Research and Practical Issues of Enterprise Information Systems

Edited by
A. Min Tjoa
Li Xu
Sohail Chaudhry

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RESEARCH AND PRACTICAL ISSUES OF ENTERPRISE INFORMATION SYSTEMS

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• Open conferences;
• Working conferences.

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Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

Any national society whose primary activity is in information may apply to become a full member of IFIP, although full membership is restricted to one society per country. Full members are entitled to vote at the annual General Assembly, National societies preferring a less committed involvement may apply for associate or corresponding membership. Associate members enjoy the same benefits as full members, but without voting rights. Corresponding members are not represented in IFIP bodies. Affiliated membership is open to non-national societies, and individual and honorary membership schemes are also offered.

RESEARCH AND PRACTICAL ISSUES OF ENTERPRISE INFORMATION SYSTEMS

IFIP TC 8 International Conference on Research and Practical Issues of Enterprise Information Systems (CONFENIS 2006) April 24-26, 2006, Vienna, Austria

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Preface

The idea for this conference came from a meeting of the IFIP (International Federation for Information Processing) Technical Committee for Information Systems (TC8) in Guimares, Portugal in June 2005. Our goal is to build an IFIP forum among the different Information Systems Communities of TC8 dealing with the increasing important area of Enterprise Information Systems. In this particular meeting the committee members intensively discussed the innovative and unique characteristics of Enterprise Information Systems as scientific sub-discipline.

Hence, in this meeting it was decided by the TC8 members that the IFIP TC8 First International Conference on Research and Practical Issues of Enterprise Information Systems (CONFENIS 2006) would be held in April 2006 in Vienna, Austria. Dr. Li Xu (USA) and Dr. A Min Tjoa (IFIP TC8) were assigned to propose a concept for this conference in order to establish an IFIP platform for EIS researchers and practitioners in the field to share experience, and discussing opportunities and challenges.

We are very pleased therefore to have this conference organised by the help of the Austrian Computer Society (OCG). OCG supports the idea of this conference due to the urgent need of research and dissemination of new techniques in this key area.

We received 180 papers from more than 30 countries for CONFENIS and the Program Committee eventually selected xx papers or extended abstracts, making an acceptance rate of xx% of submitted papers. Each paper was thoroughly reviewed by at least two qualified reviewers.

As an additional feature of CONFENIS we have invited distinguished scholars to present and discuss special aspects relevant for future applications and research.
Dr. Prof. Gottfried Vossen (University of Münster, Germany), the Director of the European Research Center for Information Systems will give a presentation on service-oriented architecture. Dr. Thomas Li, Director of IBM China Research Laboratory has a keynote speech on continual business transformation technology.

We would like to express our gratitude to all program committee members, workshop organisers and committee members and all the external referees who reviewed the papers very thoroughly and in a timely manner. Due to the high number of submissions and the quality of the submitted papers, the reviewing, and discussion process was an extraordinarily challenging task. We are therefore deeply grateful to many individual reviewers who worked with us so diligently (see list of referees). Without their time and efforts, CONFENIS 2006 and the proceedings would never have come to be.

We would specially like to thank the Chair of IFIP TC8, Professor J. Dewald Roode (South Africa), Vice-Chair Professor David Avison (France), Secretary Professor

Isabel Ramos (Portugal), and former Secretary Professor Jan Pries-Heje (Denmark), for their encouragement and guidance throughout this endeavor. We are very grateful to have the sponsorship of the Vienna University of Technology.

Special thanks are given to Dr. Sohail S. Chaudhry (USA), for his time and efforts in editing the CONFENIS proceeding, as the Managing Editor.

Special thanks must also be given to Dr. Tho Manh Nguyen (Austria) for all his enthusiastic support in the organizing tasks of CONFENIS 2006.

We would also like to thank all the authors who submitted their papers to CONFENIS 2006.

Many thanks go to Ms. Christine Tronigger for providing a great deal of supporting administering the registrations.

Finally we hope that the conference will have a real benefit for innovative approaches, which have to consider the various issues of Enterprise Information Systems, and furthermore will build a platform for further in-depth discussions between researchers in the different EIS-areas.

Professors A Min Tjoa, Prof. Lida Xu (Conference Chairs)

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Keynote Speaker: Dr. Dewald Roode, Chair, IFIP TC8

Dewald Roode obtained a masters degree in theoretical physics and a master's degree in mathematics at the University of Potchefstroom in South Africa. He completed his education by obtaining a PhD at the University of Leiden in The Netherlands. He took early retirement at the end of 2001 from the University of Pretoria, where he was Director of the School of Information Technology, but is still an extraordinary professor in the Department of Informatics. Since 2003 he is also a visiting professor in the Department of Information Systems at the University of Cape Town, and as from 2004, an honorary professor in the Faculty of Business Informatics at the Cape Peninsula University of Technology. At these institutions he continues to work with and supervise PhD students, and conducts his research work mainly in co-operation with his students. He serves on the Editorial Boards of a number of Journals in the field of Information Systems, is chairman of Technical Committee 8 on Information Systems of IFIP, a member of the Steering Committee of the World Information Technology Forum (WITFOR) and was Programme Chair of WITFOR 2005, which was held in Botswana in August 2005.

Keynote Speaker: Dr. Thomas Li, Director of IBM China Research Laboratory

Dr. Thomas Li is the Director of *IBM China Research Laboratory.* He received his PhD degree in Management Information System from the University of Texas, Austin, USA, in 1991. In addition to his many years of service with IT industry such as IBM, he is very experienced in managing startup companies, manufacturing facilities, as well as consulting practices. He is also very active in both research and higher education. He is an Adjunct Professor at top Chinese research universities such as prestigious *Peking University* and *Tsinghua University* where he offers courses "On Demand Transformation Technology". Dr. Li's technical expertise and innovative thinking has led to thirty-nine patents in object technology, digital communication, visualization tools, and database systems. In addition to publications in refereed journals, proceedings, and technical reports, he has been one of the key contributors in delivering eight commercial software products, three hardware systems, and a number of architectural designs and technical specifications.

Speech Title: Continual Business Transformation Technology

The *IBM China Research Laboratory (CRL)* was established in September 1995 and is one of the eight worldwide IBM Research laboratories. Located in Beijing, *CRL* has been growing steadily and currently employs over 150 technical staff members. The majority research staffs there hold PhD or master's degrees, and join IBM from leading research universities.

IBM Research's mission is vital to IBM's future success and the *IBM China Research Laboratory* plays a large role in meeting that goal. *CRL* continually strives to create world-class information technologies and the underlying science that propels the world's advances. *CRL* carries out joint research projects with universities and research institutes.

Keynote Speaker: Prof. Dr. Gottfried Vossen, Director of European Research Center for Information Systems

Gottfried Vossen is a Professor of Computer Science in the Department of Information Systems at the University of Muenster in Germany. He received his master's and Ph.D. degrees as well as the German habilitation in 1981, 1986, and 1990, respectively, all from the Technical University of Aachen in Germany. He has held visiting positions at the University of California at San Diego, at several German universities including the Hasso-Plattner-Institute for Software Systems Engineering in Potsdam near Berlin, at Karlstad University in Sweden and at the University of Waikato in Hamilton, New Zealand. In 2004 he became the European Editor-in-Chief of Elsevier's *Information Systems*-An International Journal, and a Director of the *European Research Center for Information Systems (ERCIS)* in Muenster. He currently also serves as the Vice Dean of the Business School at the University of Muenster. His research interests include conceptual as well as application-oriented problems concerning databases, information systems, electronic learning, and the Web. Dr. Vossen has been a member in numerous program committees of international conferences and workshops. He is an author or co-author of more than 120 publications, and an author, co-author, or co-editor of 20 books on databases, business process modeling, the Web, e-commerce, and computer architecture.

Speech Title: Have Service-Oriented Architectures Taken a Wrong Turn Already?

Information Systems: Information systems are the software and hardware systems that support data-intensive applications. *Information Systems* publishes articles concerning the design and implementation of languages, data models, algorithms, software and hardware for information systems. Subject areas include data management issues as presented in the principal international database conferences as well as data-related issues from the fields of data mining, information retrieval, natural language processing, internet data management, visual and audio information systems, scientific computing, and organizational behavior. The Editors-in-Chief are Dennis Shasha, New York, and Gottfried Vossen, Muenster.

ERCIS: The ERCIS – European Research Center for Information Systems – is a network of scientists that conduct cooperative research in the field of integrated information systems development and organizational design. For the first time, core competencies in the discipline of information systems are interrelated with issues in the field of computer science, business administration and specific legal issues within an institutional framework. Thus, a holistic view of information system development and organizational design issues can be ensured. Due to its outstanding reputation in both research and teaching within the field of information systems and business administration, the University of Muenster has been selected by the federal state of North Rhine-Westphalia to establish the *European Research Center for Information Systems*. Its objective is to undertake joint research projects that span different disciplines and countries, thus fostering research at a level that cannot be achieved by individual go-it-alone projects. The exchange of researchers, such as PhD students, lecturers or (associate) professors, is encouraged and cooperative masters and doctoral programs are also part of the overall objective. http://www.ercis.org

Have Service-Oriented Architectures Taken a Wrong Turn Already?

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Abstract. Service-oriented architectures (SOAs) are the latest industry answer to the quest for functioning software and manageable application landscapes, a quest that has been around for more than 30 years. Although basically a step in the right direction, the fact that SOAs typically proceed "bottom-up," by abstracting step-wise from the basic bit level to higher levels of service coordination and composition, appears questionable. It is argued here that a combined bottom-up/top-down strategy is needed for properly developing SOAs, in which business goals and processes are taken into account right from the beginning. Otherwise, SOAs would have taken a wrong path already.

1 Introduction

Service-oriented architectures (SOAs) are the latest industry answer to the quest for functioning software and manageable application landscapes, a quest and challenge that has been around for more than 30 years. Previous answers have included remote procedure call (RPC), object orientation, the Common Request Broker Architecture (CORBA), and remote method invocation (RMI). A general agreement on what a SOA actually is has not yet been reached, but several features are commonly attributed to a SOA, among them distribution, loose coupling, a directory service, sometime even process-orientation [2]. When it comes to realization, SOAs commonly rely on Web services [1, 4, 8], and here is where the dilemma begins: Although basically a step in the right direction, the fact that SOAs built on Web services proceed strictly "bottom-up," by abstracting step-wise from the basic bit level to higher levels of service coordination and composition, appears questionable. Indeed, Web services typically follow the standards stack shown in Figure 1.

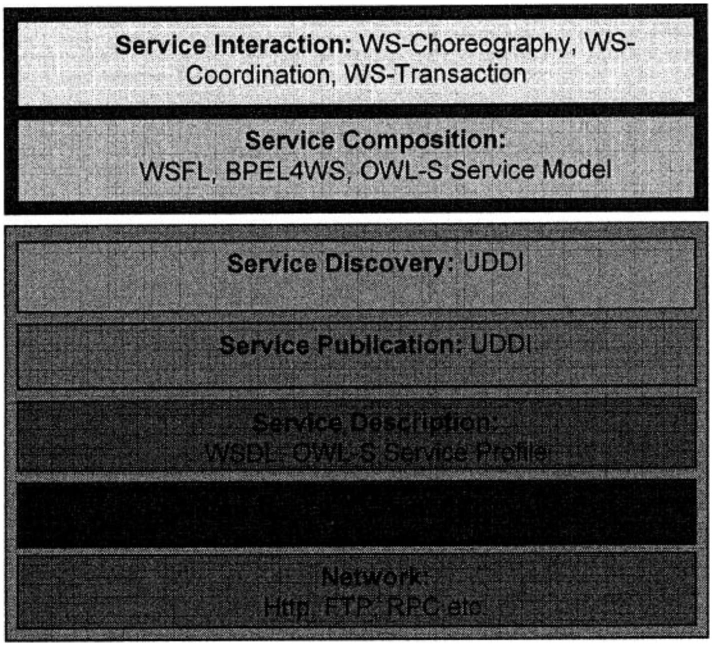

Fig. 1. The Web Services Standards Stack as advocated by industry

In this stack, a new layer of abstraction is added whenever it is detected that the existing ones are not sufficient anymore. Single messages of the network need SOAP encoding; services should have a description that is written in WSDL; service descriptions need to be published by employing UDDI so that they can indeed be discovered; single services are often not enough, so that several services need to be composed though languages like WSFL, BPEL4WS or, more recently, OWL-S; finally, several services in action need some form of coordination or transactional guarantees. In each case, there is one or more "standard" readily available for describing the intended feature, but it is not clear that this standard will still be around in a year or two, since it may happen that it is either "overruled" by a new standard; furthermore, new features may be identified, most likely again higher in abstraction, that require something else.

What we conclude from this brief consideration is that this is not a good approach. In particular, there is no end of this continued abstraction-building in sight, while at the same time the stack as it now stands is not even mature enough for wide usage (just think of the few UDDI repositories that are actually available today, in spite of the fact that the recognition that adding a "public" directory service to an otherwise RPC-style communication is very desirable is several years old by now). Moreover, studies such as [5] have shown that it is difficult to come up with conceptual underpinnings or theoretical studies of Web service fundamentals as long as industry seems to be stuck at the details of message exchanges.

It is argued in the remainder of this short paper that a combined bottom-up/top-down strategy, in which business goals and processes are taken into account right from the beginning, is more reasonable for developing SOAs then a pure bottom-up approach. Otherwise, SOAs would have taken a wrong path already and would be doomed to end in an IT nirvana, just like other developments before. We begin by looking at services in general (Section 2), then take a top-down view on SOAs (Section 3) and derive at a conclusion in Section 4.

2 The Service Idea is not new

Service orientation [2, 6, and 7] is a fundamental paradigm of computer science based on the idea that complex functionality can typically be decomposed into a collection of more elementary ones, as indicated in Figure 2.

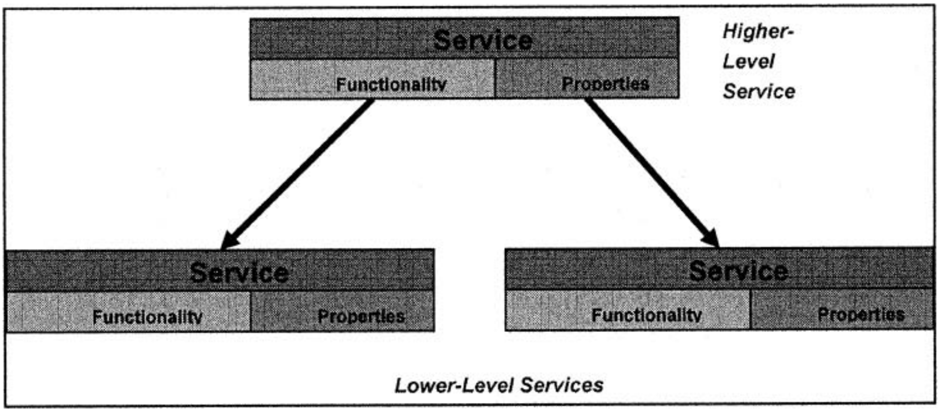

Fig. 2: Service-orientation fundamental view

Under this perception, a single service can always be seen as some functionality with specific properties. In a top-down view, the *decomposition* is important, i.e., the idea that a service as seen from above is typically composed of more fundamental functionality and hence, can be broken down into components. In a bottom-up view, lower-level services are considered to join forces in order to provide more comprehensive functionality to the next higher level.

Web services are perfectly in line with the view just described, which can be found in a number of typical computer science scenarios (e.g., computer hardware, application architectures, computer networks, to name just a few). The important addition that Web services bring along is the fact that they are now linked to a central (and ultimately public) repository, i.e., a "lookup" facility. The repository is a place where a service *provider* can publish a description of the service(s) he or she is willing or able to provide, and which service users or *clients* can query and search for appropriate services. Moreover, providers and clients are no longer tightly, but loosely coupled, since each Web service, which essentially is an individual software component, has a uniform resource identifier (URI) through which it can be placed and located anywhere in the Web.

The provider of a service "builds" the service and simultaneously creates a specification that can be published in a service repository. To this end, established standards (cf. Figure 1) include WSDL, the *Web Service Description Language*, which provides a format for service specifications. WSDL documents are typically placed in a UDDI (Universal Description, Discovery, and Integration) repository, which clients can search using the respective query language. A search will often look for one or more services in the repository, and, once the search has been successful, the client can directly talk to the provider for a service binding followed by an execution of the chosen service(s). Thereafter, service request and reply calls are exchanged between provider and client in terms of the SOAP (Simple Object Access Protocol) format. This general "setup" is shown in Figure 3; for details, see [1, 6, and 7].

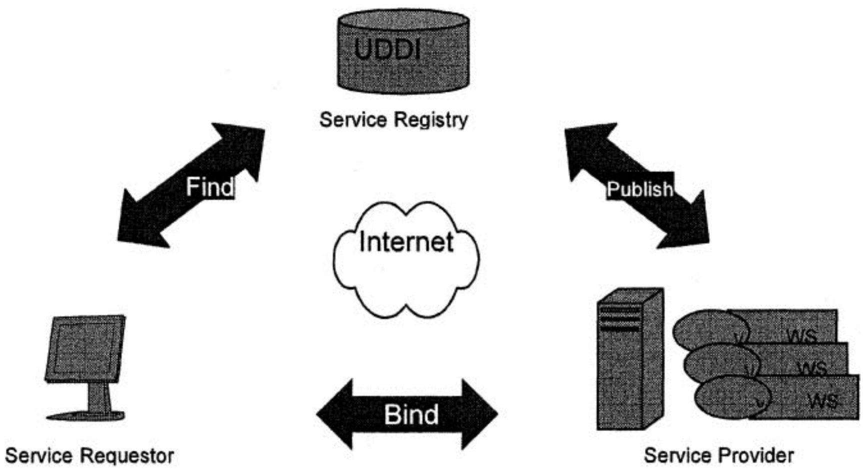

Fig. 3: Basic Web service setup

3 A Top-Down Counter Vision

A typical service-oriented architecture will have to answer the question of which services are available (within, say, a given enterprise) already, which ones need to be newly implemented, and which ones need to be obtained from a suitable provider. To this end, it is reasonable to assume that the enterprise under consideration is aware of its business processes, describing its core competences and its core operations. Thus, from a top-down development perspective, it makes sense to first come up with one or more process models that together clarify and fix the goals and procedures a client (or a collection of clients in an enterprise) wants to support by appropriately chosen services. Such models will typically be tied to a particular application domain, such as commerce, banking, the travel industry, etc. and will refer to organizational structures and also incorporate objects as well as resources occurring in processes. The next step would be to determine which portions of the overall "process map" can be grouped together in such a way that they can jointly be supported by a service. This step could involve negotiations with potential service providers on the exact amount of service or on the price [3]. The result will then be a SOA which fixes the composition and integration details at a conceptual level and beyond service and departmental borders. In essence, this approach is similar to what has led to area-specific reference models which capture the core processes of an entire branch, and which can be customized to fit the specifics of a particular enterprise. These considerations are summarized in Figure 4.

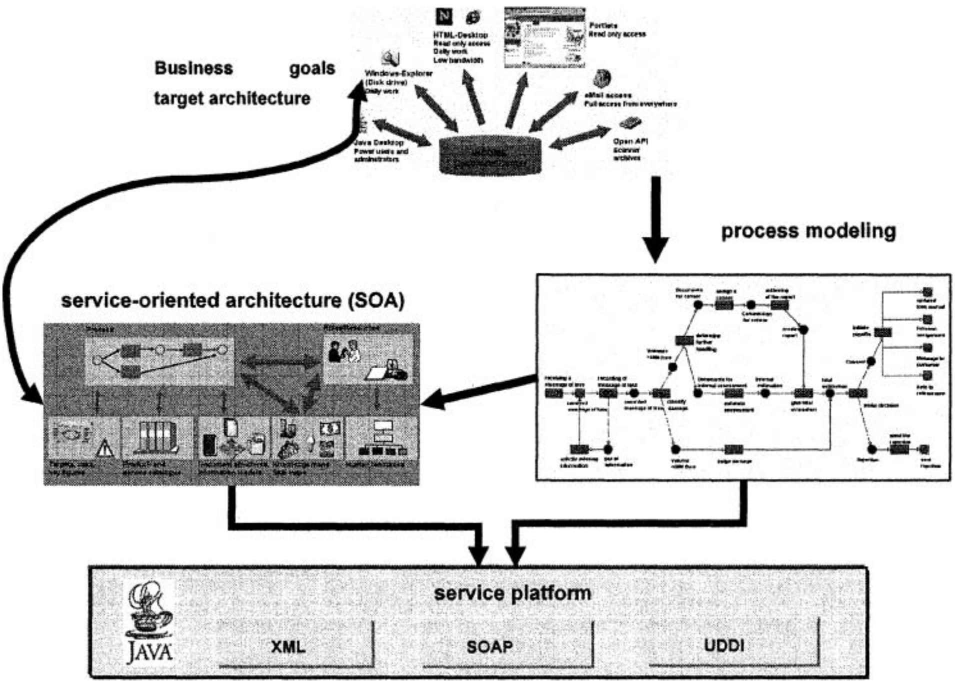

Fig. 4. Top-down approach to service-orientation

It should be mentioned that, although the big players in software development all have their own understanding of what a SOA is, how it should be developed and how supported, the view currently promoted by IBM and others may indeed be the easiest to be brought into accordance to what is shown in Figure 4, since it sees operational systems, abstracted into enterprise components at the lower end, a portal presentation layer atop a business process choreography at the higher end, and a service layer in the middle, as indicated in Figure 5.

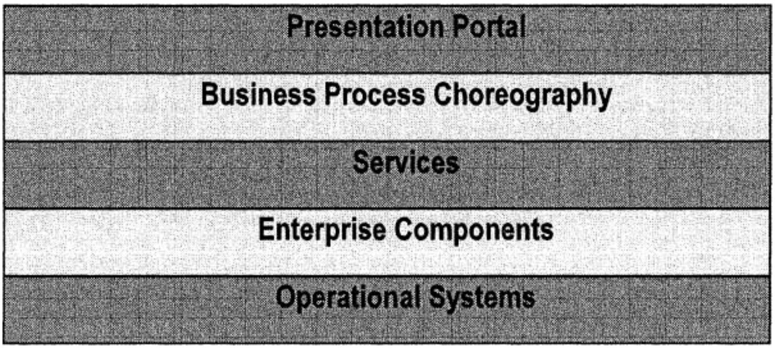

Fig. 5: Layered organization for a SOA

4 Towards SOAs That Can Work

We believe that SOAs can fly if the business *process* aspect that is always present is appropriately taken into account. From all that has been learned about business process modeling and reengineering as well as about workflow management and process automation, it has become clear over the last 15 years of research that process views are important, and that a process view of an enterprise is *the* way of capturing what the enterprise is or should be doing. Thus, it is be no means clear why this should be given up just to make room for a collection of standards that is emerging bottom-up.

On the other hand, it is also clear that a SOA will hardly ever be introduced into an environment where there has been no IT before. In other words, it makes perfectly sense to assume the presence and availability of a number of operational systems that will prevail, and that will still be around even after the SOA has been introduced. So the most reasonable way at the moment seems to be a combination of Figures 2 and 5, which is what we have tried to capture in Figure 6: Enterprise components are masked into individual services, which can be composed in order to yield more comprehensive functionality. The latter, in turn, can be referred to by business process choreography, which is the result of business process modeling, optimization, and reengineering.

True success stories of service-oriented architectures are yet to be seen; nevertheless they represent a promising paradigm for developing future enterprise integration architectures, and it is not too late for driving them in the right direction!

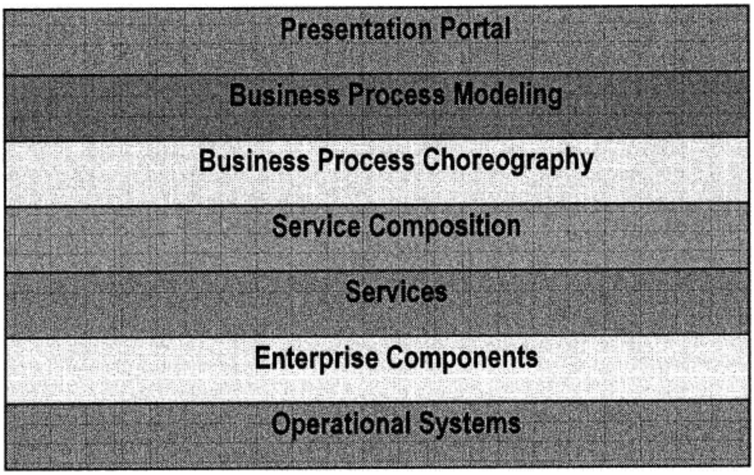

Fig. 6: Extended layered SOA organization

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Self-Organizing Model for Virtual Enterprises

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Abstract. This paper presents a new self-organizing model based on the generalized particle dynamics (GPD) for virtual enterprises.[1] Differing from traditional organizing model for virtual enterprises, the GPD-based self-organizing model may provide the optimal organization for desired virtual enterprises according to historical organizations and current requirements. The GPD conception, algorithm and its properties are discussed. The GPD-based self-organizing modeling has advantages in terms of the real-time performance, adaptability, reliability and the learning ability over traditional organizing models for virtual enterprises

1 Introduction

Distributed virtual enterprises are featured by the geographically distributed resources and jobs, heterogeneous collection of autonomous systems, and collaboration based large-scale problem-solving. Recently, Grid technologies are being integrated with Web Services technologies to provide a framework for interoperable application-to-application interactions for virtual enterprises. The orchestration of virtual enterprises requires the optimal dynamic organization for systematic resources and services.

Most of existing models usually not only regard concurrently occurring service approaches in virtual enterprises to be in dependent of each other, but also regard current service approaches to be independent of past and future service approaches in virtual enterprises. Thus the traditional virtual enterprises take into consideration neither the impact of historical organizations on current organization of virtual enterprises, nor the interference among a great number of concurrently occurring services in virtual enterprises.

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This paper proposes a generalized particle dynamics (GPD) for self-organizing virtual enterprises, which is based on a Markov-chain-type proliferation process and an automatic optimal selection process for service approaches in virtual enterprises differing from traditional organizing models, the GPD-based self-organizing model not only considers influences of historical organizations on current virtual enterprises, but also considers interference among concurrent services in virtual enterprises. As a result, the GPD-based self-organizing model may provide the optimal organization for virtual enterprises. The analysis and simulations have revealed many advantages of the self-organizing model in terms of the real-time performance, adaptability, reliability and the learning ability over traditional organizing models for virtual enterprises.

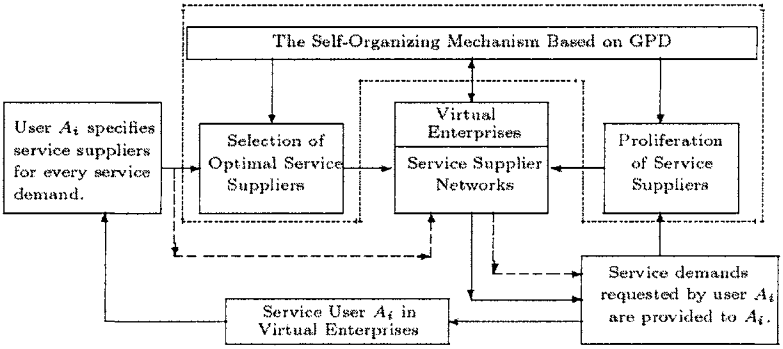

Fig. 1. The difference between the traditional model and the self-organizing model for virtual enterprises. The directed dash-lines represent the service approach in traditional virtual enterprises. The blocks that are framed by dot-lines represent the service approach in the self-organizing virtual enterprises. By the self-organizing virtual enterprises, the optimal service approaches may be realized.

2 Self-Organizing Model for Virtual Enterprises

The essential difference between the traditional model and self-organizing model for virtual enterprises is shown in Fig. 1. By the traditional model, any service user A_i in virtual enterprises should fully know and exactly specify service suppliers that may offer its service demands. On the other hand, however, by self-organizing virtual enterprises, service approaches for service demands of the user A_i are determined optimally by self-organizing service networks, rather than directly by service suppliers indicated by the user A_i. Current self-organizing service networks are established on the basis of the past service approaches through a proliferation process of service suppliers in virtual enterprises.

As shown in Fig. 2(a), for example, by traditional virtual enterprises a user in virtual enterprises exactly specifies 6 distinct service suppliers to offer it 16 kinds o service demands in a given time session τ . Once the No. 5 service supplier fails to work, 4 kinds of service demands, denoted by d, e, f, g, could not be provided. However, by self-organizing virtual enterprises, a self-organizing service networks as shown in Fig. 2(b) have been built by using service approaches before the time session τ , so that 16 kinds of service demands might be offered from as many as 15 distinct service suppliers, and most of service demands can be provided from more than one service supplier. Even the No. 5 service supplier fails to work; there is no influence on offering the user's demands. The comparison with respect to service robustness for two kinds of virtual enterprises is shown in Fig. 3, which gives the relation between the average number of lost services and the number of faulty service suppliers.

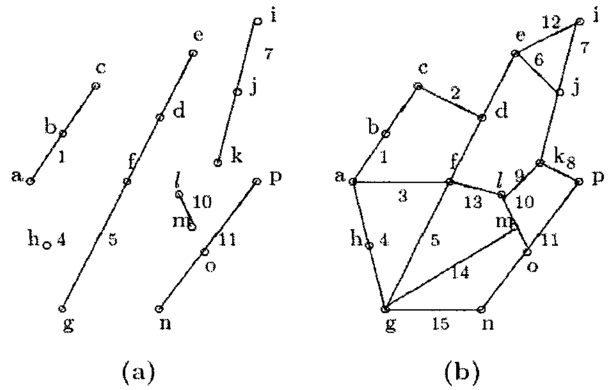

Fig. 2. The comparison of service approaches between the traditional model and the self-organizing model for virtual enterprises, where each service supplier is denoted by a solid line labeled in a digit number; each kind of service demands is denoted by a node labeled in an English letter; and if a kind of service demands can be provided by a service supplier, then the corresponding node lies on the corresponding solid line. (a) The service approaches in traditional virtual enterprises, where 6 service suppliers need to be rigidly specified to offer 16 kinds of service demands. (b) The possible service approaches in self-organizing virtual enterprises, where optimal service suppliers to offer 16 kinds of service demands may be selected from as many as 15 service suppliers.

3 Generalized Particle Dynamics

We make use of a generalized particle dynamics (GPD) to implement the proliferation process of service suppliers and service demands, and accordingly to construct powerful self-organizing service networks for self-organizing virtual enterprises. The GPD method is based on stochastic Markov processes over the space of service supplies and the space of service demands, so that current organization of virtual enterprises may be related both to past organizations and to current service demands.

Two two-dimensional $N \times N$ particle arrays, GPA-I and GPA-II, as shown in Fig. 3, are used to perform GPD's for service demands and service suppliers, respectively. In the time session τ, initially all the kinds of service demands and all the service suppliers are randomly mapped onto particles on the array GPA-I and GPA-II, respectively. Let the data object carried by a service demand particle represent a service supplier that can provide the service demand; and the data object carried by a service supplier particle represent a kind of service demands that can be provided by the service supplier. Arrays, GPA-I and GPA- II, are motion fields for service demand particles and service supplier particles, respectively. The state $s_{ij}(t)$ of the particle c_{ij} that is located at the coordinate point (i,j) on GPA-I (GPA-II, resp.) at a time t in the time session τ is equal to the data object carried by the particle. If there is no particle at the coordinate point (i,j) on GPA-I (GPA-II, resp.) at time t, then denote $s_{ij}(t) = \emptyset$. A special distribution of particles on a GPA array is called a configuration, with all the possible configurations forming a configuration space.

By the same local transitive rule, particles on GPA-I (GPA-II, resp.) randomly and concurrently move back and forth, with a motion probability being determined by a harmony function. We thus obtain a Markov stochastic process over the configuration space on GPA-I (GPA-II, resp.), which can give rise to stationary probability distributions with the maximal entropy over the corresponding configuration space. By maximal stationary probability distributions of service demand particles on GPA-I and service supplier particles on GPA-II, we may easily establish self-organizing service networks to offer optimal service approaches and to organize virtual enterprises in time session τ . For simplicity, in what follows we will discuss particle dynamics only for one of GPA-I and GPA-II.

The similarity $d_{(ij,i'j')}(t)$ between two particles c_{ij} and $c_{i'j'}$ at time t in time session τ is defined by

$$\begin{cases} 0 \le d_{(ij,\, i'j')}(t) \le 1, & \text{if } s_{ij}(t) \ne \emptyset \text{ and } s_{i'j'}(t) \ne \emptyset; \\ d_{(ij,\, i'j')}(t) = -1, & \text{if } s_{ij}(t) = \emptyset \text{ or } s_{i'j'}(t) = \emptyset. \end{cases} \tag{1}$$

The harmony $h_{(ij,i'j')}(t)$ between two particles c_{ij} and $c_{i'j'}$ at time t is defined by

$$h_{(ij,\, i'j')}(t) = \begin{cases} 1, & \text{if } d_{(ij,\, i'j')}(t) \ge \theta_{ij}; \\ 0, & \text{if } d_{(ij,\, i'j')}(t) = -1; \\ -1, & \text{if } 0 \le d_{(ij,\, i'j')}(t) < \theta_{ij}; \end{cases} \tag{2}$$

The harmony $h_{ij}(t)$ of the particle c_{ij} at time t is defined by

$$h_{ij}(t) = \sum_{(i',\, j') \in N_{ij}} h_{(ij,i'j')}(t).$$

where θ_{ij} is a previously given threshold, $0 \le \theta_{ij} \le 1$; and N_{ij} is the neighbor of the coordinate (i,j) that is defined by $N_{ij} = \{(i-1,j),(i+1,j),(i,j-1),(i,j+1)\}$.

The matrix $\Gamma(t) = [s_{ij}(t)]\left[s_{ij}(t)\right]_{N\times N}$ represents a configuration, that is, a special distribution of particles on GPA-I or GPA-II at time *t:* For descriptive convenience, a possible configuration is indicated by an index within a positive integer set *I*¤. For ;(*t*) = *u 2 I*¤, the aggregate harmony of $\Gamma(t)$ is defined by

$$\mathcal{H}(\Gamma(t)) = \mathcal{H}(u) = \sum_{i,j} w_{ij}(\tau)\, h_{ij}(t), \tag{3}$$

where $\omega_{ij}(\tau)$ is a weight coefficient which can be obtained by a learning algorithm according to a priori probability distribution of past organizations of virtual enterprises.

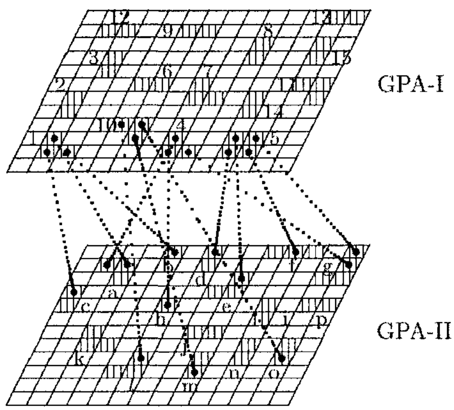

Fig. 3. Particle dynamics on two particle arrays, GPA-I and GPA-II, for self- organizing virtual enterprises. The array GPA-I is the motion field for service demand particles illustrated by shadowed squares, with a particle carrying a data object that represents a service supplier in Fig. 2(b). The array GPA-II is the motion field for service supplier particles illustrated by shadowed squares, with a particle carrying a data object that represents kind of service demands in Fig. 2(b).

If the particle c_{ij} randomly chooses the coordinate (i', j') as its motion destination at time $(t + 1)$, then the probability with which the particle c_{ij} moves to the position (i', j') at time $(t + 1)$, that is, the data object being carried by c_{ij} is successfully transited to the coordinate (i', j') at time $t+1$, is determined by

$$p = f(\triangle\mathcal{H}) = \frac{1}{(1 + e^{\triangle\mathcal{H}/T})}, \tag{4}$$

where $\Delta\mathrm{H} = \mathrm{H}(\Gamma(t)) - \mathrm{H}(\Gamma(t+1))$ is the aggregate harmony increment if the chosen transition happens. The thermodynamic temperature parameter T is used to speed up the transient to a stationary probability distribution, and to avoid stagnating into local minima.

4 Particle Dynamics Algorithms and Their Properties

For GPA-I or GPA-II, we use two exactly same duality lattices, Lattice A and Lattice B, to prepare two randomly generated configurations, u and v.

Parallel Particle Dynamics Algorithm GPDA :

Costep 1. The states of all the coordinates in Lattice A and Lattice B are set to ϕ, which indicates that no particle lies on the GPA array.

Costep 2. At the initial time t_0, all the particles are concurrently and randomly mapped on Lattice A and Lattice B, with each particle carrying a data object that represents a service supplier for particles on GPA-I and a kind of service demands for particles on GPA-II.

Costep 3. At the current time t, every particle c_{ij} on Lattice A and Lattice B concurrently compute its harmony $h_{ij}(t)$ by Eqs. (1) and (2).

Costep 4. At the current time t, Lattice A and Lattice B concurrently compute their aggregate harmonies by Eq. (3).

Costep 5. At the current time t, compute the transitive probability by Eq. (4), and then, using the transitive probability, randomly choose one from the two configurations on Lattice A and Lattice B as a candidate configuration for the next time $t + 1$ processing.

Costep 6. The configuration not chosen in Costep 5 is updated by a new randomly generated configuration for the next time $t + 1$ processing.

Costep 7. Repeat Costep 3 through Costep 6 until a stationary probability distribution over configuration space is obtained, where that with the maximal probability corresponds to the optimal service organization for virtual enterprises in the time session τ.

Given a priori probability distribution q_u with respect to the configuration u, the weight coefficients of Eq. (3) can be obtained by using the parallel learning algorithm GPD-WLA.

Parallel Learning Algorithm GPD-WLA:

Costep 1. In parallel, initiate the value $\omega_k(t_0), k \in \{1,\cdots,n\}$, where k is the number of service supplier.

Costep 2. In parallel, compute the local harmonic function $h_{i(u,k),j(u,k)}$ for the configuration u and the *k-th* service supplier.

Costep 3. Using $h_{i(u,k),j(u,k)}$ and the priori probability q_u, in parallel compute the average value $\overline{h_k}, k \in \{1,\cdots,n\}$.

Costep 4. Using $w_k(t)$ and the algorithm GPDA, obtain a stationary probability distribution p_u; and then using $h_{i(u;k);j(u;k)}$ compute the average value $\overline{h}_k$ under the probability distribution p_u; for $k \in \{1,\cdots,n\}$.

Costep 5. Let $\Delta\omega_k(t) = \overline{h_k} - \hat{h}_k$. In parallel, update the weights w_k, such that $\omega_k(t+1) = \omega_k(t) + \Delta\omega_k(t)$.

Costep 6. Once $\Delta\omega_k(t) \approx 0$ holds true, then $w_k(t)$ is just the required weight coefficient; Otherwise, go to Costep 4.

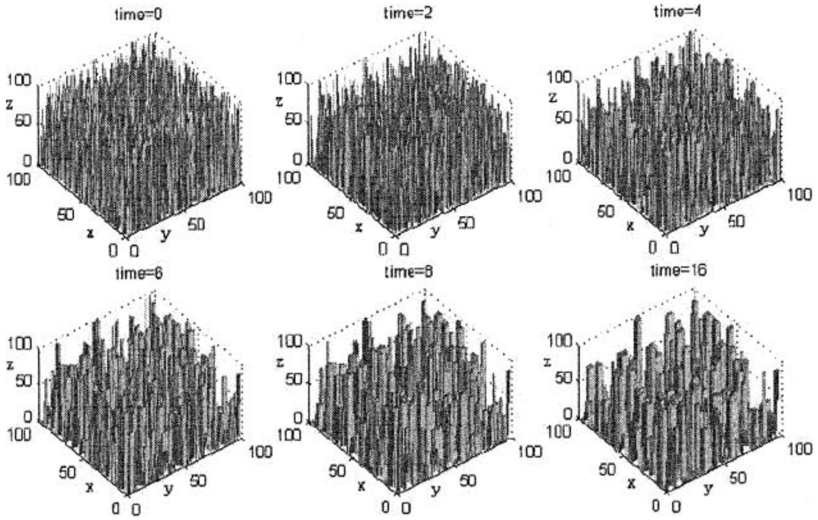

Fig. 4. The state evolution of particles on GPA-I during executing the parallel algorithm GPDA. The number of kinds of service demands: 100; The number of service suppliers: 56; The number of service requests: 4000; The number of service suppliers specified by service users: 5; The number of particles on GPA-I: 10000.

We derive properties of GPDA and GPD-WLA as follows, proofs omitted for page limitation.

Lemma 1. *The stochastic process* $\{\Gamma(t), t = 0, 1, \cdots\}$ *generated by the algorithm GPDA is a finite homogeneous Markov chain.*

Lemma 2. *The stochastic process* $\{\Gamma(t), t = 0, 1, \cdots\}$ *generated by the algorithm GPDA is an irreducible homogeneous Markov chain, where all the configurations are positive recurrent, that is, any configuration may return to itself in a finite time period with the probability 1.*

Lemma 3. *The stochastic process* $\{\Gamma(t), t = 0, 1, \cdots\}$ *generated by the algorithm GPDA must reach a stationary probability distribution over the configuration space, that is, any configuration may occur with a fixed probability. Moreover the stationary distribution is independent of the initial configuration.*

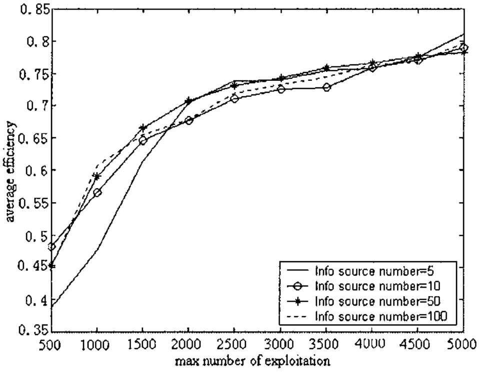

Fig. 5. The efficiency of the GPD-based self-organizing virtual enterprises increases almost monotonically with the number of service requests. The number of particles: 10000; The number of kinds of service demands: 100.

Theorem 1. *The stationary probability distribution obtained by executing the algorithm GPDA is the maximal entropy distribution over the configuration space. Moreover the stochastic configuration with the maximal probability has the maximal aggregate harmony.*

Theorem 2. *A configuration with the maximal probability in a stationary probability distribution produced by the algorithm GPDA has the minimal number of connected regions on GPA-I and GPA-II, with each region having the same service supplier for GPA-I and same kind of service demands for GPA-II.*

Theorem 3. *The parallel learning algorithm GPD-WLA can converge and gives rise to* $\lim_{t\to\infty} \omega_k(t)$ *that is equal to the Lagrange multipliers for maximizing the aggregate harmony subject to the priori probability distribution* q_u.

5 Simulations

Through a large number of simulations, we can see that the GPD-based self-organizing virtual enterprises not only greatly reduce the aggregate cost of service approaches, but also greatly increase the service reliability. The state evolution of particles during executing the parallel algorithm GPDA is shown in Fig. 5. The efficiency of GPD-based self-organizing virtual enterprises is illustrated in Fig. 6. Comparisons between different strategies for service approaches in virtual enterprises are shown in Fig. 7

6 Conclusions

We draw conclusions as follows:

• In comparison with traditional virtual enterprises, proposed GPD-based self-organizing virtual enterprises not only greatly reduce the average overhead for service approaches, but also significantly improve their real-time performance, adaptability, and reliability.

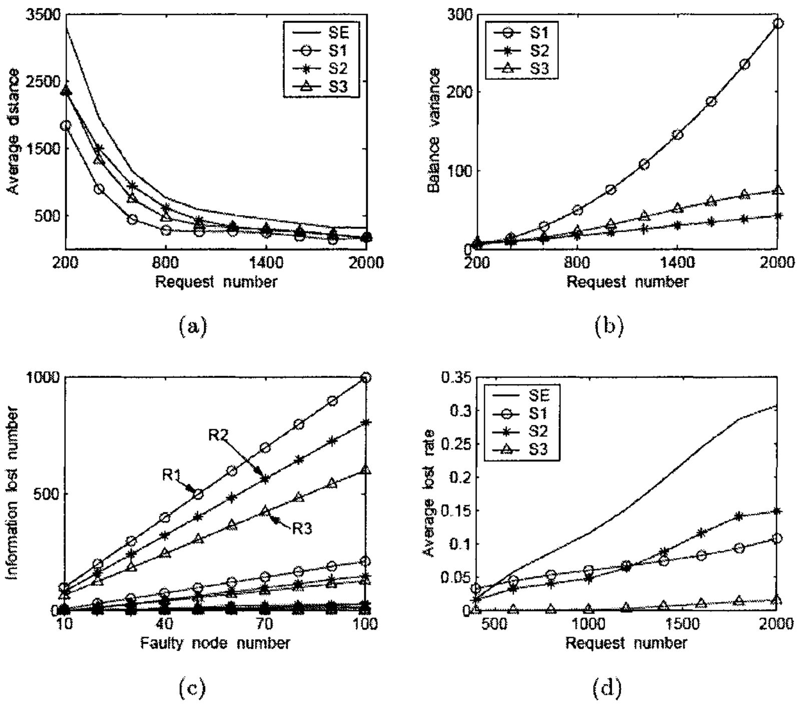

Fig. 6. Performance comparisons among different strategies of service approaches in virtual enterprises, where SE is for the traditional virtual enterprises; S1, S2 and S3 are for the GPD-based self-organizing virtual enterprises; S1 is for the Closest Selection Strategy; S2 is for the Maximal-Load Selection Strategy; S3 is for the First-Fitting Selection Strategy. R1-R3 corresponds to the number of service requests: 1000,800,600, respectively. The number of particles: 2500; The number of kinds of service demands: 50; The number of service suppliers specified by service users: 5.

- Since all the particles evolve independently and simultaneously by the same local dynamic rule, the GPD-based self-organizing virtual enterprises have higher parallelism, Moreover GPD is based on a stochastic process, it is insensitive to many emergent and random events, such as the perturbation, noise, failure and congestion in virtual enterprises.
- The model, architecture and algorithms of GPD are all independent of the problem scale under consideration, so that it is suitable for VLSI hardware implementation.
- The GPD-based self-organizing virtual enterprises can be implemented for different granularity of services. It also has advantages in terms of the ability to learn different service environment, such as different probability distribution over the service demands space and service supplier's space.

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A Spatio-temporal Database System Based on TimeDB and Oracle Spatial

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Abstract. The importance of the spatial component of data items has been long recognized and gave rise to a successful line of research and development in Geographic Information Systems (GIS). In many application domains it is also essential to deal with the evolution of data along time and to integrate spatial, temporal and other aspects of the information domain in an expressive and operationally effective manner. Until recently, temporal solutions provided by spatial database systems were semi-temporal approaches lacking full temporal support. As a consequence, most spatial database systems manage snapshots of the present state of facts without fully exploiting historical temporal aspects. This paper provides preliminary results on a spatiotemporal database implementation. The proposed system builds on existing database technologies, TimeDB and Oracle Spatial, for temporal and spatial support, respectively. The justification for the choice of these technologies is given, based on the state of the art in spatial and temporal database research. The integration of the spatial and temporal components is achieved with the extension of the TimeDB implementation layer. A set of goals has been established in order to cover both the integration of the spatial support and the enforcement of the temporal requirements in the extended system. Issues and solutions are presented and illustrative examples show the use of the implemented functionalities.

1 Introduction

Traditional databases model and keep information about some part of a real or artificial domain. Regarding the temporal aspects of facts that occur in the real word, these databases allow capturing some essence of time, which generally consist in a snapshot view of the world limited to the last update. This limitation becomes critical

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when there is the need to capture the evolution of facts over the time. To overcome this limitation, that is, to manage temporal aspects of facts in databases, Date [0] considers two distinct approaches: the semi-temporal approach, where the representation of historical data is done with timestamps, and the full-temporal approach, where the database must record the time when a fact is current in the reality - represented as an interval or a period - and in some application domains, must keep record of the time when a fact is current in the database. Such times are respectively called valid-time [0, 0] and transaction-time [3, 4]. If the first approach may lead to severe difficulties in handling some constraints and queries [0] the fact is that the full temporal approach has a higher level of complexity, requiring additional functionalities in the database system such as temporal data types, temporal operators (like begin, before, meets, contains, overlaps and coalesce) and temporal functions [0]. On the other hand, if most of the application domains are temporal by nature [0], it is also factual that some of these domains also contain spatial information [0]. In such situations it is of critical importance to manage seamlessly integrated temporal and spatial aspects. Examples of spatiotemporal domains are all the critical traffic management domains, where commercial navy, trains and airplane vessels must be permanently tracked. In the past few years spatiotemporal research has taken several important steps, but there are few implementations that address the problem of time and space in depth. Currently there are still many solutions following the so called semi-temporal approach, where much of the processing of the temporal aspects of temporal data is done at the application layer - increasing data and program complexity [0] - and not by the underlying DBMS layer, due to the lack of full temporal support. In an effort to overcome these limitations, the present work concerns the integration of two well known database technologies – TimeDB [0] and Oracle Spatial [0, 0] – in order to provide general spatial and temporal support without reducing the functionality provided by both technologies when working separately, through the ability to execute ATSQL2 [0] statements combined with spatial operators and functions. Our motivation to develop this integration is the creation of a full spatiotemporal relational database system (with bitemporal support) that constitutes the underlying layer of a larger system dedicated to manage present and past spatiotemporal urban data. In the next section we explain the selection of TimeDB for temporal support and Oracle Spatial for spatial support. In section 3 we present the reasons why the two technologies provide good integration for creating a spatiotemporal database prototype system and we point out the goals in joining the two database technologies as well as the issues that must be addressed in order to do so. Section 4 makes an overview of the system and its modules. Section 5 describes the main changes required in the translation algorithm in order that the translation process generates valid snapshot and spatial SQL. Section 5 concerns the results obtained, regarding the temporal and spatial goals. Finally, in section 7 we summarize the main conclusions of this paper and point out directions for current and future work.

2 Temporal and Spatial DBMS Implementations

Griffiths [0] states that the considerable design and implementation effort required to develop complete full spatio-temporal database systems is the main reason why research on temporal databases has focused on specific subparts of the problem like indexing or join algorithms and, consequently, there are so few implementations. The survey in [0] on temporal database systems classifies several systems - ARCADIA, Calanda, ChronoLog, HDBMS, TDBMS, TempCASE, TempIS, TimeDB, TimeIT, TimeMultiCal, and others - according to carefully thought-out criteria grouped in families. This author points out important conclusions on the tested implementations, like the dominance of the relational model with timestamped tuples and the fact that valid-time dimension has been the focus of attention leaving transaction time to a second place. More recently TEMPOS [0] and Tripod [0] emerged as temporal extensions of the ODMG object model, trying to overcome important limitations of previous extensions (TAU, TOOBIS, T_ODMG). TimeDB [0] is a client-side system [0] implementation that uses ATSQL2, provides bitemporal statements, supports upward compatibility and temporal upward compatibility, allowing legacy data and code to maintain the usability [0]. Being a layered [0] system, TimeDB can manage information from distinct DBMS technologies, among which is Oracle DMBS. In our opinion, although a client-side temporal implementation, TimeDB is not penalized by limited temporal functionality thanks to the way TimeDB deals both with translation of temporal statements and with management of temporary results. Steiner [0] considers that the translation algorithm of TimeDB can be used to translate different temporal query and modification languages into standard SQL statements. The execution of the resulting statements stores temporary results that are produced by a statement and consumed by the next one, avoiding collecting intermediate results and corresponding performance problems. Concerning spatial DMBS implementations, Medeiros [0] presents a survey focused on databases for GIS discussing several design criteria, such as data models, spatial operators, relationships, query modalities and optimization, data storage and access methods. Over these design issues, Medeiros refers database technologies and relates them to each design criteria. According to [0] a spatial DBMS must comply with three requirements: (a) to be a DBMS; (b) to provide spatial data types both for the definition of the data model and the manipulation by the query language, (c) to provide efficient algorithms for spatial operations like spatial *join* or multi-dimensional access methods (indexing). Having this in mind three Spatial DBMS implementations can be presented: ESRI ArcSDE, PostGIS and Oracle Spatial. The first constitutes a layered implementation that enhances non-spatial DBMS with the spatial support described. The other, PostGIS and Oracle Spatial [0][0] provide spatial support directly by the DBMS kernel through a spatial schema, a spatial indexing mechanism, a set of operators and functions for area-of-interest queries, spatial join queries and spatial analysis operations. Together, these functionalities allow the storage, retrieval, update and query of collections of spatial features.

