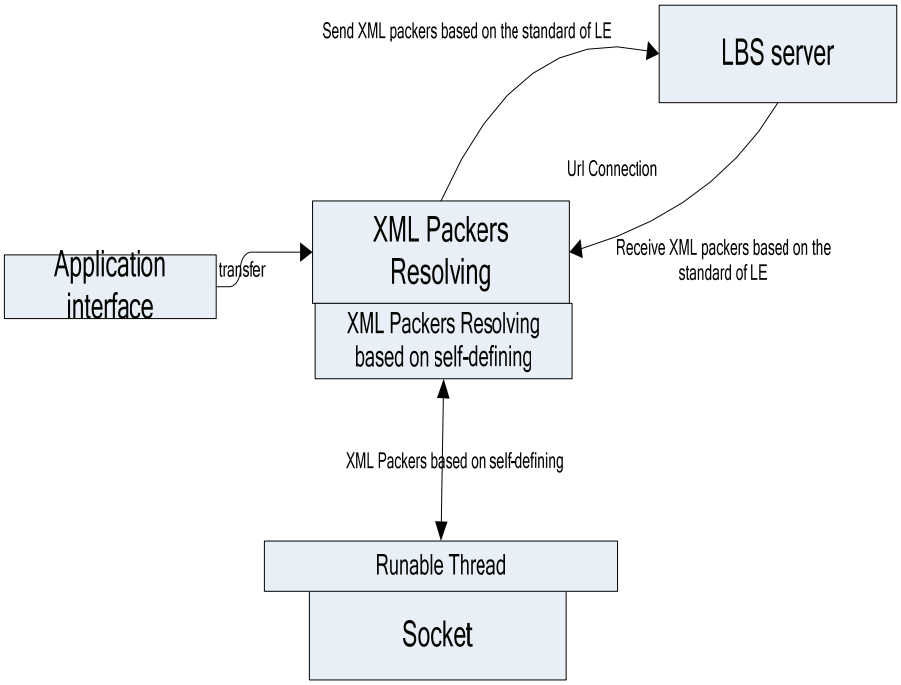

Fig. 10. Structure of the 995ARN's LBS platform

The result returned to LBS is denoted in longitude and latitude coordinate (X, Y), and we have to transform it to geographic location so that it is legible. In LBS, users may be interested in the following information: space date, such as the shortest way (path information); position of interest (location information); and non-spatial information such as

all kinds of Stat. analysis etc. Therefore how to amalgamation multi-source data efficiently become the main problem. And we design two interfaces: Query Interface and SMS Interface on the electronic map to implement the integration between SMS Platform and Electronic Map.

4.3 Electronic Map

With the development at full speed of computer technology, spatial information technology and modern information infrastructure, the importance of geographical information system (GIS) grows with each passing day in the information-based process of national economy. Nowadays the proposition of digital earth concept makes people understand the importance of GIS more deeply. Since entering 1990s, GIS got unprecedented development in the whole world and produced the enormous economic and social benefit.

In 995ARN, we use MapXtreme as a map server to achieve electronic map services. MapXtreme is the leading software development kit (SDK) for integrating location intelligence with existing business systems. It allows developers to build custom mapping applications, provide tailored views of geographic data and automate and augment business processes. MapXtreme's powerful spatial capabilities are geared toward solving real business problems, with a powerful, user-friendly feature set. Flexible deployment options include both desktop and web from a single SDK.

We use MapInfo to creat a thematic map of automobile repairers information. The key stps include: accessing map data, creating thematic map, and developing the user-defined servlet. This paper focuses on the introduction of the production of a thematic map and the development process of user-defined servlet.

4.3.1 The steps of creating a thematic map

The process of creating a thematic map includes the following steps(Shitong Zhang, 2008):

- Plan the thematic map;
- Select elements of base map and tehmatic;
- Create the table of elements *. Tab;
- Deal with data and symbols;
- Configuration notes and legend;
- Map landscaping;
- Output of thematic maps.

The flow chart of creating the thematic map can be shown in Fig.11.

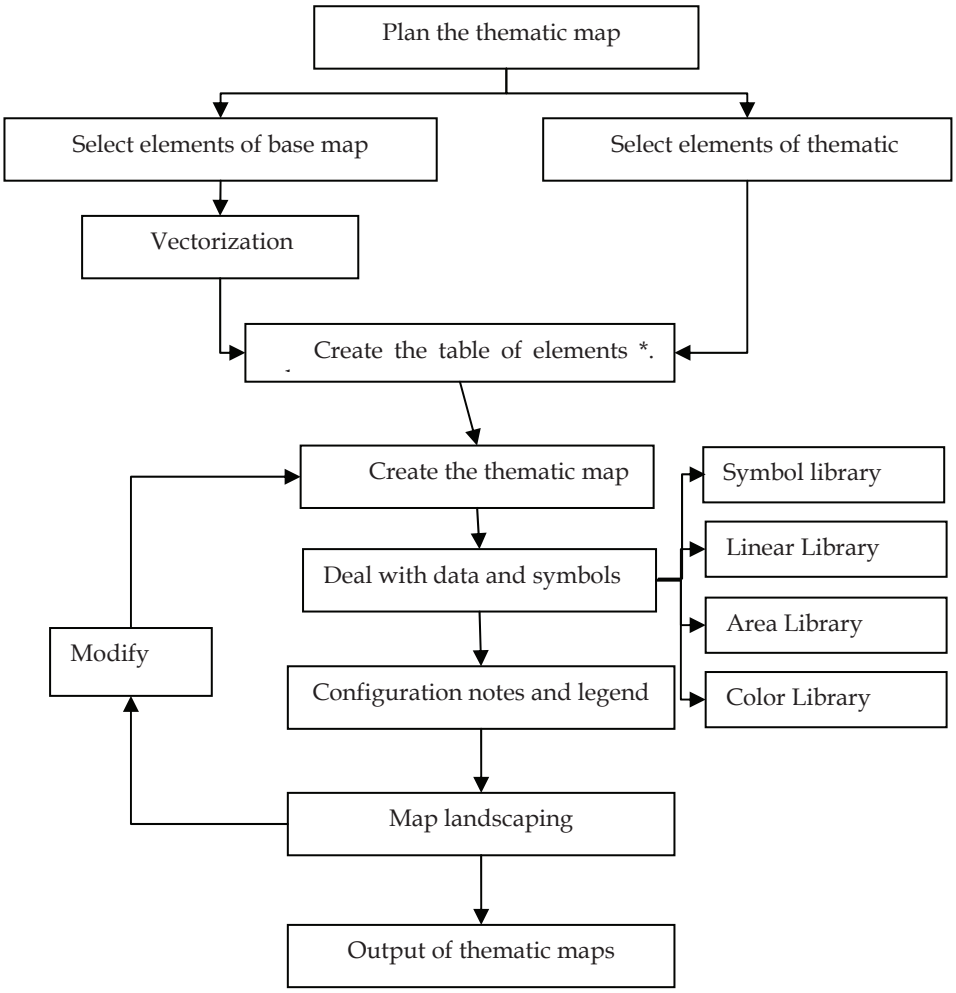

Fig. 11. The steps of creating a thematic map

4.3.2 The development process of user-defined servlet

The user-defined servlet can help us to complete map initialization, map zooming, the user-defined queries of map and user-defined interface.