3 Temporal and Spatial DBMS Implementations

The selection of Oracle Spatial as the support for spatial data in the proposed spatio-temporal system results from its support for multiple dimension geometry, the usage of spatial operators and spatial indexes, and a query language that is an extension to SQL and whose constructs can provide good integration with TimeDB ATSQL2, without harming temporal and spatial semantics. The integration of such technologies also permits the modified TimeDB layer to deal with just one DBMS for both temporal and spatial domains. The scenario of having two different DBMS managed by the modified TimeDB implementation would represent a critical performance, due to having to transfer temporary results between two DBMS. This approach would challenge one of TimeDB original major benefits concerning performance, namely the avoidance of intermediate results storage by the layer. Having settled on the underlying technologies we proceed to address the goals we expect to achieve with such integration, namely spatial related goals, temporal related goals and usability goals. Spatial related goals consist in providing TimeDB with the ability to deal with Oracle Spatial schema, geometry data types, spatial (and aggregate) functions and spatial indexes during the parsing, translation to non-temporal statements and evaluation processes, without impairing spatial functionality. Such ability provides that spatial functions and operators can be used within the modified ATSQL syntax, in order to provide spatial projections and selections. Such goals require functionalities that are not present in the original TimeDB implementation like being able to address the *mdsys* schema, in order to access and manipulate data and structures like geometry metadata tables (*mdsys.user_sdo_index_metadata*) and index metadata (*user_sdo_geom_metadata*). Also, the fact that TimeDB only addresses the tables and columns that are registered in its own metadata tables requires the proper insertion, on such tables, of the description of each column of the previous geometry metadata tables. Another issue concerns the use of spatial data types, for example *mdsys.sdo_geometry* that is widely used in the spatial domain. Among the spatial data types the aggregate data types, for example, *mdsys.sdoaggrtype* provides support for spatial aggregate functions like *sdo_aggr_union*. Finally, special care must be also provided for data type object methods, for example, *get_gtype*, from *mdsys.sdo_geometry* data type. Solving such issues provide the support for statements like:

create table countries (name char(20), capital char(20), ***boundary mdsys.sdo_geometry****) as validtime*

validtime period [1100-1350)
select ***sdo_aggr_union (mdsys.sdoaggrtype****(c.boundary, 0.005)) from countries c;*

Modifications are also required in order to be able to create and delete spatial indexes, through proper SQL statements, since indexation provide accelerated access method that is required for using spatial functions like *sdo_filter* or *sdo_within_distance*. Finally, concerning spatial related goals, it is common for a spatial data type, function or operator to have several spatial arguments, each one being another data type or spatial function with its own arguments. The support for parsing, translating and evaluating inner arguments must also be added in the modified TimeDB layer. The following SQL insert statement provides an illustration of inner arguments situation:

nonsequenced validtime period [1250-1590) insert into countries values ('portugal', 'lisboa', ***mdsys.sdo_geometry (2003, null, null, mdsys.sdo_elem_info_array (1,1003,1),...,80.0,607.0)));***

Special attention must be given to column references that are used as spatial arguments since the translation algorithm of TimeDB substitutes table and column aliases with temporary references during the translation process [0]. For example, in the following statement column references to boundary and name from table aliases a and b are replaced by internal representations of TimeDB:

validtime select a.name from countries ***a****, countries* ***b*** *where a.name = 'portugal' and b.name = 'poland' and sdo_geom.sdo_distance(****a.boundary****,* ***b.boundary****, 0.005) <=0;*

On the other hand, the temporal related goals expected to achieve with the proposed spatio-temporal integration are the goals already pointed out by Steiner [0], briefly summarized as "upward compatibility, temporal upward compatibility and orthogonality on valid time and transaction time together with the requirements listed in the definition of temporal completeness (syntactical similarity, sequenced and non-sequenced semantics of statements, substitutability of a relation in a query by another query and the support of temporal comparison predicates for time intervals [0])". This means that we expect the temporal functionality provided in original TimeDB to remain unharmed, as presented in section 6.

4 System Overview

The integration of spatial data management presented in the previous section within the original TimeDB implementation carries modifications to all TimeDB core modules (Fig. 1).

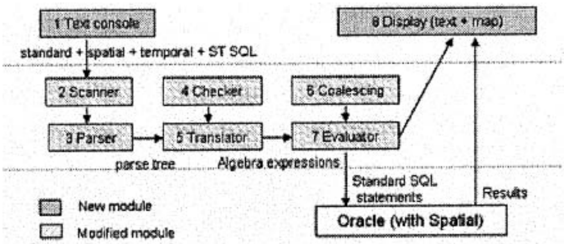

Fig. 1: modified architecture of TimeDB

In order to do so, the implementation of the proposed system relies both in changing and overriding original functionality. For example, the Scanner module has many changes, in order to recognize the spatial constructs. Also the Parser module, responsible for parsing and collecting metadata of SQL statements has several changes in order to support - among other functionality - Oracle spatial tables, method calls in spatial attributes, spatial indexing, spatial functions and operators, spatial arguments, with the possibility of each argument being another function with arguments. Furthermore, in order to keep information about these new features, we has to reformulate several structures, since the parsing process results in a binary parse tree of scalar expression objects, each of them having the required metadata to create the equivalent spatial and non-temporal SQL statements. This metadata is used by the Translator module, responsible for mapping temporal algebra into snapshot equivalent algebra. This module has also several changes in order to accommodate the proper management of spatial columns (Section 5) by temporal operators and the correct translation of spatial projection and spatial selection operators.

5 Changes to the Translation Algorithm

According to Steiner [0], the algorithm for the translation of temporal queries into non-temporal standard SQL queries translates temporal statements into temporal algebra expressions using temporal set operators (union, intersection, difference), where each argument to one of these algebra expressions is a simple temporal algebra expression or the result of another temporal set operator. The integration of Oracle Spatial functions and operations within the translation algorithm does not amount to a major problem since spatial projection and spatial selection operations are, from the perspective of temporal algebra, regarded as simple non-temporal projection and selection and operation. Spatial data types are treated by the translation algorithm, concerning temporal algebra, as other non-temporal data types like number or character strings. Nevertheless column references used as spatial arguments require proper dealing. Also, changes must be performed over the translation algorithm in order to allow temporal set operations and the valid-time coalescing to perform correctly. In both situations, the issue is raised when evaluating SQL code (generated by the translation algorithm) that contains selection operators which compare values of distinct tupples, concerning the same spatial column. Since Oracle Spatial cannot compare two spatial values through the equal operator the SQL code becomes invalid. To overcome this limitation our proposal is to go through the snapshot equivalent mappings for temporal set operators and temporal coalescing, and use:

sdo_geom.relate(table$_1$*.column*$_a$*, 'equal', table*$_2$*.column*$_a$*, <a spatial tolerance>) = 'equal'*

when comparing values in a geometry column, instead of

table$_1$*.column*$_a$ *= table*$_2$*.column*$_a$

Providing these changes in the temporal intersection set operator, the temporal difference set operator and the unitemporal coalescing operator overcomes the problems identified in the snapshot equivalent SQL code (since through *sdo_geom.relate*, Oracle Spatial provides a spatial comparison between the spatial values).

6 Known Results

Snodgrass [0] and Steiner [0] consider that upward compatibility and temporal upward compatibility are ATSQL2 requirements related with database migration. In our prototype system, upward compatibility is maintained through TimeDB original functionality, but regarded from the spatio-temporal perspective: any legal ATSQL2 statement has the same semantics and validity as in the merged ATSQL2 and Oracle Spatial syntax. An important requirement states that each legal SQL query and modification statement, executed on a temporal database, leads to the same result as if it were executed on the corresponding non-temporal database [0][0]. This requirement is also maintained valid with Oracle Spatial legal SQL query and modification statements. Also, the two classes of temporal statements in ATSQL2 (sequenced and non-sequenced) have their semantics unmodified, after the inclusion of Oracle Spatial components. To test that TimeDB functionality has been left unharmed we tested and compared the results of the demos included with original TimeDB with the results obtained in a TimeDB unmodified implementation, leading to the conclusion that, in the subset of temporal valid-time domain, now integrated with spatial support, we have not introduced any limitations or made any simplifications. Concerning spatio-temporal domain, the following sub-sections address the results of temporal compatibility and semantics, from the perspective of temporal and spatial seamless integration.

6.1 Upward Compatible queries and Temporal Upward Compatible queries

Upward compatible queries [0, 0] protect investments of legacy code and provides a gradual process of migration to a temporal DMBS of legacy code and data [0], the proposed system provides that legacy Oracle Spatial code and data can still be used providing results equivalent to those obtained in plain Oracle Spatial DBMS, that is, without awareness of the temporal support provided. Regarding temporal upward compatible queries, they allow the upgrade of legacy applications to temporal database systems and the invariance of the semantics and functionality of legacy statements [0]. This means that snapshot spatial queries issued over valid-time spatial tables will retrieve snapshot spatial results concerning the current valid-time state. For example, providing a valid-time table countries4, the following statement:

*select * from countries4*
where sdo_geom.sdo_area(countries4.boundary, 0.005) > 5000;

retrieves a snapshot result (polygonal geometry). The tupples used by this query are the subset that is considered valid at the time of execution: the non-temporal SQL issued by the evaluator module contains two selection operations that make possible to ignore other tupples (64416774529 is the chronon when the statement was created in the Translator module):

select alias_tdb0.name as name, alias_tdb0.capital as capital,
alias_tdb0.boundary as boundary from countries4 alias_tdb0 where
sdo_geom.sdo_area(alias_tdb0.boundary, 0.005) > 5000 and

alias_tdb0.vts_timedb <= ***64416774529*** *and alias_tdb0.vte_timedb >* ***64416774529***

6.2 Sequenced and Non-sequenced Queries

In what concerns sequenced queries, good for providing historical results [0, 0], temporal logic is applied and operations interpret the timestamps of tuples and use this interpretation for the calculation of the resulting tuples timestamps. TimeDB uses temporal logic to calculate the resulting relation for a query which has, for each tuple, a valid-time timestamp value associated. In such queries, spatial projection and selection operations are regarded as non-temporal operations, like the ones acting on numerical and alphanumerical columns. For example, considering a relation instance that contains historical spatio-temporal information (name, capital and boundary) illustrated in Fig. 2, the following sequenced query retrieves the valid-time periods and respective spatial union for all the countries boundaries. The spatial results of executing the statement are displayed in Fig. 3.

validtime period [1100-1350)
select sdo_aggr_union(mdsys.sdoaggrtype(c.boundary, 0.005)) from countries c;

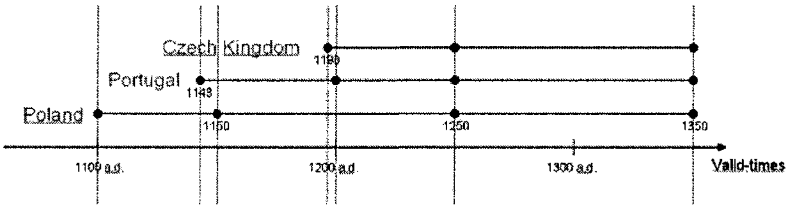

Fig. 2: Schema of database facts regarding Poland, Portugal, and Czech Kingdom, from 1100 A.D. to 1350 A.D.

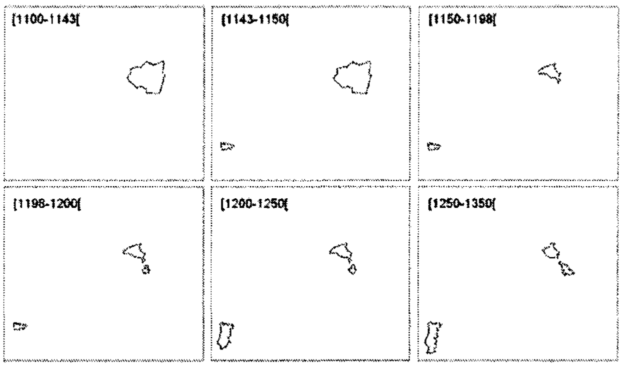

Fig. 3: Spatiotemporal results from the sequenced valid time spatial union query.

Concerning non-sequenced queries, which use non-temporal logic, attributes of temporal data type, like valid time start and end, are managed as other numerical attributes. Eventually, all database states can be used to calculate the resulting relation, as opposed to what happens in sequenced queries. For example, the following query retrieves the union of all country's boundaries disregarding the valid-time of tupples:

nonsequenced validtime
select sdo_aggr_union(mdsys.sdoaggrtype(c.boundary, 0.005)) from countries c;

7 Conclusions and Ongoing Work

Spatiotemporal database technology is required for properly addressing the subset of temporal applications that also manage spatial data and, currently, has many domains of application, from traffic management to urban data management to enterprise information management. As there are only a few systems satisfying both temporal and spatial aspects the presented work intends to contribute to this area by proposing a spatiotemporal database system based on two database technologies: TimeDB and Oracle Spatial. The selection of TimeDB is due to the amount of temporal support provided, as compared to other implementations. Oracle Spatial choice is a consequence of selecting TimeDB, since we want the spatiotemporal layer to deal with only one underlying DBMS. This also maintains the layer free from retrieving temporary results, which would harm overall performance. Regarding the integration issues, the proposed spatiotemporal database system has taken into consideration several groups of functionalities. At the parsing and interpretation level, we have identified the enhancement required on TimeDB scanner and parser modules in order to allow parsing and interpretation of Oracle spatial data types, spatial indexing, spatial functions (and aggregate functions) and spatial operators. At the level of translating temporal SQL to equivalent snapshot SQL statements, we have modified the translation algorithm in what concerns the inclusion of spatial algebra expressions that are integrated in the translated non-temporal, spatial, SQL. In this translation module we have also dealt with the issue of translating column references to the correct table and column aliases. These changes made possible for temporal operations to perform correctly (like unitemporal coalescing). Finally, at the level of retrieval of results, we have created new functionality that goes beyond textual results, being aware of spatial results and, consequently, displays them according to their spatial data type. Concerning the temporal goals, we have concluded that the integration of Oracle Spatial constructs with TimeDB ATSQL does not compromise the original temporal support of TimeDB. Upward compatibility, temporal upward compatibility, sequenced and non-sequenced semantics on valid time are maintained unharmed. Also this integration of both technologies has no impact on spatial functions: although issued in a spatiotemporal context the spatial support maintains the original functionality. Thanks to this fact and to the ability to process the most common spatial data types, all spatial operators and the great majority of spatial functions we can state that spatial goals proposed have been accomplished. The correctness of the implemented functionalities has been tested on a small data set, built to illustrate the main spatial and temporal features and dependencies. Current work includes the use of the prototype system in the domain of urban planning, where extensive geo-referenced data sets exist and querying the temporal components of information is still a challenge. Ongoing work includes providing and testing transaction time support and bi-temporal support integrated with spatial support.

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Maintaining Temporal Warehouse Models

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Abstract. DWT is a tool for the maintenance of data warehouse structures based on the temporal data warehouse model COMET. Data warehouse systems do not provide support for maintaining changes in dimension data. DWT allows keeping track of modifications made in the dimension-structure of multidimensional cubes stored in an OLAP (On-Line Analytical Processing) system. We present the overall structure of the DWT system, which allows to upload and download warehouse models in different modeling notations in a time conscious manner, load edit scripts describing changes between versions of warehouse models and apply these edit scripts. We present the workflows for maintenance of warehouse models and discuss how maintenance can be supported with the various integrated tools of DWT .

1 Introduction

Data Warehouses are integrated materialized collections of data typically from different heterogeneous data sources. They provide sophisticated support for aggregating, analyzing and comparing data to support decision making. The most popular architecture for data warehouses is the multidimensional datamodel, where transaction data (also called cells or fact data) is described in terms of masterdata (also called dimension members). Usually, members are hierarchically organized in dimensions.

Data warehouses are well prepared to deal with modifications in transaction data, e.g. the changing values of the fact *Turnover* over the time can be covered by introducing a dimension *Time*. Not surprisingly, most multidimensional models

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feature a time dimension. Surprisingly, however, data warehouses are not well prepared for changes of the structure of dimensions in spite of their requirement for serving as long term memory and the observation that such modifications happen frequently, too. It is, however, vital for the accuracy and correctness of results of OLAP queries that modifications in the structure of dimensions are correctly taken into account, in particular, when comparing data over several periods, computing trends, or computing benchmark values from data of previous periods.

Maintenance of structural modifications in data warehouses is a crucial point for keeping track of structural modifications and considering these modifications in analytical queries. There are several approaches to cope with this problem; [1-5] are some of them. Some of them (e. g. [1, 2]) allow changes only on instance level, i. e., changing the members. Others (e. g. [5]) work only on the schema level, i.e. allow changing dimension and hierarchy definitions. In [6, 7] we presented the COMET metamodel for temporal data warehousing, which allows a versioning on both, schema and instance level.

Here, we present our temporal data warehouse maintenance system DWT built upon the COMET metamodel. We show how the COMET model can be realized with a layered architecture where a temporal store is employed by non-temporal OLAP tools. We show the architecture of the system, its functionality, and the ways the system can be used. A discussion of design considerations and implementation issues of the prototype complement the paper.

2 System Overview and Functionality

Changes in the dimensional structures of OLAP cubes can cause serious problems, and today's data warehouse systems do not provide appropriate means for solving them. Based on the COMET temporal data warehouse metamodel, we present the DWT system, which is intended for dealing with such problems. The main functionalities of the DWT system are:

- *Import and Export of OLAP Cubes*: import cubes from and export cubes to virtually any OLAP system via generic interfaces.
- *Management of Structure Versions*: select a particular structure version from the DWT database, create new structure versions, and maintain relations and differences between two contiguous versions.
- *Detection of Differences*: tag differences between two structure versions, either by comparing them, importing a change list, or by manual input from the user.

A data warehouse administrator is able to adjust the OLAP cubes due to environmental changes: store the changes into the DWT database and create a set of different structure versions for a cube, each tagged with a timestamp, defining its valid time. Any structure version that was valid at an arbitrary point in time can be re-established.

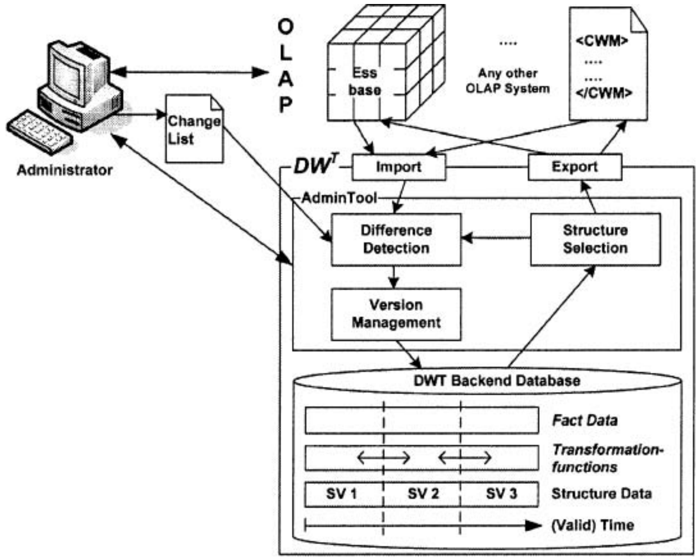


Fig. 1. Overall architecture of the system

2.1 General System Architecture

Figure 1 shows the overall architecture of the DWT system. The system's basis is a relational database that holds all versioning information. It consists of:

- The *Structure Data*, which holds the structure versions of the cubes and the changes between them (e. g. changed members, inserted dimensions)
- The *Transformation Functions*, which describe the relations between members of different structure versions.
- The *Fact Data*, which holds the cell data to be transformed with the help of
- The transformation functions.

The database is queried and filled by the DWT administration tool. This is the central part for managing the versioning process. The main components of the administration tool are the Structure Selection, the Version Management, and the Difference Detection component. The structure selection component is responsible for extracting one particular structure version from the database. The version management component is responsible for creating new structure versions from existing OLAP cubes combined with results from the difference detection component. The difference detection describes differences between imported cubes and stored structure versions (details in 2.5).

2.2 Interfaces

To interact with OLAP systems, the DWT application has two generic interfaces: to *import* cubes from and to *export* cubes to an OLAP system. For each OLAP system to be supported, one has to implement these two interfaces.

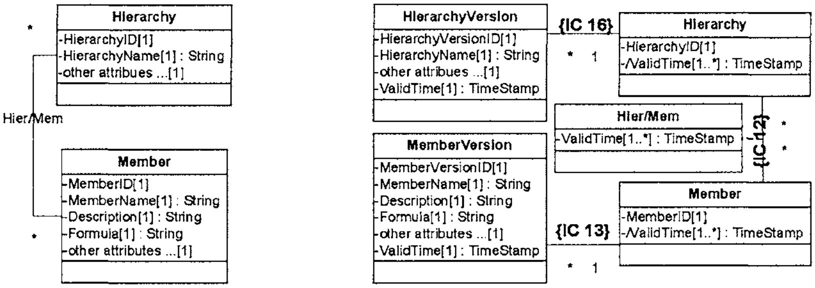
The import interface reads the data from an OLAP system. Within the DWT tool, the data is temporalized, i. e. every element is timestamped, defining its valid time and augmented with versioning information, i. e. relations to elements already stored in the database. The export interface works vice versa. It gets a single version of a cube with all its temporal and versioning information from the structure selection component. As the external OLAP system does not support such temporal information, it is removed during the export and the pure OLAP data is written to the external OLAP system.

The interfaces are shown in the top of Fig. 1. At the moment we have implementations for Hyperion Essbase [8] and a subset of the Common Warehouse Metamodel (CWM) [9], as shown in the architecture. The administrator interacts with both, the selected OLAP system (e. g. Hyperion Essbase), and the DWT administration tool. With the OLAP tool, he can do all update operations on cubes, as usual. With the DWT tool he is able to incorporate these changes into the database.

2.3 Conceptual Database Model and Temporalization

A sketch of our conceptual model for the backend database is given in [7]. Here we can only give a brief summary of the main design ideas.

As the database has to store structure data and fact data, the model includes tables for all integral parts of an OLAP cube, i.e. the cube itself, dimensions, members, hierarchies, cell data, and all necessary relations between them. All these elements, except the cell data, are subjects to versioning and are, therefore, temporalized with respect to the schema given in Fig. 2. Two of the main elements in an OLAP cube are a hierarchy and members belonging to that hierarchy. Figure 2a shows the nontemporal model of these two elements and the relation between them. Figure 2b shows the same elements and relation in a temporalized environment. The Hierarchy and the Member classes have both been split into two classes. The Member class is still the class representing the concept, and therefore holding all associations to other classes. But as all attributes may change over the time, we introduced a new class named MemberVersion which holds the values for the attributes at the given valid time. The ValidTime attribute of the Member is the sum of all valid times of the different versions. For each point in time, a Member is valid, there must exist *exactly one* valid MemberVersion, and for each point in time, a MemberVersion is valid, the corresponding Member has to be valid too. The same principles also apply for hierarchies, dimensions, and cubes. The association between Hierarchy and Member gets timestamped too. As such an association may be valid in more than one structure version; the ValidTime is a multiple attribute here. The constraint for such an association defines that there must not be any point in time, where the association is valid, but one of the associated classes is not. Of course, this schema does also apply to all other relations.



(a) Nontemporal Model (b) Temporal Model

Fig. 2. Concept of Temporalization

2.4 Functionality and Workflow

We have to consider, where to really alter the OLAP cubes and where to do the integrity checking, with respect to DWT. We decided to use the *external/external* approach for our system for the following reasons:

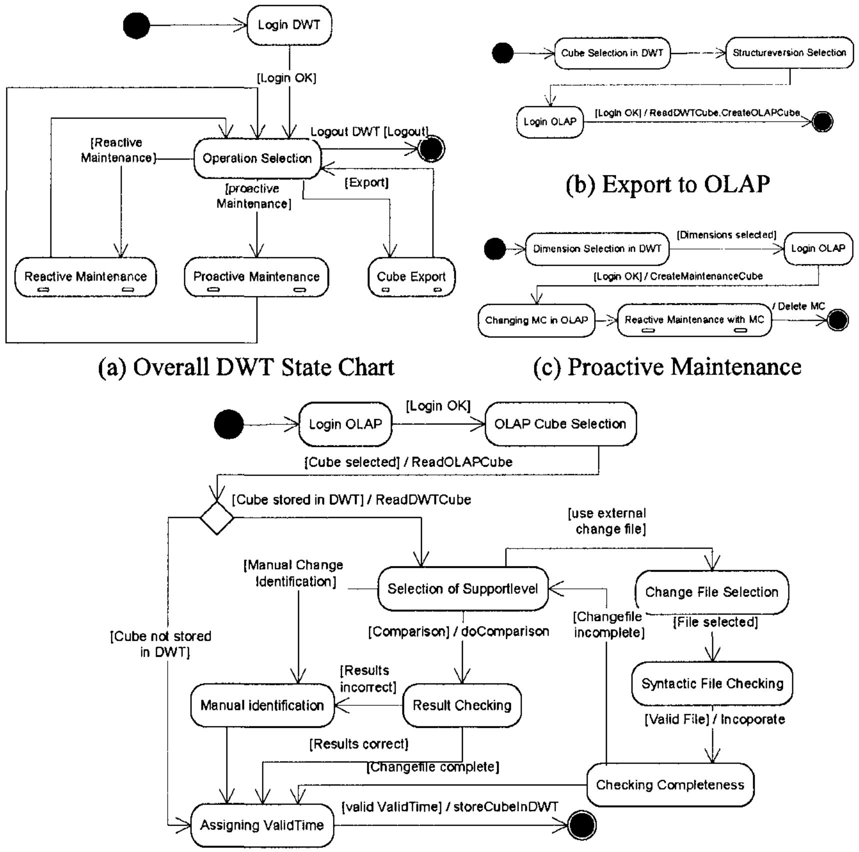
With *external/external* all updates and checks are not done in the DWT tool, but in the external OLAP application. DWT then provides the means for importing cubes, detecting and tagging changes, and incorporate them into the database. The advantages of this approach are the low implementation costs, easy extensibility, and that users can work with the OLAP tool they are familiar with. A disadvantage is that there is no direct control of the data- and controlflow outside the DWT system.

With *internal/external* all updates are done within the DWT tool, but the integrity checking is done by the external OLAP tool. The advantages of this approach are the possibility of logging changes and the partial control of the data- and controlflow. Disadvantages are the high implementation costs, because each supported OLAP system needs its own implementation of the maintenance component. Furthermore the users have to get familiar with a new tool for altering OLAP cubes.

With *internal/internal* all changes and checks are done within the DWT tool. The advantages of this approach are the complete control of the data by the DWT tool, the logging of update operations, and that there is no need for an online connection to the OLAP system. The disadvantages are again the high implementation costs and the high export for an extension to additional OLAP systems.

Figure 3 shows a set of state charts which describe the workflow in the different components. Figure 3a shows the flow for the complete application.

The *Export* (see Fig. 3b) is quite simple: The user selects one particular structure version, and a cube representing this version is created in the OLAP system. Referring back to the main functionalities, this is composed of *Structure Selection* and *Cube Export.*



(a) Overall DWT State Chart

(b) Export to OLAP

(c) Proactive Maintenance

(d) Reactive Maintenance

Fig. 3. State Charts describing the Behavior of the DWT Application

The *Reactive Maintenance* (see Fig. 3d) is a bit more complicated: After selecting and reading the cube from the OLAP system, there is either a corresponding version for this cube stored in the DWT database to be updated, or there is not. In the first case, the first thing the user has to choose is the level of support for the change detection: No Support, Structure Comparison and Change List (details in 2.5). After all changes are correctly tagged the user specifies the valid time for the new version and the system stores it into the database. In the latter case, i.e. no prior structure version for the imported cube exists; the user just gives the valid time for the cube. Then the system stores the cube structure into the database as initial structure version. Referring back to the main functionalities, the reactive maintenance uses all main functionalities except for the cube export, i.e. *Cube Import, Cube Selection, Difference Detection, Version Creation,* and *Relation Management* between versions.

For the *Proactive Maintenance* (see Fig. 3c) the user has to select the dimensions he wants to change. The DWT tool exports these dimensions into a *temporary* *maintenance cube* in the OLAP system, where the user does all desired changes. After all changes are done in the OLAP system, the user triggers a reactive maintenance with the maintenance cube, so all differences are detected and stored into the database. Referring back to the main functionalities, the proactive maintenance uses all of them, i.e. *Cube Selection, Cube Export, Cube Import, Difference Detection, Version Creation* and *Relation Management* between versions.

```
MatchingLine = Delete|Insert|Change;
Delete = Identifier Separator;
Insert = Separator Identifier;
Change = Identifier Separator Identifier;
Identifier = Path|Name;
Name = ValidCharacter {ValidCharacter};
Path = PathDelimiter Name {PathDelimiter Name};
Separator = ";";
PathDelimiter = "\";
ValidCharacter = any character valid in a member's name
```

Fig. 4. EBNF Syntax of a Change File

2.5 Identification of Changes

Identification of changes between structure versions and establishing relations between two versions of a changed element is a crucial part during the versioning process. As a changelog may not be available, we have to define other means of change detection.

The naive approach is not providing *Any Support* at all. Thus, the user is responsible for tagging all differences between the structure versions. This method is the last fallback solution, as it is time consuming and error prone.

The second possibility is *Structure Comparison*. The system applies a feasible comparison algorithm to the cube structures and detects a list of differences. Such a comparison can for instance be graph based, as described in [10]. Due to the heuristic and inductive nature of comparison algorithms, the results may contain errors. Therefore, the administrator must have the possibility to review the results and manually correct them if necessary.

If, on the other hand, the OLAP system provides the functionality to create a log of the changes applied to a cube, or there is any other possibility to obtain a list of changes outside the DWT tool, it is not necessary to identify them again during the import, but the user may import a change file consisting of a number of *MatchingLines* with the syntax describe in Fig. 4. The characters for the *Separator* or *PathDelimiter* are implementation dependent and may vary for different OLAP systems, as they may occur in a member's name. Members are identified by a path from the root to this member, or, if member names are unique, just by this name.

A *MatchingLine* may either represent the deletion, the insertion, or the change of a member, which may be any combination of update, rename, and move. Generally, it has the form `OLDID;NEWID` with the following semantics: The member identified by OLDID in the old structure version represents the same element as the member identified by NEWID in the new structure version. If no OLDID is given, the member identified by NEWID was inserted into the structure. If no NEWID is given, the member identified by OLDID was deleted from the structure. If both of them are present, this indicates a change. In this case, the correct operations can easily be detected by searching the members in both structures and comparing their properties and position. A change file may not be complete, i.e. not describe all changes between the structure versions. In this case, the user has to select additional means for identifying the remaining differences until all changes are tagged. After all changes are identified and tagged, the results are passed to the version management component. The administrator assigns a valid time and the new structure version is stored.

3 Implementation

The implementation is in Java 1.4, the backend database is Oracle 9i. The communication between database and the DWT tool uses JDBC. The interface implementation to Hyperion Essbase is done via the native Hyperion Essbase Java API. The relational schema for the DWT database was highly optimized for achieving good performance.

As the main target OLAP system on this stage is Hyperion Essbase, data warehouse outlines are represented by trees and the tree comparison algorithm defined in [10] is used to compare the two structure versions.

Figure 5 shows the screen after the matching between the two trees. The left tree denotes the structure version stored in the DWT database, the right tree represents the imported cube. Members in the DWT tree that are marked with a cross (e. g. Phantom V, Silver Spirit) could not be matched to any member in the imported tree. Members in the imported tree that are marked with a triangle (e. g. BMW 1, Silver Spirit II) could not be matched to any member in the DWT tree.

After the matching is completed, all yet unmatched nodes could have either been deleted/inserted or renamed. As the fully automated determination of renaming is not possible, we proposed a heuristic approach which calculates the most likely renaming [10]. The user has to check them and do corrections if necessary. Each accepted renaming results in an additional node matching. As the matching and renaming detection of graph nodes heavily relies on heuristics, the algorithm may return wrong results. Thus, the user must have the possibility to correct the node matching before the change detection is executed. The user may break up a detected matching and/or define new matching between unmatched nodes.

Figure 6 shows the screen after the comparison algorithm has finished. Members marked with a triangle (e. g. BMW 1, a new car in the product portfolio) have been inserted, members marked with a **C** have been changed (the engine power for Rolls-Royce cars is no longer given in kW but in HP), the **R** indicates a renaming and the **M** denotes a move (e. g. BMW is now a part of the united BMW&Rolls-Royce). During the calculation of the differences, the algorithm is transforming the old version of the tree, thus after the algorithm has finished, both trees have to be identical; therefore deleted nodes (e. g. Phantom V, which was taken out of the product portfolio) cannot be seen any longer. The dialog box in Fig. 6 shows how to assign the valid time to the new structure version after having clicked the save button.

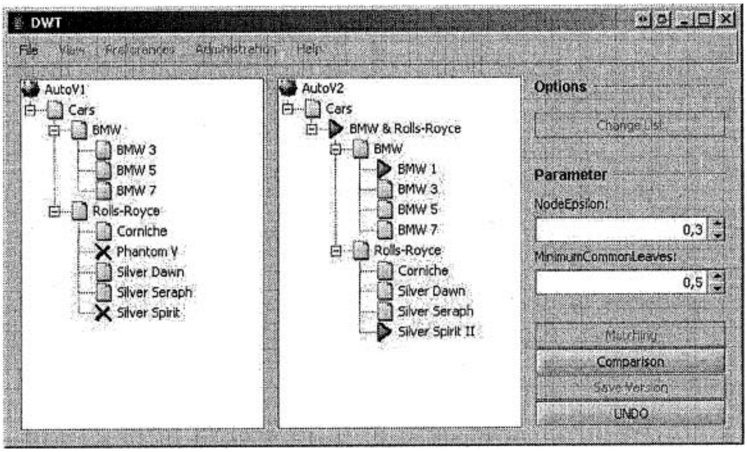


Fig. 5. Screen after Node Matching

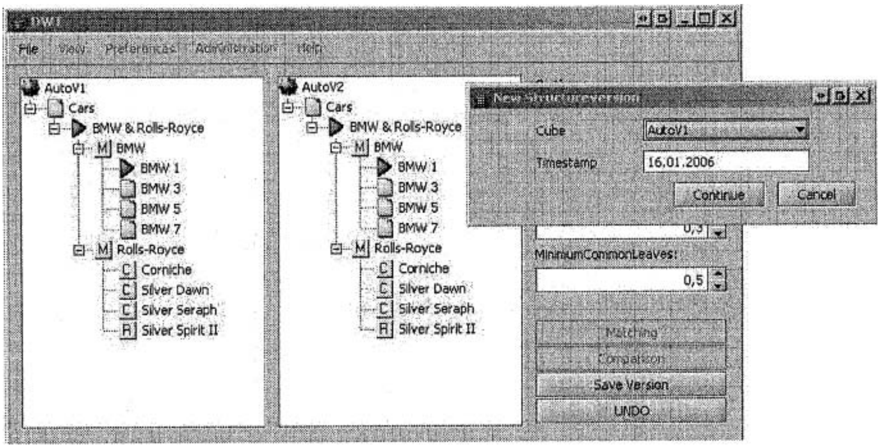


Fig. 6. Final Result of the Structure Comparison

Additional functionalities - e. g. administrative tasks or user management - which do not contain much scientific challenges are not described here.

4 Conclusions

Due to changes of the represented real world, OLAP structures have to change as well. As current implementations of DWH systems, surprisingly, do not support such changes, we defined the COMET Metamodel for temporal data warehouses. In this paper we present the DWT tool for maintaining temporal warehouse models. We describe the principal use cases and their representation in the main workflows within the tool. The administrator is enabled to store versions of a warehouse structure into a database, identify changes between different structure versions, and to re-establish any previously stored structure version. We present the general architecture and the conceptual database model, comprising temporal and versioning information. DWT offers three ways for identifying differences between two subsequent versions: a semiautomatic structure comparison if only snapshots are available, changelog application, and manual change identification.

The major advantage of such a backend tool is that the users and administrators can use their favorite OLAP frontend for doing the analysis of data and for registration of changes. The backend then makes the whole architecture temporal, i.e. provides temporal versions of the dimension structure of a data warehouse and allows that any structure version can be selected by valid time and be uploaded into the OLAP frontend. Using standard interfaces, this allows also for a mapping of dimension structures between different OLAP tools.

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Data Clustering in Enterprise Computing: A New Generalized Cellular Automata

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Abstract. This paper is devoted to novel stochastic generalized cellular automata (GCA) for self-organizing data clustering in enterprise computing.* The GCA transforms the data clustering process into a stochastic process over the configuration space in the GCA array. The proposed approach is characterized by the self-organizing clustering and many advantages in terms of the insensitivity to noise, quality robustness to clustered data, suitability for high-dimensional and massive data sets, the learning ability, and the easier hardware implementation with the VLSI systolic technology. The simulations and comparisons have shown the effectiveness and good performance of the proposed GCA approach to data clustering.

1 Introduction

The data clustering in enterprise computing, as a class of data mining technique, is to partition a data set given for enterprise computing into separate clusters, with each cluster being composed of the data objects that possess similar characteristics. Most existing clustering methods can be broadly classified into three categories: partitioning methods, hierarchical methods and locality-based methods [1]-[14].

This paper is devoted to novel generalized cellular automata (GCA) for self-organizing data clustering in enterprise computing. By the GCA clustering methods, the data objects of a given data set in enterprise computing are randomly distributed on a GCA array, and may randomly move back and forth on the GCA array with a probability related to similarity degree. The GCA thus transforms a clustering process into a stochastic self-organizing process over the configuration space of data of other components, leading to standard AND-constraints. However, it might also

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objects on the GCA array. The analysis and simulations have revealed very encouraging performance of the GCA approach to data self-organizing clustering in terms of the parallel computation, the insensitivity to noise, the quality robustness to clustered data, the suitability for high-dimensional and massive data sets, the learning ability, the openness and the easier hardware implementation with the VLSI systolic technology.

2 Generalized Cellular Automata

The GCA-based self-organizing data clustering in enterprise computing is realized by a two-dimensional $N \times N$ cellular array. At first, all the data objects for enterprise computing are randomly mapped on the GCA array, with the state $s_{ij}(\mathrm{t})$ of the cell c_{ij} being equal to the data object mapped on the cell. If there is no data object mapped on the cell c_{ij}, the state $s_{ij}(\mathrm{t})$ is denoted by ϕ; Then, according to some local dynamic rules, data objects may concurrently and stochastically move back and forth on the GCA array, with a motion probability being determined by a harmony function. Thus the special configuration of data objects on the GCA array forms a Markov stochastic process that may converge to stationary probability distributions. The data object configuration with the maximal stationary probability provides the optimal solution to self-organizing data clustering for enterprise computing.

Definition 1 *The similarity* $d(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t}))$ *between two cells* c_{ij} *and* $c_{i'j'}$ *at time* t *is defined by*

- *If* $s_{ij}(\mathrm{t}) \neq \phi$ *and* $s_{i'j'}(\mathrm{t}) \neq \phi$ *, then* $0 \leq d(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t})) \leq 1$;
- *otherwise,* $d(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t})) = -1$.

The harmony $\kappa(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t}))$ *between two cells* c_{ij} *and* $c_{i'j'}$ *at time* t *is defined by*

- If $d(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t})) \geq \theta_{\mathrm{ij}}$, then $k(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t}))=1$;
- If $0 \leq d(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t}))<\theta_{\mathrm{ij}}$, then $k(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t}))=-1$;
- If $d(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t})) = -1$, then $k(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t}))=0$;

where θ_{ij} *is a positive threshold less than* 1.

The harmony $h_{ij}(\mathrm{t})$ *of the cell* c_{ij} *at time* t *is defined by*

$$h_{ij}(\mathrm{t}) = \sum_{(i',j')\in N_{ij}} k(s_{ij}(\mathrm{t}), s_{i'j'}(\mathrm{t})). \tag{1}$$

where $N_{ij} = \{c_{i,j-1}, c_{i,j+1}, c_{i-1,j}, c_{i+1,j}\}$ *is the neighbor of the cell* c_{ij}.

Definition 2 *The matrix* $\Gamma(t) = \left[s_{ij}(t)\right]_{N\times N}$ *represents a special distribution of data objects on the GCA array at time* t. *The aggregate harmony of* $\Gamma(t)$ *is data*

data objects on the GCA array at time t. The aggregate harmony of $\Gamma(t)$ is defined by

$$\mathrm{H}(\Gamma(t)) = \sum_{i,j} \omega_{ij} h_{ij}(t), \tag{2}$$

where ω_{ij} is a weight coefficient which may be obtained by using a learning algorithm from the given priori probability distribution of data objects.

Definition 3 *A local dynamic rule for every cell in the GPM array is described in the format:*

$$[\textit{cell state } S \textit{ at time } t] \xrightarrow[\textit{action}\,\mathrm{A}]{\textit{input}\,\mathrm{I}} [\textit{cell state } S' \textit{ at time } (t{+}1)] / \textit{probalitity} P \ ,$$

which implies that the input I *imposed to a cell at time t will, with the probability* P *, trigger the action* A *and the state transition from* S *to* S'*. For any cell* c_{ij} *in a GCA array, i, j = 1, 2,...,N, the local dynamic rule set* R *is composed of the following six rules :*

$$\mathrm{R}(1): [s_{ij}(t) = \phi] \xrightarrow[\textit{receive a data object } \kappa]{c_{ij} \textit{ is selected initially}} [s_{ij}(t+1) = \kappa] / p = 1;$$

$$\mathrm{R}(2): [s_{ij}(t) \neq \phi] \xrightarrow[\textit{pass } s_{ij}(t) \textit{ to } c_{i'j'}]{c_{ij} \textit{ selects } c_{i'j'}} [s_{ij}(t+1) = \phi] / p = f(\Delta\mathrm{H});$$

$$\mathrm{R}(3): [s_{ij}(t) \neq \phi] \xrightarrow[\textit{not pass } s_{ij}(t) \textit{ to } c_{i'j'}]{c_{ij} \textit{ selects } c_{i'j'}} [s_{ij}(t+1) = s_{ij}(t)] / p = 1 - f(\Delta\mathrm{H});$$

$$\mathrm{R}(4): [s_{ij}(t) = \phi] \xrightarrow[\textit{receive } s_{i'j'}(t)]{c_{ij} \textit{ is selected by } c_{i'j'}} [s_{ij}(t+1) = s_{i'j'}(t)] / p = f(\Delta\mathrm{H});$$

$$\mathrm{R}(5): [s_{ij}(t) = \phi] \xrightarrow[\textit{no action taken}]{c_{ij} \textit{ is not selected}} [s_{ij}(t+1) = \phi] / p = 1;$$

$$\mathrm{R}(6): [s_{ij}(t) \neq \phi] \xrightarrow[\textit{no action taken}]{c_{ij} \textit{ is not selected}} [s_{ij}(t+1) = s_{ij}(t)] / p = 1,$$

where the function $f(\square)$ *is defined by* $f(\Delta\mathrm{H}) = \dfrac{1}{1 + e^{\Delta\mathrm{H}/T}}$ (3)

$\Delta\mathrm{H} = \mathrm{H}(\Gamma(t)) - \mathrm{H}(\Gamma(t+1))$ *is the harmony increment of the GCA array if the given event indicated by the local dynamic rule really happens; The temperature T is a parameter used to improve the solution quality.*

The above local transitive rules can also be illustrated in Fig. 1.

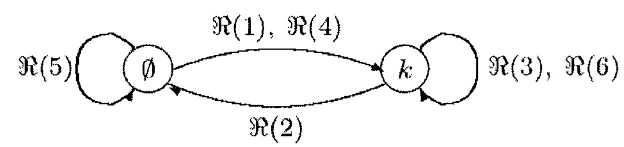

Fig. 1. The transition diagram of the cellular state of a cell by using the local dynamic rule set R , where the symbol k represents a data object mapped on a cell.

Remarks 1:

- **The motivation for cell harmony :** By the Eq. (1), the larger the total

- similarity between the cell c_{ij} and all the cells in its neighbor N_{ij} , the larger the harmony $h\left(c_{ij}(t)\right)$ is. Moreover if there is such a cell in N_{ij} that holds no data object, then the harmony 0 between the cell and the cell c_{ij} has no affect on the harmony of the cell c_{ij}.
- **The motivation for GCA harmony :** The aggregate harmony of a configuration of data objects on the GCA array may describe the global average similarity degree among all the cells and their neighboring cells. Intuitively it is expected that a better clustering should correspond to a data object configuration with larger aggregate harmony. Therefore for two configurations, *u* and *v*, of data objects on the GCA array if the aggregate harmony $\mathrm{H}(u)$ is larger than the aggregate harmony $\mathrm{H}(v)$; intuitively the probability of the transition from *u* to *v* should be less than the probability from *v* to *u*. The Eq. (3) is consistent with this intuition.

3 GCA Parallel Algorithm and Properties

To implement the GCA for self-organizing data clustering in enterprise computing, the algorithm GCAA uses two independent cellular array I and cellular array II to store two different configurations of data objects on the GCA array.

The Parallel Algorithm GCAA :
Costep 1. The state of every cell in the array I and array II is set to ϕ, indicating no data object mapped on any cell.
Costep 2. All the data objects in the given data set are concurrently and randomly mapped on the array I and array II, forming two different configurations of data objects on them.
Costep 3. Every cell c_{ij} in the array I and array II concurrently compute its harmony $h_{ij}(t)$ by Eq. (1).
Costep 4. The array I and array II concurrently compute their aggregate harmonies by Eq.(2).
Costep 5. Compute the transitive probability by Eq.(3), and then, upon the transitive probability, randomly choose one configuration from the array I and array II.
Costep 6. Using a random configuration, update the configuration on the array I or array II which has not been chosen in Costep 5.
Costep 7. Repeat Costep 3 through Costep 6 until reaching a stationary probability distribution over the configuration space on the array I and array II, where the configuration with the maximal probability corresponds to the optimal clustering.

We summarize the properties of the algorithm GCAA by the following Lemmas and Theorems whose proofs are given in Appendix.
Lemma 1 *Carrying out the algorithm GCAA is equivalent to carrying out the*

dynamic rules R .

Lemma 2 *The stochastic process* $\{\Gamma(t), t = 0, 1, \cdots\}$ *generated by executing the algorithm GCAA is a finite homogeneous Markov chain.*

Lemma 3 *The stochastic process* $\{\Gamma(t), t = 0, 1, \cdots\}$ *generated by the algorithm GCAA is an irreducible homogeneous Markov chain, where all the configurations are positive recurrent, that is, any configuration may return to itself in a finite time period with the probability 1.*

Lemma 4 *The stochastic process* $\{\Gamma(t), t = 0, 1, \cdots\}$ *generated by the algorithm GCAA must reach a stationary probability distribution over the configuration space, that is, any configuration may occur finally with a fixed probability. Moreover the stationary distribution is independent of the initial configuration.*

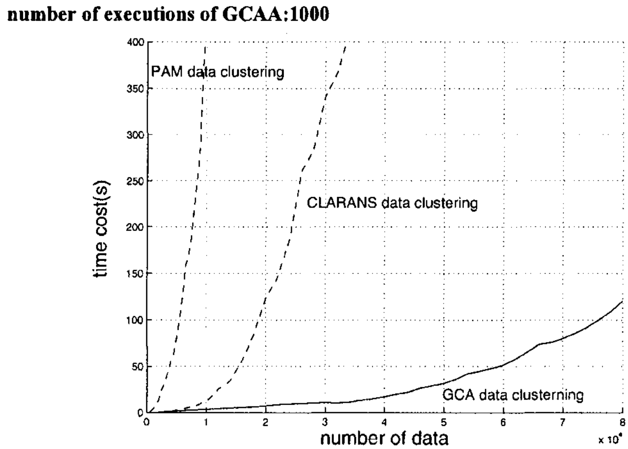

Fig. 2. The comparisons of clustering time between the proposed GCAA algorithm and PAM, CLARANS algorithms, where the best of 5 local optimal solutions for CLARANS is shown. The number of cluster: 20; The size of the data set: from 2000 to 80000. The algorithm GCAA has better performance.

Theorem 1 *The stationary probability distribution obtained by executing the algorithm GCAA is the maximal entropy distribution over the configuration space. Moreover the stochastic configuration with the maximal probability has the maximal aggregate harmony.*

Theorem 2 *A configuration with the maximal probability in a stationary probability distribution produced by the algorithm GCAA must be such a special configuration of data objects on the GCA array that has the minimal number of connected regions, with each region corresponding to a distinct cluster of the given data set.*

4 Simulations and Comparisons

Using the GCAA algorithm, the simulations on different data set sizes, different data types, various cluster shapes, noisy data set and higher dimensional data are carried out respectively.

The comparison of clustering time between the proposed GCAA algorithm and PAM, CLARANS algorithms is given in Fig. 2. We have also made many experiments and comparisons on the ability to eliminate outliers and to deal with high-dimensional data, details omitted here for the page limitation.

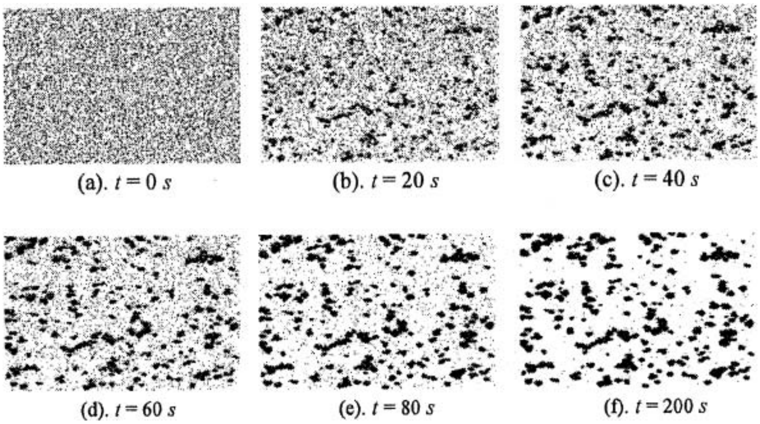

Fig. 3. The transient configurations of data objects on a GCA array during executing the algorithm GCAA, where t is the number of iterations. Number of clusters : 60; Data set size : 20000.

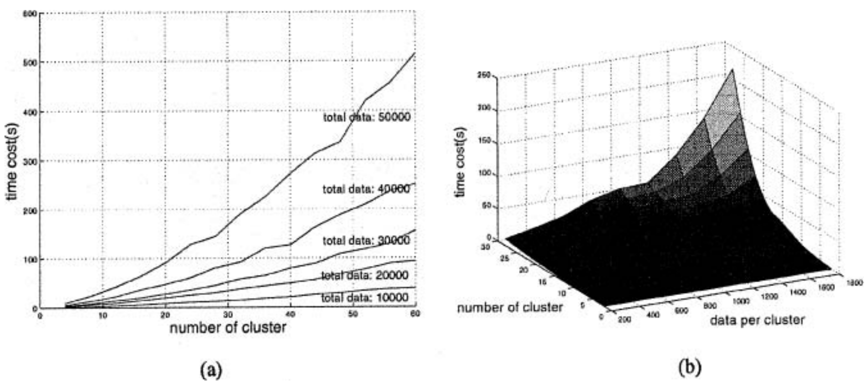

Fig. 4. The relation of GCA-based clustering time with the number of clusters and the data set size. (a). The relationship between the clustering time and the number of clusters in a data set, where number of clusters: 4-60; data set size: 10000-50000; (b). The clustering time changes with the data set size and number of clusters, where number of clusters: 2-30; data per cluster: 200-1800.

Several snaps of data clustering on the GCA array during executing the algorithm GCAA are illustrated in Fig. 3, where the initial configuration of data objects randomly mapped on the GCA array is demonstrated in Fig. 3(a), and finally almost all the similar data are successfully clustered together as shown in Fig. 3(f). The relation between the GCA clustering time, the number of clusters and the data set size is shown in Fig. 4.

5 Conclusions

The GCA approach and algorithm GCAA for self-organizing data clustering in enterprise computing have been proposed in this paper. The analysis and simulations on a variety of data sets given for enterprise computing have shown many advantages over other widely used clustering algorithms in terms of the followings:

- Faster clustering speed for both the large data set and the noisy data set;
- The ability to handle and recognize the shape-varying and size-varying clusters; The robustness to outliers, and the ability to eliminate the noise data from clustering result;
- The ability to learn the priori probability distribution of data objects and to use the previous clustering results for shortening the clustering time and improving the clustering quality;
- The suitability for high dimensional data sets, the clustering performance being not obviously affected by the data dimension.

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Appendix

Proof of Lemma 1. Randomly preparing two configurations in the array I and array II in the Costep 2 and Costep 6 amounts to alternately using the two arrays to obtain a configuration at the current time and a configuration at the next time in the same time session τ. Using the $f(\Delta\mathrm{H})$ to randomly choose a configuration from the array I and II in the Costep 5 is equivalent to carrying out the rule R simultaneously on all the cells, with the probability $f(\Delta\mathrm{H})$. As a result, Carrying out the algorithm GCAA is equivalent to carrying out the transitive rule R .

Proof of Lemma 2. The number of the possible configurations for the stochastic process $\{\Gamma(t), t = 0,1,\cdots\}$ is finite and equal to $\binom{N^2}{n}(n!)$. The transition probability from $\Gamma(t)$ to $\Gamma(t+1)$ only depends upon

$\Delta\mathrm{H} = \mathrm{H}(\Gamma(t)) - \mathrm{H}(\Gamma(t+1))$ and is independent of the configuration $\Gamma(t-i), i \geq 1$, and independent of the time t.

Proof of Lemma 3. By Eq.3, any two stochastic configurations are accessible from each other in the sense that the transitive probability from one to another is larger than zero. Thus the unique closed set in the configuration space is the set that is composed of all the possible configurations, which implies that it is irreducible. Then it follows from Lemma 2 that all the configurations of a finite inter-accessible Markov chain are all positive recurrent.

Proof of Lemma 4. By the Markov process theory, if any two stochastic states in the state space may transit by one-step from one to another with a non-zero probability, then the stochastic process must converge to a stationary state. Since any two configurations in the configuration space have finite aggregate harmonies by Eq.(1) and Eq.(2), and the transitive probability from one to another is larger than zero by the Eq.(3) accordingly, it turns out that the stochastic configuration sequence $\{\Gamma(t), t = 0,1,\cdots\}$ must finally reach a stationary probability distribution.

Proof of Theorem 1. Number all the data objects that have been mapped onto the GCA array by 1 through n, and assume that, in the given stochastic configuration $u \in \Gamma^*$, the k-th data object is carried by the cell $c_{i(u,k),j(u,k)}$ in the GCA array, $i(u,k), j(u,k) \in \{1,\cdots,N\}$, with its harmonic function value denoted by $h_{i(u,k),j(u,k)}$. At first, we try to obtain a stationary probability distribution $p_u, u \in I^*$, such that it has the maximal entropy $\max_{p_u}\left[-\sum_{u \in I^*} p_u \ln p_u\right]$, and satisfies the following constraints:

$$\sum_{u \in I^*} p_u = 1, and \sum_{u \in I^*} p_u h_{i(u,k),j(u,k)} = \overline{h_k} \; for \; \forall k \in \{1, \cdots, n\}. \tag{5}$$

where $\overline{h_k}$ is constant related to k, upon a priori probability with respect to k-th data object in data sets.

$$From \frac{\partial}{\partial p_u}\left\{\sum_{u \in I^*} p_u \ln p_u - \sum_k \left[\sum_{u \in I^*} h_{i(u,k),j(u,k)} - \overline{h_k}\right] - \lambda\left[\sum_{u \in I^*} p_u \ln p_u - 1\right]\right\} = 0,$$

we obtain $p_u^* = Z^{-1}\left\{\exp \sum_{k=1}^{n} h_{i(u,k),j(u,k)}\right\} = Z^{-1} \exp(\mathrm{H}(u)),$

where $Z = \sum_{u \in I^*} \exp\left\{\sum_k h_{i(u,k),j(u,k)}\right\}$; $\mathrm{H}(u)$ is the harmonic function value of the stochastic configuration u.

On the other hand, we make use of π^* and π_u^* to denote the stationary probability distribution and the stationary probability of the configuration u, respectively, which is yielded by concurrently executing the rule R . Then

$$\frac{\pi_u^*}{\pi_v^*} = \frac{e^{\mathrm{H}(u)/T}}{e^{\mathrm{H}(v)/T}} \; and \; \pi_u^* = Z^{-1} e^{\mathrm{H}(u)/T}$$

can be derived from $f(\mathrm{H}_t(v) - \mathrm{H}_{t+1}(u))\pi_v^* = f(\mathrm{H}_t(u) - \mathrm{H}_{t+1}(v))\pi_u^*$, and $\mathrm{H}_t(v) - \mathrm{H}_{t+1}(u) = -(\mathrm{H}_t(u) - \mathrm{H}_{t+1}(v))$.

It therefore follows that $\pi_u^* = p_u^*$ upon the temperature T, which implies that the stationary probability distribution of the stochastic process decided by the GCAA is just the maximal entropy distribution.

Moreover, it turns out that the stochastic configuration with the maximal harmonic function value has the maximal probability over the obtained stationary probability distribution.

Proof of Theorem 2. By contrary, assume that, when the dynamics of GCA has reached to the stationary probability distribution, the configuration *u* with the maximal harmony function makes some data objects that should be partitioned into the same cluster be distributed in more than one unconnected region in the GCA array. It follows from Eq. (2) that laying the same data objects in several separate unconnected regions of cells gives rise to smaller harmony function of these cells than laying in one connected region of cells. It turns out that the configuration *u* does not have the maximal value of harmony function, resulting in the contradiction to the assumption. By Theorem 1, therefore, the configuration with the maximal probability in the stationary probability distribution has the minimal number of connected regions in GCA array.

An Information Broker for Integrating Heterogeneous Hydrologic Data Sources: A Web Services Approach

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Abstract. Data integration systems have been developed to provide an integrated view of related data sources, so that all the information needed can be accessed uniformly, transparently and independently of the physical storage. In this paper we report our experience in developing the first prototype of an information broker for APAT, the Italian Agency for Environmental Protection and Technical Services. The broker provides integrated access to a huge amount of hydrological information stored into a collection of heterogeneous data sources.

1 Introduction

The pervasiveness of the network technology and the Internet has allowed the access to a multitude of interrelated data sources. Accessing data sources individually and then combining the results manually every time information is needed can be awfully time-consuming. These issues are exacerbated especially in those environments where information plays a central role and has a high economic value, posing real economic threats.

Data integration systems have been developed to provide a global view of a collection of related data sources, so that all the information needed can be accessed uniformly, transparently and independently of the physical storage location, as if it was stored into a single data source [0].

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The problem of integrating heterogeneous data sources has been deeply investigated in the last two decades. Previous research has shown a number of solutions, which can be broadly grouped into two main approaches, namely Data warehouse [0] and Mediator [0, 0]. The Data warehouse (or Materialized) approach provides a centralized static copy of information extracted in advance from multiple data sources [0].

Being a static copy, a data warehouse cannot be updated. Hence, this approach is not suitable for an environment where information change rapidly and required data is unknown *a priori* [0]. The Mediator (or Virtualized) approach comprehends a number of different implementations, such as the Knowledge-based Information Integration Systems [0], the Agent-based Systems [0], the Information Retrieval Systems [0] and the Federation Information Systems (FIS) [0].

FIS, in particular, grants the data sources composing the integration system to be:

- *autonomous*, as they can continue to operate independently;
- *heterogeneous*, as they can be produced by different vendors and use different data models as well as different query languages;
- *distributed*, as they can be physically located on different hosts.

In this paper we report our experience in developing the first prototype of an information broker which provides integrated access to a collection of related hydrological data sources.

The remainder of this paper is structured as follows. In Section 2 we present the project goal and its domain. In Section 3 we illustrate the integration process and the architecture of the prototype. In Section 4 we discuss some related systems. Finally, in Section 5 we draw conclusions and provide future directions of development.

2 Project Domain and Goal

The Agency for Environmental Protection and Technical Services (APAT) of Italy was established in 1999 to carry out scientific and technical activities in the national interest to protect the environment, water resources and the soil. It is subject to the supervision of the Ministry of the Environment and Territorial Protection and is integrated into the Environmental Agency System, which provides consulting, service and support to several other government agencies.

APAT is structured in several departments, which are themselves divided into smaller units, each offering intradepartmental services to the Agency. The Data Gathering and Management Service (DGMS) of the Inland and Marine Waters Protection Department gathers collections of hydrological, hydrographical and water quality data through monitoring networks covering the whole national territory. Data collected are huge and varied, as they include climatic, hydrometric, cartographic, and water pollution measures. Furthermore, DGMS stores and makes available the data hydrological reports concerning all the hydrological and hydrographical phenomena observed on the whole national territory since 1921 [0].

Although all the information is owned by the same organization, the huge amount of information gathered is managed by different departments and units. Besides, given the large diversity in syntax and semantic of the data collected, measures are stored into several independent systems, each based on the technology thought to be the most appropriate for the data type. Presently, DGMS uses and maintains five different and independent systems, built adopting different information storage technologies, namely MySQL, PostgreSQL, Tamino XML, Red Brick and AutoCAD. Furthermore each data source represents the back-end of an existing autonomous application that is currently operative and thus it cannot be dismissed.

The goal of the project is to develop an information broker to provide a full and user-transparent integration of the heterogeneous data sources maintained by DGMS, ensuring, at the same time, the existing legacy applications that operates on them to continue operating autonomously, without undergoing any sort of modification.

3 Information Broker

The storage of data concerning the hydrology, hydrography, and water quality of the national territory requires technologies suitable to support large amount of data with strong heterogeneity and different needs of accessing and fruition. Hence, within this wide, varied and continually changing context we have applied the Mediator approach, thus building a Federation Information Systems to provide integrated access on demand to all the data sources.

According to the taxonomy of FIS proposed in [0] our broker is a Federated Database System (FDBS), where all the components in the federation are structured sources accessible by a specific query language. A FDBS typically provides a federated schema to ensure full location and schema transparency to its users. It has a static architecture in that a FDBS does not allow a flexible structural change management of its components. Unlike the typical FDBS implementation, our broker is also enriched with a set of web services used to enable the provision of data on demand, whilst keeping the underlying data sources unchanged and autonomous.

In the first prototype the federation is composed of four databases managed by two distinct DBMS, namely MySQL Server, used for collecting real time measures, and Tamino XML Server, used for collecting data on extreme hydrological events and hydrography of the territory.

In the next sub-sections we provide further details on the schema integration process and the layered architecture.

3.1 Schema Integration Process

Schema integration refers to the process of integrating data-source local schemas into a single federated schema that will provide a global view of the federation.

Fig. 1 shows the four-step bottom-up process completed at design time, used to develop our federated schema and similar to the one proposed in [0].

The local schemas of the different component databases within the federation represent the starting point for building a federated schema.

Due to the heterogeneity of the underlying data models, the first step in the integration process is to transform the local schemas into so-called export schemas,

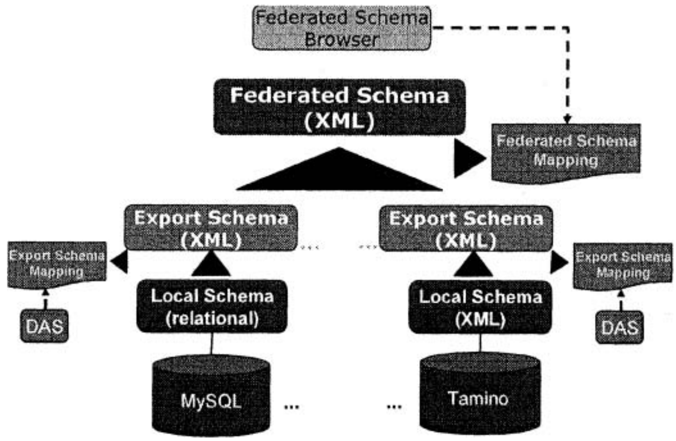

Fig. 1. Schema Integration Process

expressed in a common data model (CDM). Several options were weighted up to choose the most appropriate CDM, including relational data model, XML and OWL. Our choice was to use the XML data model because today it is the de-facto standard language to exchange information between applications and it is supported by most of the existing DBMS. Once the data model heterogeneity is overcome, the next step is the creation of the export-schema mappings, which are XML files manually generated at design time from each export schema. Such files contain the mappings between the local and export schemas, that is, the correspondences between low-level data stored and high-level domain concepts.

The third step in the integration process is the construction of the federated schema, which is supposed to represent the logical model of the virtual database containing all the data available within the federation. The federated schema is the result of the merging of all the export schemas. During the merge, all the possible conflicts have to be identified and solved. This is accomplished through two distinct activities.

The Correspondence Investigation activity searches for correspondences among the export schemas. The output of this activity is a set of conflicts, grouped in:

- *naming conflicts*, i.e. either different names are used to identify the same concept, or the same name is used to identify different concepts;
- *structural conflicts*, i.e. the same concept is represented with different structures in different schemas.

This set of conflicts is the input of the next activity, the Conflict Resolution. For naming conflicts where the same concept is identified with distinct names, a common name to use in the federated schema is chosen. For the other kind of naming conflicts the name of one of the two distinct concepts with the same name is changed. For structural conflicts, instead, each conflict is solved defining a new ad-hoc structure. Once the federated schema has been obtained, the last step in the process is to manually generate the federated-schema mapping file, an XML file that stores the correspondences between:

- complex concepts and simple concepts distributed in the different export schemas;
- simple concepts and constraints that characterize them;
- simple concepts and services able to retrieve them.

A complex concept is a concept that can be decomposed in a set of simple concepts. A simple concept, instead, is an atomic concept which cannot be further decomposed and has to be instantiated by a set of constraints.

3.2 Layered Architecture

Fig. 2 shows the broker architecture organized in three main layers:

1) the wrapper, which resolves the technical differences among the data sources available;
2) the federation, which offers a uniform way to access the data stored in data sources;
3) the presentation, which allows users to perform global queries.

3.2.1 Wrapper Layer

In the wrapper layer a Data Access Service (DAS) was developed to wrap each data source available and extract the information required on demand. Each DAS is a wrapper implemented as a web service that provides a WSDL interface to allow the remote invocation of the service via SOAP.

This solution ensures a transparent access to all distributed, heterogeneous and autonomous data sources available, since each DAS can be developed in a different implementation languages, can access sources managed by different DBMSs and can run on different platforms. However, regardless of how a DAS is programmed, it provides a unified and seamless way to access underlying information.

Each DAS provides a standard interface method to query the appropriate data source, thus the information about how actually access to the data sources is hidden inside, and the components on upper layer have a unique way to access the data. Nevertheless, even if a DAS has a uniform interface its implementation is tightly bound to the database and the DBMS it is related to.

The proposed architecture of a DAS implemented as web service grants the system to be both highly scalable, because a new data source can be added by developing a new DAS without critical effects on the upper layers, and fault tolerant, since failures in any DAS will not cause the failure of the whole broker. Furthermore, the use of web services technology and standard protocols such as HTTP, SOAP and WSDL, prevents firewall traversal issues.

Fig. 3 shows the query execution related to a MySQL database, as it is performed by a DAS. The DAS receives in input a simple concept and a set of constraints, then uses the export schema mapping file to find what query to execute. In order to actually execute the query, the DAS translates the query in SQL syntax and execute it by JDBC API.

The result of the query execution, in this example a result set, is then transformed into a XML document serialized in a string and returned to the federation layer.

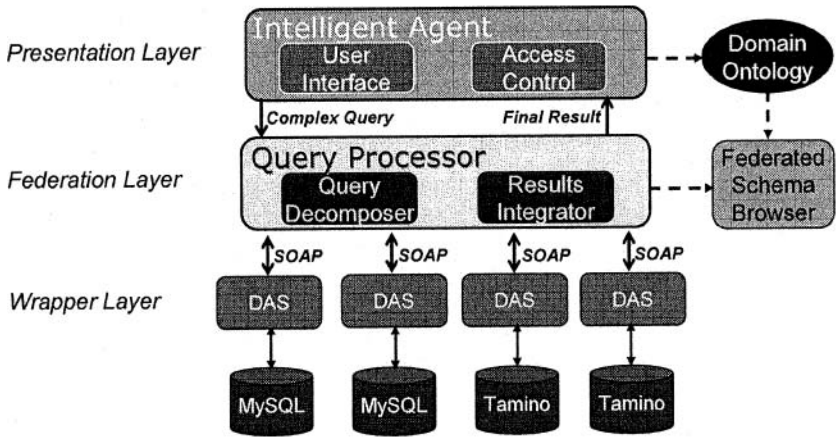

Fig. 2. Information broker architecture

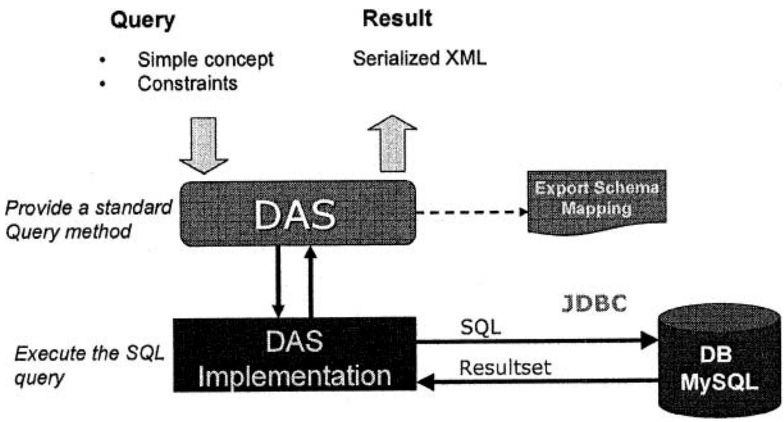

Fig. 3. Query execution performed by a DAS

3.2.2 Federation Layer

The federation layer offers a uniform and transparent access to the data sources through the Query Processor component, which is made of two subcomponents: the Query Decomposer and the Results Integrator (see **Fig. 4**).

The Query Decomposer takes in input the complex query expressed as a complex concept and a set of related constraints. Thus, it reduces a complex query into as many simple queries as the number of simple concepts that constitute the complex one. The Query Decomposer uses the Federated Schema Browser, which is an API built to provide high-level access to the federated schema mappings file, and find the

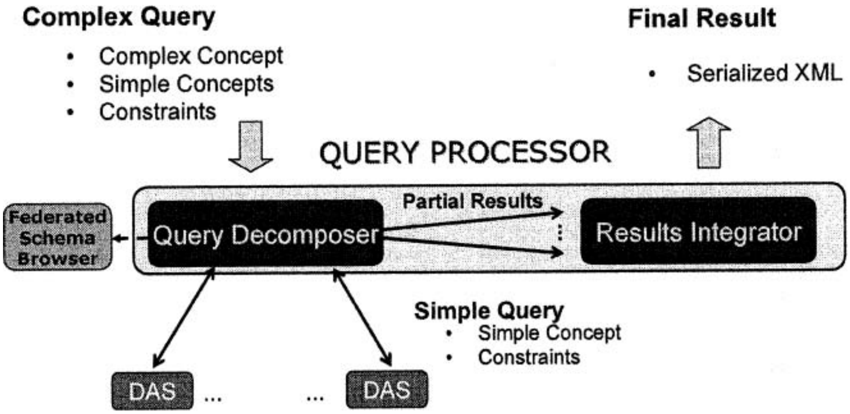

Fig. 4. Query Processor and its components

appropriate subset of constraint that characterize a simple concept. The Federated Schema Browser is used to:

- retrieve a concept, complex or simple, giving in input a name;
- retrieve all the complex concepts included in the federated schema;
- retrieve all constraints related to a given simple concept;
- find the DAS able to obtain a given simple concept.

Hence, once the Query Decomposer has created the simple queries, again it uses the Federated Schema Browser to obtain the mappings between a simple concept and the DAS capable to obtain that concept, so as to invoke the appropriate service for each concept needed.

The Query Decomposer uses the WSDL interface provided by the DAS to actually invoke the right service. All the results returned by every single DAS are passed to the Result Integrator as a set of serialized XML documents.

The Result Integrator collects the partial results obtained by each DAS queried, creates the resulting serialized document and finally returns it to the presentation layer as the final result. Such a solution preserves information about the location of the concepts, encapsulating it inside this layer and hiding it to the components in the presentation layer above. The Query Decomposer does not know how data sources have to be actually queried, because this kind of information is hidden in the wrapper layer. Thus, the QP will perform a query always in the same way, whatever the DAS to be invoked.

3.2.3 Presentation Layer

The presentation layer is composed of the Intelligent Agent and the Domain Ontology. The former represents the user interface of the system. Its main tasks are to authenticate users, driving them in the query formulation according to their adaptive profile, and to display query results. However, in the first prototype the presentation layer is just an ordinary dynamic web-based UI, which has been implemented with Java Servlet and JSP technology.

The Domain Ontology represents our hydrological domain model. Ontology is a conceptual model used to represent concepts related to a specific domain and their relationships [0]. In our architecture the Domain Ontology is meant to share knowledge about the hydrological domain and to let the Intelligent Agent browse all concepts available, thus helping it in the query formulation process.

A detailed explanation of how the agent and the ontology will be used is beyond the scope of this paper, as they will become operational only in the second prototype.

4 Related Work

In the last fifteen years a lot of research has been done in the field of the integration of heterogeneous information sources.

The Stanford-IBM Manager of Multiple Information Sources project, or TSIMMIS [0, 0], was developed by Stanford University in conjunction with IBM. A key aspect in TSIMMIS is the canonical data model, named Object Exchange Model (OEM). The OEM model forces no regularity on data and then it is possible to represent heterogeneous, changing information. The lack of a global schema in TSIMMIS, makes it possible to integrate new data sources whose schemas are partially unknown or varying during time. However, the downside of this approach is that the responsibility of resolving possible semantic heterogeneity is left to end users during query execution. Conversely, our information broker anticipates the conflict resolution at design time, during schema integration process.

The Information Manifold (IM) [0, 0] is a project developed at AT&T Bell Laboratories, with the main focus of providing declarative ways of relating a global schema to information sources, and evaluating queries based on descriptions of these information sources. IM has a global conceptual model known as a world view, against which queries are expressed. The IM approach in evaluating queries depends crucially on the information sources descriptions provided and, hence, information providers would take care to ensure that their source descriptions accurately reflect the contents and capabilities of the source relations. IM is designed using a top-down strategy, thus starting with a global information need and later adding those sources that contribute to this need. On the other hand, our broker is designed according to a bottom-up strategy, starting directly with the integration requirement of a set of data sources.

IBHIS (Integration Broker for Heterogeneous Information Sources) [0, 0] is a project funded by the UK's Engineering & Physical Sciences Research Council (EPSRC). The global view of the distributed data is achieved through the creation of one or more federated schemas, according to the user requirements. The central idea is that data become available as services on demand, without affecting the operational systems. In this context, the characterization is more data-as-a-service rather than software-as-a-service [0]. Analogously to our system, the first IBHIS prototype is based upon a FDBS enriched using web services as data source wrappers. However, in IBHIS the health and social-care domain has been chosen to simulate an integration need and all the integrated data sources are managed only by relational DBMS, namely MySQL and IBM DB2. Conversely our system grew out of an authentic integration need. Consequently, our system had to solve the problem of integrating data sources implemented using different data models and technologies such as RDBMS (e.g., MySQL and PostgreSQL), XML-native DBMS (e.g., Tamino XML Server), and computer-aided drafting systems (e.g., AutoCAD).

5 Conclusions and Future Work

The development of an integration architecture helps build a well-factored, agile and well-integrated set of applications and services, thus balancing the requirements of the enterprise business against those of individual applications. Moreover, the development of integration architecture helps users to focus on specifying what data they want rather than on describing how to obtain it. Users are relieved from the burden of finding the relevant data sources, interacting with each of them separately and, then, manually combining the data returned.

In this paper we have presented a project to develop an integration system which will provide an uniform view of the separate hydrological repositories managed by multiple departments of a government environmental agency.

In the next planned releases, other than accessing further data sources, the system will include an intelligent agent that will model adaptive user profiles to provide a personalized guidance in retrieving the information needed. In order to improve the query formulation process, the ontology will be enriched with additional hydrological concepts. According to the user profile the intelligent agent will extract only those ontological concepts which are relevant to the specific user. Selected concepts will then be prompted via the web user interface. Such an approach should relieve the user from looking for the right concepts which are buried in the wide amount of available data.

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Context-Aware Ubiquitous Service Composition Technology

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Abstract. A context-aware ubiquitous service composition technology is proposed. This can be used in both enterprise and consumer communication service environments. Because the context-awareness is the one of the most important factors in ubiquitous computing, it is insufficient in conventional service integration based on rigid interface design. The flexible service composition based on user context is required. Our proposed approach is that a service composition engine discovers suitable service elements from the network based on the user context and binds them dynamically in accordance with a semantic-level service scenario. Evaluation results show effectiveness and sufficient performance of this architecture.

1 Introduction

Ubiquitous computing environments, where not only PCs but also various other devices are connected to networks [1], are expected to offer context-aware services that match user situations and tastes. Because users' needs change dynamically according to the user context such as position or time, an idea to compose appropriate service elements in the network dynamically based on the user context is a promising approach [2][3], as an alternative approach to the conventional way of providing services, where service providers prepare services perfectly in advance.

We have established a service composition technology to achieve this requirement. It provides users with the most appropriate composed service in their context while the service scenario can be described easily by not only professional programmers but also non-professional people [3][4]. We have devised a semantic-level service description and mechanisms for service element discovery and dynamic binding. In the rest of this paper, we describe the concept, proposed architecture, example application, and evaluation results through implementation.

2 The concept of service composition

The purpose of this study is to establish basic technologies that enable non-

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professional people to compose and customize service easily by using a service composition engine implemented on their terminals such as a PC or cellular phone. Here, in this paper, we assume one prerequisite that service elements previously advertise their service description such as interface to the network.

In the B-to-B area, BPEL (Business Process Execution Language) is attracting attention. However, BPEL coordinates multiple web services for the purpose of semi-permanent system integration, and therefore not suitable for binding unknown web services according to the user context. Because BPEL requires rigid interface description such as the port type names and operation names of web services, it can be applied only to pre-known web services whose port types and operations exactly match. In other words, BPEL is not flexible in terms of context.

To achieve context aware service composition, we introduce a semantic-level service scenario description, called service template (ST). It describes the service flow of basic functions by using metadata instead of defining rigidly the interface of service elements (SEs). This allows a user to select suitable SEs from multiple candidate SEs whose interfaces are different but have equivalent functions (Fig. 1). This eliminates the describing effort of BPEL documents in each situation. One ST can provide composed service in various user contexts by searching appropriate SEs.

When a user starts to compose a service, the service composition engine discovers available SEs using the metadata described in the ST and selects the appropriate SEs from among the candidates based on the user context. Then, the engine acquires their interface information (WSDL, UPnP doc) and invokes the selected SEs. In the process of composing dynamically various SEs based on a given ST, interoperability among SEs is important. To ensure this, we applied OWL-S (Web Ontology Language for Services) [5], one of the semantic web descriptions, to SE description and implement its translation logic in our service composition engine.

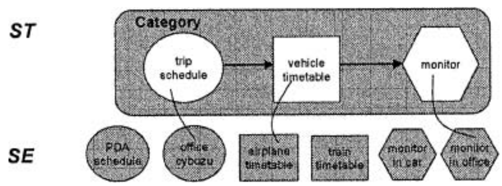

Fig. 1. An image of Service Template

3 Design of the service composition engine

3.1 Description of SE and ST using metadata

Easy composition even by non-professionals has the following requirements:

· STs can be described in a uniform way without being aware of detailed implementation of each SE.

· SEs with equivalent functions can be used equally despite differences in the vocabulary of metadata.

To satisfy these conditions, we decided to use OWL-S for SE description as mentioned above. It consists of three parts: profile, process model, and grounding. The profile has property information describing what capability the service provides;

the process model describes the service behavior such as inputs, outputs, preconditions, and the effects of processes; and the grounding describes the mapping between processes of OWL-S and native operations such as WSDL or UPnP docs.

A process is a neutral description of UPnP or WSDL. Therefore, users can describe STs by using processes as semantic metadata for native operations without paying attention to the detailed implementation. Metadata are described in a uniform way so that it is easy to create a graphical user interface (GUI) tool for describing an ST. The way of resolving vocabulary differences by tracing metadata links of OWL, which will be discussed also in 3.2, is within the scope of the semantic web and therefore familiar with OWL-S descriptions.

There have been some studies on using OWL-S; for example, [6] examines techniques for searching for web services. Task [7] manually composes two web services one of whose input matches the other's output; and Ubiquitous Service Finder [8] composes web services with the same input/output structures by binding them one after another. However, the number of web services to be composed is limited and they can only be used for simple service composition. The difference between our study and Task can be summarized as follows: Task tries to compose two services in the above-mentioned fashion in the adjacent area, which we call the bottom-up approach, while in our study a user specifies a desired composed service as an ST and then SEs that match conditions specified by the ST are discovered for the service, which we call the top-down approach. Task has some difficulties: if the number of web services within the area increases, the number of possible combinations increases rapidly, so users can no longer select one easily; and complicated services will not be provided because Task only connects web services manually one by one. On the other hand, our approach makes the selection of SEs easier because each SE is selected from only candidate SEs managed in each category described in the ST. Note that a category is a group of SE with equivalent functions. Furthermore, complicated services can be provided by describing operation tags such as branching, merging, and looping in the ST.

The flow of service composition using OWL-S is expressed as follows. SEs advertise their OWL-S description to the network. The ST specifies required functions by designating the category name, the operation metadata, and information transfer between categories. The operation metadata means a process of OWL-S. In the information transfer between categories, the mapping between the parameters of the preceding category and the parameters of the next or later category is described. The sequence for composing services by the ST is as follows: SEs are searched for using the metadata of a required function described in the ST; an appropriate SE is selected automatically or manually by using profile descriptions of discovered SEs; and the native operation of the SE is invoked using grounding description of the selected SE. An SE description is outlined in Fig. 2.

If an SE having a different vocabulary of operation metadata can provide an equivalent function (for example, one uses "buy" while another uses "purchase"), this will be resolved by vocabulary resolution by tracing links of the metadata management database, which is discussed in the next section. Vocabulary resolution increases the number of convertible SEs and can achieve flexible composition.

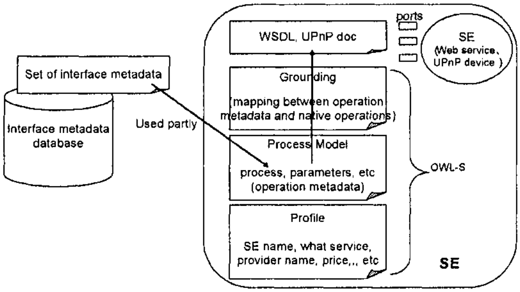

Fig. 2. Using OWL-S to describe an SE

3.2 Management of metadata to resolve the vocabulary differences

Interface metadata must be managed in a way that ST describers, SE providers, and end-users can all use them easily. For it, there are three prerequisites:

· ST describers can easily find and select operation metadata for the ST they want.

· SE providers can add new operation metadata when they implement a new function. In addition, it should be possible to register the equality relationship of metadata with a different vocabulary.

· When a user searches for SEs based on a given ST, it must be able to find all SEs with functions equivalent to the operation metadata described in that ST.

We propose a metadata management method with the features below to meet these prerequisites:

· Operation metadata are grouped into categories based on a particular purpose.

· A new category can be created by adding a new operation metadata to an existing category. A category that has a different vocabulary expression but has equivalent meaning also can be registered.

· Among categories, metadata relationships such as subclass and equality are linked with each other bi-directionally. They are described by the OWL subClassOf property and equivalentClass property.

The management method is shown in Fig. 3. A category has a collection of operation metadata with a particular purpose (for example: video, travel reservation, shopping, etc.). A rectangle shows a category and small characters (e.g., a1, b2, j4) show operation metadata that belongs to a category, and an arrow shows the relation between categories (subClassOf and equivalentClass). For example, suppose that category A has operation metadata a1 and a2. The SE provider creates category C with a new function, adds new operation metadata c3, and registers it as a subclass of the existing category. Category trees will be established by repeating this procedure. Besides the inheritance of categories, equality relationships between metadata with a different vocabulary can be described (category C and K). In Fig. 3, if metadata c3 is described in ST, the composition engine searches by using the link of OWL and finds categories C, E, F, and K.

Therefore, it is unnecessary to define uniform interfaces. SE providers can add operation metadata freely. Even if there are only limited categories at the beginning, we can expect that user-friendly categories will expand through natural selection by adding various functions to the original.

When we implemented the proposed management method, we used XML database, and OWL links between categories are described manually. These links can achieve flexible service composition in different vocabularies, but manual description requires efforts. Therefore, we are currently implementing an automatic metadata mapping method using an ontology mapping technology [9]. We expect that this automatic mapping will help the service composition over different companies.

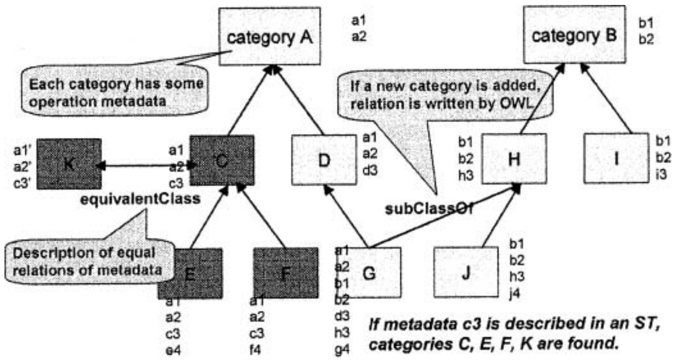

Fig. 3. Method of managing metadata

3.3 Implementation of the service composition engine

Fig. 4 shows the functional blocks of the composition engine implemented on PCs based on the ideas thus far described. It is implemented in the Java language, and uses jdk1.4.2, tomcat 4.1.31, and axis 1.1 as middleware.

The service search block obtains STs and OWL-S descriptions of SEs by means of a database, UDDI, or JXTA (Peer-to-Peer search technology). When an ST is searched for, the ST name or provider's name, etc., are used as the query keywords. Similarly, when an SE is searched for, the category name and operation metadata described in the ST are used as keywords. Using the metadata management database, OWL-S files with different vocabularies or domains can be obtained.

The resource manage block manages resources such as the ST tags, OWL-S files of SEs, sequence information of ST, and parameter information of SEs, that are used by the composed service.

The service execution block provides functions of tag execution (invocation, looping, switching, etc.), SOAP messaging, and parameter casting. When this block creates SOAP messages according to ST tag information and invokes the operation of a selected SE, the block grounds the operation metadata of the ST to the native operation of the selected SE by using the OWL-S grounding document and WSDL or UPnP doc of that SE. Parameter types casting is also executed in this block.

The event control block receives a synchronous or asynchronous event message from the SE which generates an event message (e.g., the event of a traffic accident).

The service selection block gives a score to each candidate SE by using OWL-S profile documents of the SE, user context information, and user evaluation criteria. An SE of a high score is selected automatically or manually dependently on the user policy. Details of the scoring and selecting SE algorithm are reported in [10].

The control block provides comprehensive control to perform the composition service including acquisition of ST and SE descriptions, SE and ST registration, and execution of the selected ST's tag. If the user policy of SE selection is the manual mode, this block waits for a decision from the user. Also, this block provides parameter inquiry function. This block asks each user for necessary (and unknown) parameters for SEs invocation.

The GUI (user interface) block receives inputs from the user and displays outputs.

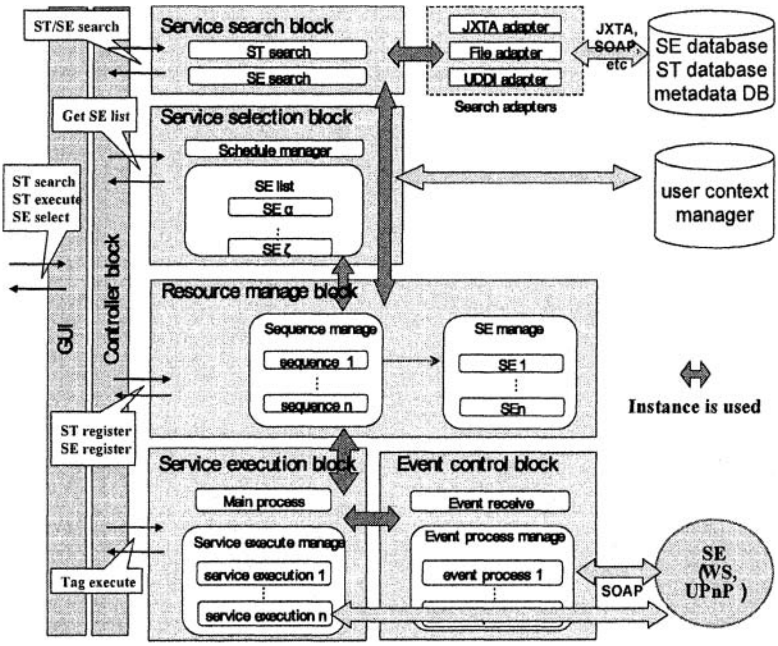

Fig. 4. Function blocks of service composition engine

4 Example Application

An example application using the service composition engine, "business trip supporter" (Fig. 5), was demonstrated on Interop2005 [11]. This service reduces routine work when a user makes a business trip. Wherever he is, when the time for him to leave comes, a device containing an alarm function near him reminds him of the departure time (according to the event of PDA scheduler), and trip information (maps, train timetable, weather, etc) is provided to the nearest printer or monitor.

The main features of this service are context-awareness and customization. The former means that an appropriate device is selected automatically according to the user's location without paying attention to differences in device interfaces thanks to the ST and the SE selection functions. In the office, a speaker may be invoked, while a pet robot with a sound device may be invoked at home because there is no other sound device at home. In the metadata DB, a pet robot is related to sound device by OWL subClassOf property, so the engine discovers the pet robot as a substitute of an alarm, using metadata tree. The latter allows a user to change an ST easily because he can describe the ST without knowing rigid interface definitions of SEs. For example, a user can easily add the weather information using the GUI ST editor.

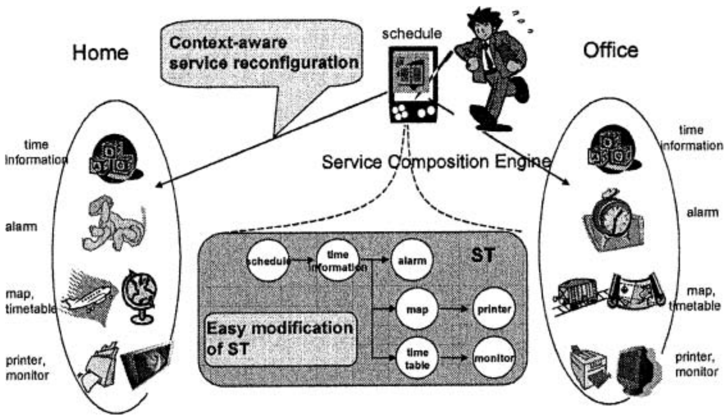

Fig. 5. Overview of business trip supporter

5 Performance measurement of the service composition engine

We have thus far explained the design concept of the composition engine and an example application. Since rich computer resources are indispensable for semantic web handling, usually high-performance servers are used to manage enormous amounts of information. However, our service composition technology aims at ad hoc service composition by using available or appropriate SEs in various user situations. Therefore, we suppose that the number of candidate SEs is not so large, and that the resources of PC or PDA are sufficient for the composition engine. We evaluated the performance of the composition engine implemented on a PC to examine if its performance is sufficient for the assumed usage areas, where an ST has about ten categories and each category has about ten candidate SEs.

5.1 Measurement of service composition

We measured the processing time and memory usage for service composition five times. The graphs in this section show the average of five measurements.

The measurement environment was as follows.

Five IBM Netvista PCs (CPU: Pentium4 2.53GHz, RAM: 512 MB, OS: Windows XP SP2) were connected to the same hub with a 100BASE-TX Ethernet cable.

- PC1 is the service composition engine. In the SE selection step, three evaluation equations are calculated and each score is summed to select appropriate SEs.

- PC2 is the metadata management database. In it, XML database, EsTerra, manages the metadata and OWL links. In this measurement, the number of OWL link steps when users search is only 1. For example, in Fig. 3, if we look at category C, the categories within one step from C, i.e., A, C, E, F, and K, are the search range.

- PC3 is the SE/ST database. PostgreSQL 8.0 manages ST, WSDL and OWL-S.

- PC4, PC5 are the servers to provide SEs. All SE are web services each of which has only one method that returns the value of the formula by mod (arg + L)*N/M.

The patterns and sections for service composition measurement were as follows.

- Measurement patterns

Number of categories described in one ST: 5, 10, 20, 40, 70, 100

Number of candidate SEs in each category: 1, 3, 10, 30, 100

Here, the operation tags described in the ST were only "invoke" (to invoke the SE's method) and "copy" (to copy the SE's parameters to another SE's parameters) and they were used once for each category. The SE with the highest score in the category was automatically (not manually) selected in SE selection.

- Measurement sections:

Startup of the composition engine, ST search, SE search, SE selection, and composed service execution.

Figs. 6 (a), (b) and Figs. 7(a), (b) show logarithmic charts of the processing time taken by the composition engine for SE search, SE selection, composed service execution, and total processing time of the five sections (vertical axis) versus the number of candidate SEs in each category (horizontal axis). For the composition engine startup and ST search, both processing times were constant (less than 500 ms). Similarly, Figs. 8 (a) and (b) show the memory usage for SE search and SE selection versus the numbers of candidate SEs in each category.

- **SE search (Fig. 6(a) and Fig. 8(a))**

For SE search, we found that as the number of candidate SEs in each category and the number of categories in one ST increased, the processing time and memory usage also increased. The reason for this is that the composition engine parsed the files of OWL-S service, profile, process, grounding, and WSDL to check the validity of the SE. Therefore, we are planning to improve this implementation to reduce the number of parsed files; for example, the grounding and WSDL files are parsed after SE selection because they are used only for SE invocation. We also found that very long processing time was required when there were many SEs. To solve this, we suppose that it is effective to narrow down the number of candidate SEs before parsing all OWL-S of SEs, by searching with context information such as position.

- **SE selection (Fig. 6(b) and Fig. 8(b))**

For SE selection, we also found that as the number of candidate SEs in each category and the number of categories in one ST increased, the processing time and memory usage increased. To solve this problem, it is also effective to narrow down the number of candidate SEs before scoring SEs, which is the same as in the SE search case. The increase in time and memory was affected by the number of items for criteria and the evaluation equations for scoring. Therefore, fewer items for the criteria and simpler equations are required to reduce the processing time. However, it should be noted that this is a trade-off with appropriate SE selection processing.

- **Execution of composed service (Fig. 7(a))**

Logically, the chart should be flat regardless of the number of candidate SEs in a category. However, when the number of candidate SEs increased, the chart showed fluctuations. This suggests that the increase affects memory control and instance control to some degree. For the processing time, however, it was so small that there was nothing to do with performances because the average time for one web service invocation was around 20 ms, the average for one parameter copy was around 50 ms, and only less than one second was required in the case of ten categories in one ST.

- **Total processing time (Fig. 7 (b))**

The total processing time was proportional to the power of 0.7–0.9 of the number of candidate SEs in each category. This is because the time for SE search and SE selection was dominant, and these times were almost proportional to the number of candidate SEs in each category and the number of categories described in an ST. We assumed that the usage area was the case where there are about 10 categories in an ST and about 10 candidate SEs in a category. In this case, the most appropriate SE was selected among 10 available SEs in various situations. In that case, only 7 seconds were required for processing, which is small enough to be feasible.

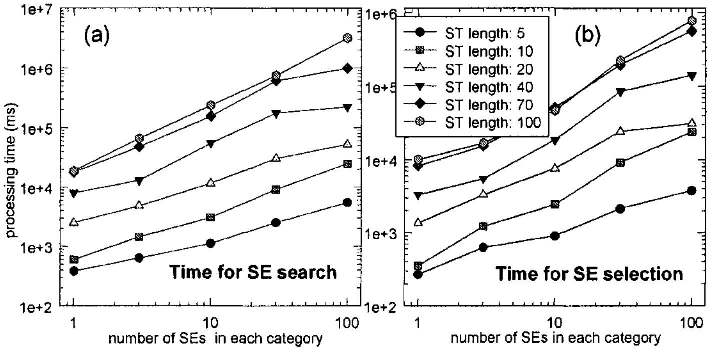

Fig. 6. (a) Time for SE search, (b) Time for SE selection

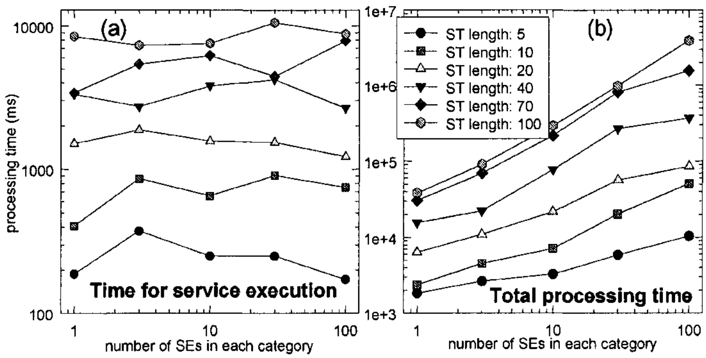

Fig. 7. (a) Time for service execution (b) Total process time versus number of SEs

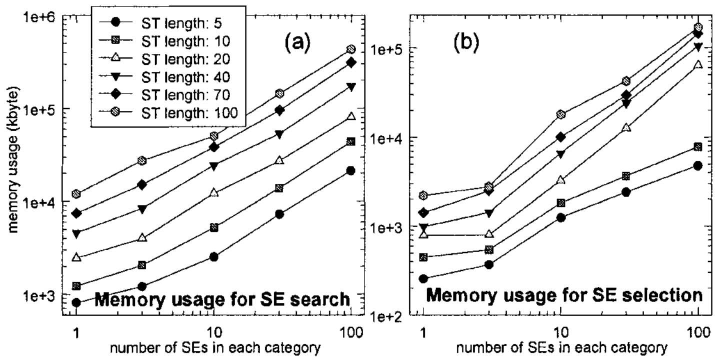

Fig. 8. (a) Memory usage for SE search, (b) Memory usage for SE selection

5.2 Discussion

When there were many candidate SEs for SE search and SE selection, the processing time was rather long. However, in the assumed usage area (about 10 categories in one ST and about 10 candidate SEs in each category) where available and appropriate devices or web services fitting well with user context were composed, it took only 7 seconds for processing time and the memory usage was only 7 Mbytes. This result shows sufficient feasibility in usage area. To enhance the performance of composition, the ideas below should be considered.

- Discover bottlenecks of searching and selection, and make modifications (e.g., modify the parsing OWL-S files)
- Narrow down the number of candidate SEs before scoring (e.g., searching for SEs using the user context, such as position).

6 Conclusions

In this paper, we described the design and implementation of a service composition engine to provide context-aware services in ubiquitous computing environments. We achieved some sample applications using our service composition technologies. We also measured the performance of the service composition engine and found that the performances of service composition in the assumed usage areas were sufficient. In the future, we intend to reduce bottlenecks in the service composition processing found in the measurement when there were many candidate SEs. We are now planning conducting actual experiments of the composition engine in a shopping mall of Aomori Japan in February 2006 to identify feasibility and other problems. In this paper, we explained the service composition engine mainly for PCs, but we have also developed a compact composition engine implemented on cellular phones [12].

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A Modeling Approach for Service-Oriented Architecture

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Abstract. Specifying service-oriented system, which is a new type of Enterprise Information System, is critical with the rapid development of Web Services. For the purpose, this paper presents an approach to model Service-Oriented Architecture (SOA). We do not exclude the traditional opinions of software architecture description as the current specification approaches; on the contrary, some similar conceptions, such as service components and connectors are defined in this paper. For architectural reuse, the notion of composite service components is specified to model services composition and that of composite connectors is defined to abstract the complex communication protocols. Within the context of the Travel Reservation System (TRS), we demonstrate the usage and practicability of our approach based-on Web Services.

1 Introduction

With the rapid development of information science and technology, different kinds of enterprise information systems are proposed to handle the diverse changes of requirements anywhere and anytime. In order to deal with the situation better, service-oriented systems are hot spots to decrease dependencies between different information artifacts. At the same time, Web Services has made considerable progress recent years, thus Service-Oriented Architecture (SOA) is paid extensive attention. SOA provides a new blueprint to solve software reuse and enterprise

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information system integration which publish business functionality in the form of programming and accessible software services, other application programs can use these services by published and discoverable interfaces [1-4]. Owing to its loosely coupled, open, high dynamic and high flexible nature, software systems developed based on SOA can be better suitable for requirement and application environment changes.

For the sake of the service-oriented system design, it is imperative to model SOA at an abstract level, taking no account into concrete technologies involved in the application employed. However it is impossible to describe SOA sufficiently by the current popular UML-based approach [5-7] and BPEL [8, 9] since UML is short of the support to describe some elements involved in software architecture and BPEL focuses on the specification of abstract or executive business processes but not on the description of functional units of system architecture. On the other hand, the existing ADLs (architecture definition languages) [10-14] cannot specify SOA very well in spite that we can benefit from the approaches based-on them.

Therefore, on the basis of traditional software architectural describing techniques, this paper puts forward a modeling method for SOA by SO-ADL. Unlike other specification approaches, we do not exclude the traditional architectural description opinions since they are helpful to specify SOA to some extend, so some similar conceptions are defined as the first-class entities in our approach. Meanwhile, to the end of architectural reuse, composite service components and composite connectors are specified, too. Then, by using Web Services [15, 16], the usage of our method is manifest within the context of the Travel Reservation System (TRS).

The remainder of this paper is organized as follow. Section 2 highlights the requirements for modeling SOA. Then, SO-ADL is illuminated in Section 3, and Section 4 elucidates the specification of Travel Reservation System (TRS). Furthermore, related work is discussed in Section 6 and Section 7 concludes this paper.

2 Requirements

SOA is a particular kind of software architectures that is designed to create a dynamically organized environment of networked services that are composable and interoperable [17]. In order to provide an effective and practical approach to specify SOA, several requirements should be taken into account at least.

Firstly, the description should capture the structure of SOA in an abstract layer and as far as SOA is concerned, services are its building blocks that communicate by transmitting synchronous or asynchronous messages. Secondly, it should give strong consideration of SOA's highly dynamic structure, highly flexible nature and its composable ability in descriptions. Thirdly, the notation has to accord with the vocabulary used to describe SOA in natural language for improving its usability and architectural reuse. Besides, the approach should keep the balance between concision and understandability, simplicity and functionality. And as the changeful nature of SOA itself, it should be open and extensible not only at describing syntax but also at specifying framework.

3 SO-ADL

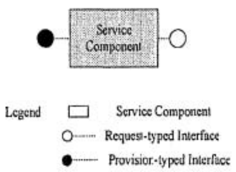
This section gives the definition of SO-ADL at length and their corresponding notations are specified, too. Unlike existing modeling approaches referred before, traditional software architectural specification techniques are not excluded in our method; on the contrary, we believe that they are helpful in SOA description issues and several similar conceptions are defined. Then, aiming at architectural reuse, our approach allows the definition of composite service components and composite connectors to abstract the complex constructs. Meanwhile, we adopt the traditional types-and-instances model and both of service components and connectors have types which are defined at design time and instances which are specified at run-time.

3.1 Service Components

The concept of *Service Components* is introduced to abstract and specify the computing units related to services since they either provide or request services or both provide and request services simultaneously. As shown in figure 1, a service component type is defined from four aspects as follows,

- *Identification* refers to the name of the service offered and it is a unique identifier, which identifies the service component.
- *Interface* specifies the service a service component provides or requests and it is a set of interaction points between a service component and its external world. The notion of interface separates the services from their implementations, and then service provider is able to change the implementation without any influence on service consumer, which only needs to know interface specifications of provider service component. There are two types of interfaces: *provision interface* and *request interface*.
- *Specification* is a brief description of services provided by service components, including *service specification*, which declares what the service offers and *service contract* that gives information about how to use the service and indicates the roles a service component acts. SO-ADL prescribes specification should be described in a machine-and-human readable format and platform-independently, while it has not any further restrictions on the definition mechanism in detail.
- *Condition* defines *pre-conditions*, *post-conditions* and *invariants* of service components that are useful during the service components' composition process. Similarly, SO-ADL does not limit the describing techniques for condition declaration and various logical methods are applicable.

At first sight, our definition of service components looks similar to the components defined in traditional ADLs given in [11-14], and they have some similar features indeed. However, compared with common components, service components are larger granularity that provide relatively integrated functionality and rely on a bigger data set. Meanwhile, service components are much closer to business requirements than ordinary components just like the advantage of SOA relative to traditional software architecture. On the other hand, service component notion is not the same as that of service since a service component is a functional unit rather than a business-oriented service in spite of their many similar properties.

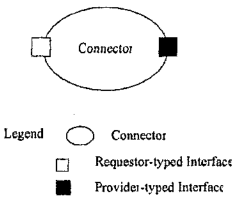



```
ServiceComponent Identification {
        Interface {
                provision p
                request r
        }
        Specification {
                serviceSpecification = "..."
                serviceContract= "..."
        }
        Condition {
                preCondition = "..."
                postCondition = "..."
                invariant= "..."
        }
}
```

Fig. 1. The Notation of Service Component Type

3.2 Connectors

The notion of connectors is used to model the communication mechanisms between service components explicitly. Note that some ADLs are short of the definitions of connectors, therefore the interaction pattern specified by them is asymmetric. Thus, the interaction patterns cannot be described independent of the computation unit, which violates the design principle of SOA. Accordingly, we define connectors in an explicitly manner and direct connections between different service components are prohibited without connectors while connectors can link each other directly.




```
Connector Identification {
        Role {
                provider p
                requestor r
        }
        Specification {
                glueProtocol = ".."
        }
        Coordinator {
                coordinationSpec=".."
        }
}
```

Fig. 2. The Notation of Connector Type

As shown in figure 2, SO-ADL specifies connector type in four aspects as following,

- *Identification* is the name of a connector that is a unique identifier to identify it.
- *Role* specifies the interface of a connector. A role prescribes the responsibility of service component that is attached to the connector and there are two types of roles: *provider* and *requestor*.
- *Specification* declares the *glue protocol* between the different roles of the connectors, which are the transport protocol between different service

components in fact. SO-ADL supports various kinds of transport protocols based-on different implementation techniques.