The following table give the main methods and descriptions of the user-defined servlet-SMSHTMLEmbeddedMapServlet.

Method name and parameters	Method Description
public void service (HttpServletRequest req, HttpServletResponse res)	The main function of servlet.
Hashtable getFormFieldsHT(HttpServletRequest req, MapToolkit toolkit)	Access to list of all the parameters of the request, and save them in the Hashtable.
MapJ initMapJ()	Initialization map object
private void sendHTMLResponse(HttpServletResponse res, HttpServletRequest req,Hashtable ht, MapToolkit toolkit, String strRequestType)	This method return the page controls of controling map and the map table.
private void sendImageResponse(HttpServletResponse res, HttpServletRequest req)	According to the user's request, the methos will generate a picture to the client.
private void sendMsgResponse(HttpServletResponse res, HttpServletRequest req)	Build a MSG to the user. This method can show the location of users.
void applyHiddenFormFields(MapJ myMap, Hashtable ht, HttpSession session)	Application of user-defined map display settings
public void FindingXYFeature(MapJ myMap,Hashtable ht,DoublePoint dp)	Accroding to the latitude and longitude, this method can return surrounding environment information.
public void FindingXYFeature2(MapJ myMap,Hashtable ht,DoublePoint dp)	Accroding to the latitude and longitude, this method cannot return surrounding environment information.
private void setMapSize(MapJ myMap, boolean bSmallSize)	Set the display size of map
public void rendeFindFeature(MapJ myMap,FeatureSet fs,DoublePoint dp)	Mark and highlight the points of map

Table 2. The main methods and descriptions of the user-defined servlet

5. Conclusion

With the advance of mobile commerce technology, mobile businesses rapidly gain its popularity. Many factors, including LBS (Location-Based Services) SMS and Electronic Map are becoming the key words of mobile business. The authors comprehend those factors as

well as extend the 995ARN using the convenience given by those factors. The mobile commerce solution of 995ARN will certainly open up a new value-added services for the project.

But, the authors believe that we can still make some expansion in the following aspects:

• Using the GPRS-model as the Means of system's communication to replace the GSM-Model, but this model's application case is relatively small, technology is also not very mature now.

• Using the technology of system recommendation such as Content-based Recommendation, Collaborative Filtering Recommendation, Association Rule-based Recommendation, Utility-based Recommendation, Knowledge-based Recommendation, Hybrid Recommendation and so on, to improve the match effect of rescue services and the value of news.

• In SNS platform, we can design interpersonal retrieval system according to the theory of "Six Degrees of Separation". For example, if A is friend of B, and C also is friend of B, system can design a retrieval path from A to C. It is A-B-C.

6. Acknowledgment

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The Automatic Attaching Function Based on the Incrementally Modular Abstraction Hierarchy

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1. Introduction

Cyberworlds are more complicated and fluid than any other previous worlds in human history, and are constantly evolving and expanding every moment. One of the features of cyberworlds is that data and its dependency are constantly changing within them. For example, millions of users communicate with each other on the Web using mobile devices, which are considered one of main elements of cyberworlds. At the same time, user requirements for cyberworlds also change and become more complicated as cyberworlds change. If a user analyzes data in business applications correctly under a dynamically changing situation using the existing technology, the schema designs of databases and application programs have to be modified whenever schemas or user requirements for output change. That leads to combinatorial explosion. To solve the problem, we need a more powerful mathematical foundation than what the current computer science enjoys. As a possible candidate, we have introduced the Incrementally Modular Abstraction Hierarchy (IMAH), deployed by one of authors (T. L. Kunii). IMAH seems to be the most suitable for reflecting cyberworlds, because it can model the architecture and the changes of cyberworlds and real worlds from a general level to a specific one, preserving invariants while preventing combinatorial explosion [1]. In our research, one of the authors (Y. Seki) has proposed an algebraic system called Formula Expression as one of finite automaton, and another (T. Kodama) has designed how to express the spaces and the maps on each level of IMAH and actually implemented IMAH as a data processing system using Formula Expression [6]. We call the system the Cellular Data System (CDS). CDS has been already applied to the development of several business application systems as a flexible system development tool. In this paper, we have introduced an automatic attaching function. The attaching map was defined in an adjunction level in IMAH [1] and the automatic attaching function is based on the map; terms as topological spaces are attached by common factors being found automatically through the automatic attaching function. If the function is used with the condition formula search that is the main data search function of CDS (2.3), it becomes a very effective measure when a user wants to analyze data in cyberworlds without losing consistency in the entire system, since a user can get the data he/she wants

without changing application programs. In addition, we put emphasis on practical use by taking up an example of the development of an organizational file permission information management system. First, we explain IMAH and Formula Expression briefly (Section 2). Second, we design the automatic attaching function and implement it (Section 3). Next, we demonstrate the effectiveness of CDS by developing an organizational file permission information management system, thereby abbreviating the process of designing and implementing most application programs. After that, a more flexible data search is shown to be possible (Section 4). Related works are mentioned (Section 5), and, finally, we conclude (Section 6).

2. The Cellular Data System

2.1 The Cellular Model

The following seven levels constitute the IMAH in the cellular model to be used for defining the architecture of cyberworlds and their modeling:

1. the homotopy (including fiber bundles) level
2. the set theoretical level
3. the topological space level
4. the adjunction space level (Fig. 2)
5. the cellular space level
6. the presentation (including geometry) level
7. the view/projection level

In modeling cyberworlds in cyberspaces, we define general properties of cyberworlds at the higher level and add more specific properties step by step while climbing down the IMAH. A cyberspace is specified by the product of a base space and a fiber bundle. The product space constitutes a cyberspace. The properties defined at the homotopy level are invariants of continuous changes of functions. *Homotopy* is a word of Greek origin that signifies continuous deformation in a general sense. The properties that do not change by continuous modifications in time and space are expressed at this level. At the set theoretical level, the elements of a cyberspace are defined, and a collection of elements constitutes a set with logical operations. When we define a function in a cyberspace, we need domains that guarantee continuity such that the neighbors are mapped to a nearby place. Therefore, a topology is introduced into a cyberspace through the concept of neighborhood. Cyberworlds are dynamic. Sometimes they are attached, an exclusive union, where the attached areas of the two cyberspaces are equivalent. It may happen that an attached space is obtained. These attached spaces can be regarded as a set of equivalent spaces called a quotient space, which is another invariant. The example of an online shop at this level is shown in Fig 2.1. At the cellular structured level, an inductive dimension is introduced into each cyberspace. At the presentation level, each space is represented in a form which may be imagined before designing cyberworlds. At the view level, the cyberworlds are projected onto view screens. This level has been well studied and developed as computer graphics. For a detailed explanation of each level, please refer to our earlier paper [1].