- *Coordinator* is defined to enable proper connectivity of service components that is responsible for the compatibility of type between connector and service component. The coordinator are defined by declaring the *coordination specification*, including the coordination information and policy which give constraints to restrict the attachments of service components and connectors.

3.3 Configuration

A service-oriented system is configured by service component instances and connector instances and the symbol-"as" in textual notation while "—"link in graphic notation are used to identify configuration relationships. For example, attachment of service component instance s and connector instance c is noted: "s.p as c.r" (p is a provision interface of s while r is a requestor role of c). That is, s provides its services to other service component instances through c. Thereby declaration of service-oriented system configuration is composed by the declaration of service component instances, connector instances as well as their attachment relationships.

As far as SOA, its configurations are open, highly dynamic and highly flexible which allow unbounded creation, deletion and modification of constructs. Therefore, we introduce a role-driven way of configuration, that is, configurations are triggered on-demand directly. Note that, roles and services are relatively determinate by business requirements in spite of the changeable structures. Further discussion is beyond of the scope of this paper. Then, based-on services and roles elicited from requirements analyzing, we can draw various configurations as blueprints of service-oriented systems.

3.4 Composite Constructs

As SOA is defined in terms of its ability to compose and recompose services, it is imperative to define the composition of service components. Therefore, the notion of *composite service components* is defined to support composed service component specifications and to achieve architectural reuse simultaneously.

Note that service components are not allowed to link one another directly, thus, composite service components have inter-structures that are configured from other service components' instances and corresponding connectors' instances. To gain service composition diagrams automatically, a composition process is designed, which can be implemented in programming language. According to the composition process, we define composite service components by declaration of their constituents' instances and their configuration. For conciseness, we do not introduce any new notation for composite service component specification while describe it based-on basic constructs defined before. In this way, composite service components are specified from four aspects in the same form as primitive service components while there are some differences in contents. As a matter of fact, SO-ADL does not give any restrictions of composing patterns and it is useful to specify different composite service component composed in different ways.

For example, figure 3 shows the ordinal composition pattern and "dummy provision" and "dummy request" are specified to define the composite service components' interfaces that are attached to the first service component's interfaces in the composing sequence and the last one. What's more, composite service component specification declares its inter-structure (or inter-configuration). As far as condition, its pre-condition and post-condition will be the pre-condition of the first service component and the last one's post-condition respectively, while its invariant will be the logical "and" of the constitutes' invariants.

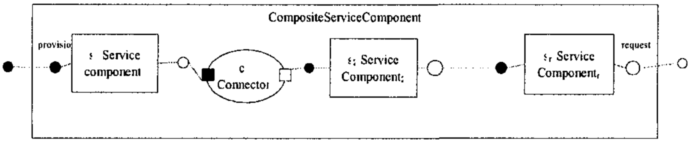


Fig. 3. Ordinal Composite Service Component Type-Graphic Notation

On the other hand, considering the complex communication mechanisms between service components, SO-ADL supports the definition of composite connectors for architectural reuse. As connectors are allowed to connect each other directly, composite connectors have interior structures that are composed by different connectors. SO-ADL does not limit the composition patterns, either. And different composite connectors can be depicted by connector specifications and their inter-structure declarations. Furthermore, the approaches presented in [18, 19] are helpful to provide some operators with which new connectors can be built up from old connectors using well-founded operators for composition.

3.5 Dynamic Structures

The dynamic changes of SOAs encounter the key issues in three aspects: dynamic modification, dynamic configuration and reconfiguration, and dynamic composition and recomposition. Dynamic modification is an intrusive change which may modify the structures or behaviors of the service components, whereas, the other ways of dynamic changes are non-intrusive changes.

Our approach supports all of the above three kinds of dynamic changes in SOA. It is obvious that the dynamic modification has no influence on the definition of SOA since SO-ADL is specified as platform-neutral and implementation-independent. At the same time, in view of the loosely-coupled nature defined in SO-ADL, the dynamic modifications almost have no effects on users.

As configurations are triggered on-demand directly in virtue of a role-driven way in our method, dynamic configuration and reconfiguration are also supported. We can identify services, roles as well as their relationship, which are elicited during the requirement analyzing by use case techniques (which is out of the scope of this paper), then, which can be mapping into the descriptions of service components and connectors. In so far as implementation, specification of constructs and their configuration relationships will be mapped to lower level. Similarly, dynamic composition and recomposition can be described in SO-ADL as an automated role-driven process, too.

4 Case Study

An application scenario of Travel Reservation System is given to manifest the effect of our approach based-on Web Services. We simplify the concrete scenario in order to illustrate the practicability of the method this paper presented and in the scenario; the requirements of the travelers trigger the dynamic configurations of service-oriented systems and composition of different service components.

To satisfy the needs of travelers, a simple reservation system may include different services, and then, we define service components in the TRS, including airline reservation service component, hotel reservation service component as well as the corresponding connectors are defined, too. Suppose a simple TRS depicted as figure 4 that is constituted from a primitive hotel reservation service component, a composite AirlineReservation service component, several Traveler service components and connectors between them. The instances of the above service components and those of the connectors compose the simple TRS.

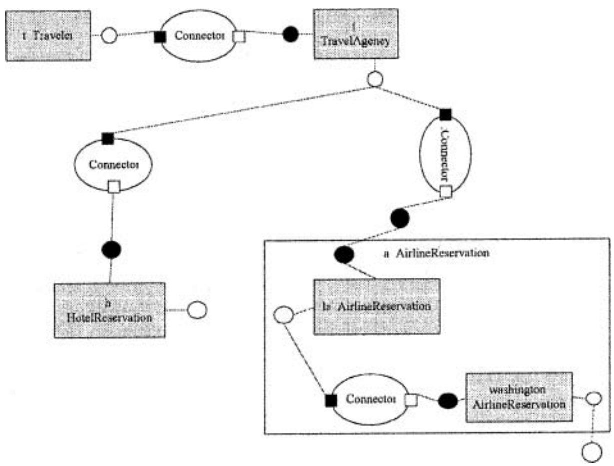


Fig. 4. The Specification of a Simple Travel Reservation System

As referred before, Web Services are used to implement the application system; therefore, WSDL [20], SOAP [21] and other techniques may be involved. Except declaration of interfaces, WSDL is adopted to specify service components' specifications that only need to indicate URIs of the WSDL documents. Furthermore, a composition process is designed to gain a service composition diagram automatically, which can be implemented in programming language. For instance, the AirlineReservation service component, which is able to provide the airline reservations from one place to Los Angeles, then to Washington, is composed from two service components that provide different airline reservation services. As far as the condition declaration of service component, description logic is used to express the pre-conditions, post-conditions and invariants, containing *and*, *or* and *not* logic symbol. Simultaneously, we can decompose a complex condition to atomic conditions, which can be matched by single service component respectively. So, several service components can be orderly composed to satisfy the request as the same as the definition of the AirlineReservation service component.

When it comes to definition of connectors, SOAP is helpful to be the glue protocol that specifies the communication pattern between different roles of connectors and it abstracts the interaction mechanisms between various service components in fact. SOAP is used as the main communication protocol of TRS that allows different composite connectors to express complex protocols yet. And the coordinator will prescribe the configuration relationships between service components and connectors, and between different connectors that may be specified by other techniques provided by Web Services (not included in this paper version).

Then, based-on the identification of roles and their relationships elicited in upper phases, we can configure a simple TRS as figure 4. Meanwhile, with the dynamic changes of roles' specification, the TRS will be dynamic reconfigured and the service components involved will be dynamic recomposed too.

5 Related Work

The work presented in this paper has been influenced by several different proposals. First of all, we are inspired by the research work on software architectures, especially the specification of different ADLs, such as Darwin [11], Wright [12, 22], xADL [13], and ABC [14]. The elements defined within them are the foundation of our describing, and the framework of our approach is benefit from them, too. Although we cannot use the tools they provided, our approach can benefit from the methodologies used by them.

On the other hand, the modeling of SOA based-on UML is a hot-spot nowadays. In most of these UML-based approaches, we noticed the methods presented by Baresi *et al.* [5, 6] and AMir *et al.* [7]. Baresi *et al.* describe SOA by the static model and dynamic model in UML, then, encode the model into a transition system. AMir *et al.* use the UML profile to specify SOA, and their SOA UML profiles consist of five profiles: the resource profile, the service profile, the message profile, the service policy profile, and the agent profile. Then the notation of UML and the stereotype is used to describe them. However, both of them fail to model SOA appropriately since UML itself lack the support to describe the peculiar elements involved in software architecture that is overcome by our approach. In addition, we can take advantage of the use case technologies defined in UML to elicit the roles and services, which are the key elements of our approach, from business requirement.

In the context, we mush mention the work done by Krüger *et al.* [10] who propose an ADL for describing service, which views roles and service components as fundamental elements in SOA. Furthermore, they substantiate their view of services as cross-cutting architectural aspects by providing a mapping from services to aspects in AspectJ. But, the ADL does not emphasize the whole structure description of SOA and the corresponding graph supports. Besides, Stojanovic *et al.* [23] present a CBD-based method to model SOA. However, it limits to the traditional component modeling techniques and does not concern the properties of SOA eligibly. The approach in this paper gives relatively sufficient consideration of the above problems.

6 Conclusions

This paper addresses the problem of modeling SOA that gives the blueprints to a kind of enterprise information system. For the purpose, SO-ADL is put forward to specify SOA and its effect is shown within the application scenario of travel reservation system. In future, we will devote ourselves to the research of SO-ADL-based service-oriented development process and its corresponding tools. At the same time, how to bridge the gap between different service-oriented development phases better is our concern, too.

Acknowledgements

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XML-based EIS – A Meta Schema for Mapping XML Schema to Relational DBS

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Abstract. Enterprise information systems (EIS) often employ relational database systems to store their content. At the same time, XML constitutes the dominant standard for data exchange as well as for the hypertext level of web-enabled EIS. Thus, the integration of XML with relational database systems to allow the storage, retrieval, and update of XML documents is of paramount importance in the context of EIS. Data model heterogeneity and schema heterogeneity, however, make this a challenging task. This paper proposes X-Ray, a generic approach facilitating the composition of XML documents out of a relational database system as well as the decomposition of XML documents to store them within a relational database system in a fully transparent way. This is achieved by means of a generic meta schema that stores all relevant information for the composition and decomposition process. This meta schema covers both, the concepts of DTDs and XML Schema concepts.

1 Introduction

Enterprise information systems (EIS) typically employ databases (DB) to store their content. At the same time, the Extensible Markup Language (XML) 16 is fast emerging as the dominant standard for data exchange between different EIS 19, 20. Furthermore, regarding the realization of EIS based on Web technology, where databases constitute the *content level*, XML has become the first choice for representing data at the *hypertext level* of a web site, i.e., the logical composition of web pages and the navigation among them 14. Because of the great importance of XML and database systems (DBS) in the context of EIS, the integration of them with respect to storage, retrieval, and update is a major need. Such integration also enables the transformation of legacy data to various data formats via XML.

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Regarding the DBS's data model underlying an XML-based EIS used for the integration we concentrate on the *relational data model*, which is especially motivated by the fact that in EIS currently, a significant amount of data is stored in pre-existing relational databases (RDBS) and will continue to be used by existing EIS in the future 5. There is an increasing demand to publish existing relational data as XML according to existing standardized XML schemata in terms of a document type definition (DTD) 16 or the more powerful XML Schema language 17* or, vice versa, for storing XML documents in existing DB incorporated by EIS.

Concerning the integration with RDBS one can distinguish three alternatives as well as combinations thereof. XML documents as a whole can be stored within a *single database attribute*, XML documents may be *decomposed* in some way ("shredding"), e.g., into a *graph structure* and stored into appropriate database tables, and finally, the *structure of XML documents may be mapped* to a corresponding relational schema wherein XML documents are stored according to the mapping (cf., e.g., 3). Only the last approach allows reusing existing relational schemata and thus is further investigated in this paper. One major challenge of this schema-to-schema mapping approach is the existence of *data model heterogeneity* and *schema heterogeneity*. In this respect, an important demand on a particular integration solution is that the *autonomy* of both the XML schema specification and the relational schema should be preserved in that neither of them has to be changed.

We have already proposed a generic approach that solves such an integration need prevalent in EIS in 7. X-Ray facilitates the composition of XML documents out of a relational database system as well as the decomposition of XML documents to store them within a relational database system in a fully transparent way. The key mechanism for the genericity of X-Ray is constituted by a meta schema that stores all relevant information to map DTDs and relational schemata. Since the adoption of XML Schema as schema specification standard for XML documents by the W3C in addition to DTDs, more and more XML documents rely on XML Schema. Therefore, this paper discusses the enhancement of X-Ray to support XML Schema, primarily focusing on the design of the meta schema.

The remainder of the paper is organized as follows. Section 2 discusses several issues of data model heterogeneity by comparing concepts of RDBS and XML schema specification languages. Section 3 gives an overview of X-Ray in terms of its design goals and architecture. Section 4 gives an insight into the meta schema, focusing on the XML Schema part. In Section 5 related work is compared to X-Ray. Finally, Section 6 concludes the paper with an outlook to future work.

2 A Tour on DTDs, XML Schema, and RDBS

Analyzing and understanding the different kinds of heterogeneities between DTDs, XML Schema, and RDBS constitutes the prerequisite for designing an appropriate meta schema for mediation purposes. Therefore, this section discusses the most crucial heterogeneity aspects. For a more detailed discussion it is referred to 9.

* Note, that in the following, we use a capital letter to denote the XML *Schema* standard and a small letter to depict any XML *schema*.

2.1 DTD versus XML Schema

The main differences between DTDs and XML Schema concern the issues of syntax, namespaces, integration mechanisms, data types, identification, and references. First of all, concerning the *syntax*, XML Schema is based on XML itself instead of using a proprietary syntax as done by DTDs. Second, opposed to DTDs, XML Schema supports *namespaces* and provides improved mechanisms to integrate different schemata. Third, concerning *typing mechanisms* XML Schema distinguishes between elements and types, whereas DTDs allow specifying element types, only. XML Schema supports not only the definition of types but also elements with same name, but different structure. In addition, DTDs support a few data types, only, whereas XML Schema provides various data types and user defined type hierarchies. Fourth, DTDs offer limited concepts to realize unique *identifiers* and *references*, in form of the data types ID and IDREF(S). These data types may be applied to XML attributes; only, their values are limited to so called XML names. Thus, neither numbers nor composite keys are allowed. The scope of uniqueness of an ID value and the references established by IDREF(S) comprise the whole XML document, instead of parts thereof. In contrast, XML Schema provides a powerful key and keyref concept comparable to the key concept well known from relational DBS.

2.2 XML versus RDBS

Similar to heterogeneities between DTDs and XML Schema, there are also several kinds of heterogeneities with respect to RDBS. These comprise the relevance of a schema, structuring and typing mechanisms, storage of values, uniqueness of names, identification, relationships, and order. First, concerning the *schema relevance* aspect XML schemata are optional, can be designed a posteriori, and are implicitly part of each XML document in form of tags. In RDBS, schemata are mandatory, have to be specified a priory, and are not replicated as part of the content. Second, regarding *structuring* and *typing mechanisms*, whereas RDBS allow a flat structure made up of relations comprising attributes, only, XML supports an arbitrary nested structure, consisting of elements of certain element types, and attributes. Element types can be categorized along two dimensions. The first dimension depicts whether the element type *contains an atomic domain* whereas the second dimension denotes whether the element type *contains a composite domain*. This distinction results in four different kinds of element types, i.e., atomic, composite with element content or mixed content, respectively, and empty. Third, looking at the *storage of values*, in RDBS values are stored within attributes, only, whereas XML allows storing values within both, elements and attributes. Fourth, regarding *uniqueness of names*, the name of a relation is required to be unique within the whole relational schema, similar to the name of an XML element type being unique throughout the DTD. XML Schema is more flexible in this respect since the name of an XML element type has to be unique within a so-called *symbol space,* only. Moreover, by means of so called *namespaces* 15, XML allows element types having the same name by using different namespace prefixes. The name of an XML attribute has to be unique within its element type, again similar to an RDBS attribute's name which has to be unique within its relation. Fifth, concerning *identification* and *relationships*, RDBS provide the well-known key and foreign key concepts that realize uniqueness of possibly composed values within a single relation and typed references. Finally, elaborating on the significance of *order*, in RDBS relations and tuples are not ordered, whereas in XML, element types and elements occur in a certain order.

3 X-Ray at a Glance

This Section gives an overview of X-Ray by focusing on the underlying design goals and by introducing its architecture.

3.1 Design Goals

The development of X-Ray as a core middleware technology for EIS was driven by the following design goals: In order to allow the integration of *existing XML schemata* and *existing RDBS schemata*, which shall *remain autonomous*, X-Ray supports a *loose coupling* by defining *explicit mapping knowledge*. To achieve *mapping transparency* and *reduce maintenance effort*, X-Ray stores the mapping knowledge *reified within a DB*. In order to support *multiple schemata* at both sides, X-Ray allows mapping a certain schema to multiple schemata at the other side. To enhance its *universal applicability* X-Ray supports both *publishing* as well as *storage* of XML documents. To establish *schema transparency*, X-Ray provides a *virtual XML view* over the RDBS, being the target of a query when accessing X-Ray. Finally, to provide *homogeneous access*, X-Ray realizes an *XML-centric* solution by using XQuery as query language to access XML data stored within the RDBS.

3.2 Architecture

The architecture of X-Ray consists of three main parts: the generic *meta schema*, the *mapping knowledge editor*, and the *composer/decomposer* component (cf. Fig. 1).

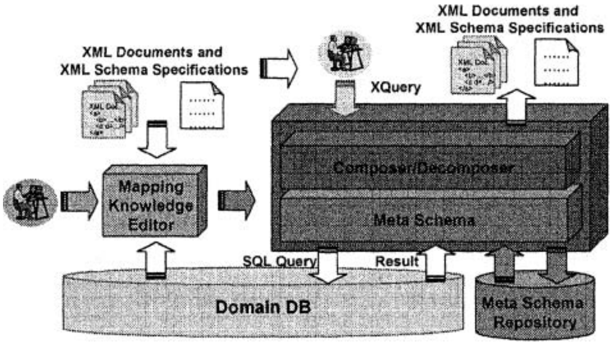

Fig. 1. Architecture of X-Ray

Before X-Ray can be used for storing and retrieving XML documents, the mapping knowledge required for mapping a certain XML schema to a certain relational schema has to be specified in an initialization phase. To support this task, the X-Ray architecture provides a *mapping knowledge editor*. On the basis of a database schema and an XML schema, the user may interactively specify the required mappings, guided by proposed mapping patterns (cf. 9). As soon as the system is initialized with the mapping knowledge which is stored within the meta schema repository, the user is able to transparently issue queries using XQuery 18 against a virtual XML view. Utilizing the mapping knowledge, the query is decomposed into corresponding SQL queries on the relational database. The result is used to compose XML documents out of flat relational data. The *composer/decomposer* component serves for storing and retrieving XML documents and therefore performs all necessary transformations based on the mapping knowledge. A first prototype of X-Ray, implemented on basis of Java and Oracle9i is already operational. Fig. 2 shows the *mapping knowledge editor* and the interface of the *composer/decomposer* component responsible for storing and retrieving data.

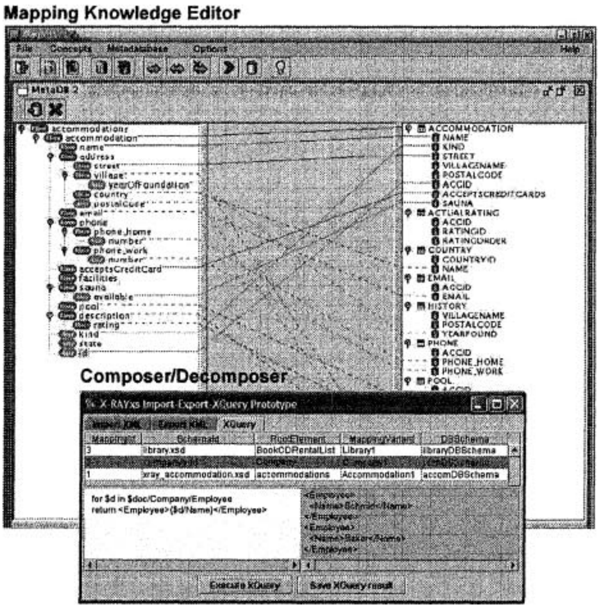

Fig. 2. Mapping Knowledge Editor and Composer/Decomposer of X-Ray

The mapping knowledge editor displays on the left hand side a certain schema for XML documents by means of graphically representing an XML Schema, whereas the right hand side shows a relational schema comprising relations together with their attributes. Mappings between these schemata are depicted by lines connecting them in a proper way. The *composer/decomposer* shows the choice of a mapping between two schemata and the selection of a particular root element. With respect to this choice, an XQuery can be issued and the corresponding result is displayed.

4 Meta Schema of X-Ray

The insights gained previously concerning data model heterogeneity and the design goals provide the basis for the meta schema. The main task of this meta schema is to mediate between heterogeneous concepts at the XML side and the relational side. Thus, it provides the basis for EIS, automatically composing XML data out of the RDB when requested and decompose them when they have to be stored.

4.1 Overall Structure of the Meta Schema

Basically, the meta schema consists of three parts describing the relevant meta knowledge (cf. the UML package diagram in Fig. 3). The `DBSchema` part is responsible for storing information about the relational schemata that shall be mapped to XML schemata. It contains information about relations, database attributes, relationships, and joins. Analogously, the `XMLSchema` part stores information about XML documents as specified by means of DTDs and XML Schemata, respectively. Finally, the `XMLDBSchemaMapping` component stores the user-defined mapping knowledge between `DBSchema` and `XMLSchema`. The goal of `XMLDBSchemaMapping` is to bridge both data model heterogeneity and schema heterogeneity in order to support a proper mapping.

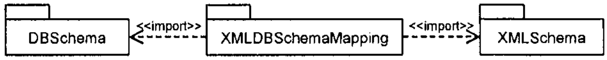

Fig. 3. Basic Parts of the X-Ray Meta Schema

In X-Ray, a database schema is not limited to be mapped to a single XML schema but may be mapped to several XML schemata and vice versa. Concerning the storage of the meta knowledge, X-Ray comprises both a relational representation of the meta schema stored within a relational database and an object-oriented representation for main memory mapping. The latter is being initialized with the content of the relational meta schema at the beginning of an X-Ray session, herewith allowing an efficient composition and decomposition of XML documents at runtime. The object-oriented representation is depicted in the following in terms of UML class diagrams. Thereby, it is focused on the `XMLSchema` part, whereby, for representation convenience, we concentrate on several classes and relationships, only. For details about the `DBSchema` and the `XMLDBSchemaMapping` part it is referred to 9.

4.2 XMLSchema Part of the Meta Schema

As already mentioned, the `XMLSchema` part stores information about both, DTDs and XML Schemata. Note, that X-Ray currently supports not the full range of concepts offered by the XML Schema standard. The selection of concepts supported by X-Ray in this first stage of development was driven by Pareto's 80/20 rule, since practice 11 has shown that there is a bundle of core XML Schema concepts which is used for most problems at hand. For discussion of those concepts not currently supported by our meta schema it is referred to Section 6. To reduce complexity, `XMLSchema` is composed into four core packages, namely `XS_SchemaComposition`, `XS_Types`, and two sub packages (`XS_SimpleUDTypes` and `XS_ComplexUDTypes`), `DocumentContent`, and `ElementContent` (cf. Fig. 4).

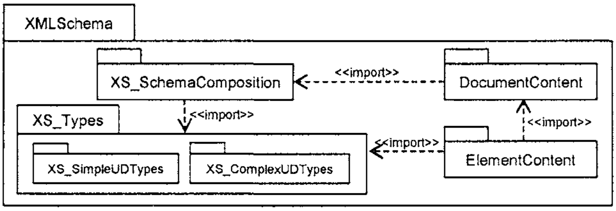

Fig. 4. Core Packages of `XMLSchema`

Note, packages prefixed with `XS_` store knowledge specific to information retained in XML Schemata and will be further discussed in this paper. `DocumentContent` and `ElementContent` describe information relevant for both, DTDs and XML Schema and are described in 9, discussing a meta schema for DTDs. The packages `XS_SchemaComposition`, `XS_Types`, `XS_SimpleUDTypes`, and `XS_ComplexUDTypes` are described in the following in more detail.

The package `XS_SchemaComposition` allows storing information about XML Schema documents, their associated namespaces as well as the composition structure of different XML Schema documents (cf. Fig. 5). A namespace may be assigned to an XML Schema by the `hasTargetNS` relationship that allows associating a prefix with the namespace via an association class. Concerning the composition structure, three different kinds of relationships between documents can be distinguished, covered in the meta schema by using recursive associations, namely `include` to incorporate documents of the same namespace or without namespace, `redefine`, a special form of include that enables to change certain specifications, and `import`, allowing to combine XML Schema documents of different namespaces. Whether namespaces of the integrated schemata may be the same or not is determined by appropriate constraints. The fact that `redefine` is a special form of `include` is expressed by means of inheritance between the respective associations, whereby the specialized relationship `redefines` is extended by the association class `Redefinition`, to specify further details. Similar to `hasTargetNS` the relationship `imports` allows assigning a prefix in the context of the respective schema import.

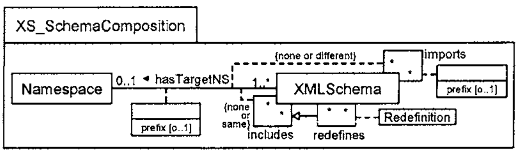

Fig. 5. Meta Schema of XML Schema Composition and Namespace

`XS_Types` is responsible for providing all necessary information concerning different kinds of types supported by XML Schema, comprising the differentiation in built-in types, i.e., *predefined types* versus *user defined types* as well as in *simple types* versus *complex types*, expressed by inheritance relationships (cf. Fig. 6). Predefined types comprise, for instance, `string`, `integer`, `date`, but also some special ones like `anyURI` to represent URIs and `QName` (qualified name) to specify a name that may have a namespace prefix. Simple types specify domains for atomic values, whereas complex types specify domains that hold nested elements, for instance.

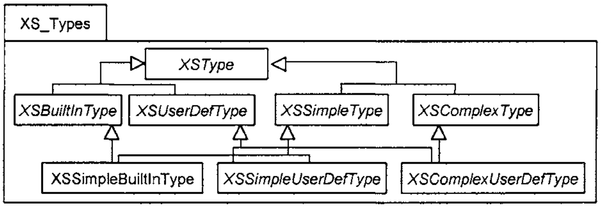

Fig. 6. Meta Schema of XML Schema Types

Resultant combinations supported by XML Schema, which are depicted in Fig. 6 by means of appropriate specializations, are simple built-in types (`XSSimpleBuiltIn Type`) as well as simple and complex user defined types (`XSSimpleUserDefType` and `XSComplexUserDefType`, respectively). Concrete occurrences of the latter two are described in corresponding sub packages.

`XS_SimpleUDTypes` allows specifying alternatives of simple user defined types, expressed by specializations of `XSSimpleUserDefType` in Fig. 7. All these alternatives are connected to `XSimpleType` by respective relationships, denoting different roles the type may play. The alternatives are restrictions (`XSRestriction`) of simple types (role `base`), unions (`XSUnion`) of simple types (role `memberType`), and finally, lists (`XSList`) of simple types (role `itemType`). By means of restrictions it is possible to specify enumerations, patterns, and lower and upper limits, for instance. This is in contrast to DTDs, where just enumerations are supported. Further, enumerations in DTDs are restricted to be of type string and may be applied to XML attributes, only. This limitation is reflected in the meta schema part for DTDs 9.

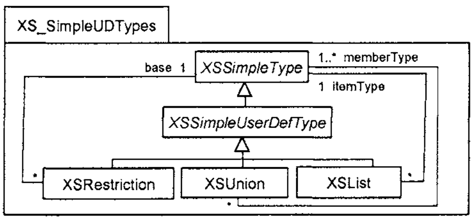

Fig. 7. Meta Schema of XML Schema Simple User-Defined Types

`XS_ComplexUDTypes` allows storing different kinds of complex user defined types, expressed by specializations of `XSComplexUserDefType` (cf. Fig. 8). First, there are composite types with element content (`XSCompositeType ElemContent`) and with mixed content (`XSCompositeTypeMixedContent`), both containing nested elements, whereby the latter in addition contains atomic values in between the nested elements. Second, there are special kinds of types also called complex types, namely types with an atomic value together with attributes (`XSAtomicTypeWithAttr`) and empty types possessing neither element content nor an atomic value (`XSEmptyType`).

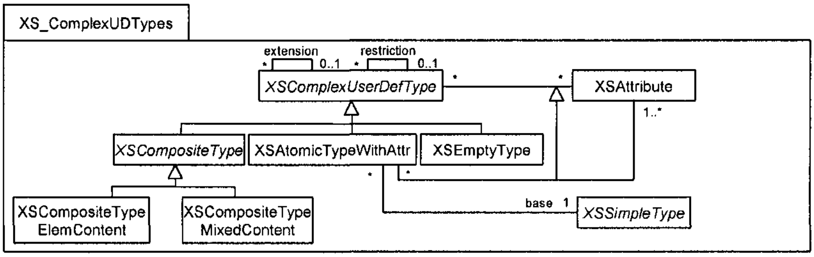

Fig. 8. Meta Schema of XML Schema Complex User-Defined Types

The former holds a relationship to `XSAttribute`, representing a specialization of the general relationship between `XSComplexUser DefType` and `XSAttribute`, in that the actual type must at least obtain one Attribute. Finally, complex user defined types may be extended and restricted, respectively, being depicted in Fig. 8 by recursive relationships of class `XSComplexUserDefType`.

5 Related Work

In 9, we provide an in-depth comparison of X-Ray to thirteen related approaches, among them research prototypes like LegoDB 2, SilkRoute 4, and XTABLES 5 as well as XML support of commercial RDBS, namely DB2 1, Oracle 6, and SQLServer 13. In the following, the most distinguishing characteristics of X-Ray with respect to the compared approaches will be summarized. Most of the approaches hard-code the *mapping knowledge* and about one-third reifies the mapping knowledge within files. Only one approach reifies the mapping knowledge within a database as X-Ray does, thus ensuring mapping transparency and easing maintenance of mapping knowledge. Only a few of the approaches support *multiple schemata* at the DB-side, whereas half of them support multiple schemata at the XML-side. Only one of these approaches supports multiple schemata at both sides, like X-Ray does by allowing multiple relationships between the reified concepts of the schemata to be defined the meta schema. About one-third serves for both, *publishing and storing* of XML documents and thus, provides a unified approach as X-Ray does. Most approaches provide *access* via the XML schema side, one approach allows to access the mapping knowledge as X-Ray does and thus to reason about the mapping knowledge by querying the DB storing the mapping knowledge.

6 Outlook

Future work goes into three different directions. First, XML Schema concepts currently not supported by the meta schema and the prototype, respectively, have to be investigated and incorporated appropriately. Concepts actually not supported by the prototype are complex types with mixed content, simple user-defined types, documentation, notations, the *any* concept, as well as element and attribute groups. Whereas element and attribute groups represent valuable concepts to facilitate reuse and thus, should be incorporated, the any concept enables XML documents or parts thereof to contain arbitrary data, not necessarily conforming to a particular part of an XML schema. Since this is in contrast to the philosophy followed by X-Ray, this concept could be supported by mapping such elements or attributes to single attributes of an RDBS relation, only, instead of decomposing them and mapping them to different attributes.

Second, it has to be elaborated to which extent existing algorithms for the semi-automatic detection of heterogeneities and the generation of subsequent mapping knowledge (cf., e.g., 12) could be employed in X-Ray, to at least partly relieve the user from the burden of defining the mapping knowledge manually. It has to be emphasized, however, that the automatic generation of mapping knowledge, i.e., without user interaction, is problematic in case of schemata developed independently of each other. Such an automatic generation would be especially feasible for the simple case where one schema should be derived from another, already existing schema, which is, however, not the focus of X-Ray.

Third, the approach of X-Ray is currently applied in the realization of ubiquitous web-enabled EIS, i.e., EIS relying on the anytime/anywhere/anymedia paradigm, being context-aware with respect to time, location, device, and user preferences, for instance. The goal is to employ X-Ray to mediate between existing XML-based context and content stored in relational databases 11. With X-Ray, maintainability and changeability of context data could be enhanced, since the mapping knowledge is not hard-coded but rather reified within a meta schema. The meta schema would allow to automatically compose context data out of an RDBS when requested and decompose them when they have to be stored.

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Continual Business Transformation Technology

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Abstract. Enterprises always have to pursue for profitability while maintaining long term competitive advantages. Today, this task becomes more challenging due to globalization and dynamic changing business environment. For each enterprise, this task can not be fulfilled without changes to its business infrastructure and IT systems. That is, enterprises need to *transform* themselves to adapt to both external and internal changes. This kind of transformation is not simply any transactional act, but rather a never-easy journey. In this paper, the concept of *continual business transformation* is introduced with key challenges identified. Based on experience from practical cases, we propose a set of business transformation technology framework that incorporates component-based approach and business-driven architecture. In the framework, *CBM* (Component Business Modeling) method is to identify transformation opportunities and provide guidance to IT architecture design from business perspectives. As transformation needs to be conducted in a holistic view, *IT Blueprint* in the framework is to provide an enterprise-wide IT design and governance model. To avoid building more silo applications as happening today in many cases, the IT Blueprint can be used to guide solution development for better alignment among different applications as well as across various stages during the transformation. Another keystone in the framework is *Assetization*, which is proposed for quality improvement and cost reduction from harvesting and reusing artifacts built in the transformation journey. Furthermore, we also illustrate how these methods and technologies were validated in a transformation engagement with a leading international bank in Asia-Pacific with satisfactory results.

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1 Introduction

In today's dynamic business environments, enterprises are forced to change in a much faster pace and broader scope [1]. Due to the limitation of resources (e.g., budget, time, human resource, etc.), concerns of risk factors, and other organizational issues, enterprises typically can not accomplish their intent in a single act. In many cases, there are changes upon the results of previous changes. Looking from a holistic view, these changes require a conscious design, instead of relying on any random, impulsive, and reactive action. These changes, when executed under a grand plan, form the transformation of the business. Transformation is a long journey, not a one-shot transaction. It has to be carried out in an incremental and progressive fashion. Each project in transformation has to be leverageable to justify succeeding projects with sustainability. Therefore, we propose this notion as "continual business transformation" and focus our research on developing innovative methods and tools to ensure coherent transformation across the whole transformation lifecycle.

The rest of this paper is structured as follows. In Section 2, business transformation trends are discussed and the gaps in methodology are examined. Then a business driven end-to-end transformation methodology framework is presented in Section 3. Its application in a customer engagement is presented in Section 4. Concluding remarks are presented in Section 5.

2 Continual Business Transformation

The environment of enterprises is under changing. Demand becomes more dynamic. Competition is more severe. New business models are continually emerging. Enterprises need transform their business model and operations, with prompt and strong supports from corresponding IT systems, so that their businesses can keep up with the demands from both the environment and their own strategies [2]. The "perfect" state of business transformation is that an enterprise can respond with speed to any customer demand, market opportunity or external threat with an integrated end-to-end business process across the company and with key partners, suppliers and customers.

It may look like a simple task superficially. In many of the state-of-art practices, practitioners believe that the final *To-Be* state of a business and its IT is most critical. The typical practice will compare the *To-Be* against the *As-Is* state, identify the gap, define the transformation roadmap accordingly, execute, and it's done! But realities suggest differently.

First, business transformation takes time and things change. During the journey, the whole ecosystem that affects the enterprise will not remain static. There are always significant changes beyond control. This makes the ideal *To-Be* state constantly changing as a moving target in the dynamically changing business environment. This concept is illustrated in Fig. 1.

Second, business transformation is carried out under constraints. With pressures from many dimensions, transformation cost and resource allocation require strong justification all the time. All these factors make the business transformation extremely hard in real practice, especially for the businesses with strong awareness of ROI (Return of Investment), time-to-market, and sustainable growth.

Third, business transformation often requires preparation in many aspects, both business side and IT side. Each side alone is incapable of accomplishing the targets.

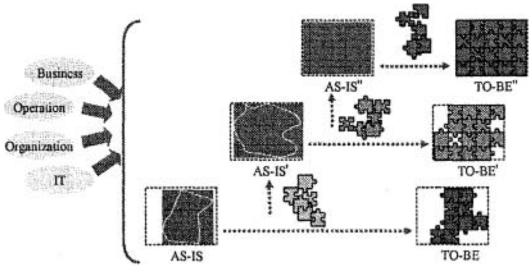

Fig. 1. Continual Business Transformation

For the moving target - *To-Be* state, it is important to follow a robust and systematic methodology to transform their businesses and building their IT system. Then all the artifacts generated each time by the methodology have some characteristics even the view of the future is evolving. Meanwhile transformation needs to take an incremental and progressive approach. It can not be done in one shot, but through a long journey.

Reducing cost and risk while achieving more is very important for sustainable transformation. This can be achieved via asset reusing, better communication for consensus, and by leveraging industry best practices. To achieve high levels of reuse, asset need be organized in a reusable way, i.e. well aligned with business and IT architecture. Reuse is not a separated process or project; instead it should an integrated part of the transformation journey [3].

In information technology, component paradigm and architecture is an efficient way to enable applications mapping on various execution platforms and provide adaptability [4, 5]. Since business changes are often the source of IT system changes, business is also desired to be componentized to speed up the responses speed to market changes and keep IT changes at the reasonable level.

These several factors and capabilities, which are critical to the success of transformation, are the ones in the journey of what we call "Continual Business Transformation". The "continual" not only reflects in continually changing environment and business needs, but also the evolving transformation journey.

3 An End-to-End Business Transformation Methodology

3.1 Methodology Overview

Based on our study and practice, a Continual Business Transformation (CBT) methodology is formed and proposed to facilitate the end-to-end transformation from business strategy to solution development as shown in Fig. 2.

- At business side, CBM (Component Business Modeling) method is adopted to componentized business to provide guidance to IT architecture design, and identify transformation opportunities as well as develop business transformation roadmap.
- At technology side, IT Blueprint method is addressed to build the enterprise-wide architectures to guide solution level design to ensure the consistency and benefit the enterprise as a whole.
- At business operation and solution side, modeling technologies in BPM (Business Process Management) is introduced to support and link the enterprise level and solution level designs (including both business and IT). Modeling technologies and tools is applied to build component-based IT solution design/implementation to fulfill the enterprise transformation vision.
- Asset Management technology is adopted to accelerate the continual process by asset harvest and reuse.

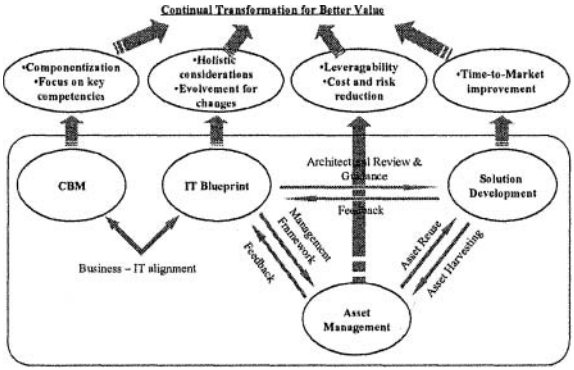

Fig. 2. Continual Business Transformation Framework Overview

Since CBT methodology is a systematic end-to-end methodology, from business level to IT level, the linkage between different parts also has been formalized and structured for interactions. Based on the integrated framework and formalized models, the requirements mentioned in Section 2.2 can be well satisfied. It should be emphasized that the end-to-end methodology does not mean that each practice should begin from CBM, then to IT blueprint and finally to solution development. In fact, it can start from any parts according to the real situation. In the followings sections, the detailed technologies for each part will be introduced.

3.2 Business Component Modeling

The idea of viewing a business as a set of interlocking components — and the underlying notions of specialization and reusability — isn't exactly new [6, 7]. Businesses have always understood that to be as efficient, effective, and profitable as possible comprising components with discrete services. Yet traditional business modeling, based on mapping individual business processes, does not incorporate this idea. Component business modeling (CBM), which is a business decomposition methodology that has been used successfully by IBM in various engagements across industry sectors [8, 9], allows analysis from multiple perspectives because it groups like activities together without regard to organizational, geographic or process boundaries, companies can more readily spot redundancy – similar business resources (people, assets and technology) that are duplicated in other corners of the company, as well as strategic, differentiating capabilities.

CBM offers a new way to analyze business and enables a clear focus on the strategic capabilities of the business. And, applying various evaluation criteria to the components—e.g. cost, revenue, strategic fit—produces a 'Heat Map,' which shows where opportunities exist. Figure 3 shows an example of a component business model for the banking industry.

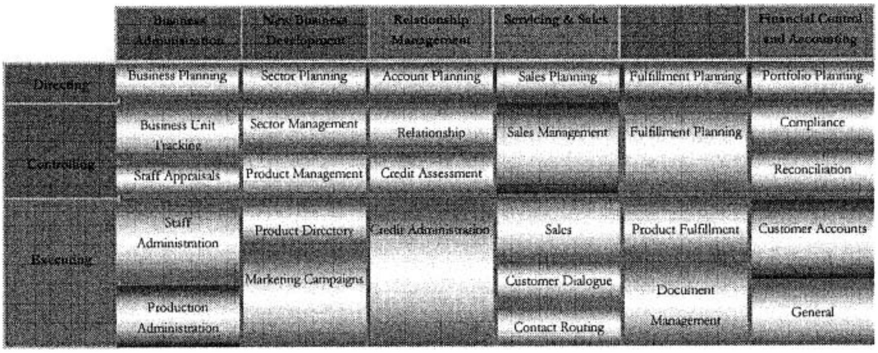

Fig. 3. A component business model

Further, we can model *As-Is* state and *To-Be* state separately with the same structure. To-Be state modeling can leverage industry map comprising best practices. Based on the comparison with *As-Is* model and *To-Be* model, the gaps can be identified for transformation opportunity generation. The gap analysis of the business component efficiency and effectiveness determines if certain technology-based reengineering can help streamline the process, improve operating efficiency and optimize strategic business advantage. Generally, three types of issues tend to arise in the shortfall assessment:

- A structure gap is a qualitative statement of the shortfall between current business organization and those that were best practices.
- A performance gap is a quantified statement of the shortfall between current

business results and those that were expected.

- An opportunity gap is a quantified assessment of the discrepancy between current business results and those achievable with a new business design.

While a performance gap can often be closed by focusing on superior execution, with no change to business design, and structure gap can be closed by simple business design, closing an opportunity gap requires a new business design.

3.3 IT Blueprint

As CBM provides a good base for figuring out the appropriate business model for an enterprise, analyzing the business operations and identifying the business transformation opportunities, we also need similar holistic views for IT. These holistic views can provide a base for individual pieces of the IT to be well described and planned, with guidelines and principles defined which can help govern future actions on refining the holistic views and the individual pieces. Although these views enforce some kind of constraints on individual pieces and individual transformation projects, it helps avoid creating new silos which can not talk with each other, and benefits the whole continual transformation a lot. We call these holistic views IT Blueprint as a whole, and have defined a framework to systematically organize the views in a way so that they can be better described, managed and used in guiding the IT transformations. Figure 4 illustrates the high level structure of the framework.

As the core of an IT Blueprint, the Blueprint Model describes the total picture of the enterprise's IT from Application, Data and Technology perspectives. This separation of concerns is crucial, because to align IT with business, we must identify what pieces of the IT are most relevant to business operations, and what the inter-relationships are. Based on our study, applications and data are very relevant ones while technologies focus more on infrastructure, which can be business function neutral to a certain extent. According to best practices nowadays, applications should be componentized and align with business operations, for which the Business Components in CBM can provide good guidance on defining the boundaries for application level components. Data should be defined by taking into account the business information needs at business operation level. In addition to the core models, principles, guidelines and standards need to be defined, together with a governance framework, which includes the necessary organizations and processes, to help govern the future changes of the core models and the execution of individual IT transformation projects. Also, according to the specific requirements of the enterprise, the suitable reference architectures can be selected and customized, which can be used as architectural assets for reuse to guide high level designs of individual solutions.

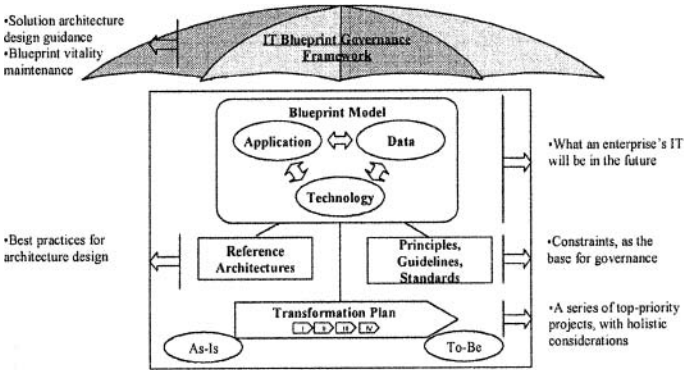

Fig. 4. IT Blueprint Framework

Although IT Blueprint is important, its value seems not directly related to short term successes. Meanwhile, building a complete IT Blueprint is costly in terms of time, money and skills involved. Even worse, the value of the static To-Be IT Blueprint built through months or even years is often under suspicion, because during that period of time, a lot of changes will happen and the To-Be can be quite different. That is why resources and supports usually go to urgent projects like adding new functions of strong customer demands or resolving a performance problem which customers complain a lot. That is also why in the long run, without architectural guidance and governance, enterprises usually face a lot of problems and come to realize that IT Blueprint is the key for a successful continual transformation.

3.4 Solution Development

IT solution building has always been the key step for enterprise business transformation. It is through solution building that business/IT strategic planning and analysis finally get into reality. With the business environment gets more and more complex & dynamic, which in turn generates higher and higher expectation on IT technologies from business side, the traditional way of building IT solutions are becoming less competent. The following challenges can be easily observed in today's solution building practices [10]:

- Gap between business requirements and IT capabilities
- Gap between overall IT architecture and individual IT solutions
- Gap on IT skills and business knowledge

Model-driven solution building approach is adopted in the methodology to address all above challenges. Basically, this method is built up by referencing and enhancing existing methodologies (such as Rational Unified Process). Figure 5 shows the main development phases and key features in the method. Models can help users better communicate with each other to gain better understanding of requirements, to design well structured solutions, and to maintain and manage the bi-way linkage between them. With the modeling of overall IT blueprint, adding corresponding solution building technologies that can fully leverage them, we can manage to build solutions that are in align with the overall blueprint, which are also evolving by receiving input from each single solutions. For more information, please refer [10].

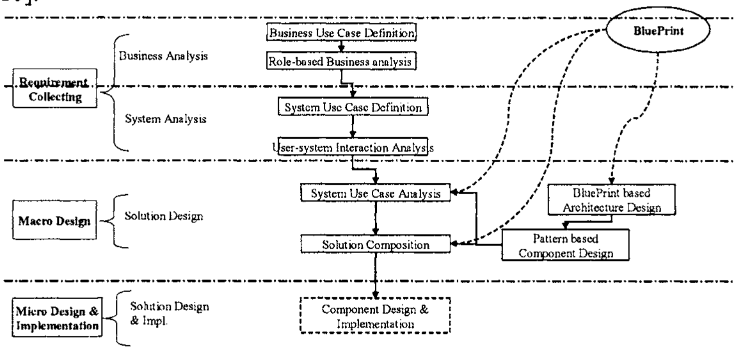

Fig. 5. Solution Building Methodology

3.5 Assetization

Sometimes the value of assetization of the business and IT stuff for a single client is not fully realized, because people usually think the chances of reuse are quite limited (although some clients need to replicate certain solutions across various geographies, and some even want to sell their own solutions to others). But if we take the time dimension of the continual transformation and the changes during the course into consideration, assetization shows specific value – once the key knowledge of both the business operations and IT systems are captured in appropriate formats, packaged and managed as assets across the enterprise, you can find that some inhibitors for continual transformation disappear. For example, the artifacts of previous solutions can be easier to share, understand and leverage in follow-on projects to facilitate decision making and development, and the strong dependence on certain key people can be alleviated to reduce cost and risk, etc.

Assets can be harvested and reused in the end to end methodology, from CBM model, IT blueprint, to solution components and infrastructure patterns. The two natures of asset are value and reusability. To increase the reusability, there are three key perspectives for asset based development as shown in Figure 6.

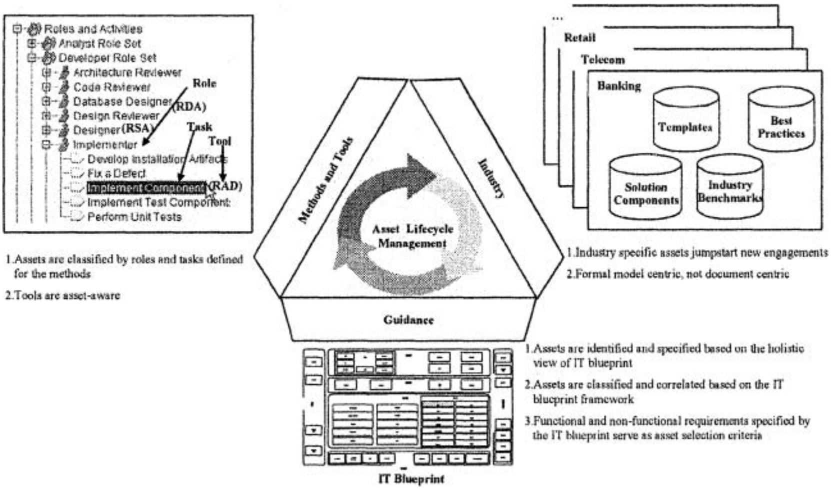

Fig. 6. Assetization in continual business transformation

- Assets should be integrated with solution methodologies and tools. Facilitated by asset aware method and tools, solution developers find right assets at right stage of methodology; at the same time, solution artifacts are developed not only for individual solution, but also developed for reuse.
- Assets can be better planned, organized and managed by using some holistic views of the enterprise, for example, IT Blueprint is good for managing IT assets. Its contents (function specification, non functional requirements, principles ...) can be served as important guidance for assetization, to improve consistency, reliability and quality. Meanwhile, since we follow IT Blueprint guided approach for solution development, the well-defined structure and relationship between IT Blueprint and IT assets can help us to clearly identify the assets that can be reused, need to be enhanced or developed in an individual solution. Similar to what IT Blueprint does for IT assets, CBM views, on the other hand, provide a good base for organizing knowledge and designs of business functions, processes, metrics, etc.
- Assets should be industry or domain specific to formally represent industry or domain best practices and insights.

3.6 Other Key Technologies

In the above framework, there is many types of models covering different perspectives and are closely related with each other. A common environment for model linkage is very important. Layered models play crucial roles in model driven business transformation. Models are prone to be changed due to various reasons. Our practice reveals that frequent model changing results in a big issue – inconsistency is usually brought by and conflict between models gradually erodes the overall solution. Current manual method costs too much and the veracity of conflict analysis is doubtful. Therefore, systematic technologies are needed to help tracing the related models in a solution, analyzing the propagation of change impacts and synchronizing the impacted models to keep the overall consistence of the solution.

In enterprise modeling, there are a lot of glossaries. It is indispensable for effective business analyzer to have a clear semantic relationship between them. So semantics technology is very important.

4 Case Study

The methods and technologies illustrated in this paper were validated in a transformation engagement in a leading international bank in Asia-Pacific. The bank mission is to become a trusted financial institution of the Pacific Rim. In the past years, this bank has achieved numerous accolades from leading financial periodicals for its competitive capability and innovation.

In an industry transformed by deregulation and consolidation, this bank is facing increasingly intense competition that forces them to find ways to increase revenue and improve customer satisfaction. Facing these challenges, this bank wants to do the following transformations: 1) enhancing strength in potential *M&A*; 2) *core System Transformation* to support continual improvement to sustain competency in market, and 3) being *Customer Centricity* to explore cross-sell and up-sell opportunities to increase profit margin. In 2004, facing market pressure and potential M&A opportunity, this bank wanted a more strategic change on core banking system and business operation. Thus Customer Oriented Core Banking System Transformation project was kicked off. On June 2005, IBM China Research Laboratory delivered a continual business transformation method to help this bank transform its flagship financial product from their legacy system to a new open framework, which is componentized, scalable, flexible and easy to reuse in future. This set of technologies bridge business and IT effectively and can be able to evolve in a disciplined way in course of the continual business transformation journey. It received very positive feedback from the customer.

5 Conclusions

Facing today's highly competitive and dynamic market environment, enterprises are forced to transform their business and IT in order to sharpen their focuses, achieve their operational efficiency and improve their responsiveness to the changes, which requires a methodology to align business with IT in an evolving way. A business driven and component based business transformation methodology framework is proposed in this paper. Based on business strategy and business needs, CBM can help identify transformation opportunities, develop transformation roadmap and guide IT architecture design from business perspective. IT blueprint method provides overall IT architecture to align enterprise application with business architecture and enterprise future development. Component-based model-driven solution building method facilitates the process from business process to solution design and implementation. Assetization method helps enterprise reuse useful assets in the continual transformation. Several other fundamental technologies are also mentioned in this paper. This methodology framework is adopted in a real customer engagement. It's proved that such methodology is effective not only seamlessly links from business design to business processes to IT implementation, but also coordinates the individual transformations to fulfill the enterprise transformation vision. It enables the customers' continual transformation to accommodate ceaselessly changing conditions.

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Business Componentization: A Guidance to Application Service Design

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Abstract. Aligning IT with business both at the strategic level and at the operation and management level is a challenge in enterprise architecture design. A simplistic approach of linking IT systems with business processes would not sustain because business processes are usually under continuous changes. In this paper, business componentization is proposed to address this challenge. An enterprise can be described as a set of business components with business services as their interaction interfaces. This paper discusses how business components can help the design of enterprise architecture. Also, we propose an interactive quantitative approach for business componentization. A business component is clustered from business activities based on a tightness evaluation of business processes, organizations, and IT systems. This paper presents a heuristic algorithm, and an aggregated clustering algorithm, for developing well-defined business component maps.

1 Introduction

In the face of dynamic business environments and markets, enterprises need to transform their business frequently and rapidly. *Business transformation* is a key executive management initiative that attempts to align technology initiatives of an enterprise closely with its market environment and business strategy, and is achieved through efforts from both of the business and IT sides of the company.

At an IT level, there has been a good deal of work for reducing the cost and effort of such transformations. It includes design methods (e.g., Object-Oriented Programming, Model-Driven Architecture, and Component-Based Development), development technologies (e.g., Integrated Development Environment), architecture

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methods (e.g., Service-Oriented Architecture, Middleware and many application-specific frameworks), software development process management (e.g., Rational United Process), and IT service management methodologies (e.g., IT Infrastructure Library), to name a few. These technologies and methodologies make IT systems and their implementation flexible and efficient for changes. However, it is apparent that an IT-level effort alone is insufficient to address the challenge of providing agile enterprise application systems supporting rapidly changing business requirements. *Enterprise Architecture* [1, 2] is an effort to bridge IT and business to achieve the intended goal of business flexibility. It provides a comprehensive and rigorous method and framework for describing a current or future structure for an enterprise's processes, information systems, personnel and organizational sub-units, so that they align with the organization's core objectives and strategic direction. Besides, it also includes certain methodologies to realize it in an enterprise. Although often associated strictly with information technology, enterprise architecture relates more broadly to the practice of business transformation, and so that it addresses business architecture, performance management and process architecture as well.

Based on the IT trends and EA methodology, the notion of services orientation is extended to an enterprise-level as SOE (Service Oriented Enterprise) 3. While it presents an ideal vision of a world in which resources are cleanly partitioned and consistently represented in terms of services, it also requires an appropriate way for service identification and implementation to make it practical. Until now, there is little work on how to identify applications or IT level services from a business perspective. To fill the gap, we propose a top-down approach using *business componentization.* In information technology, a component as a reusable building block has been an important concept to make IT systems responsive, variable and resilient. In a similar way, a *business component,* i.e., a reusable and loosely-coupled business-level block would make business architecture and operations more responsive, flexible and resilient. A business component is a logical view of part of an enterprise that includes resources, people, and systems necessary to deliver some value. An enterprise can be described as a set of business components with *business services* as the interaction interfaces. This paper discusses how business components can help the design of application services in enterprise architecture. Also, we present an interactive quantitative approach for business componentization.

The rest of this paper is structured as follows: Section 2 describes how business components can help in enterprise architecture design. Section 3 presents the heuristic algorithm for identifying business components from business activities and processes. In Section 4, conclusions are drawn and future work is outlined.

2 Business Component for Application Service Design

2.1 Business Components

In information technology, the notion of componentization is well-rooted. Especially in the hardware domain, the notion of plug-and-play has been widely accepted and applied. It implies instant connection and operation – ideally, the user should not need to restart your computer, or go through an elaborate installation routine. In the application (or software) domain, the component notion has also been widely adopted, although probably not so complete as that in the hardware domain. In business architecture, the notion of componentization is novel. Most of business design or transformation is based on a business process (or value chain) analysis. However, as market emphasizes the speed of strategic changes, componentization becomes more critical in the business architecture. If a complex business is unbundled into separate components, its strategic changes would be easier to manage. Veryard 0 gives a detailed analysis about the management and technical drivers of business componentization.

In fact, the idea of componentization has been adopted and used in many industry solutions and frameworks, though some in different wording. For example, "main process" in SAP's solution map 5 has business goals/objectives, and is composed of several processes. eTOM 6 is another example. Level 2 processes of the eTOM Framework can be viewed as the components of information and communications services industry. However, the components in most of these process-based frameworks are only high-level business processes (or activities), which cannot be directly used in business reconfiguration. For efficient business transformations, a more service-oriented notion of business components would be needed.

A business component is a unit of business functionalities that serves a unique purpose, and is comprised of a group of cohesive business activities supported by the appropriate information systems, processes, organizational structure, and performance measures. It has the potential to operate independently, in the extreme case as part of another company. The composition of a business component is illustrated in Fig 1.

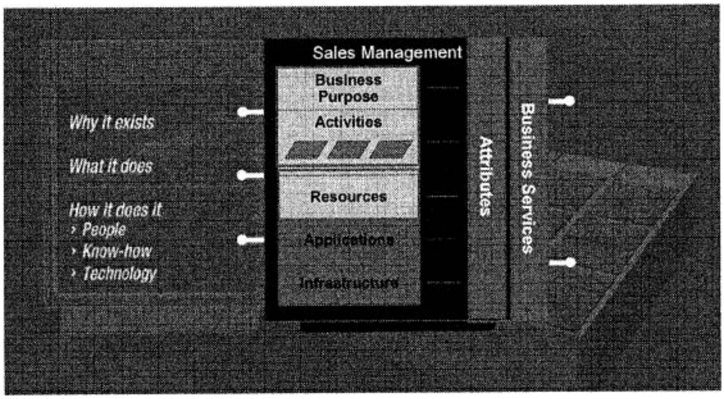

Fig. 1. Business component

From an external perspective, a business component can be described by business services that it offers and refers to, and related KPIs (Key performance Indicators). A business service is usually based on grouping of business functionalities. The grouping may be based on workflow, tasks, activities, and often include implicit or explicit rules. From an internal perspective, a business component can be described by business activities, resources, technology, and business process. The relationship between a business component and other entities is shown in Fig. 2.

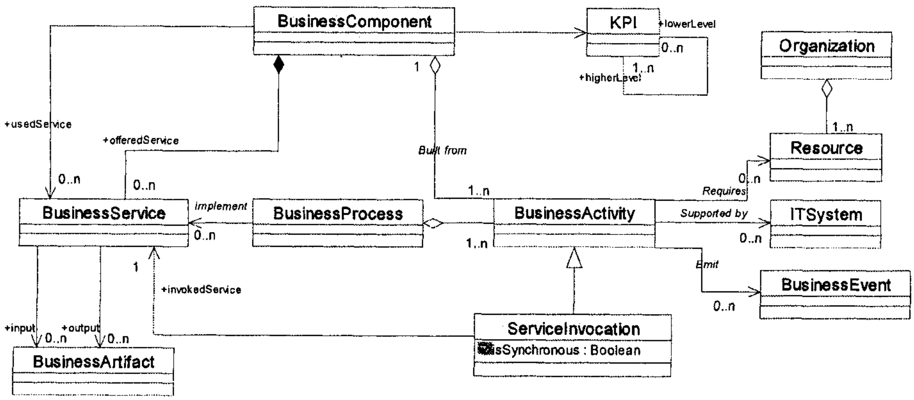

Fig. 2. The relationship between business component and related entities

It is important to note that the notion of business components mentioned in this paper differs significantly from what is presented in other literatures 7. Often, a business component is defined as an IT component that is used in business applications. The business component in presented this paper describes business level content.

Component Business Model (CBM) 8 is a technique for modeling an enterprise as a set of non-overlapping components in order to identify opportunities for innovation and improvement. Business components are organized as tabular view called as *business component map* with business competencies as columns and accountability levels as rows. An *accountability level* characterizes the scope and intent of activity and decision-making. The three levels used in CBM are directing, controlling and executing. Directing is about strategy, overall direction and policy. Controlling is about monitoring, managing exceptions and tactical decision making. Finally, executing is about doing the work. A *business competency* is defined as a large business area with characteristic skills and capabilities, for example, product development or supply chain. A component map is logical view of business operations, so it can be independent from enterprise size. Enterprises in the same industry can share the same or similar component maps, referred to as industry maps.

There is no simple compositional relationship between business processes and business components, because a business process is often a hierarchical structure. A high-level business process may depict the interaction between several business components, while a detail-level business process (or business activity) may lie inside of a business component. A business component can be viewed as a suitable-granularity business entity with a clear interface (i.e., business services). Thus, it is desirable for a business component to be supported by a single application, an IT component, or a minimum number of applications (or IT components) at least 9.

2.2 Business Components for IT Architecture

IT services can be classified into several categories, such as application services, infrastructure services, and enterprise service bus 10. It is hard to identify infrastructure services and enterprise service bus from business perspective, because these services are mostly designed from the IT perspective. Therefore, standard or reference IT service architecture (such as On Demand Operation Environment 10, or Service Oriented Computing 3) is often indispensable in IT architecture design. A business service potentially provides guidance for an application service. Below, an IT service refers to an application service.

Even specified to an application service, there is no simple way to convert a business service to an IT services. For instance, in a bank's business component map, let us assume that a business component, say, "application processing," offers two business services, "customer application submission" and "customer application status query". Also let us assume that it invokes three business services, i.e., the "product information query" service from the component "product profile", the "customer profile" service from the component "customer relationship management", and the "document recording" service from the component "document management". First, it is important to note that not all business services will be implemented as IT services, e.g., the "application submission" service can be a manual process where paper-based applications are transferred between branches. Secondly, a business service may have several implementation patterns. For example, the "application submission" service can be implemented as a web service, a phone-based service, or even a manual channel.

However, a business service can provide certain guidance for IT service design in the specification of functional requirements, non-functional requirements, and data. The relationship between business services and application services is shown in Fig. 3. Another potential guidance lies in the interaction patterns. The interaction patterns of business components may be used to design the communication patterns of IT components.

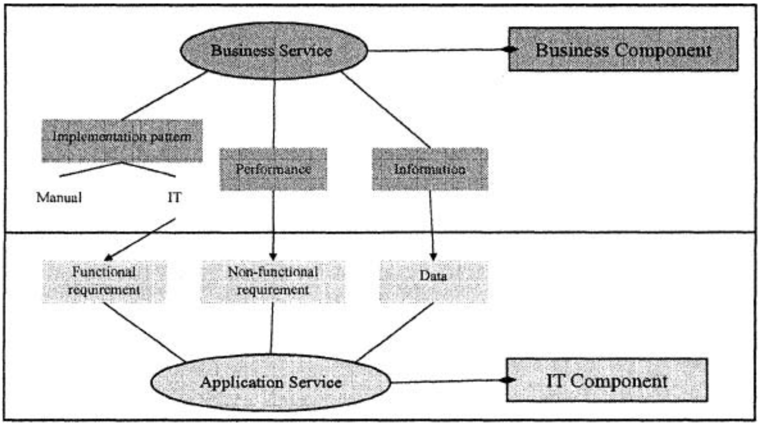

Fig. 3. Business component guidance in application service design

Combined with the existing reference IT service architecture, application services can be identified through business services. Certain common or infrastructure IT services will provided by the IT service architecture. If an application service is well-aligned with a business service, high-level process changes will have little impact on applications, because the interfaces at the business level will not be changed, and the impact of detailed process changes within a business component will be localized.

3 Business Component Identification

In previous sections, we assume that the business component map already exists. In practice, construction of a business component map for an enterprise is a challenging problem. One approach would be to create an enterprise map by customizing reference models such as industry maps developed in previous CBM consulting practices. Another approach would be to build one from existing artifacts such as business processes and activities, applications, organization, etc. This paper focuses on the latter approach and proposes a quantitative method.

A business component is specified by as a set of business activities (or business processes), offered/referred business services, execution organization, and supporting IT systems. Services are logical artifacts which depend on business component partitions. Without business component partitions, it is difficult to know what business services should be offered or referred. In contrast, business activities (or business process), organization, and IT system are all concrete, and they can be used to identify business components. To construct a general business component, business activities are often used as clustering elements.

A business component can be formed by manually clustering business activities into a component by using human perception of "tightness" among activities. However, the process can be formalized and automated while leveraging human knowledge. We propose an interactive quantitative approach, which consists of the following steps: 1) establish criteria tree to measure the tightness among activities; 2) evaluate the tightness of activities using the criteria tree; and 3) At last, cluster activities into business components by a clustering algorithm which uses the calculated tightness values among activities.

3.1 Criteria Tree and Tightness Evaluation

Similarly to a software component, a business component is expected to be tightly related by internal elements, while loosely-coupled with external components. In an Object-Orient Design 11, there are several metrics for deciding whether a class is appropriate, such as COB (Coupling between Object Classes) which measures the number of related classes, and LCOM (Lack of Cohesion in Method) which measures how methods are invoked by use cases. However, those measures are devised for post-evaluation, that is, measurement is done after the design is completed for checking if the design is appropriate. For the business component design, it would be desirable if it is possible to evaluate them at the design time.

The internal tightness among business activities can be evaluated for three aspects: process (e.g., time constraints and performance influence), organization (e.g., skill level or goal similarity), and IT system. From the process perspective, the interaction among business components should be kept at a low level. From the organization view, the human resource that a component requires should possess similar skill sets. From the IT view, the activities in a component are desired to be supported by the same IT system. Each aspect can be further break down to a criteria tree according to enterprise preference. Through criteria tree and evaluation methodology such as AHP 12 (Analytical Hierarchical Process), the tightness among business activity i and j, f_{ij}, can be evaluated.

3.2 Three-step Partition Procedure

For the clustering process, the following problems need be addressed:

- Input complexity, i.e., the quantity of input needed by the quantitative approach. This requirement is important, because it is usually hard for the user to accept a quantitative approach that requires too much input.

- Computational complexity, the component partition is a combinational problem. Without an appropriate heuristic algorithm, the computational complexity will be prohibitively high. A solution to this problem will be discussed in Section 3.3.
- Flexibility for user, the algorithm should allow user interaction during execution, which will be discussed in Section 3.4.

In business component identification, if the pair-wise comparison is applied to all the n activities in activities matrix, the input complexity will be $O(n^2)$. An activity matrix typically has about 300~500 activities, so overall pair-wise comparison is unsuitable.

To address the input complexity problem, we proposes a multiple-step partition approach, which allows the activity clustering to be carried out in several sections independently, and then components to be clustered from the local components. Below the intersection between an accountability level and a business competency is called as a *cell*. A cell usually contains multiple activities.

The business competency and the accounting level are important description of business activities. It is more likely that the activities with the same business competency and/or accounting level have a tighter relationship. Thus, instead of performing comparison of activity pairs over the entire activity matrix, it is more efficient to first focus on the activities with the same business competency and/or accounting level. Based on this idea, the following 3-step partition procedure is proposed:

1. Partitioning is applied to each cell independently;
2. Then, partitioning is applied to each column, i.e., business competency, independently. The composition is applied to adjacent rows, i.e., the accountability levels.
3. Finally, the partitioning is applied between columns.

Now, let us analyzes the input complexity of the algorithm by using a sample activity matrix with 3 rows and k columns, and m pieces of activity in each cell. If one-shot procedure which requires the pair-wise comparisons among all the $3km$ activities is adopted, the input data complexity will be $O(9k^2m^2)$. For the proposed three-step procedure, the data needed in the first step is $O(3km^2)$. Suppose that there are l components in each cell after the first step. The data complexity in the second step is $O(2k^2l)$. Suppose that there are average j components in each cell after the first step. If a component occupies two rows, it will be regarded as two components in calculating j. The data complexity in the third step is $O(3k^2j^2)$. To sum up, the input complexity of the multiple-step procedure is about $1/3 \sim 1/3k$ of that of the one-shot procedure.

3.3 Aggregated Clustering Algorithm for Activity Clustering

Aggregated clustering algorithm (ACA) tries to cluster most tightly related activities into a business component considering both tightness evaluation and cluster size, because best practices of the CBM methodology shows that the size of individual business components (i.e., the number of contained activities) should not differ significantly. The objects to be clustered can be business activities or components.

For the sake of simplicity, objects (activities or components) to be partitioned are referred to as a general name of elements, and objects after partitioning are referred to as clusters.

The input to ACA includes m elements and their tightness evaluation value. There are three control parameters. L denotes the final number of components. Threshold $\lambda \in [0,1]$ is used to terminate the clustering process when all the element affinities are below the threshold. Parameter α is used to balance the size of different components by increasing the value of α. The computational complexity of ACA is $O(m^2)$.

Step 1 Let the m initial elements be m independent components $\{G_i\}$. Denote the size of cluster G_i (i.e., the number of activities in G_i) as n_i. Total number of activities as N is given by $N = \sum n_i$. The average size of clusters, $\bar{n}$, is given by $\bar{n} = N / m$.

Denote the tightness between cluster G_i and G_j as d_{ij}, which satisfies $d_{ji} = d_{ij}$. To avoid the self-clustering, let $d_{ii} = 0$.

For $i = 1,2,\cdots,m$, $j = i+1, i+2,\cdots,m$, let

$$\rho_{ij} = \left(\frac{n_i + n_j}{2\bar{n}}\right)^{\alpha}, \text{ and } d_{ij} = d_{ji} = f_{ij} / \rho_{ij}.$$

Whence, α is a weight value, which can be adjusted by users.

Step 2 Find $d_{kl} = \max\{d_{ij} : i,j = 1,2,\cdots,m\}$ $(k < l)$. Aggregate G_k and G_l into a new cluster, and let it replace the original G_k. Let $n_k = n_k + n_l$, $\bar{n} = N/(m-1)$,

For $i = 1,\cdots,k-1,k+1,\cdots,l-1,l+1,\cdots,m$, let

$$\rho_{ik} = \left(\frac{n_i + n_k}{2\bar{n}}\right)^{\alpha}, \text{ and } d_{ik} = d_{ki} = \max\{d_{ik}, d_{il}\} / \rho_{ik}.$$

Delete column l and row l from matrix D. Let $m = m - 1$.

Step 3 Repeat Step 2, until the number of clusters decreases to a given number L, or $\max d_{ij} < \lambda$.

3.4 User Interaction

The business component identification algorithms should be able to utilize human knowledge, because the accuracy of the tightness evaluation may heavily depend on domain knowledge. To leverage human knowledge and expertise, the proposed algorithms allow user interactions. Table 1 summarizes several user interaction scenarios, which can be translated as constraints or input of ACA.

Table 1. User interaction and handling method

User scenarios	*Translation to ACA*
Only selected elements will be clustered	Limit the elements input to the algorithm
Existed components cannot be altered	Limit the elements input to the algorithm
Element i and j must be joined together	$f_{ij} = 1$
Element i and j cannot be joined together	$f_{ij} = 0$
Delete current components	Free activities from components

3.5 Example

In the activity matrix shown in Fig. 4, there are 20 business activities. The number of comparisons (input complexity) of the one-shot approach would be 190, while that of the three-step approach would be 57. A pure algorithm-based approach is followed. The activities within the same red double block belong to the same business component.

	Business Administration	Product Management	Acquisitions
Directing	Develop business strategy	Develop segmentation strategy	Design and plan campaign
	Identify core capabilities	Define target segments	Define acquisition strategy
	Define organization structure	Track activity against segment plans/budgets	Develop target segment characteristics
	Develop operating model for the organization	Analyze product portfolio	Plan, define and conduct in-market acquisition tests
Controlling	Monitor Performance to Plan	Develop product specifications and features	Develop balanced building campaigns
	Design and develop HR policies		Monitor execution of campaigns
Executing	Train staff	Deploy product	Acquire target prospect list

Fig. 4. Activity clustering

4 Conclusions

Aligning IT with business at the strategic level and also at the operation and management level is a challenge in enterprise architecture design. We argued in this paper that business components provide useful views and guidance for application service design which was difficult with the traditional business process-based models. Also, we proposed an interactive quantitative approach to constructing business components from business activities based on the tightness evaluation of business processes, organizations, and IT systems. This paper presented an aggregated clustering algorithm to help form well-defined business component maps with input data complexity, computational complexity, and user interaction flexibility.

Business componentization augments Enterprise Architecture with a novel view of businesses and help guide the IT architecture design. In addition, an extension to component business modeling provides analytical capabilities for business transformation and outsourcing. There are a number of interesting technical problems in this new direction of study. For example, it would be useful to identify and compose business services directly from business interaction, once business components are identified. Another interesting problem would be transformation between business services and IT services by using a formal model transformation technique.

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Particle Model to Optimize Enterprise Computing

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Abstract. This paper presents a novel generalized particle model (GPM) for the parallel optimization of enterprise computing*. Since enterprise computing always involves the resource allocation, task assignment, and behavior coordination, without loss of generality, the proposed GPM is devoted to the optimization of enterprise computing in the context of the resource allocation and task assignment in complex environment. GPM transforms the optimization of enterprise computing into the kinematics and dynamics of massive particles in a force-field. The GPM approach has many advantages in terms of the high-scale parallelism, multi-objective optimization, multi-type coordination, multi-degree personality, and the ability to handle complex factors. Simulations have shown the effectiveness and suitability of the proposed GPM approach to optimize the enterprise computing.

1 Introduction

The distributed enterprise computing is featured by the geographically distributed resources and jobs, heterogeneous collection of autonomous systems, and collaboration based large-scale problem-solving. Since enterprise computing always involves the resource allocation, task assignment, and behavior coordination, their optimization in complex environment is of great significance for the quality-assurance and performance-improvement of enterprise computing.

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There have been numerous algorithms and strategies for the optimization of enterprise computing. But most of them have the following limitations and disadvantages:

• Not suitable for enterprise computing in complex environment that may be related to multi-type coordinate, multi-degree autonomy, multi-objective optimization, multi-granularity coalition, and randomly and concurrently occurring phenomena.

• Just simpler coordination, such as cooperation and competition, is considered. Unilateral, unaware and unconscious co-ordinations are almost not taken into account.

• It is usually assumed that every entity of enterprise computing tries to increase either the aggregate utility of whole systems or its own personal utility. It turns out that all the entities seem to be either completely unselfish or completely selfish. Different autonomy and personality are not well embodied.

• The global control, global information exchange, and global objective are always required, so that enterprise computing can be realized only in series or small-scale parallel manner.

• The influence of the time-varying availability of entities, such as congestion, failure and priority level, on enterprise computing is not well considered. Particularly, the stochastic, emergent and concurrent nature of many phenomena can not be treated very well.

To overcome the above-mentioned limitations, this paper proposes a novel generalized particle model (GPM), which transforms the optimization of enterprise computing into the kinematics and dynamics of massive particles in a force-field. The features of the GPM-based enterprise computing optimization include the large-scale parallelism, multi-objective optimization, multi-type co- ordination, multi-degree autonomy, multi-granularity coalition, and the ability to deal with complex time-varying factors, e.g. the congestion, failure, and priority. Simulations have shown the effectiveness and suitability of the proposed GPM approach to the enterprise computing optimization.

2 Generalized Particle Model for Enterprise Computing

In order to formalize the enterprise computing optimization, consider the parallel distributed resource allocation among users. $Ç(\tau) = \{G_1, \cdots, G_m\}$ be a finite set of resource users, and $A\ (t) = \{A_1, \cdots, A_n\}$ be a finite set of resource suppliers in the time session τ . The supplier A_i provides the user G_j with the resource $a_{ij}(t)$ at time t, and meanwhile the user G_j offers the payment $p_{ij}(t)$ for the unit resource of A_i. The supplier A_i has the intention strength $\zeta_{ij}(t)$ for the user G_j , which is used to describe the effect of complex phenomena, such as interaction, congestion, failure, and priority. We thus obtain an assignment matrix $S(t) = [s_{ik}(t)]_{n \times m}$,as shown in Fig. 1, where $s_{ij}(t) = \langle a_{ij}(t), p_{ij}(t), \zeta_{ij}(t) \rangle$. For convenience, they are normalized such that $0 \le a_{ij}(t) \le 1, 0 \le p_{ij}(t) \le 1$ and $-1 \le \zeta ij \le +1$.

The conceptual diagram of a generalized particle model (GPM) for the enterprise computing optimization is shown in Fig. 2, where the particle s_{ik} in a force-field corresponds to the entry s_{ik} in the assignment matrix S. A particle may be driven by several kinds of forces that are produced by the force-field, other particles and itself. The gravitational force produced by the force-field tries to drive a particle to move towards boundaries of the force-field, which embodies the tendency that a particle pursues maximizing the aggregate benefit of systems. The pushing or pulling forces produced by other particles are used to embody social coordination among resource suppliers and users. The self- driving force produced by a particle itself represents autonomy and personality of individual supplier and user of resources. Under the exertion of resultant forces, all the particles may move concurrently in a force-field. In this way, the GPM transforms the optimization problem of resource allocation for enterprise computing into the kinematics and dynamics of massive particles in a force-field.

	G_1	·	G_m
A_1	$a_{11}(t), p_{11}(t), \zeta_{11}(t)$	·	$a_{1m}(t), p_{1m}(t), \zeta_{1m}(t)$
·	...	·	...
A_i	$a_{i1}(t), p_{i1}(t), \zeta_{i1}(t)$	·	$a_{im}(t), p_{im}(t), \zeta_{im}(t)$
·	...	·	...
A_n	$a_{n1}(t), p_{n1}(t), \zeta_{n1}(t)$	·	$a_{nm}(t), p_{nm}(t), \zeta_{nm}(t)$

Fig. 1. The assignment matrix for the enterprise computing optimization, $S(t) = [s_{ik}(t)]_{n \times m}$, where $s_{ij}(t) = \langle a_{ij}(t), p_{ij}(t), \zeta_{ij}(t) \rangle$

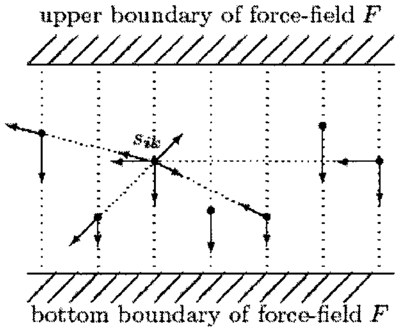

Fig. 2. Generalized particle model for the enterprise computing optimization.

Definition 1. Let $u_{ik}(t)$ be the utility of particle s_{ik} at time t, and let J(t) be the aggregate utility of all particles. They are defined by

$$u_{ik}(t) = a_{ik}[1 - \exp(-p_{ik}(t)a_{ik}(t))] \tag{1}$$

$$J(t) = a\sum_{i=1}^{n}\sum_{k=1}^{m} u_{ik}(t) \tag{2}$$

where $a_{ik}, a \geq 0$, and a_{ik} is related to the activities of supplies A_i and user G_j, such as congestion degree, failure rate, and priority level.

Definition 2. At time t, the potential energy function P(t) that is related to the gravitational force of force-field F is defined by

$$P(t) = \varepsilon^2 \ln \sum_{i=1}^{n} \sum_{k=1}^{m} \exp[-u_{ik}^2(t)/2\varepsilon^2] - \varepsilon^2 \ln mn \tag{3}$$

where $0 < \varepsilon < 1$.

Definition 3. At time t, the potential energy function Q(t) that is related to interactive forces among particles is defined by

$$Q(t) = \xi \sum_{i=1}^{n} \left| \sum_{k=1}^{m} a_{ik}(t) - r_i(t) \right|^2 - \sum_{i,k} \int_0^{u_{ik}} \left\{ [1 + \exp(-\zeta ikx)]^{-1} - 0.5 \right\} dx \tag{4}$$

where $0 < \xi < 1$; r_i is the capacity of resource supplier A_i. The second term of Q(t) represents social co-ordinations among them, where $-1 \leq \zeta ij \leq +1$.

Definition 4. The hybrid energy function of the particle s_{ik} at time t is defined by

$$\Gamma_{ik}(t) = -\lambda_{ik}^{(1)} u_{ik}(t) - \lambda_{ik}^{(2)} J(t) + \lambda_{ik}^{(3)} P(t) + \lambda_{ik}^{(4)} Q_{ik}(t) \tag{5}$$

where $0 < \lambda_{ik}^{(1)}, \lambda_{ik}^{(2)}, \lambda_{ik}^{(3)}, \lambda_{ik}^{(4)} \leq 1$.

Definition 5. Let the coordinate origin be located at the central line between the upper and bottom boundaries of force-field F, and $q_{ik}(t)$ be the vertical coordinate of particle s_{ik} at time t. The dynamic equation for particle s_{ik} is defined by

$$\begin{cases} dq_{ik}(t)/dt = \Psi_{ik}^{(1)}(t) - \Psi_{ik}^{(2)}(t) & (6) \\ \Psi_{ik}^{(1)}(t) = -q_{ik}(t) + \gamma v_{ik}(t) & (6a) \\ \Psi_{ik}^{(2)}(t) = I_{ik} + \sum_{j=1}^{m} w_{ik} u_{jk}(t) + \sum_{j=1}^{m} w_{ij} u_{ij}(t) & (6b) \end{cases}$$

where $\gamma > 1$, I_{ik} is a constant bias. The weight w_{jk} represents the polymerization strength of particles, s_{ik} and s_{ik}, and w_{ij} represents the polymerization strength of particles, s_{ik} and s_{ij}. The dynamic state $v_{ik}(t)$ is a piecewise linear function of $q_{ik}(t)$, which is defined by

$$\begin{cases} 0 & if \quad q_{ik}(t) < 0 \\ q_{ik}(t) & if \quad 0 \leq q_{ik}(t) \leq 1 \\ 1 & if \quad q_{ik}(t) > 1 \end{cases} \tag{7}$$

Parallel Algorithm (GPMA):

Costep 1. Initiate in parallel $a_{ik}(t_0)$, $p_{ik}(t_0)$,and $q_{ik}(t_0)$ for $i \in \{1,\cdots,n\}$, $k \in \{1,\cdots,m\}$.

Costep 2. By Eq.(1), calculate in parallel the utility $u_{ik}(t)$ of every particle s_{ik} in force-field F at time t;

Costep 3. Calculate in parallel $\Psi_{ik}^{(1)}(t)$ by Eq.(6a), and $\Psi_{ik}^{(2)}(t)$ by Eq.(6b) of every particle s_{ik};

Costep 4. If all particles reach their equilibrium states at time t, then finish with success; Otherwise, modify a_{ik} and p_{ik} by the following Eqs.(8) and (9), respectively, then go to Costep 2.

$$dp_{ik}(t)/dt = \lambda_{ik}^{(1)}\frac{\partial u_{ik}(t)}{\partial p_{ik}(t)} + \lambda_{ik}^{(2)}\frac{\partial J(t)}{\partial p_{ik}(t)} - \lambda_{ik}^{(3)}\frac{\partial P(t)}{\partial p_{ik}(t)} - \lambda_{ik}^{(4)}\frac{\partial Q(t)}{\partial p_{ik}(t)} + \lambda_{ik}^{(5)}q_{ik}(t) \tag{8}$$

$$da_{ik}(t)/dt = \lambda_{ik}^{(1)}\frac{\partial u_{ik}(t)}{\partial a_{ik}(t)} + \lambda_{ik}^{(2)}\frac{\partial J(t)}{\partial a_{ik}(t)} - \lambda_{ik}^{(3)}\frac{\partial P(t)}{\partial a_{ik}(t)} - \lambda_{ik}^{(4)}\frac{\partial Q(t)}{\partial a_{ik}(t)} + \lambda_{ik}^{(5)}q_{ik}(t) \tag{9}$$

where $0 < \lambda_{ik}^{(5)} < 1$.

3 Properties of Generalized Particle Model

We summarize properties of GPM for enterprise computing optimization in the following Lemmas and Theorems, which involve the correctness, convergence and stability of GPM. For page limitation, their proofs are omitted.

Lemma 1. The first and second terms of Eqs. (8); (9) enable the particle s_{ik} to increase the personal utility of the resource supplier A_i from the user G_k, in direct proportion to $\lambda_{ik}^{(1)} + a\lambda_{ik}^{(2)}$.

Lemma 2. Updating p_{ik} and a_{ik} by Eqs.(8); (9); respectively, gives rise to monotonic increase of the aggregate utility of all the particles, in direct proportion to $a\lambda_{ik}^{(2)}$.

Lemma 3. If ε is very small, then decreasing the potential energy P(t) of Eq. (3) amounts to increasing the minimal utility of all the particles.

Lemma 4. The third terms of Eqs. (8); (9) enable the particle s_{ik} to increase the minimal utility of all the particles, in direct proportion to $\lambda_{ik}^{(3)}w_{ik}^{2}(t)$, where

$$w_{ik}^{2}(t) = \exp[-(uik(t))^2/2\varepsilon^2] / \sum_{i=1}^{m} \exp[-u_{ik}(t)^2/2\varepsilon^2]$$

Lemma 5. The fourth terms of Eqs.(9); (10) enable the particle s_{ik} to monotonic decrease of the potential energy Q(t), in direct proportion to the value of $\lambda_{ik}^{(4)}$

Theorem 1. Updating p_{ik} and a_{ik} by Eqs.(8); (9); respectively, gives rise to decreasing the hybrid energy function $\Gamma_{ik}(t)$ where very particle may autonomously determine its optimization objective according to its own personality and intention.
Theorem 2. The algorithm GPMA can dynamically optimize in parallel the resource allocation for enterprise computing in the context of multi-type social coordination, multi-degree autonomy and multi-objective optimization.

Lemma 6. If $\gamma - 1 > -\Psi_{ik}^{(2)}(t) > 0, \frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} < 1$ for $q_{ik}(t) < 0$ and $q_{ik}(t) > 1$;and $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} \geq 1 - \gamma$ for $0 < q_{ik}(t) < 1$ remain valid, then a stable equilibrium point of the particle s_{ik} will be either ($q_{ik}(t) > 1, v_{ik}(t) = 1$) or ($q_{ik}(t) < 0, v_{ik}(t) = 0$).

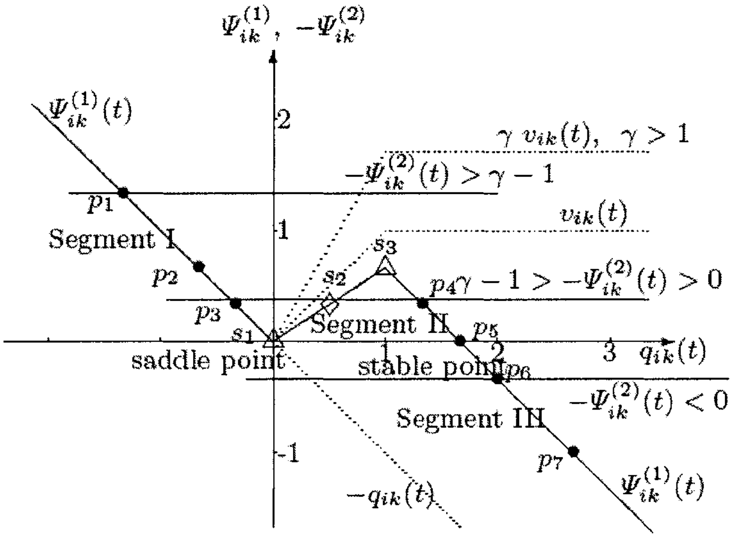

Fig. 3. When $\gamma > 1$, the possible equilibrium points of the dynamic status $v_{ik}(t)$ of a particle s_{ik}. The point where $-\Psi_{ik}^{(2)}(t)$ equals $\Psi_{ik}^{(1)}(t)$ is an equilibrium point. The symbols, •,□ and ◊ denote a stable equilibrium point, saddle point and unstable equilibrium point, respectively.

Lemma 7. If $\gamma > 1, -\Psi_{ik}^{(2)}(t) < 0$ and $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} < 1$ for $q_{ik}(t) > 1$ remain valid, then a stable equilibrium point of the particle s_{ik} will be ($q_{ik}(t) > 1, v_{ik}(t) = 1$).

Lemma 8. $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} < 1$ for $q_{ik}(t) < 0$ remain valid, then a stable equilibrium point of the particle s_{ik} will be ($q_{ik}(t) < 0, v_{ik}(t) = 0$).

Lemma 9. If $\gamma > 1$, $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} < 1$ for $q_{ik}(t) = 1^{+0}$ and $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} \geq 1 - \gamma$ for $q_{ik}(t) = 1^{-0}$ remain valid, then the equilibrium point ($q_{ik}(t) = 1, v_{ik}(t) = 1$) is saddle point. Moreover, if $\gamma > 1$, $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} < 1$ for $q_{ik}(t) = 1^{-0}$ and $\frac{\partial \Psi_{ik}^{(1)}(t)}{\partial q_{ik}(t)} \geq 1 - \gamma$ for $q_{ik}(t) = 1^{+0}$ remain valid, then the equilibrium point ($q_{ik}(t) = 0, v_{ik}(t) = 0$) is saddle point.

Theorem 3. If $\gamma > 1$ and $0 \leq q_{ik}(t_0) \leq 1$ remain valid, then the dynamical Eq. (6) has a stable equilibrium point if $0 < -\Psi_{ik}^{(2)}(t) < \gamma - 1$.

Theorem 4. If the condition of Theorem 3 remains valid, then GPM will converge to a stable equilibrium state.

4 Simulations

Some simulation results on the algorithm GPMA for the enterprise computing optimization in the context of resource allocation and task assignment in complex environment are given as follows.

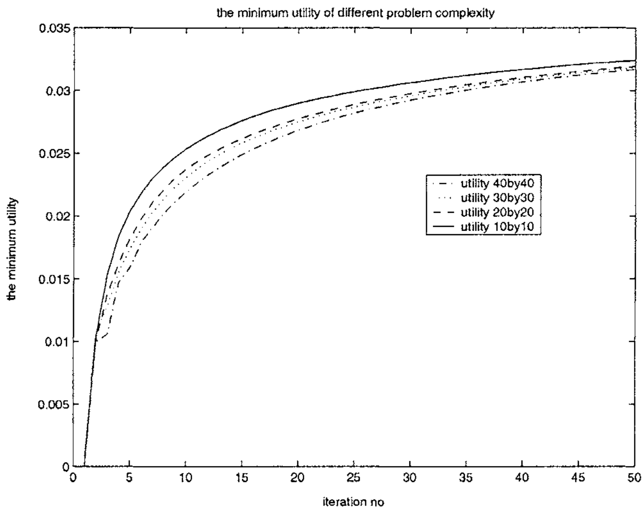

Fig. 4. For different problem sizes, the transient of minimal personal utility among all the particles during executing the algorithm GPMA, where the number of particles: 100, 400, 900, 1600 corresponds to problem size: 10 × 10; 20 × 20; 30 × 30; 40 × 40, respectively.

- **Influence of problem size on the utility for enterprise computing optimization:** For different problem sizes, the transients of the minimal personal utility among all the particles and the aggregate utility of all the particles during executing the algorithm GPMA are shown in Fig. 4 and Fig. 5, respectively. We can see that for different problem sizes using the GPMA always gives rise to the increase of the minimal personal utility.

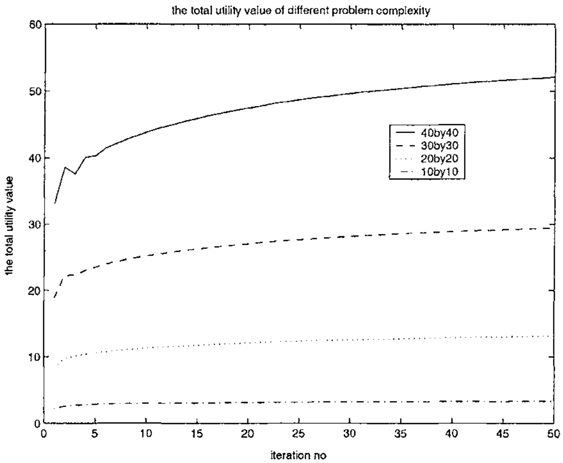

Fig. 5. For different problem sizes, the transient of the aggregate utility of all the particles during executing the algorithm GPM.

- **The influence of problem size on optimization criteria:** In order to evaluate the optimality performance of GPMA, we use the three criteria: the fairness FN, resource utilization rate RUR, and user satisfactory degree USD. For different problem sizes, the transients of the aggregate utilization rate of resource suppliers, and aggregate satisfactory degree of resource users are shown in Fig. 6.

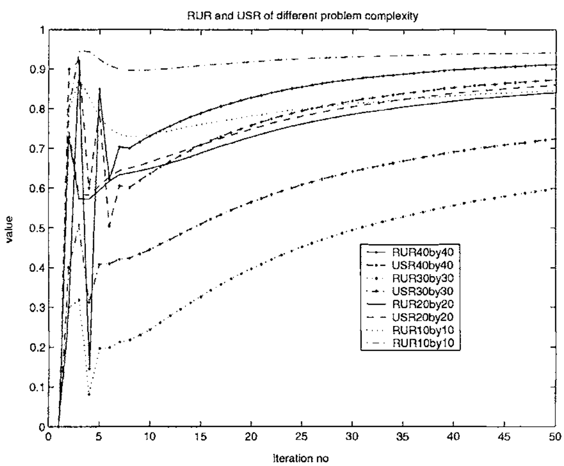

Fig. 6. For different problem sizes, the transients of the aggregate utilization rate of resources and the aggregate satisfactory degree of users during executing the algorithm GPMA.

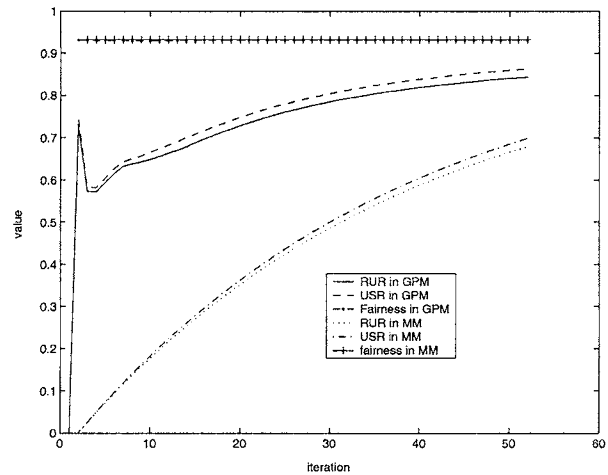

Fig. 7. For 30 $\times$ 30 problem size, the performance comparison between GPAA and the Max-Min Algorithm in terms of transients of the allocation fairness, aggregate utilization rate of resource suppliers, and aggregate satisfactory degree of resource users.

- **Comparisons:** The comparisons between the algorithm GPMA and the famous Max-Min algorithm (MMA) are shown in Fig. 7, which demonstrate that, for different problem sizes, GPMA can converge to a stable equilibrium solution much faster than the MMA. The algorithm GPMA exhibits much better optimality performance than MMA in terms of the aggregate utilization rate of resource suppliers and aggregate satisfactory degree of resource users, whereas they have almost approximately equal allocation fairness.

5 Conclusions

We have proposed a new generalized particle model (GPM) for parallel and distributed optimization of enterprise computing in complex environment. The GPM's properties have been proven in detail. GPM may deal with multi-type social coordination, multi-degree autonomy, multi-objective optimization, multi-granularity coalition, and some complex phenomena, e.g. congestion, failure and priority. The proposed generalized particle approach also has the advantages in terms of parallelism and feasibility for hardware implementation by VLSI technology.

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Intelligent Enterprises for Construction: Bridging the Technology and Knowledge Gaps through Innovation and Education

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Abstract. The paper addresses the main issues of the technology shift much needed in the construction sector of Singapore. The reason being there is a prevalent understanding that this sector invests little in information technology (IT) as compared with the other economic sectors. Essentially, the shift entails the bridging of a knowledge gap between industry and research academia. And, it is argued that a mindset change among construction practitioners will be required as a move to embrace artificial intelligence (AI) in their business and operational decisions. The recommendations put forward are that, in the short term, the knowledge gap can be filled when construction-sector organisations have acquired the basic infrastructures (or building blocks) of intelligent enterprise architecture and, in the long term, education can sustain the growth of intelligent enterprises by supplying knowledge workers to these enterprises. The research methodology comprises a postal questionnaire survey of construction-sector organisations and a review of the literature on AI in construction management.

1 Introduction

Singapore aims to become an intelligent nation in 2015 (iN2015) and is developing a 10-year master plan to grow the infocomm sector (www.in2015.sg). The broad intent is for Singapore to use infocomm technologies to enhance competitiveness of the key economic sectors and build a well-connected society. And, in order to achieve this end, the plan will have to involve identifying new possibilities for Singapore's industries, economy and society through the innovative use of infocomm

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technologies. Long-term directions and strategies will need to be mapped for the development of the future national infocomm infrastructure, as well as the development of new infocomm clusters and enterprises and the associated manpower capabilities. On 8 March 2005, the Infocomm Development Authority of Singapore (IDA) had unveiled its fifth and most significant Infocomm Technology Roadmap (ITR5) and the next era of technologies, such as sensor technology, biocomputing, nanotechnology and other emerging technologies. The ITR5 had envisaged that the Computing and Communication Waves would be revolutionised by innovations in nano and biotechnologies so as to herald the arrival of a new Sentient Era during which context-aware sensors and intelligent agents will automate, analyse, synthesise and present personalised information to users in a proactive way.

While the Singapore Government is drawing up the intelligent nation 2015 masterplan, it is clear that new possibilities and opportunities will be created for the various economic sectors by further enhancing their infocomm technological capabilities. This paper discusses the need to bridge the knowledge gap between the industrial and research- academic sectors of the construction industry. It argues that while organisations have to acquire the basic infrastructures of intelligent enterprise architecture, the mindset of industry players has to change towards embracing artificial intelligence (AI) in their business and operational decisions.

2 Construction Industry and Potential for Technological Innovation

The construction industry is most often associated with complexity; in terms of the nature of work, management of processes, organisation of parties' relationships, and including its inter-relationship with the rest of the economy. In a recent comparison of innovation in the construction, services and manufacturing sectors in the UK [1], it was highlighted that construction, as a sector, is seen as low performing, exhibiting low rates of innovative activity [2 - 4]. Essentially, the ability to innovate can create possibilities for firms to gain competitive advantage over their industrial rivals. However, it was also noted that there is also a wide range of different factors in the industrial environment that may shape the potential for innovation by individual firms and that the nature of technological opportunities is one of them [5].

3 Building Blocks of an Intelligent Enterprise

According to Sharma and Gupta [6], enterprises need six basic building blocks for the intelligent enterprise architecture. The first building block is technology infrastructure, which enables the business to organise and access its information, regardless of its form. The second component of intelligent enterprises should have transaction processing infrastructure, which supports the daily functions of the business. The third component of intelligent enterprises is an integrating technology, that is, data warehousing. The fourth component is decision process management, which focuses on key operational functions that are enhanced with the benefits of data warehousing. The fifth component is the analytical applications suite of the enterprise, which shapes key directional decisions that affect future business results. Finally, the sixth component includes information and knowledge delivery services.

4 Potential for Creating Intelligent Enterprises in Construction

This paper aims to establish that construction-sector organisations need to transform themselves into intelligent enterprises in order to remain relevant and competitive in a knowledge-based economy.

4.1 Data Collection

A postal questionnaire survey was conducted in 2003, targeting a total of 754 companies operating in the local construction industry in the areas of architecture, engineering, quantity surveying, property development, construction, and product manufacturing and supplies. 84 companies responded to the survey, giving the rate of response at 11.1 per cent. While the questionnaire contained a broad range of questions on information technology (IT) adoption, selected questions are related to the building blocks of an intelligent enterprise.

4.2 Data Analysis

Data from the survey had been analysed to assess the potential for construction-sector companies in Singapore becoming intelligent enterprises [7]. Here, the main objective is to examine only the potential for the larger construction companies, as classified by the number of employees and total annual sales. The premise for this study is derived from the findings of a related study by Acar et al. [8]. Their study concluded that larger-sized construction enterprises are more innovative, especially in their adoption of ICTs, as well as in the diffusion of new technologies among enterprises in this class. Eight large construction companies have been selected for the analysis and they belong to the class of companies that employs 50 to 299 persons and has an annual turnover of up to US$30 million. In the definition of small and medium enterprises (SMEs), as adapted from [9], this class of enterprises is considered as medium sized.

Results of the analysis of potential for large construction companies to become intelligent enterprises are given in Table 1.

5 Artificial Intelligence in Construction Management

On the research front, keen interests in studying the use of AI began in the eighties. Brandon [10] reviewed the historical development of expert systems in the areas of construction economics and construction management to highlight their potential and limitations. Since the early nineties, artificial neural networks (ANNs) have become popular, especially in the area of construction management. Their superiority over expert systems stems from the nature of construction problems which is of pattern recognition rather than deep reasoning about the problem elements [11]. More recently, genetic algorithms (GAs), another biological-based method, are gaining recognition in solving construction optimisation problems either alone or in combination with ANNs.

5.1 Studies on construction project management using traditional approaches and biological-based (AI) techniques

5.1.1 Planning of project resources

For construction resource estimation, mainly dealing with project time and cost, the use of stochastic simulation techniques had been prevalent since the late seventies. Carr [12] presented a simulation model for uncertainty determination of the timing of each construction activity, even when the activity durations are not independent of each other. As an integrated approach, Woolery and Crandall [13] proposed the use of a stochastic network model, based on Monte-Carlo simulation, to model the dependencies between network activities for construction scheduling. As a means to augment pre-contract planning for large and complex projects or for re-planning work in progress, the use of Monte-Carlo simulation was also proposed for developing construction resource models [14]. A suite of computer programmes, known as the *Construction Project Simulator*, was developed to generate simulation outputs for duration and cost predictions, and cash flow curves, based on costs, resources, weather, and productivity data [15]. Considering mathematical approaches as complex solutions to construction resource modelling, Cusack [16] presented a simplified approach to the planning and control of cost and project duration by applying heuristics to model the time-cost relationship. As a major addition to the repertoire of existing computer-based project scheduling tools, Ahuja and Nandakumar [17] developed a comprehensive model to simulate and combine the impact of the significant uncertainty variables, such as weather, space congestion, workmen absenteeism, and incorporated it in the activity duration estimates as it revises them. Further research developments in the area of project scheduling include the development of a systematic methodology for stochastic scheduling involving eight steps [18] and the formulation of a linear integer model for optimisation of project schedules to achieve the primary objective of minimising total project cost [19].

It was only in the late nineties that the capabilities of both ANNs and GAs had been explored to plan and control project time and costs. A judgment-based forecasting approach, using multiple regression techniques and ANNs, was proposed by Al-Tabtabai et al. [20] to identify schedule variances from a baseline plan for typical construction projects. It essentially uses ANNs to capture the complex nonlinear decision-making process of project experts involved in schedule monitoring and prediction. For time-cost optimisation problems in construction planning, Li and Love [21] evaluated the performance of a basic GA system and implement modifications to the crossover and mutation operations. Besides outperforming the basic system, the improved GA system was found to be able to generate a whole class of alternative solutions close to the optimum. On the other hand, Adeli and Karim [22] adopted ANNs for solving the nonlinear optimisation problem for construction project scheduling. By varying the construction duration, one can solve the cost-duration trade-off problem, and obtain the global optimum schedule and the corresponding minimum construction cost.

5.1.2 Estimation of project cash flow

Since the mid-eighties, traditional techniques ranging from mathematical formulation of the S-curve to stochastic simulation of the patterns of construction project expenditure had been applied to estimate and predict construction cash flow. As a general approach, Tucker [23] introduced the mathematical formulation of construction cash flow curves using an analogy between the probability of failure in reliability theory and the probability of payment during construction. It permits the exploration of any function to define the payment completion rate from which the cumulative payment and payment density functions can be derived. More specifically for the *post hoc* examination of construction project net cash flows, Kenley and Wilson [24] proposed a model based upon the logit transformation which was found to be very flexible and capable of adapting to the wide degree of inter-project variability. In contrast with deterministic approaches, simulation of expenditure patterns of construction projects to analyse and examine their shapes was proposed by Khosrowshahi [25] as a means of facilitating mathematical models for ease of application, user involvement and user comprehension. To further improve on current standard value S-curves, Kaka and Price [26] focused their attention on cost commitment curves instead, especially to help contractors generate the value and cash-out curves at the tendering stage. The applicability of such curves was tested on several project classification criteria and curve-fitting was carried out using the logit transformation technique [27].