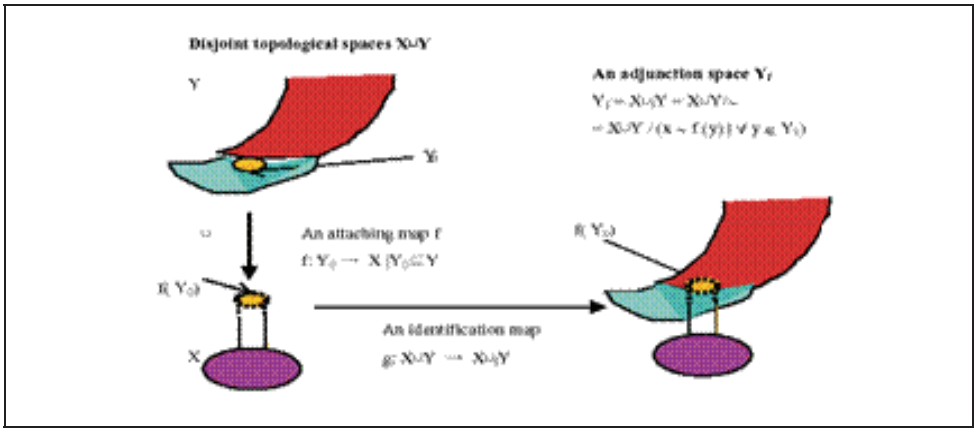


Fig. 2. Example of e-manufacturing on an adjunction space level

2.2 Formula Expression

Formula Expression in the alphabet is the result of finite times application of the following (1)-(7).

(1) w ($\in\Sigma$) is Formula Expression
(2) unit element ε is Formula Expression
(3) zero element φ is Formula Expression
(4) when r and s are Formula Expression, addition of r+s is also Formula Expression
(5) when r and s are Formula Expression, multiplication of r×s is also Formula Expression
(6) when r is Formula Expression, (r) is also Formula Expression
(7) when r is Formula Expression, {r} is also Formula Expression

Strength of combination is the order of (4) and (5). If there is no confusion, ×, (), {} can be abbreviated. + means disjoint union and is expressed as specifically and × is also expressed as Π. In short, you can say " a formula consists of an addition of terms, a term consists of a multiplication of factors, and if the () or {} bracket is added to a formula, it becomes recursively the factor". In Formula Expression, four maps (the expansion map, the bind map, the division map, the attachment map) are defined. The grammar that generates Formula Expression is defined as follows:

You assume that Σ_L is a set of ideograms and its element is w ($\in\Sigma_L$).

$$G = (\{E, T, F, id\}, \Sigma_L \cup \{+, \times, (,), \{, \}\}, P, E),$$
$$P = \{E \to T \mid E+T,\ T \to F \mid T \times F,\ F \to (E) \mid \{E\} \mid id,\ id \to w\}$$

Here, E is called a formula, T is called a term, F is called a factor, id is called an identifier; + is called an addition operation, × is called a multiplication operation, () is called a 1st bracket, and {} is called a 2nd bracket. If you paraphrase the above-mentioned grammar, you can say "a formula consists of an addition of terms, a term consists of a multiplication of factors, and if a 1st or 2nd bracket is added to a formula, it becomes recursively the factor". And when a term is a component of a formula, we say that the formula *has* the term. And when a factor

of the bracket that *includes* a term is a component of a formula, we say that the formula includes the term. It is the same with a term and a factor. An example is shown below.

The term $a(b+c)\{d+e\}$ *has* factors a, $(b+c)$, $\{d+e\}$, and *includes* factors b, c, d, e.

2.3 A Condition Formula Search

If a user can specify search conditions, searches will become more functional when searching data from data storage. Here, we introduce the function for specifying conditions defining a condition formula by Formula Expression into CDS. We call it a condition formula search, which is one of the main functions of CDS.

1) Logical operation. Let propositions P, Q be sets which include characters p, q respectively. The conjunction, disjunction and negation of them in logical operation are defined by Formula Expression as follows:

1) Conjunction
$$P \wedge Q = p \times q$$
2) Disjunction
$$P \vee Q = p + q$$
3) Negation
$$\neg P = !p$$

2) A condition formula processing map *f*. A formula created from these is called a condition formula. "!" is a special factor which means negation. Recursivity by () in Formula Expression is supported so that the recursive search condition of a user is expressed by a condition formula. A condition formula processing map f is a map that gets a disjoint union of terms which satisfies a condition formula from a formula. When condition formula processing is considered, the concept of a remainder of spaces is inevitable. A remainder acquisition map g is a map that has a term that doesn't include a specified factor. If you assume x to be a formula and p, $!p$, $p+q$, $p \times q$, $!(p+q)$, $!(p \times q)$ to be condition formulas, the images of $(x, p+q)$, $(x, p \times q)$, $(x, !(p+q))$, $(x, !(p \times q))$ by f, g are the following:

$$f(x, p) = g(x, !p)$$
$$f(x, !p) = g(x, p)$$
$$f(x, p+q) = f(x, p)+f(g(x, p), q)$$
$$f(x, p \times q) = f(f(x, p), q)$$
$$f(x, !(p+q)) = g(g(x, p), q)$$
$$f(x, !(p \times q)) = g(f(f(x, p), q)$$

Figure 2.3 shows each image by the condition formula processing map f. It is obvious that any complicated condition formula can be processed using combinations of the above six correspondences.

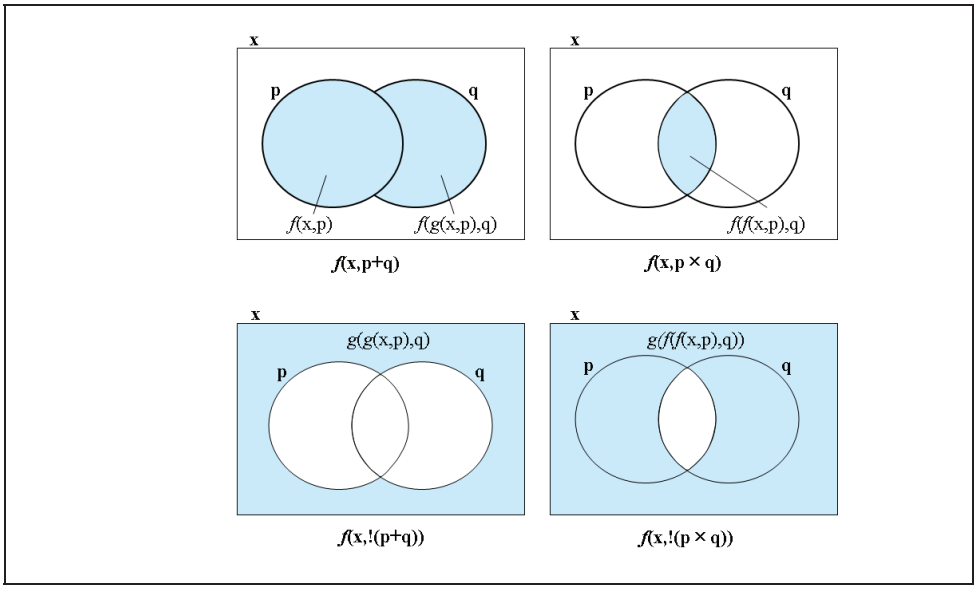


Fig. 2.3 Images by the condition formula processing

3. The Automatic Attaching Function

3.1 Definition

An attaching map on the adjunction space level is a continuous and surjective mapping [1]. Given two disjoint topological spaces X and Y,