More recently, studies had departed from generating alternative forms of the S-curve for project budget and cost estimations to applying more sophisticated algorithms of ANNs and GAs. A neural network approach was used to identify the key management factors that affect budget performance in a construction project and develop a prediction model based on their complex relationships [28]. Adeli and Wu [29] formulated the regularisation neural network for construction cost estimation by incorporating a regularisation term in the error function to compensate for the overfitting problem and improve estimation outside the scope of available data points. The performance of this new computational model depends only on the training examples; and not on the architecture of the network, learning parameters and number of training iterations. Hegazy and Ayed [30] also used ANNs for their study on parametric cost estimation but relied on simplex optimisation and GAs to determine the network weights. Accordingly, the weights that produced the best cost prediction for the historical cases were used to find the optimum network.

5.2 Studies on construction site management using traditional approaches and biological-based (AI) techniques

5.2.1 Optimisation of site operations

On simulating construction site operations, studies had started in the late seventies which applied deterministic methods as well as stochastic or probabilistic approaches. Based on a deterministic approach, Gates and Scarpa [31] derived mathematical formulas to optimise the rate of pour that dictates formwork design, the number of uses of formwork, and the number and height of lifts. Customised simulation tools have also been developed for specific construction operations such as the SCRAPESIM for earth-moving owing to the cost significance of this activity where inaccuracies in estimating may greatly influence the profit margin of an earth-moving contractor [32]. For solving large-scale operational problems, interactive man-computer graphics systems and heuristic modelling approaches for simulation have been proposed [33]. Different applications of stochastic techniques to simulate construction activity have been described by Pilcher and Flood [34] and their review of previous and current research serves to acknowledge the potentially usefulness of computer-based simulation for construction managers in supplementing intuition and expertise. To further enhance existing simulation tools for construction operations, Paulson et al. [35] proposed a system that combines videotape data collection from field construction operations, statistical reduction and analysis of data, and computer-based simulation modelling. A more recent research had extended the boundary of simulation models to include a sensitivity analysis of the concreting operations in a set of possible resource combinations [36].

As complexity in construction operational problems increased, the use of ANNs had also been explored in the early nineties [37]. An ANN approach was proposed by Flood [38] to achieve an optimal sequencing of construction tasks with the aim of minimising production time. Based on the efficient solutions obtained in the study to the sequencing problem, he concluded on the possibility of applying ANNs to other types of operational problems such as resource allocation, material cutting and site layout. Flood [39] also illustrated with the use of a conceptual ANN model to simulate a construction process by linking network modules, representing a queuing facility, storage facility or productive resource, to design a complete network description.

5.2.2 Estimation of site productivity

Site productivity studies which adopted traditional approaches such as simulation prevailed in the mid-eighties. An interactive system for the analysis of construction operations by integrating quantity development and process simulation to estimate productivity and cost was proposed by Tavakoli [40]. By applying the learning curve theory to construction productivity, five basic mathematical models for learning curves, ranging from straight-line to exponential forms, were evaluated on estimating and predictive abilities [41]. Thomas and Yiakoamis [42] developed a factor model using multiple regression techniques to mathematically explain variability caused by the effects of temperature and relative humidity in the daily productivity data.

However, from the mid-nineties, ANNs had been used to estimate site operation productivity, as well as labour productivity. Chao and Skibniewski [43] adopted a neural-network and observation-data-based approach to estimate the production rate for the excavation and hauling operation. Experimenting on a different construction operation, Portas and AbouRizk [44] developed a three-layered ANN with a fuzzy output structure to estimate construction productivity for concrete formwork tasks. For modelling construction labour productivity, Sonmez and Rowings [45] adopted a methodology based on regression and ANNs techniques to develop prediction models for concrete pouring, formwork and concrete finishing tasks. It has presented an approach for the evaluation of the impact of multiple factors, considered simultaneously, on labour productivity.

5.2.3 Optimisation of site equipment selection

Similarly for equipment selection, studies had adopted conventional simulation approaches in the early eighties. Woods and Harris [46] developed a truck allocation model for concrete distribution by applying computer-based simulation to obtain the most suitable combination of trucks in the fleet in order to minimise operating costs and reduce waste space from part loads. However, mathematical techniques were relied upon to propose an algorithm which can define the least expensive cranage cost for a project based on varying the type and number of cranes used during construction [47]. Both queuing theory and simulation techniques were adopted by Touran and Taher [48] to develop a model that can predict the productivity, as well as determine the optimum fleet size using sensitivity analysis, of the earth-moving operation. For materials handling, Wijesundera and Harris [49] developed a dynamic interactive simulation model to allow for varying crane type, size and location, skip size, delivery system and construction crew size to evaluate the effects on utilisation levels and costs for different methods of working.

It was only in the early nineties that biological-based (AI) methodologies had been experimented in the domain of construction equipment selection. To classify earthmoving equipment according to the speed of operation, Karshenas and Feng [50] used ANNs as a modular approach to facilitate the inclusion and removal of new and obsolete equipment considered by the network. Specifically for the optimum selection of excavating and haulage equipment in opencast mining, Haidar et al. [51] designed a decision-support system using a hybrid knowledge-based system and GAs. The knowledge base relates mainly to the selection of equipment in broad categories while the advanced GAs search techniques find the input variables that can achieve the optimal cost.

6 Summary of Main Results

The paper had addressed, firstly, the technology shift and, secondly, the knowledge shift, that are needed in the construction industry. The main results are summarised as follows:

Firstly, the survey of large construction companies had shown that they possessed very strong hardware and software capability. Also, half of them were aware of the strategic use of the technology and had formalised their IT strategy. However, computerisation of work functions, as implied from their ability to process administrative and business (or operational) transactions, as well as digital transmission of documents internally and externally, was only progressing in stages (therefore, this building block is not fully developed). On data warehousing, it was unveiled that the mining of (strategic) data relating to clients' needs and requirements, and product or service differentiation so as to attain business leadership was primary to such companies. However, their ability to apply intelligent processing and analysis as a strategic decision process management function was found to be under-developed, even though key areas had been identified (namely, design, project and site management) where IT had added value to raising productivity. The infrastructure for delivery of information and knowledge was also found to be under-developed.

Secondly, having identified project and site management as two key areas where the capability of intelligent processing and analysis of data (as a building block of an intelligent enterprise) can be built upon, a review of the relevant literature had provided the basis. It was acknowledged that academic research on planning (and or optimisation) of project resources, project cash flow, site operations, site productivity and site equipment selection began in the late eighties. Empirical studies that had compared conventional techniques with biological-based (AI) ones have proven the latter to be superior.

6 Conclusions and Main Recommendations

The paper concludes as follows:

a. To fill the 'technology gap' between traditional construction-sector organisations and intelligent enterprises: There is a need for organisations to have an enterprise-wide view of key business operations with the tools to link business strategy with operational execution in order to view, manage and act quickly and strategically.
b. To fill the 'knowledge gap' bbetween the industry and research academia: It is vital to appreciate that training and education are sustainable means to transfer new knowledge to the industry.

Over time, it is foreseeable that the relationship between education and the creation of intelligent enterprises will evolve into a symbiotic one when knowledge workers become a vital resource to such organisations. In turn, a knowledge industry provides the playing field for intelligent enterprises which then allows them to deploy more workers who have been trained to fit into their intelligent roles naturally.

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Table 1. A summary of the assessment of potential to become construction intelligent enterprises

Building Block	**Main Finding**	**Assessment of Potential to become Construction Intelligent Enterprises**
1st Building Block: Technology Infrastructure	On hardware - All (100%) of the staff use the PC or terminal at work. - A high percentage (80.6%) of staff has their own PC. - All (100%) of the companies have a LAN. - On software - All (100%) of the staff use the Email. - A very high percentage (87.5%) of staff uses Word Processing. - All (100%) of the staff use Spreadsheet. - A very high percentage (87.5%) of companies uses software for technical calculation. - A high percentage (75.0%) of companies uses software for time planning. - All (100%) of the companies have a CAD software. - Global connectivity - A high percentage (75.0%) of companies has permanent connection to the Internet. - A high percentage (75.0%) of companies has a Home Page. - Spending on technology infrastructure - 20% of companies spend 20% of annual turnover on IT. - 85.7% of companies have made investment in IT in the last 2 years.	The potential in relation to hardware technology is **very strong**. The potential in relation to software technology is **very strong**. The potential in relation to global connectivity is **very strong** in terms of accessibility to web-based technology. There is a high percentage of spending on IT by some companies; and a high percentage of them has invested in IT in the last 2 years.
2nd Building Block: Transaction Processing Infrastructure	Types of computerised functions - There is an even spread of companies that have indicated that both administrative and business (or technical) functions have been computerised. Level of computerisation of functions - The general level of computerisation of administrative and business functions by companies is in the moderate range (25% to 75%). Digital transmission of documents - The general level of digital transmission of documents is low. A moderate percentage (62.5%) of companies has indicated it would be useful to web-based applications for storage and transfer of project documents.	The potential in relation to transaction processing is **moderately strong**, but the general trend is towards computerising administrative functions before the business (or technical) functions.
3rd Building Block: Data Warehousing	Use of data for strategic decision - The link between business strategy and IT strategy is moderate. 50% of the companies have indicated they have an IT strategy in a written form. Types of data required for strategic business decision - The important performance criteria for IT strategy as a driver have been noted as satisfying customer demand and attaining business leadership.	The potential in relation to data warehousing is **moderately strong** and the strategic requirements for it have been identified.

4th Building Block: Decision Process Management	<u>Impact of IT on work processes</u> - Characteristics that affect future business results such as speed of work, quality of documents and complexity have increased. - Productivity for core business functions (namely, design, project management, site management) has been noted to have increased by more than 10% and, hence, they will continue to lead key directional decisions. - Document handling and portable/mobile systems have been noted as top areas which companies plan to increase the use of IT.	The potential in relation to intelligence processing, analysis, and delivery of information and knowledge is **under-developed**, although the types of key operational functions that can benefit from such intelligence have been identified.
5th Building Block: Analytical Applications Suite		
6th Building Block: Information and Knowledge Delivery Services		

Grid Computing Simulation and Verification Based on pi Calculus

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Abstract. As weakness exists in describing behaviors and mobility in Petri Net theory, we put forward a mode using pi calculus to describe the gird computing, and present its simulation and verification. We briefly introduce the pi calculus at first. Then, it is drawn in detail how to outline single node computing and grid computing by pi calculus: it can be described as a two-player game. The first player moves the first token from the node to a neighboring node along an outgoing edge. On the other hand, the second player can respond only by moving the other token from the node it is on to adjacent node along an outgoing edge. It can be defined the winning mechanism which is related to the relation of the two computing ways: strong bi-simulation, weak simulation or reduction simulation. Many properties (such as deadlock or mutual exclusion violation) may be checked in this fashion. At last an example scenario is presented.

1 Introduction

To provide security modeling, a modeling language - SJAN is described in [1]. SJAN models its security representation by the simple reductions. Once a scenario has been modeled, it can be easily implemented in the real implementation language. SJAN is also suitable for modeling web-services based computation and grid computing. It is developed a logical framework usable for representing, monitoring and enforcing service contracts like SLAs with a combination of adequate logical formalisms in [2]. It may be used in the automation of contract enforcement processes such as the detection of contract violations, authorization control, conflict detection, service billing and reporting. It is not suitable for grid computing or web-service based computation simulation and verification. It is presented a novel grid Node by Node security model in [3]. The numerous grid nodes are partitioned into different autonomy areas and each area is designated a server. SPI calculus is used to verify the security negotiation process. It is a security model which cannot be used

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for grid computing simulation to reflect the relationship between single node computing and grid computing. A calculus is defined for spatial reasoning on a grid structure in [4]. It also presents a logical calculus, investigates the complexity of the satisfiability problem, and proves its NP completeness and specifies additionally a concrete algorithm for solving it. In the paper [5], an abstract model of agent-based service publication and discovery for resource management in grid context is presented, which is the basis for analyzing service publication and discovery. Qi et al. [6] presents a new calculus called Membrane Calculus for gird transactions based on P systems and Petri Nets. The paper provides a general semantic calculus of Grid transactions which has two distinct advantages: dynamic structure and location mobility.

A task may be completed in a computer (node) – we call it single node computing, and it may be divided into several subtasks and finished in many computers (nodes) – grid computing. But what is the relationship of single node computing solution and grid computing solution for a task? If a task can be done by single node, and whether it can be completed by grid computing? Otherwise, if it can be done by grid computing, and whether it can be completed by single node?

In order to solve these problems, a two-player game simulation is introduced: a two-player game on the directed graph who nodes are the processes and whose arrows are given by the transition relation. The two players representing single node and grid computing respectively move alternately. The play is finite, and one player may be in its final position the player whose turn it is cannot move. If a player wins, then it can simulate the other. If losing, it cannot simulate.

The contributes of this paper are: 1) putting forward a new model to support concurrent grid computing or web serviced based computation simulation and verification; 2) using pi calculus to describe the business transaction processes; 3) presenting the algorithms for discussing the relation of the single node computing and grid computing.

This paper has been organized as follows. In Section 2 we introduce the pi calculus notation and its functionality briefly. In Section 3 we describe the idea of modeling web-services based computation and grid computing. Then grid computing simulation discussion and verification solution based on pi calculus will be addressed in Section 4. An example scenario is provided in section 5. In Section 6 we conclude our work and describe our future plan.

2 π-Calculus

The pi calculus provides a framework for describing concurrent systems and reasoning about their behaviors. The entities of the pi calculus are names and processes. Names can be thought of as communication pipelines. Processes, or agents, use names to interact, and pass names to one another by informing them in interactions. Names received by a process can be used and mentioned by it in further interactions. Processes can be defined as follows [7-10]:

$$P ::= 0 \mid \overline{x}y.P \mid x(z).P \mid \tau.P \mid [x=y].P \mid P+Q \mid P \mid Q \mid vzP \mid !P$$

Where,
(1) 0 is inaction; it is a process that can do nothing;
(2) The output prefix $xy.P$ sends the name y via the name x and evolves to P;
(3)The input prefix $x(z).P$ can receive any name via x and continue as P with the received name substituted for the bound variable z.
(4) The unobservable prefix $\tau.P$ can evolve invisibly to P. As in CCS (A calculus of Communicating Systems), τ can be thought of as expressing an internal action of a process.
(5) The match prefix can evolve as P if x and y are the same name, and can do nothing otherwise.
(6) $P+Q$ are those of P together with those of Q. When one of them is chosen, the other is rendered void.
(7) $P \mid Q$. The components P and Q can be executed independently and can interact via shared names. For instance, $\bar{x}yP \mid x(z)Q$ has this capability: to send y via name x, to receive a name via x, and evolve to $P \mid Q(y/z)$ invisibly as an effect of an interaction between its components via the shared name x;
(8) In the restriction vzP, the scope of the name z is restricted to P. Components of P can use z to interact with one another.
(9) Finally, the replication $!P$ can be thought of as an infinite composition $P \mid P \mid \ldots$.
To make process evolvement behavior precise, and it is defined the reduction rule: $\rightarrow$, on processes. The assertion $P \rightarrow P'$ expresses that process P can evolve to process P as a result of an interaction that is an action within P. The essence of reduction is captured in:
$(\bar{x}y.P_1+M_1) \mid (x(z).P_2+M_2) \rightarrow P_1 \mid P_2\{y/z\}$
The process P, on the left of the arrow consists of two components. Process P1 $(\bar{x}y.P_1+M_1)$ can send y via x, and process P2 $(x(z).P_2+M_2)$ receive a name via x. It expresses that P has a reduction arising form an interaction between its components (P1, P2) via x. y is passed form the first component to the second and it will substitute the placeholder z in P_2, the two prefixes are consumed. The other two components, expressed by M_1 and M_2, are rendered void; in summary, P evolves to $P_1 \mid P_2\{y/z\}$. Table 1 presents the reduction rules.

Table 1. The Reduction Rules

R-INTER	$(\bar{x}y.P_1+M_1) \mid (x(z).P_2+M_2) \rightarrow P_1 \mid P_2\{y/z\}$
R-TAU	$\tau.P+M \rightarrow P$
R-PAR	$\dfrac{P_1 \rightarrow P_1'}{P_1 \mid P_2 \rightarrow P_1' \mid P_2}$
R-RES	$\dfrac{P \rightarrow P'}{vzP \rightarrow vzP'}$

R-STRUCT	$\dfrac{P_1 \equiv P_2 \to P_2' \mid P_1'}{P_1 \to P_1'}$

In pi calculus, its operational semantic can be represented as labeled transition system (LTS).

Definition 1 Labeled Transition System (LTS) LTS can be defined as:

LTS = $(S, T, \{\xrightarrow{t} : t \in T\})$

S: set of states (processes, agents)

T: set of transition labels (actions), and may use Act instead.

$\xrightarrow{t} \subseteq S \times T \times S$: transition relation

The transitions of each composite process (agent) should follow label transition rules such as:

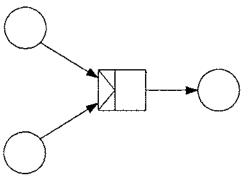
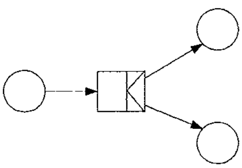
$$\frac{P \xrightarrow{\alpha} P'}{P \mid Q \xrightarrow{\alpha} P' \mid Q} bn(\alpha) \cap fn(Q) = \phi$$

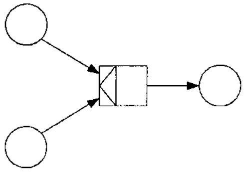
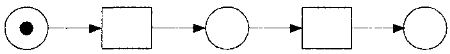
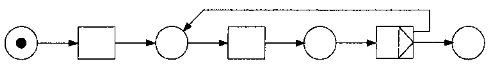
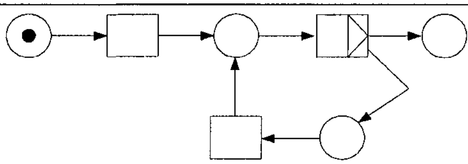
3 Modeling web-services based computation and grid computing

3.1 Expressing workflow basic forms in pi calculus

A task can be described in workflow. There are the following basic workflow forms: AND-join, AND-split, OR-join, OR-split, Iteration and Causality [11]. Table 2 gives their forms in Petri Net and pi calculus.

Table 2. Workflow Basic Forms in pi calculus

Workflow meta	Petri Net	π calculus
And-join		$P = a.R'$ $Q = b.R'$ $P \mid Q \to R'$ $R' = c.R$
And-split		$P = a.(b.Q \mid c.R)$

Or-join		$P = a.c.R$ $Q = b.c.R$
Or-split	**Error! Objects cannot be created from editing field codes.**	$P = a.c.Q + b.c.R$
Causality		$P = a.Q$ $Q = b.R$
Do-Iteration		$P = a.Q$ $Q = b.P + b.0$
While-Iteration		$P = a.b.P + a.0$

3.2 Computing Modeling

It can be used to simulate a single node computing and the grid computing between many nodes as a two-player game on the directed graph who nodes are the processes and whose arrows are given by the transition relation. The two players move alternately. The play is finite, and one player may be in its final position the player whose turn it is cannot move. A play begins with two nodes occupied by tokens. The first player moves the first token from the node to a neighboring node along an outgoing edge. On the other hand, the second player can respond only by moving the other token from the node it is on to a neighboring node along an outgoing edge. If the play is infinite, then the second player wins. If after some finite number of steps the player whose turn it is cannot move, then that player loses.

For given starting processes, the second player has a winning strategy for the game if and only if the processes are reduction bi-similar. That is, they are related by a bi-simulation on the graph.

At the beginning of introducing the bi-simulation, we first describe the τ action. Our aim in analyzing the behavior of composite systems is to ignore, as far as possible, their internal actions. We userτto represent the internal action of a composite process. τ does not represent a potential communication, and is therefore not directly observable. We regard two processes as equivalent if they exhibit the same (in some sense) pattern of external actions. This amounts to abstracting form such a process just that external aspect of its behavior which is relevant when it occurs as a component of a still complicated process.

The relations of process P (we use it to represent single node computing or grid computing) and Q (the left computing) can be described as Definition 2 –Definition 6.

The transition relations describe how processes can evolve step by step. The transition $P \xrightarrow{\alpha} P'$ expresses that P can evolve to P' by performing the action α, sending or receiving a name. $P \overset{\alpha}{\Rightarrow} P'$ expresses that P can evolve to P' as a result of an evolution whose content is action α, but which may involve any number of internal actions before or after α.

4 Computing Verification

Pi-calculus can be used to simulate the grid computing, and it can also present grid computing verification. It can use the following algorithms to accomplish this function.

Algorithm 1

1) begin.

2) divide the task into several sub-tasks according to each node's computing capability;

3) present the workflow diagram according to the transaction rules in single node computing;

4) present the workflow diagram according to the transaction rules for grid computing;

5)change them into the pi-calculus form by LTS(Table 3 - Workflow Basic Forms in pi calculus, Table 2 -Lable transition rules and Table 1- reduction rules) obtained in steps 3) and 4), and it can be expressed by P and Q respectively;

6) check if existing deadlocks or mutual exclusion violation in them;

7) deduce the bi-simulation type of them belong to: weak bi-simulation, reduction bi-simulation or strong bi-simulation defined in section 3. This can be described as a two-player game. P is a player, and Q is the other. If P wins, then Q cannot simulate the grid computing, that is, the grid computing among the nodes are not successful to accomplish the assigned task. If Q wins, the grid computing is succeeding in completing the mission. If there are the above simulations between P and Q, we say Q wins. Otherwise, Q loses;

8) end.

5 An Example Scenario

The following is a diagram of describing "open account" for a bank client as shown in Fig 1. Assigning that this job is completed with three nodes (computers), which are client representative (abbr. representative), credit manager (abbr. manager) and client. Here a represents an account.

The grid computing is as following:

$$Representative \stackrel{def}{=} in(a).Start(a)$$
$$Start(a) \stackrel{def}{=} Collect(a)$$

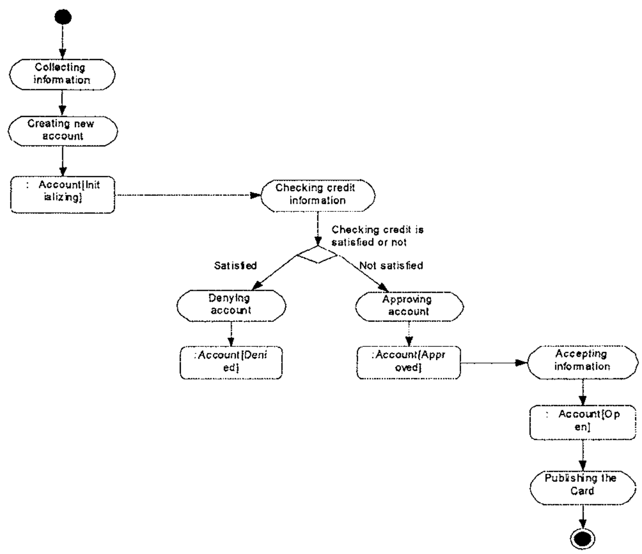


Fig. 1. Activity diagram of Open Account

$$Collect(a) \stackrel{def}{=} Create(a)$$

$$Create(a) \stackrel{def}{=} Initialize(a)$$

$$Initialize(a) \stackrel{def}{=} \overline{out}\ (Initializing(a)).Representative$$

$$Manager \stackrel{def}{=} in(b).startEvaluate(b)$$

$$startEvaluate(b) \stackrel{def}{=} if\ satisfied(b)\ then\ Approve(b)\ else\ Deny(b)\ \ (Approve(b) + Deny(b))$$

$Deny(b) \stackrel{def}{=} done(b).Manager$

$Approve(b) \stackrel{def}{=} \overline{out}\ (Approved(b)).Manager$

$Client \stackrel{def}{=} in(c).startOpen(c)$

$StartOpen(c) \stackrel{def}{=} Accept(c)$

$Accept(c) \stackrel{def}{=} Open(a)$

$Open(c) \stackrel{def}{=} Publish(c)$

$Publish(c) \stackrel{def}{=} \overline{out}\ (done(c)).Client$

In the other way, this task can be done in a single computer (node). The single node computing is as following:

$Representative \stackrel{def}{=} in(a).Start(a)$

$Start(a) \stackrel{def}{=} Collect(a)$

$Collect(a) \stackrel{def}{=} Create(a)$

$Create(a) \stackrel{def}{=} Initialize(a)$

$Initialize(a) \stackrel{def}{=} \overline{out}$

$(Initializing(a)).\ in(Initializing(a)).startEvaluate(Initializing(a))$

$startEvaluate(Initializing(a)) \stackrel{def}{=} if \quad satisfied(Initializing(a)) \quad then$

$Approve(Initializing(a)) \quad else \quad Deny(Initializing(a)) \quad (Approve(Initializing(a)) \ + Deny(Initializing(a)))$

$Deny(Initializing(a)) \stackrel{def}{=} \overline{out}\ (done(Initializing(a))).Representative$

$Approve(Initializing(a) \stackrel{def}{=} \overline{out}\ (\quad Approved(Initializing(a)))$

$.in(Approved(Initializing(a))).startOpen(Approve(Initializing(a)))$

$StartOpen(Approve(Initializing(a))) \stackrel{def}{=} Accept(Approve(Initializing(a)))$

$Accept(Approve(Initializing(a))) \stackrel{def}{=} Open(Approve(Initializing(a)))$

$Open(a) \stackrel{def}{=} Publish(Approve(Initializing(a)))$

$$Publish(Approve(Initializing(a))) \overset{def}{=} \overline{out}\,(done(Approve(Initializing(a)))).Representative$$

The Mobility Workbench (MWB) is an automated tool for manipulating and analyzing mobile concurrent systems (those with evolving connectivity structures) described in the polyadic pi calculus.

The main feature of this version of the MWB is checking open bi-simulation equivalences, and doing so with high efficiency. The open bi-simulation equivalences are described in a polyadic setting, and efficient characterisations of both the strong and the weak equivalences are illustrated and proven to coincide with their standard formulations.

We use MWB here to check the relations of the above processes as shown in Fig 2. It is revealed that the two processes are strong bi-simulation, and they can simulate each other.

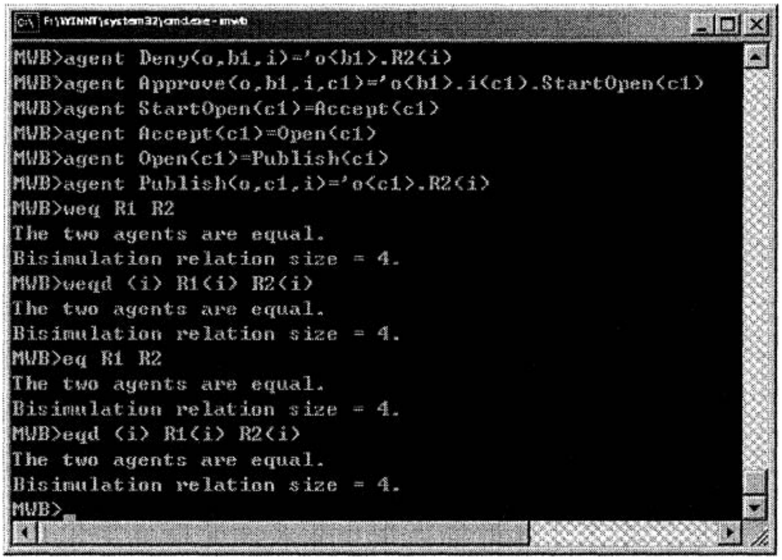


Fig. 2. Computing simulation and verification by MWB

6 Conclusions and Future Work

In order to describe the relationship of single node computing solution and grid computing solution for a task, a two-player game simulation is introduced. At first, a new model is put forward to support concurrent grid computing or web serviced based computation simulation and verification; then pi calculus is used to describe the business transaction processes; finally, it is presented the algorithms for discussing the relation of the single node computing and grid computing. As Petri Net theory lacks of the ability of expressing process behaviors and mobility, this mode supports describing the process behaviors and the communications among the

Processes. Additionally, it also discloses the relationship of single node computing solution of grid computing solution. In the future, we will detail the model checking and verifying functionality to meet the rigorous demands from grid computing.

Acknowledgments

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Formalization of Mining Association Rules based on Relational Database in EIS

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Abstract. In this paper, we study the concrete signification of association rules in relational database, and propose a new formalization and a general process of mining association rules, which is comprehensive, and easy to use and understand. It lays a foundation of designing systems for mining association rules based on relational database, and is a direction for system designer.

1 Introduction

Data mining, also known as knowledge discovery in database, has been recognized as a new area for database research, which provides an effective tool for making use of massive amounts of data. KDD is defined as the uncommon procedure, which finds the new, valid, potentially useful, and comprehensible mode [1].

One of the main Data Mining modes is discovering association rules. The problem of finding association rules between items in sales transaction was first introduced by Agrawal in 1993 [2]. An example of such a rule is that "90% of customers who buy bread and butter, also buy milk at one time". The example gives the idea that, how large is the possibility of customers buying something together with some other things. This is one of the most typical applications of association rules – basket analysis. It is extremely valuable for market strategy to find all of such rules. Besides, there are still other applications of association rules, including attached mailing, catalog design, add-on sales, store layout, and customer segmentation based on buying patterns.

At present, a lot of researches mainly focus on the mining algorithm of association rules [2, 3, and 4] and the updating technique [5, 6, and 7]. There are few papers concerning with the specific meanings of item, itemset, and a set of transactions, which are important conceptions in association rules, in the practice application. But that is the first question, which the designer of association rules

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mining system should take into account. Without a good solution, the applications of association rules mining system will be restricted.

In this paper, the specific meanings of such definitions in association rules are studied based on relational database in EIS. A complete, simple formal statement of association rules is introduced, and a general procedure of mining association rules in relational database is described. This work is significant for designing an association rules mining system based on relational database in EIS.

2 Problem Statement

The researches of association rules are application driven. Development of the bar-code technology has made it possible for the super market and big marketplace to collect and store massive amount of data. In order to gather the useful information from the massive amount of event data, help managers deciding the market strategy, and improve decision-making ability. Agrawal [3] introduced the problem of mining association rules in 1993, and gave a formal statement of association rules, which is widely cited, in 1994.

An association rule is defined as following [3]:

Let $I = \{i_1, i_2, ..., i_m\}$ be a set of *m* different items. Let *D* be a set of transaction, where each transaction *T* is a set of items such that $T \subseteq I$. A unique identifier, called *TID*, is associated with each transaction. If $X \subseteq I$, and $X \subseteq T$, we say that a transaction *T* contains *X*.

An association rule is an implication of the form $X \Rightarrow Y$, where $X \subset I, Y \subset I$, and $X \cap Y = \phi$. The rule $X \Rightarrow Y$ holds in the transaction set *D*, if s% of transaction in *D* contains $X \cup Y$, and c% of transaction in *D* that contain *X* also contain *Y*. Here *s* is called support, and *c* is called confidence.

The problem of mining association rules is to generate all association rules that have user-specified minimum support and minimum confidence. That is to say, the support and confidence of those association rules should not smaller than the minimum support and minimum confidence. The minsupport denotes the statistical minimum support of a set of data. The minconfidence denotes the minimum confidence of rules.

According to the definition of association rules, let $I = \{A, B, C, D, E\}$, Table 1 shows an example of a set of transaction *D*.

Table 1. Transaction set *D*

TID	ITEMS
100	A C D
200	B C E
300	A B C E
400	B E

Most of the papers, concerning with algorithms of association rules, take the similar example to describe algorithms, since association rules are highly generalized, where the concepts of item, itemset, and transaction set are abstracted.

For instance, an item is denoted by a character without any particular meaning; as the same, the transaction set *D* has no fixed format, which can be data files, relation tables, or results of a relation expression.

Such abstract concepts make the study about algorithm independent on particular application, so the algorithm designer don't need to pay too much attention on item, and itemset, etc, but can concentrate on the research on algorithms of mining association rules.

At present, relational database is abroad used in EIS, and massive data are stored in relational tables of different forms. Therefore, it is an urgent problem to open out the specific meaning of item, itemset, etc. in relational database, and to clear the story format of transaction sets in relational database.

3 Formalization of Mining Association Rules in Relation Database

For fully understanding the problem of association rules, it is very important to clarify the concept of item, and itemset. In order to clear the particular meaning of item, and itemset in relational database used in EIS, and make association rules understandable and usable, we put forward a new formal statement of association rules. And based on that, the storage format of transaction sets (Transactional database, Non-transactional database), and the mining procedure of association rules are studied.

3.1 Formalization of association rules

Definition 1 – 5 give the formal statement of association rules:

Definition 1. Itemset $I_n = \{(a,v) | a \in I, v \subseteq p_a\}$, where I is attribution set, p_a is the range of attribution *a*, and v is the subset of p_a.

Definition 2. Given a transaction set *D*, where each transaction $T = \{(a,\delta) | a \in I, \delta \in p_a\}$.

Definition 3. If $\forall(a,v) \in X, \exists(a,\delta) \in T$, where $\delta \subseteq v$, then we say transaction $T(T \in D)$ supports $X(X \subseteq I_n)$.

Definition 4. If s% of transaction set *D* support $X \cup Y$, and c% of transaction, which support X, also support Y, then the support and confidence of this rule are *s* and *c*, respectively.

Definition 5. An association rule is an implication expression like $X \Rightarrow Y$, where $X \subset I_n$, $Y \subset I_n$, and $X \cap Y = \phi$. The rule $X \Rightarrow Y$ is true in transaction set *D*, when s% of *D* contain $X \cup Y$, and c% of *D* contain X and Y. Here, *s* is called support, and *c* is called confidence.

The problem of mining association rules in relational database used in EIS, is just the procedure of finding all of the association rules that satisfy minisupport and miniconfidence.

According to Def. 1, every item in itemset I_n contain a pair of attribution a and its range v (attribution name, range). The values of attribution can be Boolean and multi-value. Boolean attribution can only be 0 and 1; Quantitative value attributions are classified as two group: Numerical Attribute, for instance, ages, prices, etc; and Categorical Attribution, for instance, brand, producer, etc. For example, among the data of census in Table 2, AGE is numerical attribute, workclass is categorical attribute, and since GENDER only has two values: MALE and FEMALE, it can be regarded as Boolean attribute.

In [8], according to the range of attribute value, the problems of association rules are categorized as the Boolean Association Rules Problem (BARP) and quantitative association rules problem (QARP). BARP is regarded as basic and special case of QARP, and it is the procedure of finding the relations between Boolean attributes whose value is 1.

This kind of formal statement can be used not only for BARP, but also for QARP. The difference is that, in BARP the attributes have Boolean values, and the relations between attributes with value 1 are interested. Thus, in BARP, the itemset is simplified as $\overline{I_n} = \{(a,1) | a \in I\}$, each transaction in D is simplified as $\overline{T} = \{(a,1) | a \in I\}$, where I is a set of attributes.

Table 2. The census data are stored in the form of Non-transactional Database

PERSON_ID	AGE	WORKCLASS	GENDER
1	29	Fed-gov	MALE
2	30	Loc-gov	FEMALE
3	50	Never	MALE
4	26	No-pay	FEMALE
5	38	Private	FEMALE
6	40	SelfEI	MALE
7	26	Sta-gov	MALE

3.2 Transactional database and Non-transactional database

In order to mine association rules in relational database used in EIS, it is necessary to understand the organization form of transaction databases, namely how to store one transaction into database. According to the storage manner of transaction T in D, transaction database D can be divided into two types: Transactional Database and Non-transactional Database.

Definition 6. If the relational table stored in transaction database D, contains three columns: *TID* (Transaction ID), Attribute Name, Attribute Value; and one transaction data is stored in several such records, this transaction database D is called Transactional Database.

Definition 7. If in the relational table, each field corresponds to one attribute except *TID*, and one transaction data is stored in one such record, then this transaction database *D* is call Non-transactional Database.

In Table 2, the database *D* storing the census data is Non-transactional Database, while in Table 3 the census data are stored in the form of Transactional Database.

Transaction data stored in the Transactional Database and the Non-transactional Database are the same, and can be easily transformed. Generally the Non-transactional Database is easier to handle than the Transactional Database, but the Transactional Database is preferred in the following two cases: 1) the transaction set contains a large number of attributes; 2) the attribute values in the transaction set are sparse. For example, the transaction data of supermarket should be stored in the Transactional Database, since there are a variety of goods (the number of attributes is large), while the purchase of customers are finite (each transaction contains only a little attributes).

Table 3. The census data are stored in the form of Transactional Database

TID	Attribute Name	Value
1	AGE	29
1	WORKCLASS	Fed-gov
1	GENDER	MALE
...	...	...
5	AGE	38
5	WORKCLASS	Private
5	GENDER	FEMALE
...	...	...

3.3 Procedure of Mining Association Rules in Relational Database

According to the formal statement of association rules and the type of transaction databases, the procedure of mining association rules in relational database used in EIS, includes 5 steps:

Step 1: Analyze the structure of transaction database *D*: Transactional Database or Non-transactional Database.

Step 2: According to the structure of transaction database *D*, obtain the attributes, which will be appear in the resulting association rules; and according to the type of attributes, do discretization of attributes.

Assume *A* is a multi-value attribute, with values in $[l, r]$. If *A* is quantitative value attribute, $[l, r]$will be divided into *N* equal partition, or use CP (clustering partitioning) algorithm to determine the partition; If *A* is categorization attribute, conclude partitioning is applied, e.g. partitioning according to rules (general knowledge) – pencil, eraser and pen are attributed to stationery; Or attribute the first *N* of most frequently appeared attributes as one category, attribute the rest as "others" category. It is not necessary to discretize Boolean attribute.

Step 3: Map the partition $[l_k, r_k]$or attribute values into pair (*A*, *K*), all of those pairs make up of itemset.

Step 4: Substitute the values of each attribute in transaction database D with the partition $[l_k, r_k]$ or attribute values, and the resulting transaction database is denoted as $\overline{D}$.

Step 5: Apply the available algorithms of mining association rules, e.g. Apriori, to mine the association rules in $\overline{D}$.

From the census data in Table 2, Quantitative Attribute AGE and Categorization Attribute WORKCLASS are discretized to get the itemset I_n, as shown in formula Eq. (1), where Boolean Attribute GENDER remains the same. The discretized census database $\overline{D}$ is illustrated in Table 4.

$$I_n = \begin{Bmatrix} (AGE,[20,30]),(AGE,[30,40]),(AGE,[40,50]),.. \\ (WORKCLASS,\text{Government}), \\ (WORKCLASS,\text{Unemployed}), \\ (WORKCLASS,\text{Others}), \\ (GENDER,MALE), \\ (GENDER,FEMALE) \end{Bmatrix} \tag{1}$$

where
Government={Fed-gov,Loc-gov,Sta-gov},
Unemployed={Never,No-pay},
Others={Private,SelfEI}

Table 4. The discretized census database $\overline{D}$

PERSON_ID	AGE	WORKCLASS	GENDER
1	[20,30]	Government	MALE
2	[20,30]	Government	FEMALE
3	[40,50]	Unemployed	MALE
4	[20,30]	Unemployed	FEMALE
5	[30,40]	Others	FEMALE
6	[30,40]	Others	MALE
7	[20,30]	Government	MALE

4 An Example

Based on the analysis of mining association rules problem, we developed a visual mining tool ARMiner (Association Rule Miner) for association rules. ARMiner was developed in JAVA. It supports ORACLE Database, and realized Apriori Algorithm. ARMiner mainly solved two problems: 1). the discretization of transaction data; 2). the implementation of Apriori Algorithm.

ARMiner provides a wizard tool, which simplifies the discrization procedure of transaction data. Firstly, the wizard requires the user to supply the relational tables or views of transaction data, and select their types – Transaction Database or Non-transaction Database. Then the transaction data are discretized according to the processing rule selected by users.

The discretized transaction data (item, itemset), the intermediate results from Apriori Algorithm, and the final resulting association rules are stored in the form of relational tables in the system database, Figure 1 shows the ER Diagram of these tables.

Table 5-9 show the tables, created by ARMiner during the procedure of mining association rules in the census data of Table 2. The tables in Table 5-7 store the discretization of transaction data, including item, itemset, and new transaction data, which are the same meaning with I_n in Eq.(1) and $\overline{D}$ in Table 4. The table in Table 8 stores the set of large *K-itemset* and its support, which are generated in the procedure of mining association rules. And the final resulting association rules are stored in table shown in Table 9. The required association rules can be easily exported from the system. For example, export the first *N* rules, which have largest support, or export the rules in the descending order of confidence.

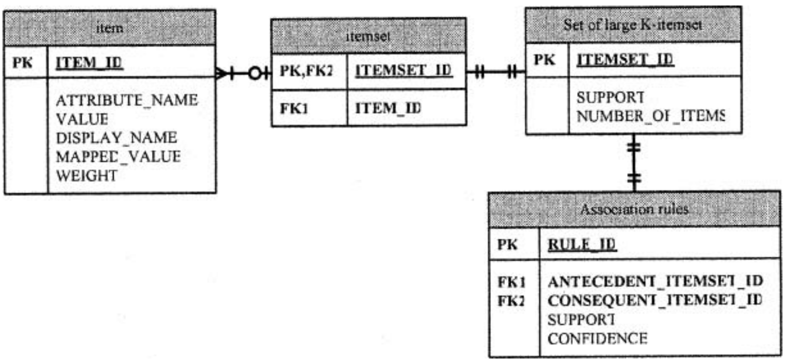

Fig. 1. ER Diagram

Table 5. item

ITEM_ID	ATTRIBUTE_NAME	VALUE	DISPLAY_NAME
1	AGE	1	<=30
2	AGE	2	30-40
3	AGE	3	>=40
4	GENDER	1	MALE
5	GENDER	2	FEMALE
6	WORKCLASS	1	Government
7	WORKCLASS	2	Others
8	WORKCLASS	3	Unemployed

Table 6. itemset

ITEMSET_ID	ITEM_ID
1	1
2	3
3	4
4	5
5	6
6	7
7	1
7	7
8	1
...	...

Table 7. View of new transaction data $\overline{D}$

PERSON_ID	AGE	GENDER	WORKCLASS
1	<=30	MALE	Government
2	30-40	FEMALE	Government
3	>=40	MALE	Unemployed
4	<=30	FEMALE	Unemployed
5	30-40	FEMALE	Others
6	30-40	MALE	Others
7	<=30	MALE	Government

Table 8. Set of large K-itemset

ITEMSET_ID	SUPPORT	NUMBER_OF_ITEMS
1	4.29	1
2	1.43	1
3	5.71	1
4	4.29	1
5	4.29	1
6	2.86	2

Table 9. Association rules

RULE_ID	ANTECEDENT _ITEMSET_ID	CONSEQUENT _ITEMSET_ID	SUPPORT	CONFIDENCE
1	1	5	0.286	0.66
2	5	1	0.286	0.66
3	19	1	0.143	0.5
4	17	4	0.286	0.66

5 Conclusions

Through the formal study of mining association rules in relational database, this paper states the particular meaning of item, itemset, which are the essential concept of association rules, in the relational database, and their inherent relations. It also demonstrates the two forms of transaction data in relational database – Transaction Database, and Non-Transaction Database. Those studies is significant for constructing association rules mining system based on relational database in EIS, and also helpful for researchers who are new to the problem of association rules.

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Architectural Design of Distributed Operation Monitoring Systems

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Abstract. This paper presents an architectural design of distributed information systems used for monitoring operations of gas turbine power generation systems. The software architectural design logically uses a star topology that connects local operation monitoring systems to a central operation monitoring system. The systems are composed in accordance with the concept of three tier model on basis of COM technologies. It is argued that asynchronous and synchronous communication mechanisms are required to for different data transmission scenarios. Finally, COM+ services are implemented to support object pooling, transaction coordination and security control.

1 Introduction

Gas turbines are increasingly used for electrical-power generation, in addition to driving various vehicles, because of their higher energy conversion efficiencies, flexibility and lower environmental impacts. As a gas turbine based power generation system is very complex in perspectives of operation and maintenance, a power station or plant is basically incapable of independently maintaining the system without technical support from gas turbine manufacturers. Consequently, a gas turbine manufacturer is required to provide technical support throughout the product lifecycle from installation, routine operation and failure diagnosis to disposal.

To win market share and increase customer satisfaction, a gas turbine manufacturer has to quickly respond to customer's service requests. Conventionally, a gas turbine manufacturer usually dispatched service engineers to diagnose the latent troubles and fix emerging problems on installation sites, which was quite time and cost consuming. To reduce maintenance service lead-times and costs, a gas turbine manufacturer needs to exploit the benefits of information technologies. With help of distributed information systems, a gas turbine manufacturer may remotely

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monitor and control the running statuses of its products which are dispersedly installed in different geographical areas.

On basis of advances in network and component technologies, researchers have studied approaches for remotely monitoring and controlling system operations. Wang et al present a framework for building web-based systems that can be used for remotely monitoring and control machines in a distributed environment [1]. The primary objectives of all maintenance strategies are to reduce equipment downtime, increase reliability and availability of the equipment which at the same time optimizes the life-cycle costs of the equipment [2]. A recent paper presents an integrated data management system for monitoring and operational evaluation of remote Renewable Energy Sources (RES) plants [3].

This paper presents architectural design of an enterprise information system for monitoring and controlling gas turbine power generation systems. The research work is triggered by a gas turbine manufacturer's need to improve service performance with constrained service capacities. It is accepted that an enterprise information system is required in order to provide operators with the best practices, to develop optimal equipment maintenance schedules, and to make best use of the company's service capacities. This paper outlines the primary considerations in the initial system design phase. The considerations concern how system components are constructed and are bound up to constitute a whole. The preliminary decisions set a conceptual system configuration and guidelines for detailed system design and development.

2 Component Based System Architecture

The primary objectives of implementing the operation monitoring system are multi-folds. First, the system is expected to both reactively and proactively provide operators and the gas turbine manufacturer with real-time operation parameters, such as temperatures, flux, speeds, pressures and energy outputs. Second, the system should analyze and predict the equipment operation health, and develop inspection and maintenance schedules with aim of minimizing the downtime. Third, the system is responsible for generating alarming events in case that some parameters pass the set thresholds and/or some failures occur. Fourth, the system is expected to collect sufficient data and to enable the manufacturer to quickly diagnose the failure causes.

As the gas turbine manufacturer has an increasing number of customers to be supported in parallel, the operation monitoring system has to be dispersedly installed on both the manufacturer's and the customers' computers. Logically, the distributed installations of the operation monitoring systems form a star topology as shown in figure 1. A central monitoring system installed in the manufacturer is like a hub that connects local operation monitoring systems installed in the power stations.

All large applications are developed with guidance of some architecture either explicitly documented or implicitly shared in the developer's minds. Information system architectures specify the system compositions and interacting mechanisms among the constituent components. Both the central and local operation monitoring systems are designed in conformance with the three tier architecture, namely presentation, business and data tier.

The objective of system architectural design is to improve the information system's performance in terms of modularity, reusability, scalability, maintainability and reconfigurability. To this end, it is determined that component based system architecture be used for developing the operation monitoring systems. Among the three prevailing alternatives of CORBA, Sun J2EE and Microsoft COM, the COM technology is chosen as the software component developing tool. The COM component based architecture does not need third-party platforms. And, it is easier to implement access security mechanisms to ensure legal data access and operations on basis of authentication and authorization approaches.

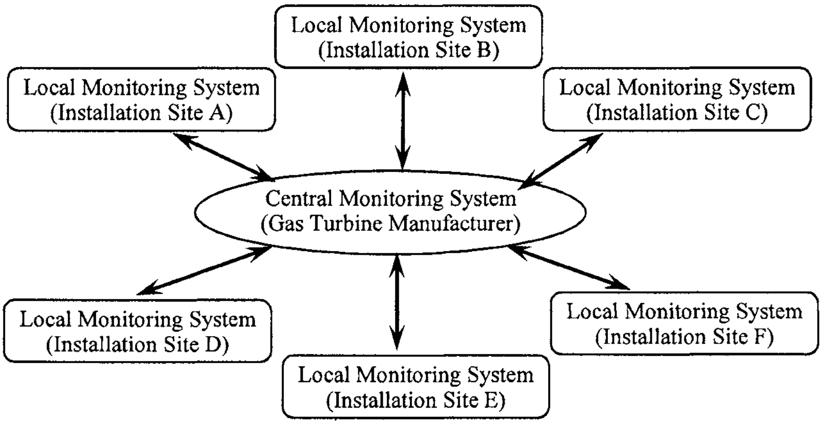

Fig. 1. Star Topology of System Installations

As shown in figure 2, the presentation tiers known as system clients are responsible for manipulating interactions between users and the business tiers through elaborately designed windows, pop-up dialogs, tabs and other view forms. The presentation tiers are to be coded as monolithic applications, which also contain some ActiveX components for graphically displaying operational data in curves, forms and diagrams. More specifically, the local operation monitoring system's clients provide operators with graphical interfaces displaying the measured operational data, and accepting user queries and commands.

The business tiers are to be coded as groups of COM components executing business procedures. A number of various sensors are embedded within the power generation system to measure real-time temperature, flux, vibration, noise, etc. COM servers at the business tier of a local operation monitoring system is responsible for retrieving data from various sensors and data collecting units by providing standard interfaces to encapsulate the measuring devices. The COM servers compare the collected data with parameter settings and analyze operational tendencies. Central monitoring system's servers contain more sophisticated fault-diagnosis algorithms, instead of simply comparing thresholds.

The data tiers are responsible for physical storage and manipulation of data among the distributed data resources. The data tiers are to be coded as ADO components providing standard methods for database connections, data access and operations. Some business rules or operation constraints on data objects are to be enforced via means of stored procedures.

The operation monitoring system's clients and COM servers separately reside on different computers. Basically, the COM objects reactively respond to clients' requests and/or requests from other COM objects. When a client activates the servers, they reactively forward back the collected data. To reduce the communication loads between the clients and COM servers, the clients do not periodically activate the COM servers for collecting operational data. The system clients keep on waiting for event arrivals and do not activate the COM servers without human commands. For the same sake, the COM objects of the central monitoring system will not activate the COM objects of the local monitoring systems until it is requested by a service engineer.

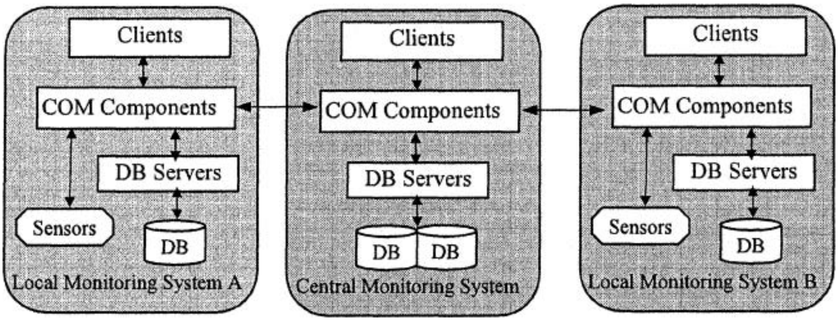

Fig. 2. Three tier System Architecture

However, when a sensor determines some abnormalities, the corresponding COM object may also proactively invoke the clients and other relevant COM objects. When one or more COM servers invoke a client, generating alarming events, the client calls embedded event handling procedures. To support the dual activations, the COM objects are designed as connectable objects implementing the IConnectionPointContainer interface containing a number of IConnectionPoint interfaces. Clients call a server's IConnectionPointContainer interface to obtain a pointer to the connectable object and call IConnectionPoint methods to create connections. Clients use the sink objects to implement the methods defined in the server's outgoing interfaces.

3 Hybrid Communication Mechanisms

Business requirement analysis indicates that a variety of business components are to be developed handling different business logic. For instance, a *Configuration*

Control component is needed to set system parameters like types of data to be sampled, displaying modes, sampling frequencies, algorithms to be used, alarming event types and levels. *Data Sampling* components are developed to encapsulate sensors and compare the collected data with predefined thresholds. *Data Reconciliation* components check inconsistencies among a group of collected data against various thermodynamic models, filtering out noises, drifting errors, sensor bias and other inaccuracies. There are also other components responsible for fault prediction, alarming, spare part management, service supports. Instead of presenting the business components in details, this section discusses the communication mechanisms among these components.

A communication between two objects is a request and response process where a client object initiates a request and a server object responds a reply. The business nature determines that the remote monitoring system implements a hybrid mechanism of synchronous communications and asynchronous communications.