$$Y \quad {}_{f}X = Y \quad X / \sim$$

is an attaching space obtained by *attaching* X to Y by an *attaching map* f (or by identifying points $x \quad X_0 \sim X_0 \quad X$ with their images $f(x) \quad Y$, namely by a surjective map f)

$$f: X_0 \| Y.$$

The automatic attaching function of CDS based on the attaching map is the function that attaches several terms in a formula by the common factor(s). If you assume the map to be *g*, the entire set of formulas to be A, the entire set of terms to be B and the entire set of factors to be C, *g*: A → A. Arbitrary terms r, s, t, u, p, q (∈C) follow these rules:

g: r×p×s+t×p×u → {r+s}p{t+u}

g: r×p×s+t×q×u → r×p×s+t×q×u (when there is no common factor.)

In short, terms in a formula are attached by the common factor(s) between them through the automatic attaching function, so that the formula is separated into attaching spaces and others. A simple example is shown below.

g:
color×red(fruit×apple+rainbow)+human×blood×red+blue(sea+sky)+green(tree ×leaf+seaweed)
↦
{color+human×blood}red{(fruit×apple+rainbow)+ε}+(blue(sea+sky)+green(tree ×leaf+seaweed))

In this example, the common factor is “red”.

3.2 Implementation

This application was developed using Java Servlet and Tomcat 5.0 as a Web server. The specifications of the server were:

OS: Red Hat Enterprise Linux 5
CPU: Intel Core2 Duo (1.8GHz)
RAM: 4GB
Web server: Apache 2.2.2
AP server: Tomcat 5.5.4
JAVA: JDK1.5.015
RDB: mysql5.1
HD: 240GB

The specifications of the client machine were:

OS: Windows XP
CPU: Intel Core2 Duo (3.00GHz)
RAM: 3.23GB

A quotient acquisition map is the main function of an automatic attaching map. Figure 3.2 is the algorithm of the map. In this algorithm, the absolute position of the specified factor by the function of the language and the term including the factor are acquired first. Next, the nearest brackets of the term are acquired and, because the term becomes a factor, a recursive operation is done. Details are abbreviated due to the restriction on the number of pages.

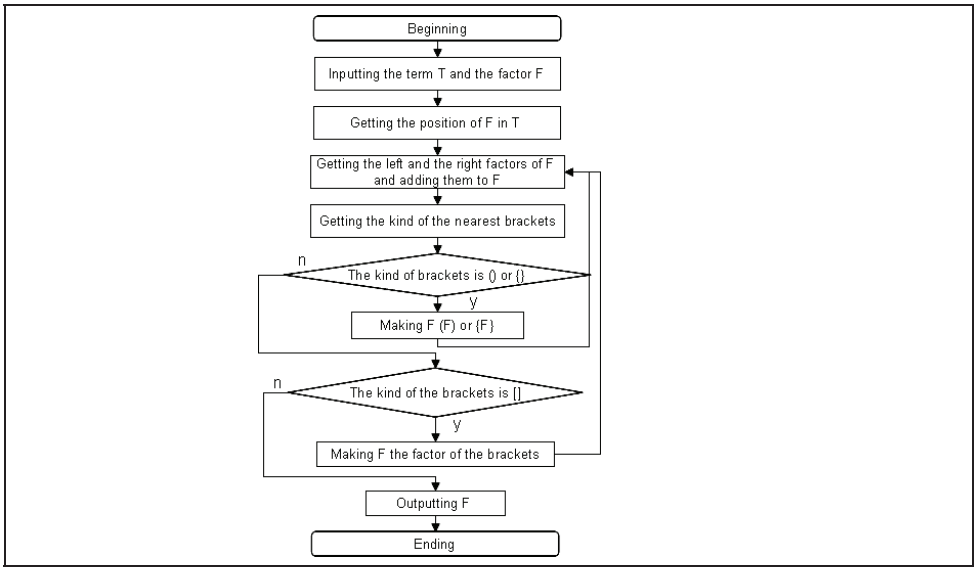


Fig. 4.2 The flowchart of the algorithm for a quotien

4. Case Study: An Organizational File Permission Information Management System

4.1 Outline

We have developed a business application system for managing file permission information in an organization using CDS. In this system, file permission information is managed under the assumption that its organizational structure or relations among staff and their assignments or file structure often change. In this section, we simplify all data without losing generality. This system is currently being used by companies in Japan such as ACS, Inc. and Maeda Corp. to manage file permission information.

4.2 The Space Design

We design a formula for the spaces as follows.

1. A formula for organization data for the company as a topological space
   OrgInfo(Σ*monthi*(Σ*nodei,1*(Σ*nodei,2*(Σ…(Σ*nodei,j*(Σ*staffi,j,k*)))))
   node: a factor which expresses the node of an organizational structure
   month: a factor which expresses month data

2. A formula for file permission data for files as a topological space
   PermissionInfo(Σ*nodei,1*(Σ*nodei,2*(Σ…(Σ*nodei,j*(Σ*staffi,j,k*×*permissioni,j,k*×*monthi,j,k*×*filenamei,j,k*)))))
   filename: a factor which expresses file name data
   permission: a factor which expresses file permission data of *r* meaning readable or *w* meaning writable

3. A formula for file data as a cellular space
   FileInfo(Σ*monthi*×*filename*$_i${Σattribute*j,k*}(Σ{Σvalue*j,k*})})

4.3 Data Input

Here, data on employees of a company are to be managed. If a user wants to input data on the organization structure in September of the year expressed in Fig 4.3-1, he/she creates formula 4.3-1 according to the space design.
formula 4.3-1:
OrgInfo(Sep.×(HQ1(SalesDept.(Staff(Kodama+Morihashi)+Dept.Head×Arai)+Personnel Dept.(Staff×Seki)+HQ1Head×Ishiguro)))