As shown in figure 3, there exist two kinds of interactions, namely vertical interactions between different tiers within a local system or the central system, and horizontal interactions between the central system's business tier and a local system's business tier. There is no communication between any two local systems. Communications between the clients at the presentation tiers and the COM objects at the business tiers are asynchronous. And, communications between COM objects of the central system's business tier and COM objects of a local system's business tier are also asynchronous. However, the asynchronous communications are implemented with two mechanisms. The clients launch asynchronous calls to COM servers in different thread spaces by implementing multi-thread models, which allows users execute multiple tasks in parallel. While COM objects of the central system and those of the local systems use message queues to transmit messages. Local COM objects use the asynchronous message queues to periodically send a gas turbine's operation parameters to the central system's COM objects. And, the central objects use the asynchronous message queues to send the local COM objects maintenance instructions, schedules, diagnosis predictions, spare parts preparations, and so on.

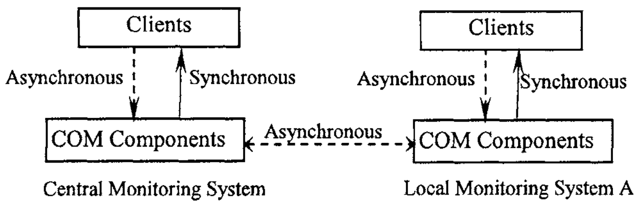

Fig. 3. Hybrid Communication Mechanisms

The asynchronous messaging mechanism does not need to create direct a connection between a sender and a receiver at the same time. The sender may put data into an existing message queue (or create a new message queue), and the receiver retrieves data from the message queue. One important reason to use the messaging mechanism is that it is more reliable and robust on unstable network connections.

On the other hands, most communications made by COM objects in the business tier to the clients are synchronous. At the business tiers, COM objects responsible for detecting operation abnormalities contain a list of clients to be activated for emergencies. In case of urgency, the business COM objects calls the sinks' event handling methods that reside in the clients' main running processes requiring instant responses. The synchronous communication mechanism requires that the clients instantly handle the COM objects' calls before proceeding to execute other tasks.

In some cases, the central client needs to communicate with the COM objects at a local system's business tier, to handle some alarming events. As a central client is not able to directly communicate with a local COM object, the communications are implemented via a central COM object's retransmissions. The COM technology provides two approaches to support the retransmitted communications; containment and aggregation. Containment allows a COM component contains other COM components, and the outer component declares the inner components' interfaces. At run-time, the outer component delegates client's calls to the inner components and presents the outcomes to the client. Aggregation allows a COM component to expose inner components' interfaces to clients who don't know it. At run-time, the outer component passes a pointer to the inner component's interface to a client call. In our design, the containment approach is adopted to reduce communication loads and coding complexity.

4 Interaction Mechanisms with Central Components

As the operation monitoring systems are deployed in a star topology, some COM components at the central system's business tier are to be frequently called by a large number of dispersed clients. This gives a rise to a number of problems. First, creating and destroying a COM object for each client's call is very expensive in terms of memory, time and CPU loads. Second, some COM components are transactional, operating simultaneously on the central data sources and local data sources, which have to be strictly coordinated. Third, an effective security mechanism is required to validate numerous calls to these objects. The COM+ services are used to solve these problems.

As shown in figure 4, these COM components are added to a COM+ server application that runs in an independent process. A COM component, integrated to a COM+ application, is known as a configured component, which is associated with a context object that defines the execution environment for the component.

COM+ uses an object pooling technique to maintain a number of instances of a configured component in a pool, which will be activated for any call to the component. An object pool is created and maintained for each configured component. Clients are not directly served by the component's instances, but via the pool manager. Subsequently, COM+ provides transaction support to maintain the data integrity over multiple data sources. To do this, pools of the components involved in the same transaction have to be aggregated. COM+ provides role-based security framework that assigns roles to classes, interfaces, and methods.

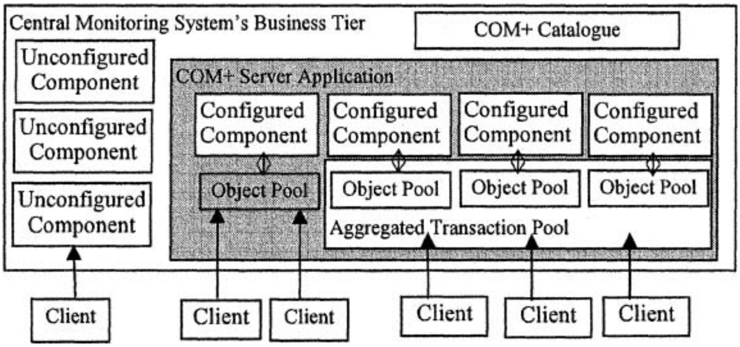

Fig. 4. Interaction Mechanisms with the Central System's COM components

5 Conclusions

Unique business requirements demand that operation statuses of gas turbine systems should be monitored both locally on sites and remotely over distances. Therefore, the enterprise information system is determined to consist of two kinds of loosely coupled information systems. The central operation monitoring system installed within the manufacturing company performs more sophisticated fault prediction and analysis algorithms, and develops maintenance schedules. The local operation monitoring systems installed on operation sites perform simple monitoring logic like on-line data sampling, threshold checking, fault alarming and urgency handling.

It is decided that the systems are to be conceptually designed in conformance to a three-tier architecture on basis of the COM technologies. In the distributed environments, it is identified that communications exist both within a single system, and among the central system and a local system. Asynchronous and synchronous communication mechanisms are used for different scenarios. It is further identified that COM+ services are required to support the complicated business logic executed by the central operation monitoring system.

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A UML 2 Profile for Event Driven Process Chains *

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Abstract. The Event-driven Process Chain (EPCs) is a very well established business process modelling diagram. It can be used as the starting point for software development and therefore, software engineers have to read these diagrams but prefer a well-known notation. For that reason, we have developed a UML 2 profile for EPCs based on a 1 - 1 mapping with UML 2 Activity Diagrams. The profile is tested with an example business process.

1 Introduction

Event-driven Process Chains (EPCs) have become widely-used for business process modelling in organisations. EPCs are based on Petri nets and incorporate role concepts and data models like ER models or UML class diagrams. As EPCs and software developers share models, and because business processes represent business requirements in a formal notation, EPCs can be used as the starting point for software development. For example, an EPC can be utilised to elicit requirements for a new software system, or to check whether the functions of an existing software system match with the requirements of a new business process. But most software developers are not aware of EPCs or are not able to read the models, as different modelling languages are used in traditional software engineering. In order to overcome this gap, we have developed a UML 2 profile for EPCs, with the goal:

- To provide EPC models to software developers in a well-known notation.
- To present EPC models to software developers through UML tools.

UML profiles provide an extension mechanism for building UML models for particular domains. Surprisingly, none of the existing UML profiles for business process modelling 0, 3, 4, 6, and 9] cover EPCs. Generally, well-established business process languages have never been considered for UML profiles before.

The UML 2 profile for EPCs is realised as a 1-1 mapping between EPCs and UML2 activity diagrams, as both diagram types provide similar concepts. The contribution of the UML 2 profile for EPCs is:

- EPCs are available in a lot of modelling tools. The profile facilitates the seamless integration of already available EPC process models into a UML tool, without any additional modelling effort. In contrast, business process

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modelling diagrams that have no sufficient tool support require modelling from scratch.

- It provides business process models to software developers in UML notation. As software systems support the business processes of an organisation, the profile represents business requirements to software developers in a formal and well-known modelling notation.
- The profile can support the elicitation of requirements from the business process models for the software systems to be developed. Deriving requirements from the business process models ensures a business-goal oriented software development.
- The profile can be integrated into the Computation Independent Model (CIM) of the Object Management Group's (OMG) Model Driven Architecture (MDA) approach. Because the CIM model is a business model capturing the requirements of the software systems and is traceable to code, the integration of the UML profile can improve the quality of the requirements and the design of the software. The profile is raising the level of abstraction at which software development starts.
- The UML 2 profile for EPCs can be easily extended and mapped to Business Process Execution Languages (BPEL). Mapping tools are able to take the business processes models developed in a UML tool and convert them to the correct BPEL, and vice versa. Thus, high productivity will be resulting, even if the underlying technology changes.
- The profile could abandon Business Process Modelling Tools, as almost all UML-tools support UML profiles.
- The profile integrates EPC models into the standard software development environment and can be seen as a further step towards bridging the gap between business process engineering and software engineering.

Based on the theoretical concepts of the EPC in Section 2, and its meta-model (Section 3), we have developed the UML 2 profile for EPCs described in Section 4. It is realised as a 1 - 1 mapping between EPCs and UML 2 activity diagrams. Each element of the EPC meta-model is described with stereotypes. For expressing constraints on the UML 2 profile for EPCs we use the Object Constraint Language. The UML 2 profile for EPCs is tested with an example business processes in Section 5. Related work is discussed in Section 6.

2 The Event-Driven Process Chain (EPC)

The EPC 0 has been developed within the framework of the Architecture of Integrated Information System (ARIS) and is used by many companies for modelling, analysing, and redesigning business processes. The EPC is based on the concepts of stochastic networks and Petri nets. EPCs are targeted to be easy understood and used by business people. The ARIS concept 0 divides complex processes models into separate views, in order to reduce the complexity. The views can be handled independently as well as related. There are three views focusing on functions, data, and the organisation (see Fig. 1), and an additional view focusing on their integration.

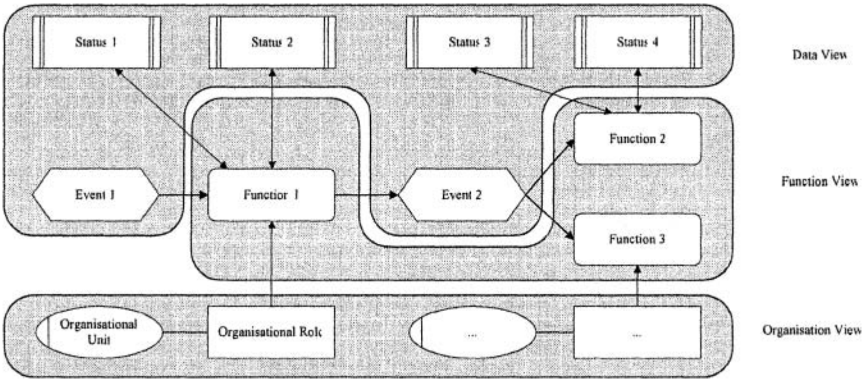


Fig. 1. Architecture of Integrated Information System (ARIS) Views

The *Data View* contains events and statuses. Events such as "customer order received" and statuses such as "article status" represent data. The *Function View* contains the description of the activities to be performed, the individual sub-functions, and relationships that exist between the functions. The *Organisation View* represents the organisational structure. This includes organisational units, employees and roles as well as their relationships. The *Control View* links functions, organisation and data. It integrates the design results, which were initially developed separately. The functions, events, information resources, and organisation units are connected by the control flow. The resulting model is the EPC. It consists of the following elements:

- *Functions* are active elements and model the activities within the company.
- *Events* are created by processing functions or by actors outside of the model. An event may act as a pre- or post-condition of a function.
- *Logical operators* connect functions and events. There are three types of logical operators: AND, XOR (exclusive or) and OR.
- The *Organisation Unit* or *Role* is responsible for performing a function.
- The *Information Objects* portray input data serving as the basis for a function, or output data produced by a function. They correspond to entities or attributes of Chen's Entity-Relationship model or the UML class diagram.
- The *Deliverables* represent services or products functions produce or need.

3 Meta-Model of the Event-Driven Process Chain

As already mentioned, EPCs are widely-used for business process modelling in organisations, not only in the German speaking language area but meanwhile worldwide. The meta-model of the EPC is described in Fig. 2. Each EPC consists of one or more *Functions* and two or more *Events*, as an EPC starts and ends with an event and requires at least one function for describing a process. That means that a function has at least one successor and one predecessor. Both, functions and events can be (re)used in several EPCs. An event has 4 attributes, *start, intermediate, end* and *trigger*. Start, intermediate and end shows if the event is at the beginning, middle or end of a process. Trigger demonstrates if an event triggers a logical operator. A function can be either a *Complex Function* or an *Elementary Function* and may be connected with one or more *Additional Process Objects.* A complex function may be refined by one or more functions. A function is connected with two *Control Flow Connectors*. An event is connected with one or two control flow connectors, as events start the EPC. Control flows link events with functions, but also events or functions with *Logical Operators.* A logical operator can be either an *XOR, OR* or *AND.* It is connected at least with 3 control flows, one or more incoming as well as outgoing connectors.

An *Additional Process Object* may be assigned to one or more functions. A *Deliverable*, an *Information Object* and an *Organisational Structure* are called additional process objects. All three types of additional process objects may be assigned to one or more functions. The organisational structure can be an *Organisational Role* or an *Organisational Unit*, the latter is refined by one or more organisational roles. The organisational structure is connected with one or more *Organisational Flow Connectors.* The information object is connected with one or more *Data Flow Connectors* and the deliverable is connected with one or more *Input/Output Flow Connectors.*

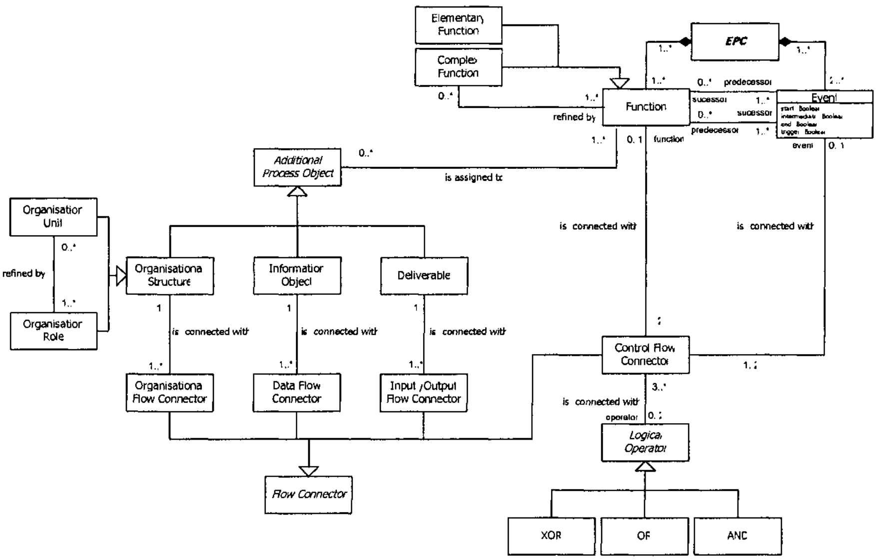


Fig. 2. Meta-Model of the Event-Driven Process Chain

4 The UML 2 Profile for EPCs

In this section we describe the UML 2 profile for EPCs. UML offers a possibility to extend and adapt its meta-model to a specific area of application through the creation of profiles. UML profiles are UML packages with the stereotype «profile». A profile can extend a meta-model or another profile 0 while preserving the syntax and semantic of existing UML elements. It adds elements which extend existing classes. UML profiles consist of *stereotypes*, *constraints* and *tagged values*.

The UML 2 profile for EPCs provides business process models in UML 2 notation. It can be used as the starting point for software development in order to achieve a better coordination between business processes and the supporting software systems. The profile is realised as a 1-1 mapping between EPCs and UML 2 activity diagrams, as both diagram types have similar concepts. In Table 1 to 4 every element of the EPC gets a proper element or base class of the UML 2 activity diagram assigned. For expressing constraints on the UML 2 profile for EPCs we use the Object Constraint Language (OCL) 0, described in Table 5.

Table 1. Mapping of EPC Functions and Events to UML 2 Elements

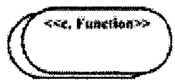
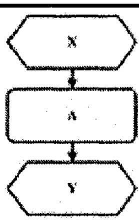
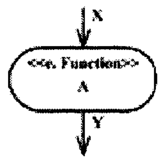
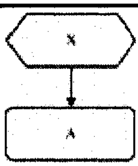
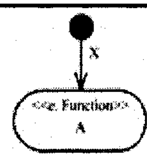
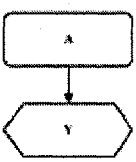
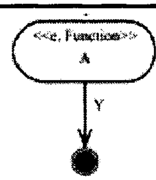
EPC Element	EPC Notation	UML 2 Base Class	UML Profile
Elementary Function		Action	
Complex Function		Action	
Event		Control Flow	
Start Event		Initial Node	
End Event		Final Node	

Table 2. Mapping of EPC Additional Process Objects to UML 2 Elements

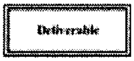
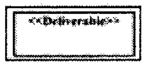
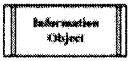
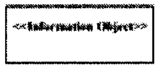
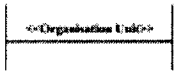
EPC Element	EPC Notation	UML 2 Base Class	UML Profile
Deliverable		Object	
Information Object		Data Store Node	
Organisation Unit		Activity Partition	
Organisation Role		Activity Partition	

Table 3. Mapping of EPC Flow Connectors to UML 2 Elements

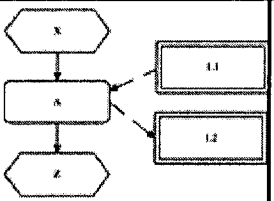
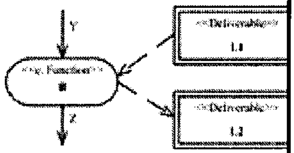
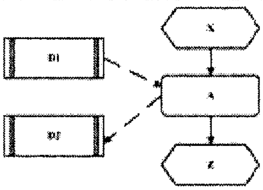
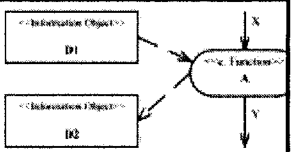
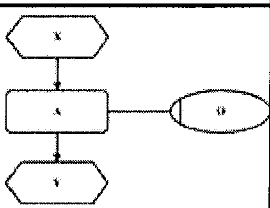
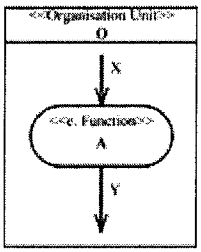
EPC Element	EPC Notation	UML 2 Base Class	UML profile
Input / Output Flow Con-nector		Object Flow	
Data Flow Connector		Object Flow	
Organisa-tion Flow Connector		Activity Partition	

Table 4. Mapping of EPC Logical Operators to UML 2 Elements

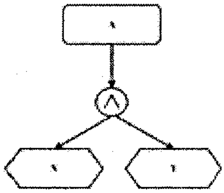
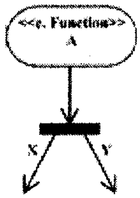
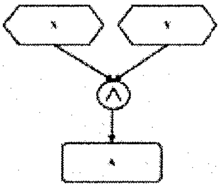
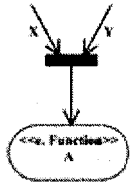
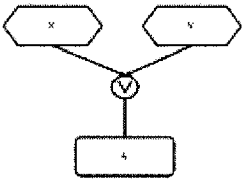
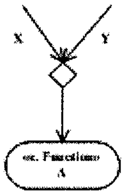
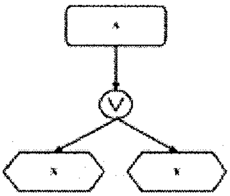
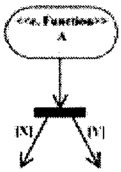
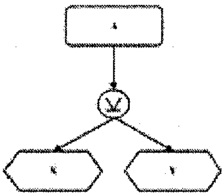
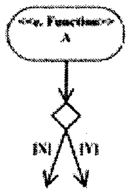
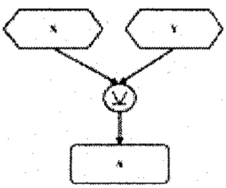
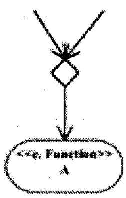
EPC	EPC Notation	UML 2.0 Base Class	UML Profile
AND		Fork Node	
AND		Join Node	
OR		Merge Node	
OR		Fork Node with guards	
XOR		Decision Node (with Guards)	
XOR		Merge Node	

Table 5. Constraints of the UML 2 Profile for EPCs

UML 2 Base Class	EPC Element	Constraints

Action	Function	Before and after a function always happens an event.
		`context Function inv:`
		`self.Event[predecessor] and`
		`self.Event[successor] ->size() > 0`

Function	Complex Function	A complex function is refined by one ore more functions.
		`context ComplexFunction inv:`
		`self.Function->size() >= 1`

Control Flow	Event	An event is always the starting and the endpoint of the profile.
		context Event inv:
		`if Event.start = true and`
		`Event.intermediate = false and Event.end = false`
		`then function[predecessor] ->size() = 0`
		`endif`
		`if Event.intermediate = true and`
		`Event.start = false and Event.end = false`
		`then Function[predecessor] and`
		`Function[successor] size() > 0`
		`endif`
		`if Event.end = true and Event.start = false and`
		`Event.intermediate = false`
		`then Function[successor] ->size() = 0`
		`endif`
		An event is not allowed to trigger a xor-decision and or-fork.
		context Event inv:
		`self.trigger=true implies not`
		`LogicalOperator.XOR and LogicalOperator.OR`

Control Flow	Control Flow Connector	A control flow connector is only allowed to connect not more than 2 of function, event and logical operator.
		`context Control Flow Connector inv:`
		`function + event + operator->sum() <=2`

Activity Partition	Organisation Unit	An organisation unit is assigned to one ore more functions.
		`context OrganisationUnit inv:`
		`self.Function->size() >= 1`
		An organisation unit is assigned to one ore more organisation roles.
		`context OrganisationUnit inv:`
		`self.OrganisationRole->size() >= 1`

Activity Partition	Organisation Role	An organisation role is assigned to one ore more functions.
		`context OrganisationRole inv:`
		`self.Function->size() >= 1`

Data Store Node	Information Object	An information object is assigned to one ore more functions.
		`context InformationObject inv:`
		`self.Function->size() >= 1`

Object Node	Deliverable	A deliverable is assigned to one ore more functions.
		`context Deliverable inv:`
		`self.Function->size() >= 1`

5 Example

We show the practical applicability of the UML 2 profile for EPCs with the example business process of an insurance company: *Processing of Automobile Insurance*

Claims. The process is modelled with EPCs (**Error! Reference source not found.**) as well as with the UML 2 Profile for EPCs (Fig.), subsequently we compare both. Every new claim from an insured person is recorded and calculated by a financial expert. Depending on the calculated insurance sum the process is divided into a path for a minor or a major amount. For minor damages, the garage will be contacted for information about the damage. For major damages, the insurance history of the customer will be checked and the garage will be also contacted. After the examination of results, a decision will be made. If the decision is positive, the insurance company will pay for the damage, otherwise no bank transfer will be done.

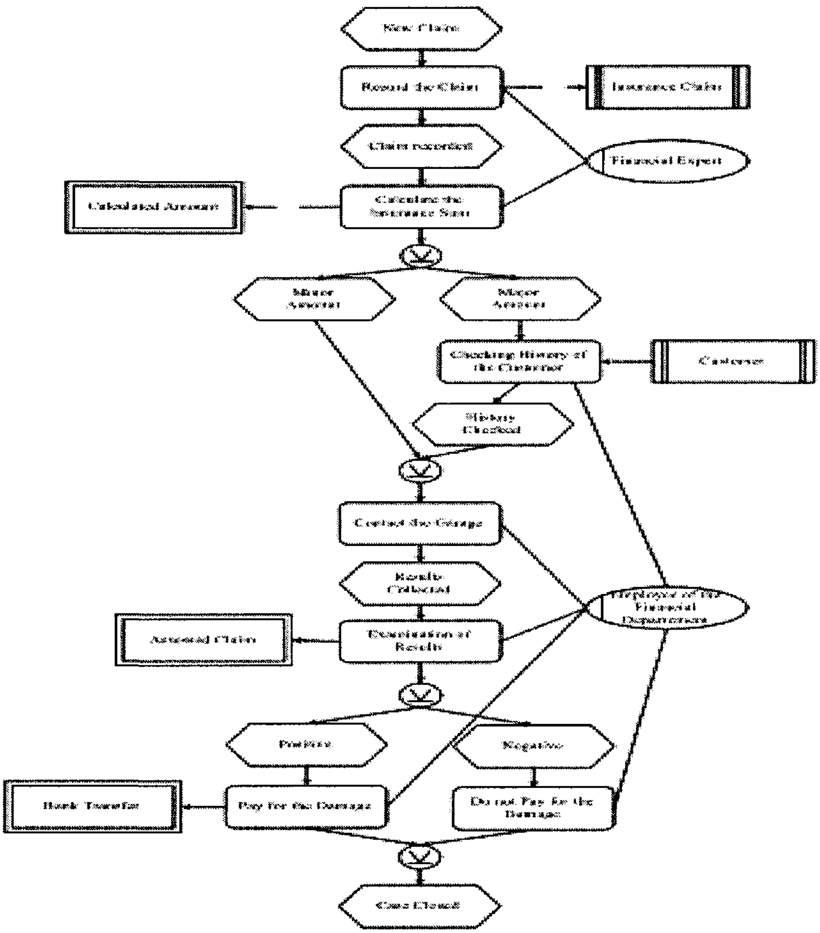


Fig. 3 . Processi ng of Automobile Insurance Claims in EPC Notation

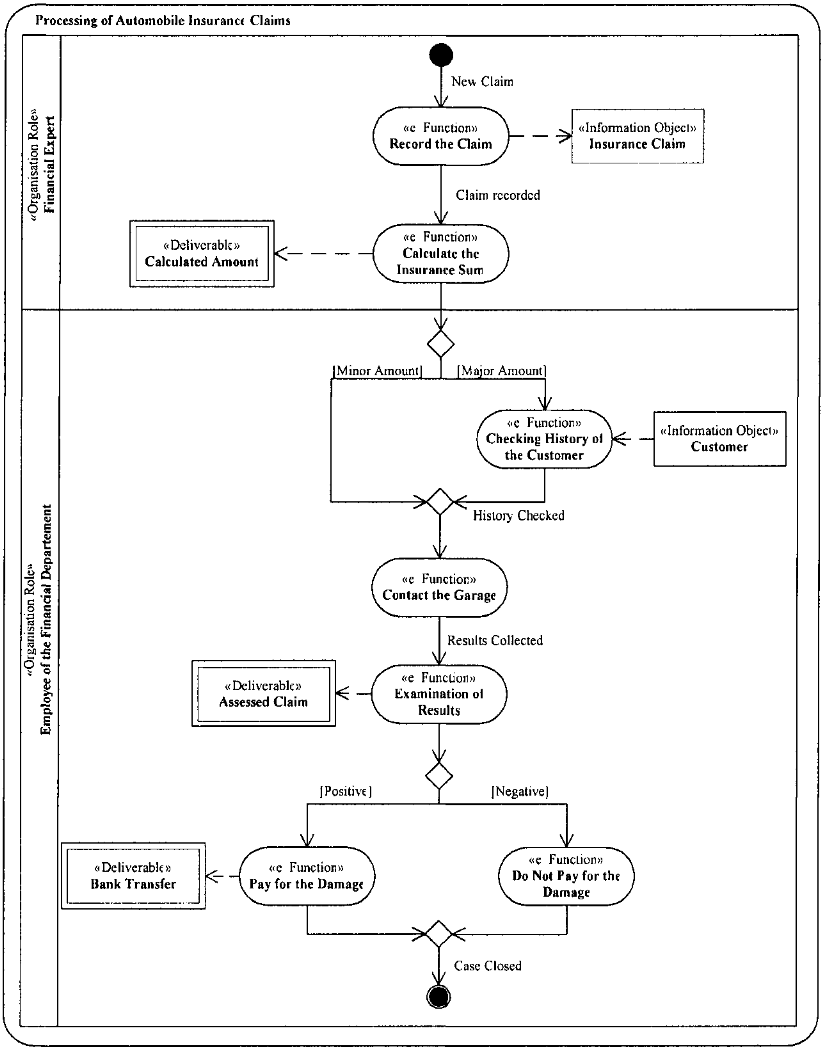


Fig. 4. Processing of Automobile Insurance Claims in UML 2 Notation

Comparing the EPC process model in **Error! Reference source not found.** 3 with the UML2 profile for EPCs process model in Fig. 4, we can see that the latter is not running into complexity and very well readable. It appears almost more structured than the original EPC model because firstly, the organisational structure is at the boundary of the model. Secondly, the EPC events, which are sometimes creating additional complexity without any benefit, are in the background of the model. In both cases, the elements of the process model are reduced. Thus, the developed UML 2 profile is more structured than the original EPC.

6 Related Work

In the current literature, there are already some UML profiles for business process modelling available. The profiles focus on the sequential flow of the business process, but do not represent EPCs at all. Most existing profiles are based on UML 1.4., whereby the UML 2 profile for EPCs is based on UML 2.

The UML Profile for Business Modeling 0 is defined in the UML 1.4 specification and embodies the object-oriented approach for business engineering developed by Jacobson et al. 0. The model lacks a detailed process flow. Johnston extended 0 with an activity diagram, called the Rational UML Profile for business modeling 0.

The UML 2 profile for Business Process Modelling in 0 captures business process characteristics from a wide angle like the customer, the process owner, goals, measures and products, but does not consider the detailed flow.

Activity Nets - a UML profile for modeling workflow and business processes 0 targets the modelling of business process architectures and concurrent processes.

The UML profile for Business Modelling in 0 is focusing on the integration of business processes into software development. The profile maps between business concepts and software artefacts and describes the process flow in a very a detailed way.

7 Conclusions

In this paper, we developed a UML 2 profile for EPCs targeting software developers to view EPC models in a familiar notation. The profile is realised as a 1-1 mapping between EPCs and UML 2 activity diagrams. Each element of the EPC meta-model was described with stereotypes. The profile was tested with an example process.

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Transforming the IT organization for E-Business: A Perspective of Integration

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Abstract. In the context of E-business, IT organization designs meet the serious challenges. To allow the business to engage in IT-enabled E-business strategy initiatives, transforming traditional IT organization is imperative. As an effective method of solving complex problems and building organism, the theory of integration provides an original idea and methodology for the innovational transformation of IT organization. Based on the investigation of integration theory along with the relevant research results in the field of IRM, this paper explores and expounds the MCAS mode of IT organizational integration and explores the frameworks of IT organizational integration from three aspects of organizational member's competence, activity and structure and the transforming model of IT organization.

1 Introduction

Although there are endless mutation and variations of IT organization structures, these changes originate from traditional organizational design thinking and it was designed not to change but to preserve [1]. IT organizations are still viewed as machine bureaucracy and it becomes slow, inflexibility, creativeless and an E-business obstacle to be overcome. In the context of E-Business, IT organizations need to be organic with flexibility and spontaneity. In order to efficiently exploit and utilize IT potential and advantage to support E-business strategy, the basic designing idea and model of IT organization should be changed.

As an effective method of solving complex problems and building organic whole, the theory of integration provides an original idea and methodology for the innovational transformation of IT organization. So the objective of this paper is to explore the basic ideas and application of integration in IT organization design and

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offer a new integration-oriented theoretical approach to deal with the challenges of E-Business faced by IT organization.

This paper is divided in the following sections: firstly the investigations of related work are described along with the relevant research results on IT organizational integration. Secondly, based on analyzing the challenges of E-Business on IT organizational design, the innovational integration-oriented idea of transformation of IT organization is expounded. Thirdly, the conceptual model of integration for the new transforming approach of IT organization is explored. Finally, the conclusion and the future research are summarized.

2 Related work

It is very clear in the history of IRM development that integration has become one of the core ideas in the fields of theory research and practice on IRM [2]. According the view of Horton [3], IT organization is an ensemble of several vocations in different IT fields and they should be integrated though they were isolated and scattered ago. Marchand and Kresslein [4] thought that the integrated management of the functions of "isolated islands" in IT organization is the necessary condition and important guarantee for extremely utilizing the advantages of IT in business. Hence, it became an effective way to transforming IT organization that integrating IT organization based on the functions of IT to solving the problem of "isolated islands".

CIO architecture represents the future transformational direction of IT organization. Rotes and Bonn [5] believed that the key of CIO architecture is the integration of some responsibilities which are originally taken by the separated fields or institutions. Pei [6] thought that the responsibility of IT organization shouldn't be limited by the functions of IT and should integrate some responsibilities of business and management Huo [6] proposed that the functions of IT organization should be integrated into four institutions including Strategy Planning center, Information Center, IT Center and E-Business Center.

Bernard [7] believed that traditional IT organization designing based on the views of job division and specialization and scattered activities and proposed that process is an important basis for transforming IT organizational structure. Furthermore, Brown and Ross, Sambamurthy [8] and Windley [9] described core IT activities from the view of managing IT functions and explored the integration modes of processes respectively.

The results of researches discussed above show that there are some flaws in those ideas and models of IT organization integration. Firstly, although those transforming design all applied the idea and method of integration in some degrees, the traditional designing thinking based on the division of work or function still in charge of the IT organizational integration. Secondly, those integration models didn't provide enough concern on the basic element of organization i.e. human. Although IT function integration, responsibility integration and process integration are related with human more or less, they didn't grasp the pivot point—the knowledge or skills possessed by members of IT organization. Thirdly, although those methods of IT organization integration reorganized the organization's institutions or members according to their functions and integrated them into the corresponding frame, they ignore the transformation of the ways of managing and controlling the members and their activities. The commanding mechanism of control and coordination is not only an obstacle for the cooperation, but also not beneficial for the promotion of organization's reactive capacity and the flexible level.

3 Challenges and Innovation of IT organization

Objectives of IT organizational transformation

To allow the business to engage in IT-enabled E-business strategy initiatives, IT organization design for E-business age meet the challenges and should archive following objectives:

1. Flexibility. A high degree of uncertainty remains in the ways of E-Business. So the IT organization should adapt to the changes of business circumstances and business requirements and provide IT support and service agilely.
2. Responsiveness. Time is a key factor of the competition in E-Business. In order to support E-Business strategy, IT organization should react promptly to changing business environments and enable business to execute all actions swiftly.
3. Collaboration. The essence of E-Business is the virtually collaborative value creation and so the members of IT organization should collaborate and work harmoniously together toward shared business aims.
4. Innovation. E-business is the transformation of business and innovation is the source of core competitiveness and competitive advantage in E-business era. So IT organization design should promote the exchange and share of knowledge and archive innovation in solving the problems of requirements in business transformation.
5. Spontaneity. Internet changes everything. IT organization is not just a bureaucratic machine but an organism. So the design of IT organization should permit it to evolve dynamically to stay in harmony with the changing circumstances and business.

Integration based on MCAS: Innovation of IT organization

As an effective method of solving complex problems and building organic whole, integration is identified by the behavior characteristics: positive and intentional, creative, dynamic, open and optimizing the whole Apparently, applying integration idea in the design of IT organization can utilize the advantages of integration and promote the achievement of the objectives of IT organization transformation.

With the specific functions and goals, IT organization is a system in which two or more persons work together according to a certain structure. IT organizational integration is the application of integration in the IT organizational design. As basic element of IT organization, human is the core of integration. According a certain mode, IT organizational integration makes every member into an organism and achieves radically promotion of the whole functions of IT organization through the mutual impacts between the members in the organization to provide better support and service for the strategy and business.

As a system, the achievement of the whole function of IT organization is the result of activities of members who work together in a certain structure. So in order to transformation IT organization, integration in enterprise IT organization should includes three important contents, integration of members' competences, integration of members' activities and integration of members' structure. Figure 1 summarizes the basic mode of integration in IT organizational design which named MCAS mode.

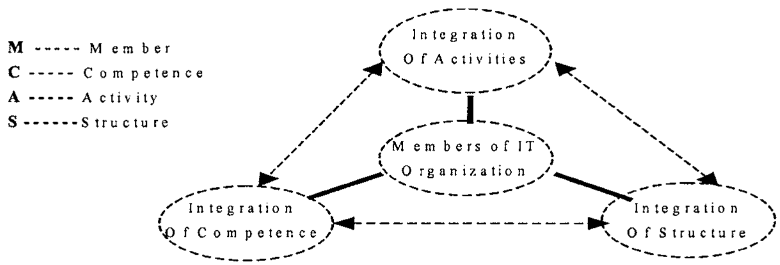

Figure 1: MCAS Mode of IT organizational integration

The MCAS integration mode of IT organization around the core of people is conformity with the human-centered managerial thinking and the integration in above three aspects also conform to the principle of alignment between the inside and outside of organizational strategy. Obviously, MCAS mode presents the advantages of integration on transforming IT organization.

1. Integration of competence attains the supplementary, competitive and harmonious relations among organizational member's competence and promotes the building of the core competence system of IT organization. Through sharing and exchanging knowledge and skill with others, IT organization can effectively exploit and utilize the potential of IT asset and information resources to support E-business strategy and meet E-business requirements creatively.

Generally, the capacity of IT organization is a group of skills which belong to each member separately and also involve in many aspects of the organization. However, just these separated skills couldn't produce great achievement. So, integrating the skills of members into an effective capacity system according to a certain reasonable framework is imperative. Sambamurthy [8], Feeny and Willcocks [10], Marchand, Kettinger and Rollins [11] eluciated that the capacity system of IT organization involves some different fields and several core abilities are the keys to establish an effective capacity system.

Based on these studies, we distinguish and define the core abilities of IT organization from four important aspects .These four core abilities comprise the capacity system of IT organization and provide the basic framework for the integration of members' competence. The ability of S&D is oriented for the aspects of business and strategy. The ability of R&D is oriented for the aspects of IT. The ability of A&S is oriented for the aspects of business requirement support and service. The ability of RM is oriented for the aspects of the information resource and information activities.

2. Integration of activities breaks the restrictions of the specialized divisions of labor and reduces the cost of coordination and promotes collaboration in organization. Through integrating the traditional fragmentary work of organizational member into corresponding process, IT organization can not only improve individual working efficiency but also promote the whole efficiency of organization. With these reasonable and flexible business processes, IT organization can support E-business effectively swiftly.

According to Value Chain Theory, the value created by business actually comes from a series of activities. Process is a series of elaborately designed activities carried on for providing product or service for specific customers or market [12] and a customer-centered organization should increasingly be a process-oriented organization [13].

The definitions of IT organizational processes are not consolidated and mostly just focus on information technology [8, 9, and 14]. Obviously, it is partial to limit the definition of the processes of IT organization just into the scope of IT. According to Davenport's definition and description [12] about process, the definition of IT organization processes should face customers, moreover they should be aligned with organizational capabilities. Therefore, combining with IT organizational capabilities discussed above, the basic processes of IT organization can be generally divided into five aspects involving the strategic planning, the resource management, the exploitation and implementation of solution, the application support and service and customer management, which constitute the framework of integration of activities .

3. Integration of structure effectively makes various inside and outside relations and factors of organization structure (such as, relationships for report, the ways to control or make a decision and so on) become harmonious. Through integration of different organizational mechanisms, members of IT organization can conveniently and effectively communicate and coordinate with others, which should increasingly reduce the rigid degree of organization structure and erase the strict organizational boundary. This will not only enhance greatly the agility and adaptability of the IT organization but also promote the collaboration and innovation.

The traditional structure design partially emphasizes the stability, formalization and professional efficiency and ignores flexibility and spontaneity, hampers cooperation, creation and change. This kind of organizational structure becomes the barrier of organizational business changing ,Generally, the organizational structure stipulates in the work that the organization must do in the specific framework which involving some factors such as the reporting relations, the working procedure, the controlling structure, the authorization and the decision process etc. of the organization [15].

Hence, in order to transform IT organization and make it organically, Integration of structure should combine different organizational structure factors organically in a certain mode to form the competitive supplementary and harmonious relations among those organizational relationships. Based on the basic element of IT organization---human, we could distinguish the complicated relationships from four aspects including controlling method, connecting mechanism, working mode and decision mode which constitute the basic framework of integration of structure.

4 Conclusions

Facing the challenges of E-Business, integration should become an important direction and method for transforming IT organization. MCAS transcends traditional design of IT organization based on utilizing integration theory extensively. According to the MCAS mode of IT organizational integration, we might transform traditional IT organization to be harmonious, flexible and creative and make IT organization effectively adapt to E-business circumstances and support the achievement of E-business strategy. Future researches will explore the measurement and evaluation of IT organizational integration and study the managerial mechanisms and tactics of IT organizational integration.

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Usage of Enterprise Modeling Processes and Information Systems Design to Forecast Demand

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Abstract. Managing the great complexity of enterprise system, due to entities numbers, decision and process varieties involved to be controlled results in a very hard task because deals with the integration of its operations and its information systems. Moreover, the enterprises find themselves in a constant changing process, reacting in a dynamic and competitive environment where their business processes are constantly altered. The transformation of business processes into models allows to analyze and redefine them. Through computing tools usage it is possible to minimize the cost and risks of an enterprise integration design. This article claims for the necessity of modeling the processes in order to define more precisely the enterprise business requirements and the adequate usage of the modeling methodologies. Following these patterns, the paper concerns the process modeling relative to the domain of demand forecasting as a practical example. The domain of demand forecasting was built based on a theoretical review. The resulting models considered as reference model are transformed into information systems and have the aim to introduce a generic solution and be start point of better practical forecasting. The proposal is to promote the adequacy of the information system to the real needs of an enterprise in order to enable it to obtain and accompany better results, minimizing design errors, time, money and effort. The enterprise processes modeling are obtained with the usage of CIMOSA language and to the support information system it was used the UML language.

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1 Introduction

Over the last years, deep changes have affected the competitive enterprise environment. Manage the production became a very harder task due to the necessity of integration of high qualified human resource, parallel to the competitive strategies which add value and improve productivity in the enterprise developing operations.

Furthermore, the global competition and the outsourcing have caused the fragmentation of the supplies chains, making the enterprises seek for collaboration with others through global conectiviness in order to find potential businesses and establish concrete business patterns [1, 2]. To control all these business world variants is a high-risk and complex undertaking and it needs great capital investment, and to have its effect minimized it needs an adequate use of methodologies.

Open system architecture for computer-integrated manufacturing (CIMOSA) [3, 4] is one of the greatest initiatives in the research of enterprise integration. This architecture establishes a set of concepts and a model-based integration approach. The general, partial and particular principles enable the creation of reference models, or general solution which allows testing, adjusting and adaptations in agreement to the enterprise reality.

In this study to make the matter clearer and to exemplify the modelling process it will be detached only one area of the company: the demand forecasting. Generally, in small-to-medium enterprises, this subject area is very regardless due to the limited capacity of their investments, the little knowledge of their managers and also the fragility of the organization in the productive processes.

Based on a general model to the demand forecasting proposed by Santos [5], this article detaches the usage of enterprise models in the orientation design of an information system to aid the demand forecasting, using the reference models CIMOSA and UML for modelling information system. Its also describes briefly the functioning of an implemented prototype, as well as the difficulty of transporting the world enterprise pieces of information to an information system.

This article is structured as follows. Section 2 examines the aspects of the enterprise modelling. Section 3 discourses about the necessity of information in the enterprise decision-making. Section 4 introduces a general view of the demand forecasting. Section 5 deals with modelling systems. Section 6 describes the process models of the demand forecasting and the support information system. Section 7 presents some consideration about the new technologies and section 8 final considerations, as well as future works.

2 Enterprise Modelling

Designing the enterprise involves different enterprise models, each one detaching features and ignoring others. The enterprise modelling generally consists of several models such as: product, resource, activity, information, organization, economical and some decision structures, however, for their development some techniques and support tools are needed.

Through a model it is possible to plan, obtain procedures and documentation consistently show the enterprise reality, accomplish modifications in accordance with the desirable future situation, and incorporate the knowledge and technologies really necessary to the business with more security.

Enterprise modelling can be defined as the art of externalising knowledge, that is, it adds value to the enterprise which needs to be shared. And in order to detach the use of enterprise modelling follows a concise background along the run [6]:

• Mid-70's: SADT, ER model, DFD, semantic nets (IT appli. dev't)

• 80's: CIM methods (ICAM-IDEF, GRAI, CAM-I)

• Late 80's: EU AMICE's CIMOSA / BPR (process orientation)

• Over the 90's:

- ERP deployment (DEM, ARIS, ...)

- Workflow management systems (WPDL)

- Object orientation (IEM, UML, ...)

- Ontologies (IDEF5, TOVE, Enterprise Ontology, PSL, i*)

Vernadat [6] also detaches some modelling tools which implement the above introduced methodologies, accordingly with the following classification:

• Commercial EM tools: ARIS Toolset, FirstSTEP, Bonapart, KBSI tools, PrimeObject, Enterprise Modeler, MO2GO, emaGIM, CimTool, ...

• Workflow Management tools: IBM Flow Mark, Oracle Workflow, Ultimus, WorkParty, Ensemble, InConcert, Action Workflow, OPEN/Workflow, Staffware, Lotus Notes, ...

CIMOSA is still one of the most comprehensive approaches to the development of enterprise models making possible the attainment of an integrated enterprise model which captures and structures the essential characteristics of the enterprise, besides supplying conditions for infrastructure that has supported the integration of the operations of the enterprise. Its objective is to cover essential enterprise aspects in one integrated model. These aspects, in brief, include business processes that compound the enterprise such as: function (business process), information (necessary to business process, as order), resources (necessary to the business process, as people and tools) and organization (the enterprise structure, as enterprises, departments, units and cells). Beyond reaching great flexibility with the instantiation principle, where generic building blocks can be detailed forming the partial model named reference architecture which can be particularized in accordance with the specific documentation of each enterprise [3, 7, and 8].

To deal with the current variants of the business world it is necessary to find convenient techniques, study, analyze, test and propose solutions. The enterprise model will enable an information system design with greater consistency, once all the reality of the enterprise will be able to be surveyed and the true business necessities known, organized and registered through the model.

3 Enterprise Decision Making and the Need of Information

Nowadays, to keep the integration of the several enterprise areas and to integrate its internal and external environments involve some connectiviness such as: internet, extranet, palmtops, and mobiles. Enterprises to become more competitive establish relationships among other companies creating new structures of business. This highlights the potential of the Internet to redesign enterprises in a panorama dominated by dynamic business relationships [2].

This scenario requires enterprises to be able to integrate and coordinate business processes, which go beyond their limits involving several autonomous entities. However, many organizations, especially, the small-to-medium enterprises, are reluctant to invest time and money in models to support decision making [5]. Extracting intelligent strategies and decision support tools need to be considered. The use of reference models can help to extend and support many decision strategies as production optimization, sells analysis, development of new products and services, investment analysis and the adoption of technologies [9].

The necessity of information and integration of the several enterprise areas normally depends on diverse factors such as: problem featuring, impact comprehension and identification. To capture these pieces of information reflecting the way they are found in the enterprise is a must to model them.

4 Systems Modelling

A model can be used to articulate with precision the necessities of the enterprise information and show a great deal of the processing logic which is implicit and not declared to the users. The difficulty in transporting the situation of a real world into a computing system is in leading with the complexity and the number of variable involved. To establish, give priority and connect these variants in way that it can represent faithfully the problem.

The vocabulary and the rules of the UML (Unified Modelling Language) [10, 11] indicate how to create and read well-formatted models, but they do not point out which models should be created nor when one should create them. The object is the main building block of all systems. A modelling language has the target turned back to the conceptual and physical representations of a system.

The CIMOSA generic constructs of the modelling language are provided in textual description and with templates, containing header, attributes and relationships. An overview of the modelling language constructs and their relationships is given in an UML Meta model graphical representation [12].

The models describes in this study are obtained from the enterprise models built with CIMOSA, which captures all the information necessary and after analysis filters the necessary information to compose the information system model UML.

5 Demand Forecasting

In the enterprise environment the demand forecasting is important, especially for the rationalization of the resources and for the correct planning of the client answering level. All planning activity requires forecasting about a future fact; if the forecasting becomes better, better will be the used hypothesis to the planning.

Enterprises, mainly the small-to-medium size, do not make the product demand forecasting as practice integrated from their habitual procedures. In some cases it is used only qualitative procedures and opinions. Great part of the enterprises due to intense daily and the lack of capacity possess a distorted understanding of the involved knowledge in the forecasting, executing activities that do not give potential results.

In accordance with Nikolopoulos and Assimakopoulos [13] the forecasting to enterprise represents one of the crucial factors with the aim to improve the performance of several industry operations and managements and thus help to ensure the efficient resource usage. It can create advantages for the enterprise with the addition of intelligent features as support and decision tools.

Santos [5] found the main problems to low the application of demand forecasting in small-to-medium enterprises: (i) based only in the opinion of analysts (not always enabled to this function); and (ii) difficulty to adjust qualitative questions, opinions, with quantitative questions obtained with the application of mathematical models.

The forecasting is an indispensable piece of information to the production planning, sales and finance of an enterprise, allowing the managers to foresee the future and plan adequately the actions to the development of capacity plans, cash flow, sales, production, storage, work force, purchases, and so on. An information system to forecast demand of a product will be able to provide an understanding and accompaniment of the forecasting, so guaranteeing a consistent base, but flexible through the usage of the resources and devices that adapt themselves to the different realities of the enterprise.

6 Modelling Demand Forecasting and Information System

To model the demand forecasting of products is a sufficiently difficult task since it is an area of the enterprise with diverse characteristics that depend on the size and segment, beyond other factors as: economic, quantitative data, opinions of specialists and integration with other areas of the enterprise.

Enterprise modelling consists of understand the essential features of a system and writing these down in a systematic manner [3]. This work presents a reference model [5], taken from a bibliographical review. The survey and the organization of this environment of generic forecast were obtained with application of the CIMOSA language. The expected one is formalisation of the involved knowledge in the demand forecasting of products promoting the reengineering of the processes and the construction of the information system.

After the capture of requirements and description of the business process in CIMOSA constructors, the object views are all analysed to derive the conceptual schema of the supporting information system using UML models. The UML is a powerful and analytical technique in easy-to-use or user-friendly languages which could be readily applied by business users. The obtained reference model elaborated follows a sequence of development and had two mains activities: *Enterprise Model and Model Information System.*

Enterprise Model – it uses CIMOSA language to define generic operational environment forecasting for the enterprise, or either, the domain forecast and its main components, processes, relationships, activities and information:

1) Requirements Definition Modelling (RDM) – in this level it captures the essential needs. The mains steps are to identify and to define:

- Domain of the work – Domains (DMi);
- Elementary processes of each domain – Domain processes (DPi);
- Activities that compose each domain process – enterprise activities (EAi);
- To establish the input and output information for each activity of enterprise – Object view (OVi).

2) Project Modelling Specification (PMS) – in this level of the modelling the RDM is expanded (DMi, DPi, EAi, OVi) the constructors are detailed.

Model Information System – extended the PMS and it uses UML language defining the conceptual schema:

1) From the enterprise model (PMS), it must be found and described actions that produce results of value for the system and who carries through each action. They are defined: Use Case Diagram and description use cases.
2) Based in the Enterprise Activities and Object View (PMS), and in the use cases description. The object class and relationships had been represented in the Class Diagram.
3) The detailed analysis of models PMS, Class Diagram and Use Case Model assists in the specification of the Sequence Diagram.

The environment of the demand forecast frequently involves two main areas of the company such as: the (i) PCP (Production Control Planning), for example, to plan the productive system (Plan production elaboration, to define goods and services to be offered to the market, to install equipment and to make use of work power) as well as to planning the use of the productive system (to organize production plans, storage, purchase plans, supply replacement, of the production sequencings); and the (ii) area of the marketing and sales department that has objectives such as: make decisions with relation to the promotion and discounting for amount, or launching of new product, or investment in advertisement, or penetration of new markets.

Fig. 1. Represents the forecast model concentrated in four great main processes: the Register of data, the Design of the forecast, the Demand forecasting and the Accompanying of the errors of the forecasting. The support information system to the demand forecasting implements the procedure considered in the Fig 1. The procedure begins from a request of the demand forecasting for one determined end (as to prepare a forecasting for one determined products family). This request initiates a forecasting design where some activities must be executed in order to prepare the forecasting.

The model is flexible allowing in accordance with management analysis, adjustments in the forecasting design, in the demand data, in the forecasting and the calculation of the errors, in order to get the demand forecasting closer to reality as possible.

In the process Register demand data, the data used in the demand forecasting must represent the demand for the product, which is not always compared to occurred sales.