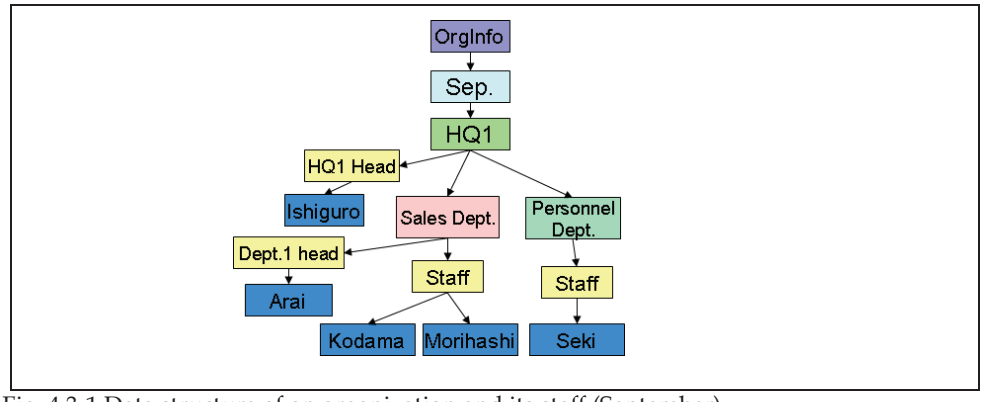
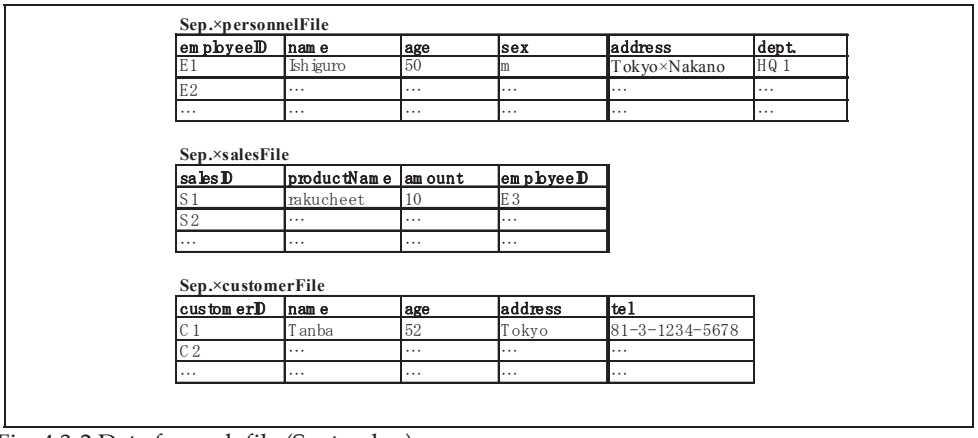


Fig. 4.3-1 Data structure of an organization and its staff (September)

If a user is to manage files for employee data, sales data and customer data in Fig 4.3-2, he/she creates a formula for each data as a disjoint union of cellular spaces according to the space design and adds it to the previous formula (formula 4.3-2). In this way, those files whose structures are different can be inputted by the + function of CDS.

formula 4.3-2:
(formula4.3-1)+FileInfo(Sep.×personnelFile×employeeID{name+age+sex+address+dept.}(E1{"Ishiguro"+50+m+"Tokyo×Nakano"+HQ1}+E2{…}+…)+Sep.×salesFile×salesID{productName+amount+employeeID}(S1{"rakusheet"+10+E3}+S2{…}+…)+Sep.×customerFile×customerID{name+age+address+tel}(C1{"Tanba"+52+"Tokyo"+"81-3-1234-5678"}+C2{…}+…))



Sep.×personnelFile

employeeID	name	age	sex	address	dept.
E1	Ishiguro	50	m	Tokyo×Nakano	HQ 1
E2	…	…	…	…	…
…	…	…	…	…	…

Sep.×salesFile

salesID	productName	amount	employeeID
S1	rakucheet	10	E3
S2	…	…	…
…	…	…	…

Sep.×customerFile

customerID	name	age	address	tel
C1	Tanba	52	Tokyo	81-3-1234-5678
C2	…	…	…	…
…	…	…	…	…

Fig. 4.3-2 Data for each file (September)

If a user wants to input data for the file permission in September of the year expressed in Fig 4.3-3, he/she also creates a formula according to the space design and adds it to the previous formula (formula 4.3-3). At this time, a user can even give *r (readable)* or *w (writable)* permission of attributes of a file to each employee. For example, if the head of the Sales Department is given *r* permission of attributes "employeeID", "name" of the personnel file, a formula for the permission data is expressed as "SalesDept.×Dept.1head×r×personnelFile(*employeeID+name)*", and if the staff in the Sales Department is given *r* or *w* permission of the attribute *except "address" and "tel"* of the customer file, a formula for the permission data is expressed as "SalesDept.×Staff((r+w)(salesFile+customerFile(*!address×!tel*)))"

formula 4.3-3:

(formula 4.3-2)+PermissionInfo(Sep.(HQ1(HQ1Head(r+w)(customerFile+salesFile+personnelFile)+SalesDept.(Dept.1head((r+w)(customerFile+salesFile)+(r)personnelFile(employeeID+name))+Staff((r+w)(salesFile+customerFile(!address×!tel×!specialMention)))+PersonnelDept.×Staff(r+w)personnelFile×!specialMention)))

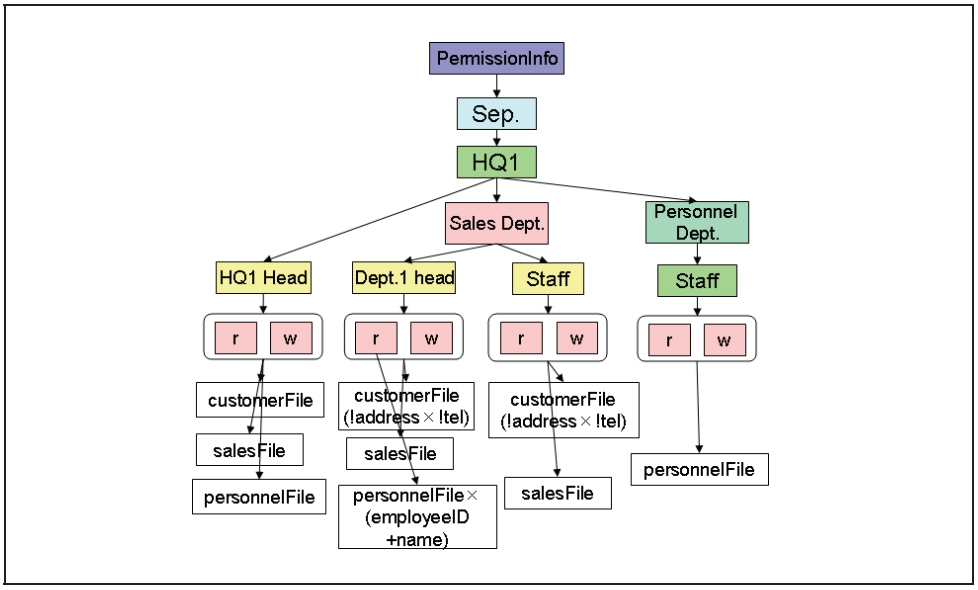


Fig. 4.3-3 The data structure of organizational positions and their file permission data (September)

Next, in the following month, when the temporal project "*ProjectA*" is complete and two staff members from different departments are assigned to the project temporally, as seen in Fig 4.3-4, a user creates a formula and adds it to the previous formula (formula 4.3-4).

formula 4.3-4:

(formula4.3-3)+OrgInfo(Oct.×(HQ1(SalesDept.(Staff(Kodama+Morihashi)+Dept.Head ×Arai)+PersonnelDept.(Staff×Seki)+HQ1Head×Ishiguro+*ProjectA(Kodama+Seki)*))))

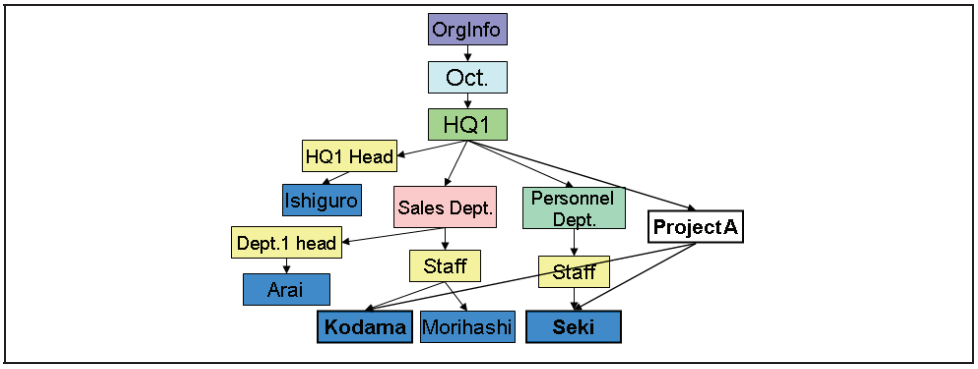
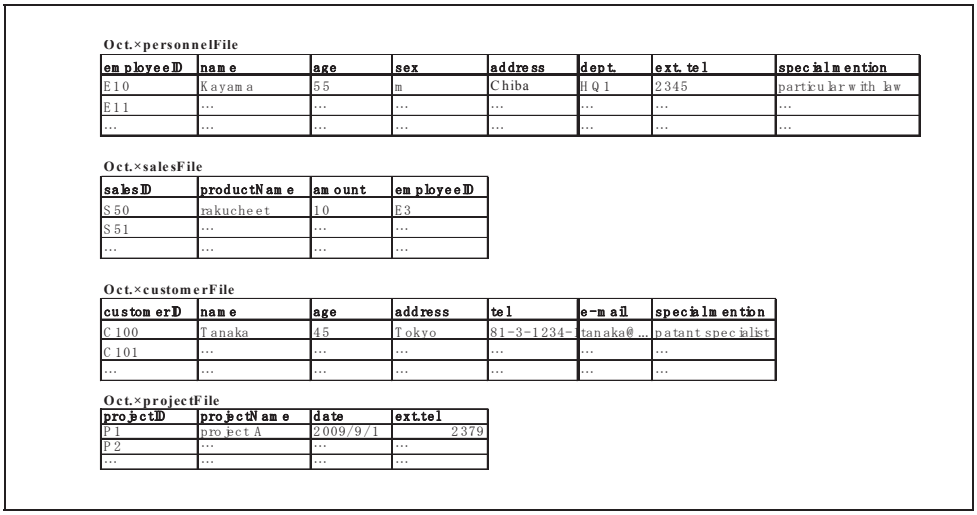


Fig. 4.3-4 Data structure of an organization and its staff

In formula 4.3-4, the overlap of projects to an employee is allowed because, if the factors for each staff member are the same, equivalence is guaranteed in CDS. And, obviously, you see that a user can add a new project as he/she likes using the + function of CDS.



Oct.×personnelFile

employeeID	name	age	sex	address	dept.	ext. tel	special mention
E10	Kayama	55	m	Chiba	HQ1	2345	particular with law
E11	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…

Oct.×salesFile

salesID	productName	amount	employeeID
S50	rakucheet	10	E3
S51	…	…	…
…	…	…	…

Oct.×customerFile

customerID	name	age	address	tel	e-mail	special mention
C100	Tanaka	45	Tokyo	81-3-1234-	tanaka@...	patant specialist
C101	…	…	…	…	…	…
…	…	…	…	…	…	…

Oct.×projectFile

projectID	projectName	date	ext.tel
P1	project A	2009/9/1	2379
P2	…	…	…
…	…	…	…

Fig. 4.3-5 Data for each file (October)

And in the same way, when the file structure of employee or customer data changes in October (the columns of "*ext. tel*", "*special mention*" are added to the personnel file and the columns of "*e-mail*","*special mention*" are added to the customer file), a user only has to create a formula for each piece of data in October as a disjoint union of cellular spaces according to the space design and adds it to the previous formula (formula 4.3-5). In doing this, you don't need to consider differences in file structure at all.

formula 4.3-5:

(formula 4.3-4)+FileInfo(Octp.×personnelFile×employeeID{name+age+sex+address+dept.+*ext.tel*+*specialMention*}(E10{"Kayama"+55+m+"Chiba"+HQ1+*2345*+*"particular with law"*}+E11{…}+…)+Oct.×salesFile×salesID{productName+amount+employeeID}(S50{"rakutrack"+10+E5}+S2{…}+…)+Oct.×customerFile×customerID{name+age+address+tel+*e-mail*+*specialMention*}(C100{"Tanaka"+45+"Tokyo"+"81-3-1234-1234"+"*tanaka@...*"+"*patent specialist*"}+C101{…}+…))+Oct.×projectFile×projectID{projectName+date+ext.tel}(P1{"projectA"+"2009/09/01"+"2379"}+P2{…}+…)

If a user wants to input data for the file permission in October of the year expressed in Fig 4.3-6, he/she also creates a formula according to the space design and adds it to the previous formula (formula 4.3-6).

formula 4.3-6:

(formula 4.3-5)+PermissionInfo(Oct.(HQ1(HQ1Head(r+w)(customerFile+salesFile+personnelFile)+SalesDept.(Dept.1head((r+w)(customerFile+salesFile)+(r)personnelFile(emp

loyeeID+name))+Staff((r+w)(salesFile+customerFile(!address×!tel×!specialMention)))+
PersonnelDept.×Staff(r+w)personnelFile×!specialMention)+*ProjectA(r+w)projectFile*)))

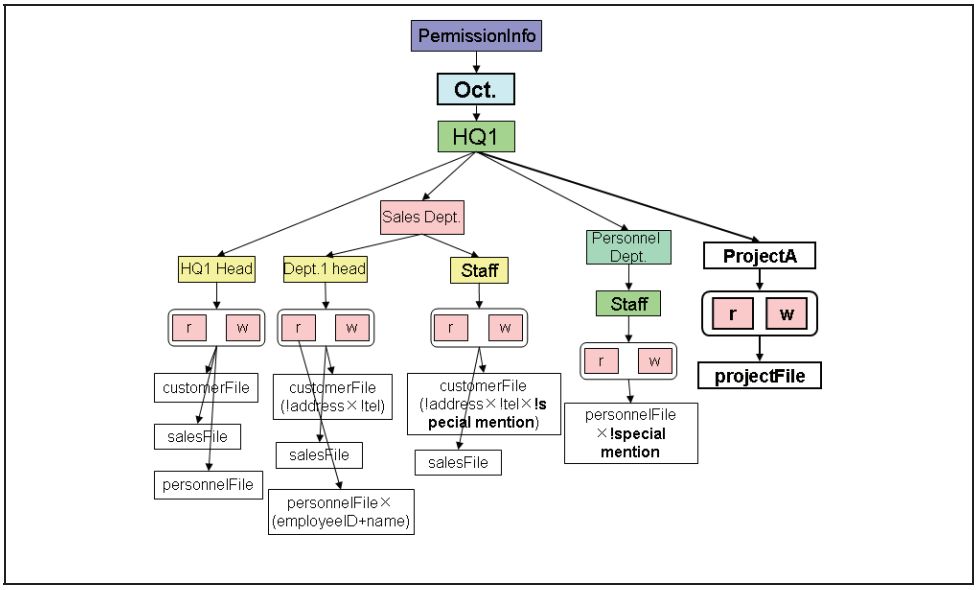


Fig. 4.3-6 The data structure of organizational positions and their file permission data (October)

In this way, when a user inputs data about the employees, the organization, the file permission, or the files in a table format, even if the staff are assigned to a temporal project necessitating changes in the organizational structure or the attributes of the file data change or file permission management is detailed, database schema and application programs do not need to be modified.

4.4 Data Output

If a user wants to search for the questions "Which files contain data that Mr. *Kodama* can *read* ?", firstly he/she creates the condition formula "*OrgInfo*×*Kodama*+*PermissionInfo*×*r*" and gets the image of formula 4.3-6 through the condition formula processing map *f* (2.3) and attaches the result by the automatic attaching map *g* (3.1).

g(*f* (*formula 4.3-6*, "*OrgInfo*×*Kodama*+*PermissionInfo*×*r*"))
={OrgInfo+PermissionInfo}(*(Sep.+Oct.)*HQ1×SalesDept.×Staff{Kodama+r×(*customerFile(!address*×*!tel*×*!specialMention)+salesFile*)}+*Oct.*×HQ1×ProjectA{Kodama+*r*×*projectFile*})

The figure is shown (Fig 4.4-1). From the above data, a user can know that the file names of the user requirement are the customer file (except the attributes of "address", "tel", "special mention"), the sales file of the both months and the project file of October. Secondly, from

the result (the parts underlined), he/she creates the condition formula *"FileInfo×(Sep.+Oct.)×(customerFile(!address×!tel×!specialMention)+salesFile)+Oct.×projectFile"* to get the file data and gets the image of formula 4.3-6 by the condition formula processing map *h*.

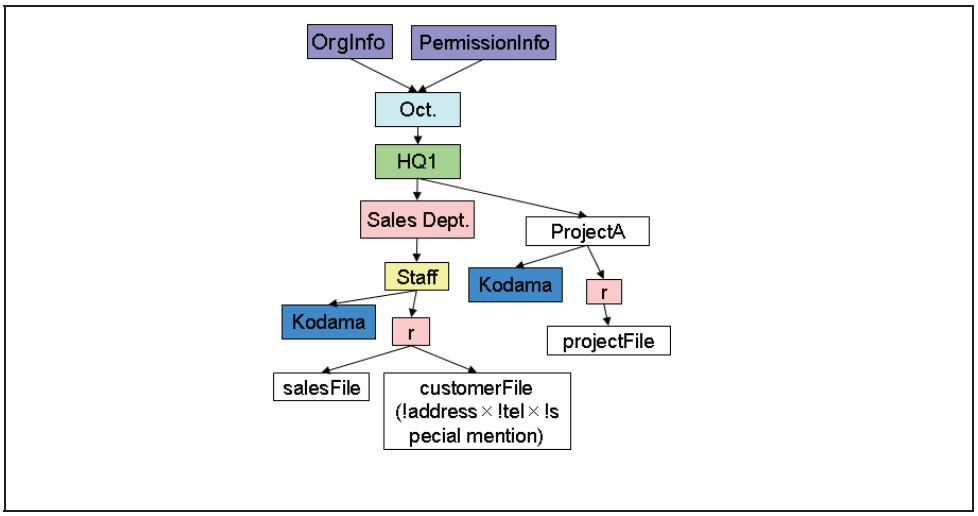
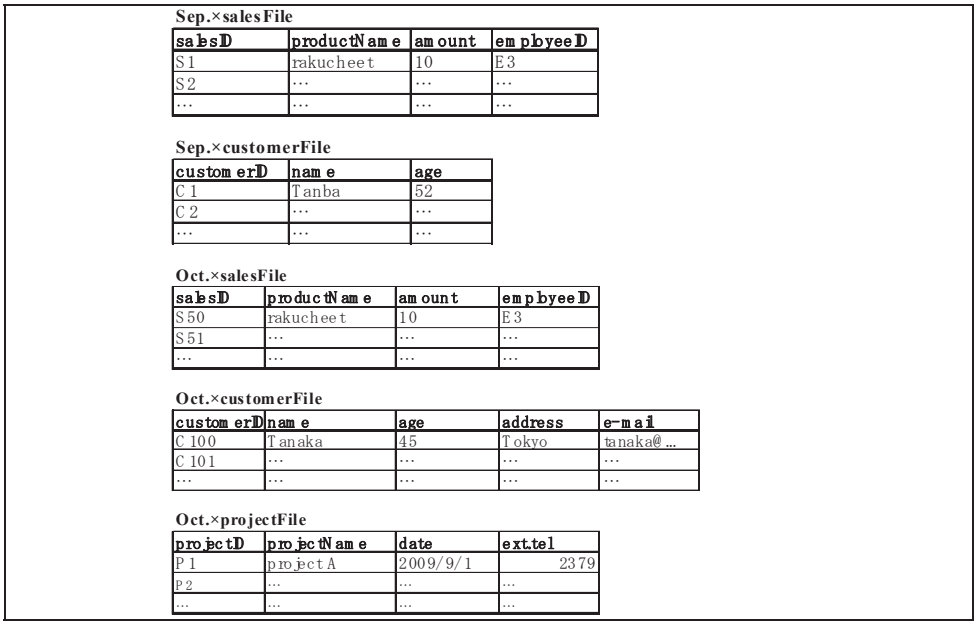


Fig. 4.4-1 Data structure of the image by *"OrgInfo×Kodama+PermissionInfo×r"*

h(*formula3.4-6, FileInfo×(Sep.+Oct.)(customerFile(!address×!tel×!specialMention)+salesFile)+Oct.×projectFile*)
= Sep.(salesFile×salesID{productName+amount+employeeID}(S1{"rakusheet"+10+E3}+S2{…}+…)+customerFile×customerID{name+age}(C1{"Tanba"+52}+C2{…}+…))+Oct.(salesFile×salesID{productName+amount+employeeID}(S50{"rakutrackt"+10+E5}+S2{…}+…)+customerFile×customerID{name+age+e-mail}(C100{"Tanaka"+45+"tanaka@..."}+C101{…}+…))+projectFile×projectID{projectName+date+ext.tel}(P1{"projectA"+"2009/09/01"+"2379"}+P2{…}+…)

The simple figure is shown below (Figure 4.4-2).



Sep.×salesFile

salesID	productName	amount	employeeID
S1	rakucheet	10	E3
S2	…	…	…
…	…	…	…

Sep.×customerFile

customerID	name	age
C1	Tanba	52
C2	…	…
…	…	…

Oct.×salesFile

salesID	productName	amount	employeeID
S50	rakucheet	10	E3
S51	…	…	…
…	…	…	…

Oct.×customerFile

customerID	name	age	address	e-mail
C100	Tanaka	45	Tokyo	tanaka@…
C101	…	…	…	…
…	…	…	…	…

Oct.×projectFile

projectID	projectName	date	ext.tel
P1	projectA	2009/9/1	2379
P2	…	…	…
…	…	…	…

Fig. 4.4-2 outputted data

These outputted data are the parts that Mr. Kodama can read from all data files.
Next, if a user wants to search for the questions "Who can read and write the personnel file for October in HQ1?" and "Who can read data of the attribute 'special mention'?", in the same way he/she creates first the condition formula "*OrgInfo*×*(HQ1*×*Oct.)*+*PermissionInfo*×*(r*+*w)*×*personnelFile*" and gets the image of formula 4.3-6 through the map *f* and attaches the result by the attaching map *g*.

g(f (*formula 4.3-6*, "*OrgInfo*×*(HQ1*×*Oct.)*+*PermissionInfo*×*(r*+*w)*×*personnelFile"))*
={OrgInfo+PermissionInfo}×Oct.×HQ1(HQ1Head{Ishiguro+(r+w)personnelFile}+Per sonnnelDept.×Staff{Seki+(r+w)personnelFile×!specialMention})

The figure is shown below (Fig 4.4-3). From the outputted result, a user can know that the employees who can read and write the personnel file of October in HQ1 are "*Ishiguro*" and "*Seki*" and that it is "*Ishiguro*" who can read data of the attribute 'special mention' in the file.
In this way, if a user uses the condition formula processing map and the automatic attaching map to the inputted data appropriately, he/she gets the data desired without modifying file structure and application programs for output.

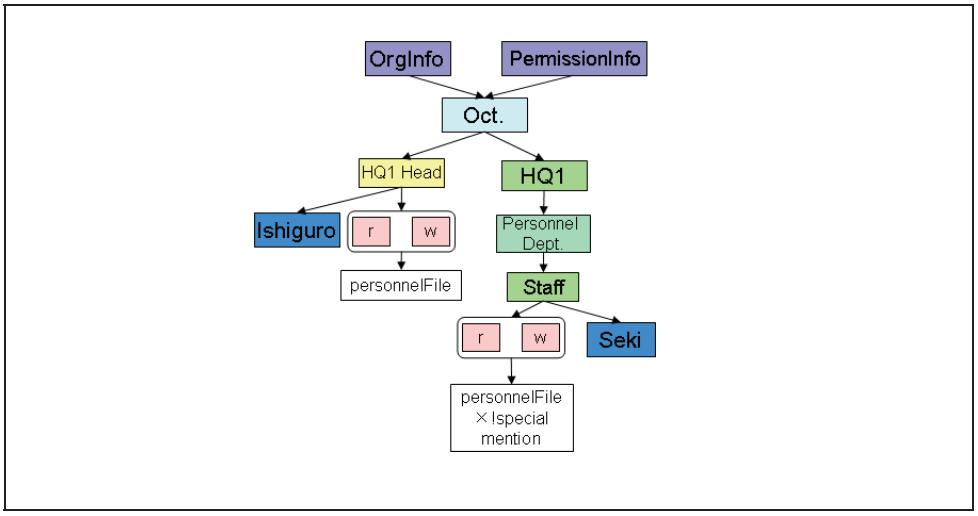


Fig. 4.4-3 Data structure of the image by "*OrgInfo*×*(HQ1*×*Oct.)*+*PermissionInfo*×*(r*+*w)*×*personnelFile*"

4.5 Considerations

In existing development of an organizational file permission information management system, when there are unexpected situations in personnel affairs such as staff changing posts being transferred or participating in multiple temporary projects; when file permission management goes into details, such as permission being given, not to the entire file, but to each attribute of the file; when file structure changes, such as through the addition or deletion of attributes of the file data or the attribute name of the file data changing; when the organizational structure changes, such as with the merging or dividing of departments, it is generally difficult to cope with the changes because the database design or application programs need to be modified, which can be costly. On the other hand, if CDS is employed in system development, the design of data structure as formulas is more adaptable to changes in data structure, such as those relating to organizational structure or changes in relations among staff and their assignments, file permission and managerial positions, or changes in file structure, and the formula for a state at a certain point in time can be expressed as the disjoint union of formulas up to that state. In the above examples, the formulas for the situation in October consist of the formulas for the situation in September and the formulas for the change parts since that time. Therefore, only a few programs need to be modified, and a user can get the data he/she wants flexibly and automatically by using the maps of CDS. In other words, the business objects and their relations and business logic are described directly by CDS and the data that a user wants are outputted in parts from the inputted data through the maps of CDS.

5. Related works

The distinctive features of our research are the application of the concept of topological processing, which deals with a subset as an element, and that the cellular space extends the topological space, as seen in Section 2. The conceptual model in [2] is based on an ER model and is the model where tree structure is applied. The approach in [3] aims at grouping data of a graph structure where each node has attributes. The ER model, graph structure and tree structure are expressed as special cases of topological space, and a node with attributes is expressed as one case of the cellular space. So these models are included in the function of CDS. Many works dealing with XML schema have been done. The approach in [4] aims at introducing simple formalism into XML schema definition for its complexity. An equivalence relation of elements is supported in CDS, so that complexity and redundancy in schema definition are avoided if CDS is employed, and a homotopy preservation function is introduced into CDS in the model for preserving information. As a result, the problems described in [5] do not need to be considered in CDS. Some works of inductive data processing have been done recently. CDS also can be considered as one of those inductive systems. The goal of research on the inductive database system of [7] is to develop a methodology for integrating a wide range of knowledge generation operators with a relational database and a knowledge base. The main achievement in [8] is a new inductive query language extending SQL, with the goal of supporting the whole knowledge discovery process, from pre-processing via data mining to post-processing. If you use the methods in [7], [8], the attributes according to users' interests have to be designed in advance. Therefore it is difficult to cope with changes in users' interests. If you use CDS, a formula for a topological space without an attribute as a dimension in database designing can be created so that the attributes of objects don't need to be designed in advance. Plenty of CASE tools are currently available, but they are effective for data structure that is already defined. The differences from CDS are mainly that we apply a novel model, IMAH, for building CDS, and that CDS, not only visualizes objects, but can also model business logic using Formula Expression, so that, if spaces are designed, they function immediately.

6. Conclusion and Future Work

In this paper, we have introduced an automatic attaching function into CDS. We have applied CDS to the development of a file permission information management system and verified its effectiveness. Using this function with the condition formula search, a user can get the data he/she wants from formulas as data storage according to user requirements. There are two points that we should emphasize for future work. First, the search conditions of users, as well as data for input/output, are expressed as formulas. This certainly brings the system which is developing, including user requirements recursively. This will be connected to the implementation of a process graph, which is a model for automating business processes. Second, the quality of the system using CDS is closely dependent on how the formulas are designed. The design of formulas is fully various, because Formula Expression is very simple in describing business objects and their relations. Therefore, the creativity of a system developer who designs formulas becomes more important.

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