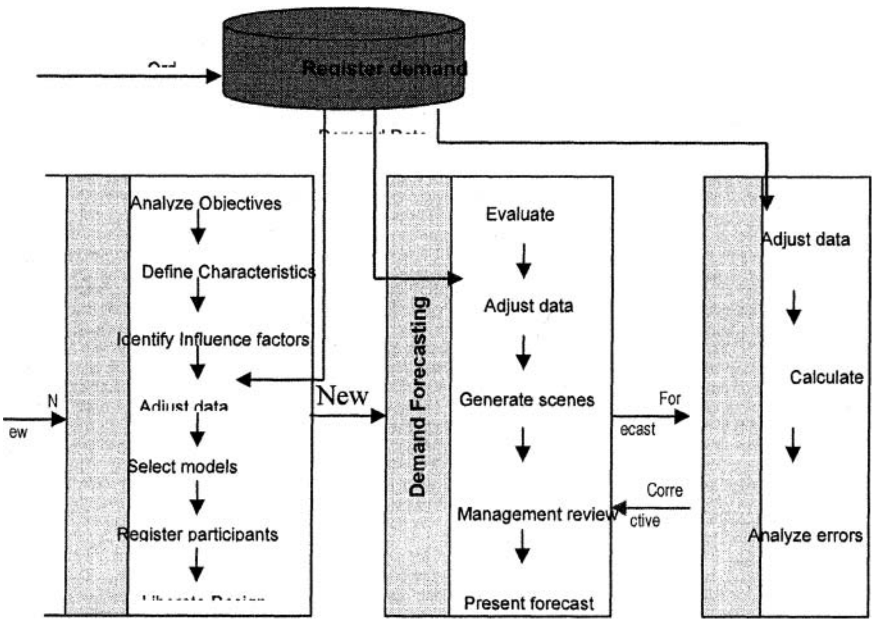

Fig. 1. Procedure considered by Santos [5].

The forecasting design possess seven activities such as: (1) define objectives (type, stated period, family); soon after (2) define forecasting characteristics (horizon of time, region, type of customer); after that (3) identify influence external and internal factors such as: price of purchase, promotion of the competitors, launching of new products, description of purchases, as well as the action of the government, action of competitors, climate, level of economic activity. Next it is adjusted (4) demand data in agreement with the defined factors; it follows (5) the election of models that will be used in it the calculation of the demand forecasting (mathematical and statistical models); later it is defined (6) participants of the forecasting, or either the sectors that participate of the forecasting process. In this point it is important to detach that the people who participates in the forecasting have the responsibility for the preparation of the demand forecasting, and generally it is the ones of the marketing or sales sectors, however the staff of the PCP also must participate because it is a sector directly affected by the forecasting. Moreover, in small-to-medium enterprises, generally speaking, there is no specialisation of the activities, so the staff of the PCP is also responsible for these attributions as well as the purchases and forecasting elaboration. Finally (7) to liberate the design for the accomplishment of the actual forecasting.

After liberating the forecasting process design to the participants, the system generates a solicitation of forecasting process to start it. This is composed of five activities. The data of the solicitation of the forecasting process are, initially, (1) analysed, where occasionally, it can be necessary (2) to adjust the most recent data of the demand. Later it must (3) be generated the scenarios, where the system will calculate the forecasting in accordance with the selected mathematical models, and the hypotheses considered in the model, as defined in the demand forecasting design described previously. After that it is accomplished the (4) management review, then if the manager judges necessary, there will be done an adjustment for the values of the scenario that will define the final forecasting and must be done a description, justifying the new adjustment and finally (5) to present the forecasting.

Results of the demand forecasting calculated from the products demand are evaluated in the procedure of accompanying the errors. This procedure possess three activities that are: (1) to calculate the error, where the system will calculate automatically at all final period the errors of forecasting, and in case that the error exceeds the acceptable limits, corrective actions must be taken in order to adjust the forecasting process or even though to review the design. Next, in case it is necessary, it is done a (2) new adjustment of data, and finally (3) it is analysed the errors leaving registered in the system the reasons of the error and control actions that must be taken in order to correct the forecasting.

For the development and documentation of the models are used support computing tools. In the modelling processes of the demand forecasting it was used CimTOOL software and in the modelling of the information system it was used Rational Rose software.

The information system to aid the demand forecasting implements the reference model of the demand forecasting process. It has the objective to supply a view of how this process can be carried through and adapted in accordance with the company, allowing the managers to analyse the demand, to adjust the production and moreover to serve as study and simulation of the products demand forecasting of the enterprise.

7 Discussion

Some business practices point to ERP (Enterprise Resources Planning) flexibility that the ERP systems allow the decisions and the data base from all parts of the organization be reflected on the planning and control systems of the rest of the organization [14]. This can be obtained through a vertical form with sets of pre-configured standard systems which allow adjusting to combine specific or partial requirements as it is proposed by CIMOSA [1].

Many studies have been developed to promote an open modelling architecture to general model; however, the data collection of a company linked to an ERP data base can present greater flexibility and be more efficient in model maintenance. Allied to intelligent methods of analysing it can provide answers to the problems that were not considered during the design. The model proposed by Dewhurst [9] can be analyzed by multiple perspectives, if applied OLAP tools (on-line analytic).

It is used to integrate the current necessities of the market and provide the access to the competitive advantages as connectiveness, collaboration among enterprises, BI (Business Intelligence) and low cost application. Considering the knowledge acquisition of the enterprise and its transformation into an integrated information system, it is extremely important the employment of techniques for the survey and elicitation of what is intended to design, although each technique highlights one or even several aspects of the problem at question and does not represent the success guarantee.

On the other hand, initiatives go forward to a challenge of reaching a solution which integrates better practices and extends the model to open architectures of low cost and more flexible or adaptable as the ERP5 project proposes. The aim of the ERP5 project is to draw and develop a complete configuration of ERP software components and provide sufficient information (juridical, social, theoretical) in order to able everyone to understand and implement the ERP in small-to-medium enterprises [15, 16].

ERP5 is an audacious design and seeks to associate the great necessity of the enterprises in obtaining a solution of low cost [15, 16] implements the ERP concepts, Internet (e-business) and abstract enterprise (multi-enterprise). However the existing gap between the knowledge acquisition and design performance per se still represents a great challenge.

8 Conclusions

This study approached a proposal of approximating the operations and enterprise information systems detaching the usage of some pieces of information in the enterprise. To the enterprise reference models could be used to give safe, rapid and economical directions to the designs of particular models of enterprise systems.

The process modeling through CIMOSA provided an organized set of pieces of information, facilitating the mapping to design a system with UML. The prototype based on a reference model as proposed will be able to be customized, that is, adapted to answer to the particularities of a determined enterprise, and it will be used as an additional component of some managing enterprise system.

In the support system proposed to the model during the accomplishment of the activities of the forecasting processes are also present some fields where analysis and description will be done. The systematic register of these data allows placing the decisions and conclusions in accordance with the time (period) and the context. Allowing a comparison of the results of the mathematical models selected with the pieces of information of qualitative analysis, executed by experts it is possible to assess and test new parameters and/or models, aiming to approximate to the reality the results forecasted and make possible the decision with a greater consistency.

With the aim to have influence on and favour potentialities of future works it might be used solutions as Data warehouse to, for example, transform the operational data into strategic ones, transforming this into an automatic decision support system, and use extraction tools on information as data Mining [5].

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J2EE Development Based on the JSED Template

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Abstract. This article proposes the JSED template which is directed by the MVC design pattern and behaves as the Session Facade design pattern, and then gives its working principle, finally introduces how to use the JSED template in coding in actual J2EE developing environment.

1 Introduction

With the rapid development of Internet, J2EE component developing technology has become more and more widely applied in Web information system development by its mature features such as open, inter-platform and security. The MVC and the Session Facade and such J2EE basic design patterns have become the prevailing way increasingly in J2EE component development. How to integrate the classical design patterns and convert them into practical developing template has got more and more attention.

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2 J2EE Platform

2.1 J2EE Architecture

J2EE is a multi-layer, distributed and Component-Oriented enterprise level application mode proposed by SUN [1], which is composed by a series of services, APIs and protocols that offer functional supports to the development of Web-based multi-layer application. In J2EE application system, these components can be divided by function, and distribute on different computers and stay at corresponding layers.

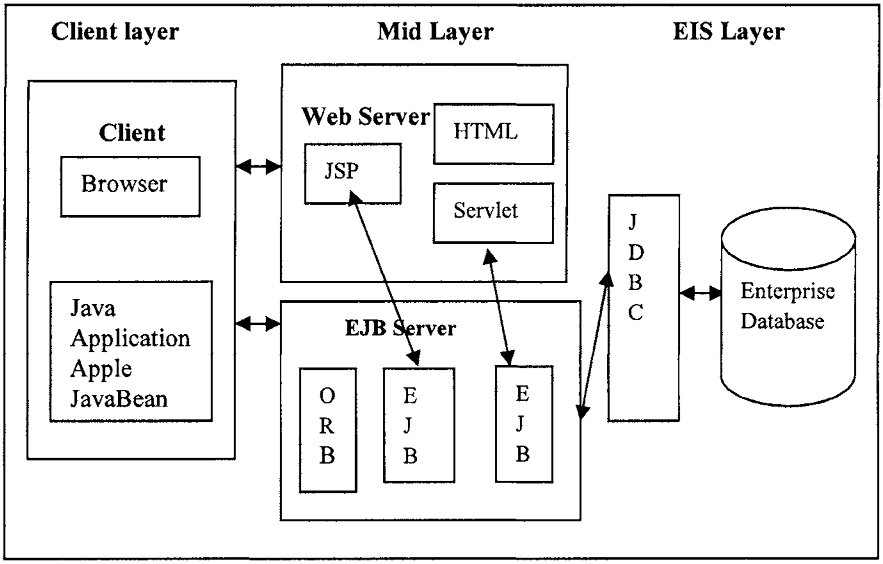

Fig. 1. Web Information System based on J2EE architecture

As shown in Fig. 1, J2EE is specially designed for creating multi-layer application. J2EE design is based on the following three layers: the Client Layer, the Mid Layer which also includes the Web Layer and the EJB Layer, and the EIS Layer. In the first two layers (the Client Layer and the Mid Layer), J2EE standard defines the components below [1]: Client components, Web components and EJB components.

2.2 EJB Technology

EJB is the core of J2EE. EJB (Enterprise Java Bean) is a category of object-oriented component, which is mainly used in developing, realizing and deploying distributed business logic, positioned at the Mid Layer of J2EE triad-layers. The core concept of EJB is to separate the business logic and the system logic of lower-layers so that the developers just need to take care of the business logic and the system level service will be offered by application server (e.g. WebLogic Server) [2]. EJB 2.0 standard has defined three kinds of EJB as follows:

- Session Bean invoked by client components or Web components to accomplish server operations, e.g. accessing databases, invoking other EJB, etc.
- Entity Bean□on behalf of the persistent stored data, representative example is the records stored in databases.
- Message-Driven Bean□allowing EJB to receive JMS message asynchronously.

3 J2EE Design Patterns

3.1 The MVC Design Pattern

MVC is a comparatively successfully and widely used design pattern, particular suitable to design multi-layers application. MVC Design Pattern adopts a sort of idea of "Matrix Structure" which abstracts the application as Model, View and Controller [3].

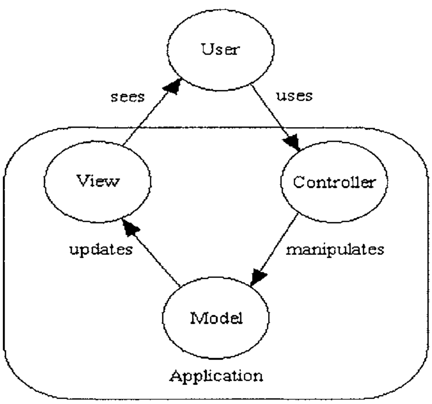

Fig. 2. The basic MVC relationship

Fig. 2 illustrates the relationship of the three parts in MVC Design Pattern [4, 5].As shown in Fig. 2, The Model, View and Controler are completely different in function in order to improve the quality of the software [6]. They are also intimately related and in constant contact. Therefore, they must reference each other.

In the Java language the MVC Design Pattern is described as having the following components [4]:

- An application model with its data representation and business logic.
- Views that provide data presentation and user input.
- A controller to dispatch requests and control flow.

The purpose of the MVC pattern is to separate the model from the view so that changes to the view can be implemented or even additional views created, without having to refashion the model [4].

3.2 The Session Facade Design Pattern

EJB design is the core model of J2EE component design, which emphasizes repeatability, maintainability, transplantable and so on. In the meanwhile, most of the J2EE applications contains data storage layer. Therefore, Client's accessing to Entity Beans is significant to EJB development. The simplest way to access Entity Beans is to access directly via client components, i.e. adding accessing code directly to the code of client components. But there are a great many hidden troubles in adopting this method, such as network load problems, exposing database substructure information, destroying transplantability of EJB, etc. In order to solve the above problems, in EJB design, it's necessary to avoid using client components and Web components to access Entity Beans directly. The best solution is to utilize the Session Facade Pattern in J2EE application system development. The Session Facade pattern realizes the Facade Design Pattern conception via using Session Beans, i.e. using Session Beans to pack Entity Beans to invoke methods of Entity Beans. An Entity Bean represents data in the database, and all operation to Entity Beans represents the change of substructure data. The synchronization process of Entity Beans and databases is managed by the container. Session Beans are used to process business logic and workflow, which is the abstraction of client work. Web layer is used to process the enterprise's present logic, i.e. processing the interaction between EJB layer and client layer, including reception and response of client requirements and sending the requirements to EJB and receive its response.

4 The JSED Template

4.1 The JSED Template Principle

EJB component is the core of J2EE. Although Java Servlet□Java Bean and JSP are not necessary components of J2EE application projects, they can work with EJB to offer application environment based on Java cohesion.

The MVC Design Pattern and the Session Facade Design Pattern are classical design patterns of J2EE application. In practical development, it should be guided by the basic pattern concept to design component development template that suitable to the actual situation. Component development has put the basic design pattern principle into practice, e.g. what components compose the three essential elements of the MVC pattern and the rule should be followed by the interfaces between these elements in actual development environment, etc. Proposal of the component template can greatly shorten component development cycle.

According to the analysis of the MVC and the Session Facade design pattern, the JSED (JSP-Session Bean-Entity Bean-Database) template is structured on the basis of integration and improving on these two design patterns. Following the main idea of the MVC pattern ,this template maps the three parts of the MVC pattern as different J2EE components, the Model part is mapped as the EJB components, the View part is mapped as the JSP-view components, and the Controller part is mapped as the JSP-controller components, i.e. inserting Java code into JSP to invoke EJB in the EJB server [7].While introducing the MVC pattern, the JSED template also uses the Session Facade pattern to organize and coordinate the invoking relationship between components in every part. Entity Beans access database components via JDBC; Stateless Session Beans access Entity Beans and executes business logic; JSP components (including JSP-view components and JSP-controller components)are used for showing data and submitting users' operation in order to accomplish view and control logic. In other words, the JSED template put forward by this article succeeds to the characteristics that the MVC and Session Facade patterns adapts to J2EE multi-layer application development.

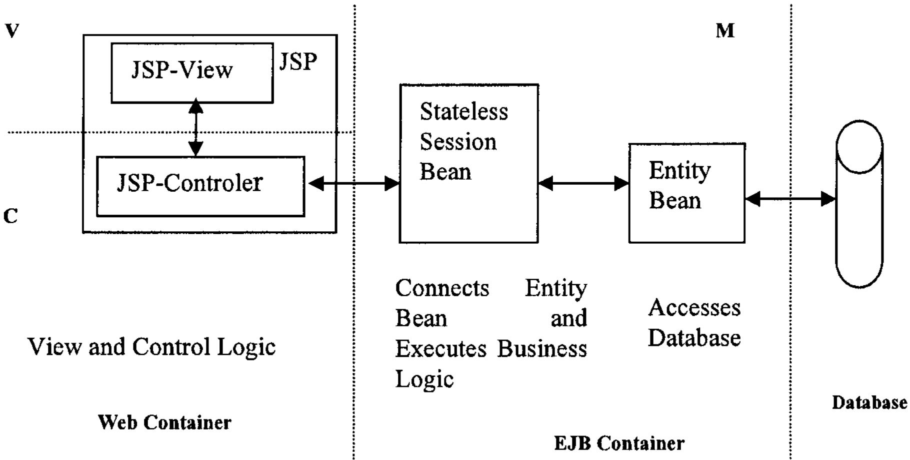

Fig. 3. Architecture of the JSED Template

A procedure here describes the specific steps about the JSED template.

(1) Various requirements from clients are delivered to JSP-Controller components via JSP-View components.

(2) According to the requirements, JSP-Controller components call EJB container for executing the corresponding business logic functions, for example, instantiating Session Bean objects, invoking Session Bean methods, updating or abstracting Session Bean objects' state.

(3) EJB container instantiates Session Bean objects as soon as it receives the requirements.

(4) According to the requirements from JSP-controller components, Session Beans execute the corresponding business logic functions, usually accessing Entity Beans via EJB container to operate the data. The results are looped back to the corresponding JSP-Controller components also via EJB container.

(5) JSP-Controller components deliver the results from Session Beans to the corresponding JSP-View components. These results are then formatted [8] by JSP-View components and looped back to clients by Web server.

4.2 JSED-based Coding Template

Directed by the JSED template principle, the specific coding template differs in the actual developing environment, which is mainly embodied in E-D link and S-E link. Here, following the D-E-S-J order, the JSED component coding template is given(the italicized parts need to be codified according to the actual circumstances).The actual development environment is described as follows: the database system is SQL Server 2000, the application server system is Weblogic Server 8.0, and the J2EE developing tool is JbuilderX.

(1) E-D Template (the template by which Entity Beans and Databases are connected)

- Create an EJB Model in the corresponding Project of JbuilderX to pack the interrelated Entity Beans and Session Beans, and then import a Database Schema to express the database which needs to be correlative with Entity Beans. In Database Schema Provider ,the database connection information should be set as follows:

  Driver: weblogic.jdbc.mssqlserver4.Driver
  URL: jdbc:weblogic:mssqlserver4:*Database Name@ DB Server Name*
  Username: *Login Name of SQL Server Identity Verification*
  Password: *Login Name of SQL Server Identity Verification*
  JNDI name: *Database JNDI Name Need to be Related*
  Other settings are empty

- Select a table in the imported Database Schema to create the corresponding Entity Beans (CMP is suggested). Entity Beans can be set and codified. It needs to be emphasized that the property named "Interface" should be set as "local", which means the local reference of Session Beans to Entity Beans.

(2) S-E Template (the template by which Session Beans and Entity Beans are connected)

- Create a stateless Session Bean in the EJB Model, and then create EJB Local References for the stateless Session Bean to access Entity Beans. The parameters are set as follows [9]:

  Name: *Local Reference Name*
  Select "isLink"
  Link: *name of the Entity Bean to be referred to*
  Type: Entity
  LocalHome: *Name of Database Associated With Entity Bean .Home Interface Name of Entity Bean*
  Local: *Name of Database Associated With Entity Bean. Entity Bean Name*

- In the source code of the Bean class, the coding template used to access Entity Bean is as follows:

```
public class Session Bean Name implements SessionBean {
  SessionContext sessionContext;
```

```
private Entity Bean Name  Entity Bean instance Name =null;
private Home Interface Name of Entity Bean  Home Object Name of Entity
Bean =null;
public void ejbCreate() throws CreateException {
  try{
    Context context=new InitialContext();
    Object ref=context.lookup("java:/comp/env/ Entity Bean Name ");
    Home Object Name of  Entity Bean =( Home Interface Name of Entity
    Bean)ref;
   }catch(Exception e){e.printStackTrace();}
}// access Entity Beans while creating Session Beans
...... //other call-back methods


public void setSessionContext(SessionContext sessionContext) {
  this.sessionContext = sessionContext;
}
...... //operation logic methods of Session Beans

}
```

(3) J-S Template (the template by which JSP components and Session Beans are connected)

- Create a class named GetInitialContext ,and the coding template is as follows:

```
public class GetInitialContext {
  public  Context getInitialContext() throws Exception {
    String url = "t3://application sever name:7001";
    String user = null;
    String password = null;
    Properties properties = null;
    try {
      properties = new Properties();
      properties.put(Context.INITIAL_CONTEXT_FACTORY,
                  "weblogic.jndi.WLInitialContextFactory"); [10]
      properties.put(Context.PROVIDER_URL, url);
      if (user != null) {
        properties.put(Context.SECURITY_PRINCIPAL, user);
        properties.put(Context.SECURITY_CREDENTIALS, password == null ?
                    "" : password);
      }
      return new InitialContext(properties);
    }
    catch(Exception e) {
      System.out.println("Unable to connect to WebLogic server at " + url);
      System.out.println("Please make sure that the server is running.");
      throw e;
    }
  }
```

```
}
```

- Create JSP components to invoke Session Beans, and the coding template using for connecting Session Beans is as follows(the boldfaced"**GetInitialContext**" in the code is the class defined in the previous step),

```
<%@ page import="Project Name. Session Bean Name, Project Name. Home
  Interface Name of Session Bean, Project Name.GetInitialContext"%>
<% //invoke Session Bean facade
  Session Bean name Remote Interface Object Name of Session Bean =null;
  Home Interface Name of Session Bean Home Object Name of Session Bean;
   try{
    GetInitialContext ic=new GetInitialContext();
    Context ctx = ic.getInitialContext();
    Object objref=ctx.lookup("Session Bean name");
    Home Object Name of Session Bean =(Home Interface Name of Session
    Bean)PortableRemoteObject.narrow(objref, Home Interface Name of Session
    Bean.class);
    Remote Interface Object Name of Session Bean = Home Object Name of
  Session Bean.create();
   ......//
```

- The operation logic methods of Session Bean are invoked by the under mentioned template in JSP-Control components,
  Remote Interface Object Name of Session Bean. Operation logic method Name of Session Bean (Parameter Table);

5 Conclusions

In allusion to the practical application of the MVC and the Session Facade and other J2EE basic design patterns, we put forward the JSED template which is used in actual J2EE development.

In this paper, the principle and workflow of the JSED template are discussed, and the main code of this template is presented via the integration of the corresponding supporting tools and development environment.

It's obvious that it is more convenient to develop a web information system with legible structure, high performance, high security and high expansibility by applying the JSED template in J2EE development.

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Enterprise Knowledge Integration by Semantic Web

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Abstract. In today's enterprise, separate knowledge in different operation systems without integration makes decision-making difficult. To solve this problem, an application framework, which supports enterprise knowledge integration (EKI), is put forward. The framework has a multi-layer architecture and is implemented by semantic web technologies based on enterprise's legacy systems. Four key technologies are studied: data semantic transformation, unified knowledge representation by RDF/RDFS, constructing knowledge chain and knowledge query. A referenced approach to develop the framework is also proposed. Finally, a practical application in a large-scale corporation of Hydropower Engineering is further provided to illustrate the framework.

1 Introduction

Nowadays, knowledge has emerged as the most important determinant of accelerating innovation, core competition and competitive advantage. Generally, there are some separate application systems in a company to manage the data and data flow, which are only capable of coping with operation-layered problems. Whereas, it is more valuable to transform data into knowledge, integrate dispersed knowledge and build up knowledge repository via knowledge chain.

Many scholars have made a lot of achievements in the theory and technology on Knowledge Management (KM). Therein, [1] defines some concepts about KM, analyzes connotations of Knowledge, KM and KM systems, and puts emphasis on arguing about the use of Information Technologies in KM activities; In order to achieve the goal of KM, i.e. Knowledge Integration, and to solve problems by the multiple vendor application systems running in one company, a solution is proposed in [2], which is based on the distributed relation databases, XML and metadata; Ontology is becoming a major issue recently, and [3] describes a system architecture and its implementation, which makes use of ontologies to organize, share and query

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knowledge objects; Production design is a knowledge-intensive work, and an Internet-based distributive knowledge integration system to meet the demand of product designers on various knowledge resources is proposed in [4], which is based on STEP standard and combines the artificial neural networks and active server pages techniques. The relative studies have accomplished many valuable results. However, most of them only focus on one special part of knowledge integration. The further work needs to focus on how to develop highly efficient knowledge integration applications in the companies from systematical point of view.

In this paper, by applying Semantic Web technology, an application framework of enterprise knowledge integration systems is put forward. The framework is multi-layered and based on legacy enterprise application systems. The rest of the paper is organized as follows: Section 2 gives an overview of the framework's main architecture and functionalities; Section 3 describes four key technologies; Section 4 presents a referenced approach to build a knowledge integration system; Section 5 shows a practical example to illustrate the framework; And finally, section 6 concludes the paper with additional comments and future work.

2 The Architecture of the Proposed Framework

The formal definition for Knowledge Integration was raised by Grant [5], who indicated that "Knowledge Integration (KI) is the first role of enterprise and the nature of enterprise capability". Enterprise Knowledge Integration (EKI) researches the methods of knowledge acquirement, storage, sharing and reuse, and aims to integrate various knowledge resources and to make company as an organic whole.

This paper proposes a framework of EKI by applying Semantic Web technology. The architecture of the framework is divided into 4 layers: data layer, application layer, knowledge integration layer and knowledge service layer.

(1) Data Layer. It is the basis of the architecture, storing all the data coming form enterprise systems. Under the framework, those data, which can be semantically transformed to be knowledge, are the focus of the data layer.

(2) Application layer. It is the collection of all the application systems. Most enterprises have some application systems already, such as manufacture management system (MMS), equipment and material management system (EMS), customer relationship management system (CRMS) and human resource management system (HRMS), etc. In the architecture showed in Fig. 1, knowledge is acquired from all these systems and then transformed to proper format.

(3) Knowledge integration layer. It is the kernel of the whole architecture, realized by semantic web technology. The final target of EKI is to share, reuse the knowledge and improve the knowledge innovation. One of the most important problems is how to analyze, understand and deal with the knowledge automatically by computer, which is the advantage of semantic web.

(4) Knowledge service layer. It means all kinds of specific services supplied for knowledge workers such as knowledge search engine, knowledge map, etc. The intelligent services can help knowledge workers fulfill their work effectively.

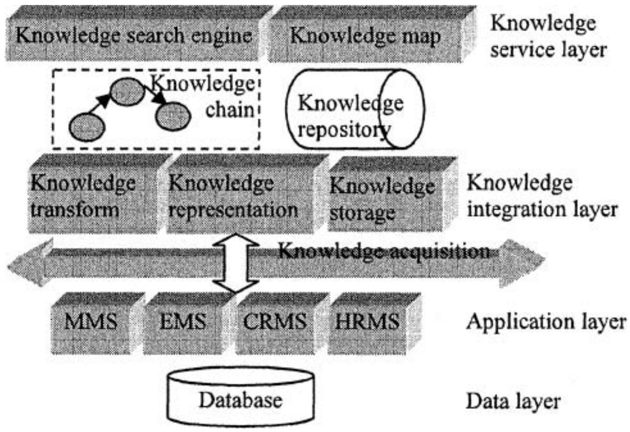

Fig. 1. The Architecture of EKI Application Framework.

3 Key Technologies of the Proposed Framework

Semantic Web [6] was put forward by Tim Berners-Lee. And the researches on semantic web have reaped some achievements already, such as RDF. Researches of next phase should be on the themes of how to put them into application. To realize the framework proposed in this paper, four key technologies are involved.

3.1 Semantically Transforming Data to Knowledge

XML has been the de facto standard for data exchange and transformation. Nearly all the relational databases and information systems can provide business-describing documents easily in the format of XML. However, XML is not strictly a semantic language, lacking strict model, theory and logic. The understanding to a XML document relies on the programs parsing XML. While using semantic web to do system integration, we can attach semantic information to the data. In the semantic web architecture, the language for knowledge representation, such as RDF, are all based on XML, so it is feasible to semantically transform the XML data to ontology [7]. This paper proposes the process of semantically transformation of data, the crucial part of EKI, which covers three layers, data layer, business system layer and knowledge integration layer, see Fig. 2.

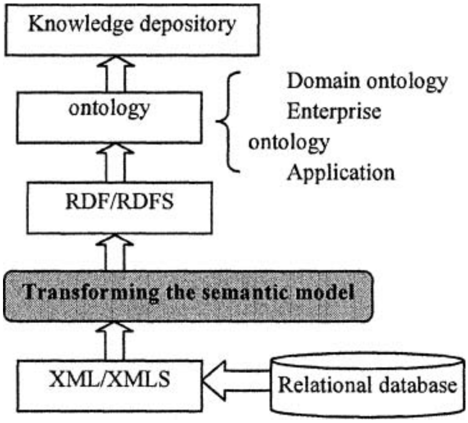

Fig. 2. semantically transforming data to knowledge

3.2 Unified Representation of Knowledge by RDF/RDFS

One of the most important problems, which occur when integrating the enterprise data from various kinds of separate application systems in the knowledge layer, is semantic non-interoperability. Ontology, which is defined by Gruber [8] as an explicit specification of a conceptualization, is considered to be a useful approach to achieve semantic interoperability. For knowledge integration based on ontology, the interoperability must be in the same domain context or the knowledge share must be from semantic transforming agent. Therefore, the representation of domain knowledge must be from domain ontology, which is constructed in each domain. Based on Perez's research [9], domain ontology can be represented as follows.

$DO = \{V, I, R, F^D, A^D\}$, where

DO, the collection of domain ontology;

V, the concept collection of the domain, is usually organized by sorts;

I, the cases collection of the domain while case means the realization of some concepts;

R, the collection of the relationships between concepts, which should subject to $V \cap R = ¢$ and $R \to V \times V$;

FD, the collection of the functions available in the domain;

AD, the collection of the axioms of the domain.

RDF (Resource Description Framework) is recommended by W3C to describe resource and their semantic criteria. RDF, taking XML as its realizing language, provides a simple and powerful data model. Three types of objects are included: resource, which could be any information except basic data types; property, which describes specific aspect, character and relationship of resource; statement, which is composed of resource, its property and its value. RDF data model could be the basic model for any complicated one. In EKI, domain knowledge, not so complicated and so many as the information on the internet, is more concentrated and structured and therefore is very fit for being represented by RDF. The ontologies representation in the proposed framework is shown in Fig. 3.

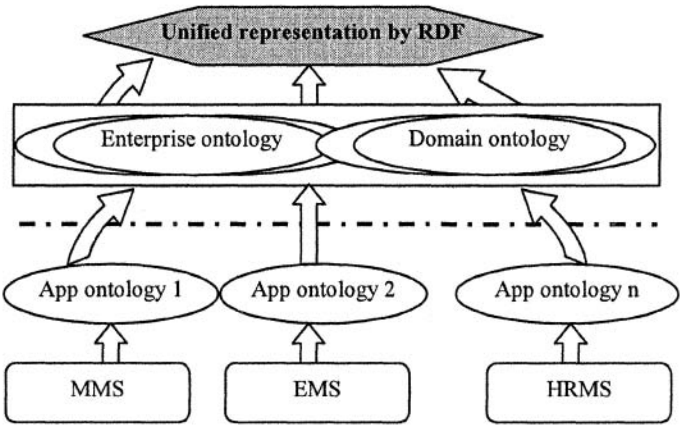

Fig. 3. unified representation by RDF

3.3 Construct Knowledge Chain

Knowledge chain is the crucial task of EKI, which includes two important elements -- knowledge nodes and relationships. Knowledge nodes are combined by various kinds of relationships. Knowledge chain is generally based on work flow of application systems.

In this architecture, knowledge can be communicated on the level of semantics by using RDF in describing unified enterprise knowledge. RDF statement can be represented by a triple <subject, predicate, object>, which can be described easily by directed graph. Therefore, RDF is suitable for the language of knowledge chain, by which all the related knowledge of the domain could be connected on the level of semantics, so that knowledge share and reuse can be greatly improved.

3.4 Knowledge Query

According to the proposed architecture, knowledge query is actually the semantic query to the ontologies represented by RDF. Ontology depository is usually composed by enterprise ontologies and application ontologies. Enterprise ontologies, which provide common concepts collection, are the share vocabularies for different application systems. Application ontologies provide ontologies used by each application.

Different concepts can be used in different systems, which can be interoperated by ontologies mapping and agents. Three steps are followed when doing a knowledge query. First is enterprise ontologies query. Second is transformation from enterprise ontologies to application ontologies. At present, query language based on RDF and XML have been well developed.

RDQL is the ontology query language recommended by W3C. Clause with SELECT is used to recognize the variable returned from the query. Clause with FROM is used to specify the URI used by the RDF model. Clause with WHERE is used to specify the triple in the RDF. Clause with AND is used to specify the Boolean expression. Clause with USING is used to provide abbreviation of URI.

XQeuery, which provides a unified method to search, retrieve XML based on XPath, is the query language for XML recommended by W3C. Both RDQL and XML are similar to SQL in syntax. Therefore, it is easy to transform between them. The procedure of knowledge query is showed in Fig.4.

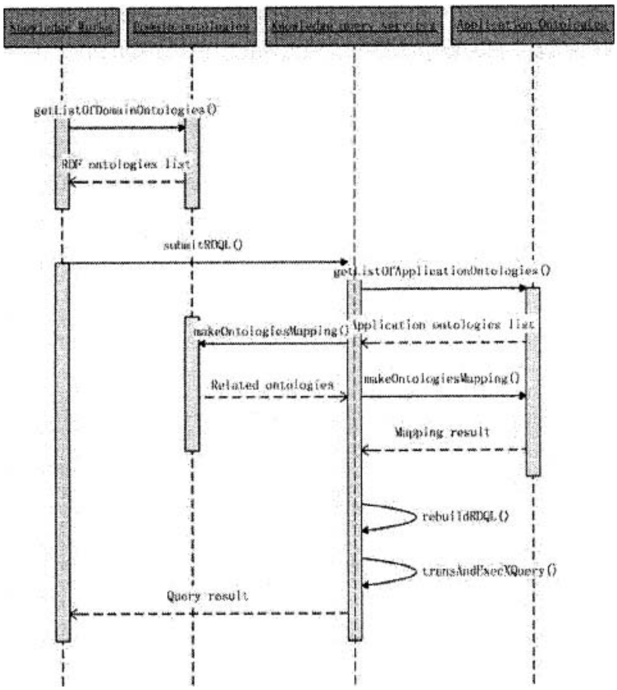

Fig. 4. the process of knowledge query

4 The Developing Approach of the Proposed Framework

The framework proposed above can be developed by eight universal steps which can also be expanded according to your own requirements. For example, Case Based Reasoning (CBR) application is an important content when building an EKI system for supporting those enterprises which put emphasis on products design.

Step 1, to construct ontologies. First, domain ontologies construction, which is lead by domain experts, is to describe the concepts of the domain and their relationships. Second, enterprise ontologies construction, which is lead by enterprise's knowledge workers, is to describe concepts of the enterprise and their relationships. Third, application ontologies construction, which is lead by system developers, is to describe the concepts of specific business and their relationships.

Step 2, to define ontology mapping. In this process, mapping tables are usually used to record the relationships between ontologies.

Step 3, to store data in XML. Define the XML schemas for the data, and transform the data from the relational database to the format of XML by XML Schema.

Step 4, to transform data between XML/XML schema and RDF/RDF schema. This is the foundation of knowledge query.

Step 5, to represent knowledge in RDF.

Step 6, to construct knowledge chain and build knowledge depository.

Step 7, to develop knowledge services, including knowledge search engine, knowledge map, etc.

Step 8, to query knowledge. The query here includes initiative query, which returns the results according to the conditions submitted by the user, and automatic query, also called knowledge recommendation which recommends the useful knowledge to the user automatically by intelligent agent technology.

5 Application of the Proposed Framework

In the hydropower engineering, the project management is a complicated work, which involves plans, contracts, people, materials, financial affairs, and so on. Much correlative information is produced during the process. The following section describes the applying of the proposed framework in a famous large-scale hydropower Chinese corporation.

5.1 The Case Model

The systems include project construction management system, contract management system, human resource management system, and equipment and material management system. Thereinafter, a simplified data mode of the systems is described. It presents the relationship of Engineering, Contract, People, and Equipment, which are the core business entities. As fig. 5, Engineering, Contract, Project Manager, Equipment are application ontologies; Project Owner, Project Classification, Project Area, Project Manager, and Unit Work are enterprise ontologies; All 18 parts including Area code, Work code, etc, which compose the hydropower engineering patent code specification, are domain ontologies.

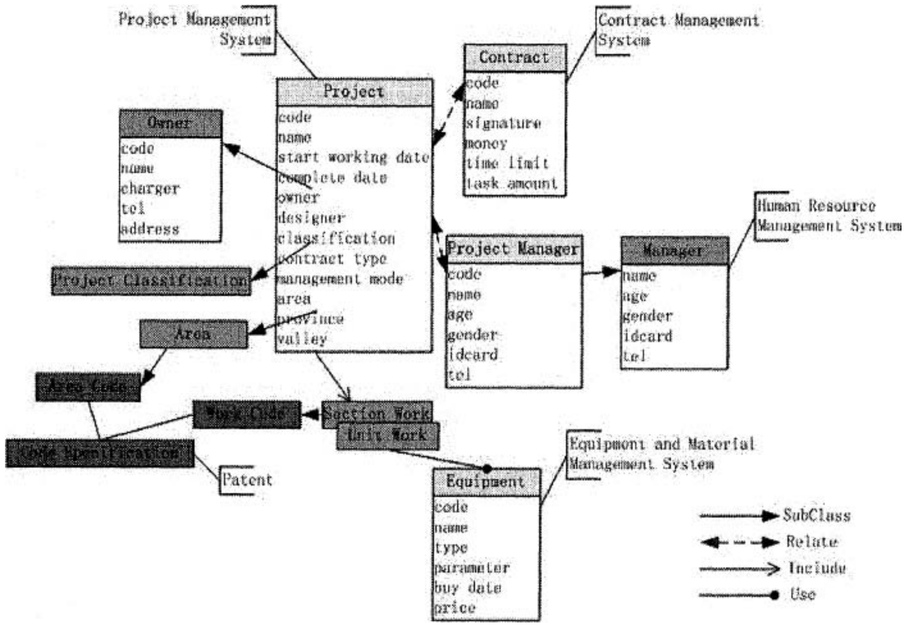

Fig. 5. a simplified case model

5.2 Ontologies Representation by RDF

The ontologies of the model can be represented by RDF. For example, the RDF representation of the Project ontology is shown in Table 1.

Table 1. The Project ontology

Class	Property
<rdfs:Class rdf:about="GZB:Project"> <rdfs:subClassOf rdf:resource=" rdfs#Resource"/> </rdfs:Class> <rdfs:Class rdf:about="GZB:Owner"> <rdfs:subClassOf rdf:resource=" rdfs#Resource"/> </rdfs:Class> ...	<rdf:Property rdf:about="GZB:Project Name"> <rdfs:domain rdf:resource="GZB:Project"/> <rdfs:range rdf:resource="rdfs#Literral"/> </rdf:Property> <rdf:Property rdf:about="GZB:Project Code"> <rdfs:domain rdf:resource="GZB:Porject"/> <rdfs:range rdf:resource="rdfs#Literral"/> </rdf:Property> <rdf:Property rdf:about="GZB:Owner">
Relation	<rdfs:domain

```
<rdf:Description
  rdf:about="GZB:Project">
 <GZB:Include
    resource="GZB:Section
Work"/>
</rdf:Description>
<rdf:Description
  rdf:about="GZB:Section Work">
  <GZB:Include
    resource="GZB:Unit Work"/>
</rdf:Description>
...
```

```
rdf:resource="GZB:Project"/>
<rdfs:range rdf:resource="GZB:Owner"/>
</rdf:Property>
<rdf:Property
  rdf:about="GZB:Project Area"/>
<rdfs:domain
rdf:resource="GZB:Project"/>
<rdfs:range rdf:resource="GZB:Area"/>
</rdf:Property>
...
```

5.3 RDQL Query

The query can be made by RDQL. For example, based on the above case model, make the semantic query: "How about the price of the same Unit Work (concrete for foundation) in different projects"? The RDQL query of the question is:

```
SELECT   ?project, ?price, ?item
WHERE    (?project rdf:type GZB:Project)
   AND   (?price rdf:Property ?project)
  AND    (?project GZB:Include ?item)
  AND    (?item rdf:type GZB:Unit Work)
  AND    (?item eq "concrete for foundation")
USING    GZB FOR http://localhost/gzb-schema#
         rdf FOR http://www.w3.org/1999/02/22-rdf-syntax-ns#
```

6 Conclusions

The knowledge in an enterprise is always discrete, out of order, and allocated in separate application systems. Knowledge integration is for the knowledge users to better the knowledge sharing and reuse. However, EKI is such a complicated systemic engineering that there are still many problems to be further researched, such as how to do knowledge representation and semantic query by a more powerful language of OWL. So are the semantic similarity calculation methods, and the knowledge inference technologies, etc.

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Enterprise Information Integration

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Abstract In this article, we aim to develop a Web application for a chemist industrial environment. This application provides interfaces for operator and interfaces for supervisor. All interfaces are included in MES (Manufacturing Execution System) functionalities. The first are used to collect information and so provide e-collection. The second are used for passive e-supervision. These last, are similar to synoptic but have not the same objectives. Interfaces are based on click on boxes. Stereotypes of EWA-UML are adequate for this application. Application is developed upon JSP technologies.

1 Introduction

We develop this application in Algerian chemist industrial environment. The factory produces ammoniac. It has DCS (Distributed Control System) that supervise production: NINA System I/A Series de FOXBORO. Exchange system is based on ETHERNET TCP/IP with server for history and five stations for control. In recent years MES have managed all activities and resources production processes in an effort to reduce cycle time, low inventory, and increase productivity [1]. Manufacturing Execution Systems (MES) are a recently defined category of industrial software for the plant floor/manufacturing environment. So, our work is integrated in MES and has two objectives: First, reduce time for data collection and provide e-collection at plant floor. Second, provide passive supervision for agent at third level in CIM. This allows him to access database and display the most important information. In each case, we present interfaces.

Paper is organised as: In section one, we give an introduction. Section two we summarise developed applications. Section three presents interactions techniques. Section four presents component diagram of board journal. In section 5 we give architecture's application. In section 6 we present e-collection and e-supervision interfaces. Paper is ended by a conclusion.

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2 Data Collection

We note that some examples of applications that have been developed in areas such as general manufacturing [2], power generation [3], automotive [5], and electronics [4], [6] based on screen and GUI. For our work, we are interested in electronics collection.

3 Interaction Techniques

There are several software interaction techniques [7]. GUI was designed for interaction techniques that let the operators select elements that accomplish the desired tasks. Command buttons, and dialog boxes were some of the interaction techniques used for application to keep it simple in code design and ensure application usability. Buttons are individual and isolated regions within the display which can be selected by the operators to invoke specific operations. Clicking on the button invokes a command and its meaning is indicated by the button caption or button background colour. Dialog boxes are information windows used to capture the operators attention about some important information or giving feedback in the interaction.

4 UML/WAE Design

Journal board is the most important document. It contains whole data about production. It was a form filled by operator. Fig. 1 presents component diagram [8].

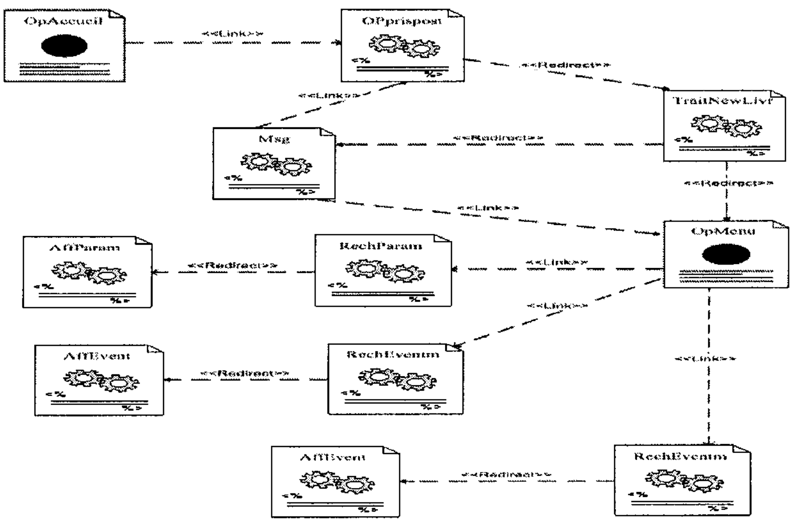

Fig. 1. Component diagram

5 Architecture System

The SGRDB is Access 2002 and Requests are executed with JBDC/SQL. Application is deployed in 3-Tiers Client/server architecture based on JSP technologies and Javabean [9].

6 Interfaces

We present two types of interfaces: e-collection and e-supervision. All interfaces are in French language because it is the language used in Algeria, and all documents in factory are in French.

6.1 e-collection

Fig. 2 shows interface used to input event at the first floor of pyramid CIM. It is filled by operator.

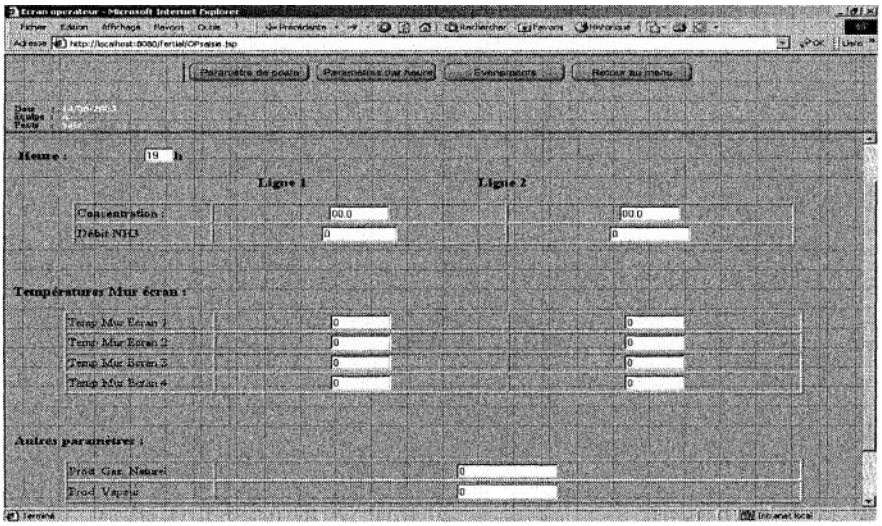

Fig. 2. Interface for event e-collection

Fig. 3 shows interface with form filled by operator to input important consummation.

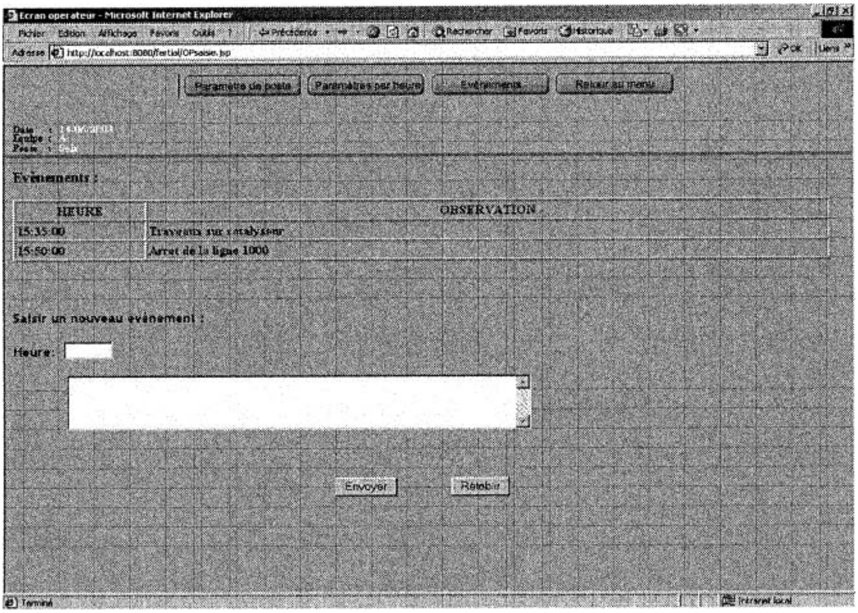

Fig.3. Interface for e-collection

6.3 Passive e-Supervision

Interface for passive e-supervision is similar to synoptic developed for floor plant in production of NHO3. It provides a real vision on plant and it is used by agent to access at data in data base. Agent clicks on green box to display data associated to consummation of natural gas (in middle of interface) and associated to consummation of vapour (in bottom of interface).

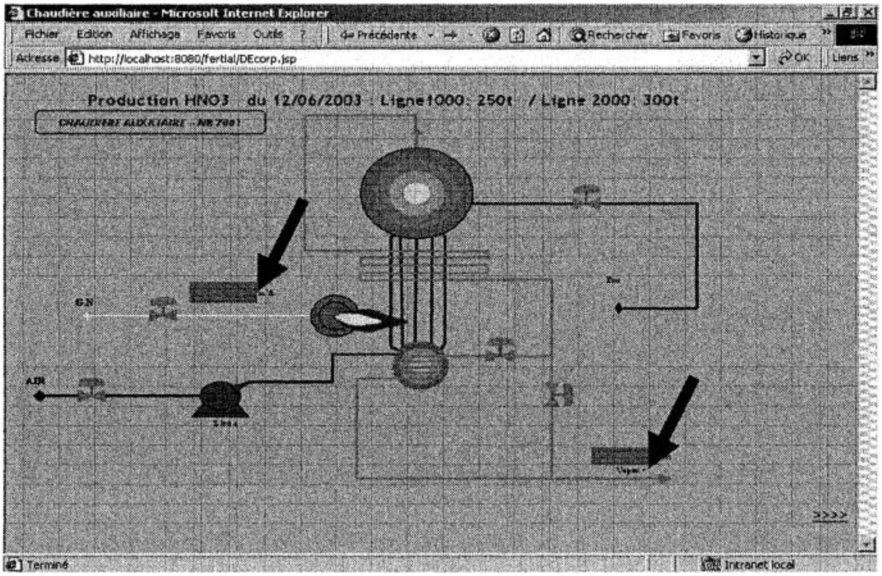

Fig. 4. Supervision interface for NHO3 production

Fig. 4 is similar to synoptic developed for floor plant in production of NHO3. It provides a real vision on plant and it is used by agent in third floor to access at data in data base. Agent clicks on green box to display data associated to consummation of FI103 (in middle of interface) and associated to debit of NH3 (in middle of interface).

7 Conclusion

In this paper we have developed enterprise information system integration with two types of interfaces: the first for operator to collect information and store them in real time. The second for agent in third floor of pyramid CIM. These interfaces are similar to synoptic but have not the same role. It indicates by click on boxes to the agent the values of most important parameters. We used EWA-UML for conception. This application reduces document and storage time and provides a real vision for agent when he access to production parameters. However, this application must have a high security to avoid intrusions because it is installed over a TCP/IP.

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Value-Oriented IT Project Portfolio Management

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Abstract. In the present enterprise computing environment, it becomes more and more important to be able to demonstrate financial gains of IT (Information Technology) initiatives compared to their cost. A valuation methodology is a logical, repeatable framework for making IT investment decisions and monitoring projects to ensure that they ultimately contribute to the financial health and growth of the enterprise. Traditionally, organizations have used a bottom-up approach for technology valuation by using metrics such as return on investment and net present value. While it provides a simple, easy-to-understand valuation mechanism, the traditional approach is limited in the type of analyses. To provide more flexible and versatile valuation of technology, we propose a value-oriented project portfolio management with which organizations can view IT staff and initiatives not only as costs but also as assets managed in a similar way as a fund manager would apply to any other investment. The proposed approach is comprised of multiple steps that collectively compute and help maximizing value of IT initiatives for business transformation. It integrates a value model with a project portfolio to factor in financial values in selecting projects and optimizing the portfolio.

Introduction

In the present enterprise computing environment, it becomes more and more important to be able to demonstrate financial gains of IT (Information Technology) initiatives compared to their cost [1]. Most organizations are constrained by resources to meet their requirements and objectives. Selecting projects to fund poses an important and hard problem faced by CIOs and CTOs of the organizations. It is not as simple as ranking the proposals and funding them from the top of the list until resource is depleted. Organizations need to analyze the business value and balance

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the benefits that project portfolios provide with their respective constraints, and they need to do so in a meaningful way [2]. To meet this requirement, organizations need a valuation methodology, which provides a logical, repeatable framework for making IT investment decisions and monitoring projects to ensure that they ultimately contribute to the financial health and growth of the enterprise.

Traditionally, organizations have used a bottom-up approach for technology valuation. First, they would define financial metrics such as ROI (Return on Investment), NPV (Net Present Value), IRR (internal rate of return), pay-back period, etc [3, 4]. Then, they use the metrics to evaluate candidate initiatives. The most significant limitation of using the traditional approach to project prioritization is that they provide, at best, only a partial representation of what is relevant. Financial metrics, quite simply, capture the objectives of an organization only partially. There are non-financial, intangible objectives in organizations such as customer satisfaction and brand image. To provide more flexible and versatile valuation of technology, we propose a value-oriented project portfolio management with which organizations can view IT staff and projects not only as costs but also as assets managed in a similar way as a fund manager would apply to any other investment.

The rest of this paper is structured as follows: Section 2 presents the valuation framework of the proposed value-oriented IT project portfolio management. The following sections describe each step of the value-oriented project portfolio management framework in detail, and explain their analysis methods, with examples. Sections 3, 4, 5, and 6 present analyses using component business modeling, solution similarity measures, value driver trees, and portfolio analysis algorithms, respectively. Section 7 summarizes previous work, and discusses how the presented approach is different. In Section 8, conclusions are drawn and future work is outlined.

The Framework

Based on our study and practice, a value-oriented project portfolio management methodology is formed and proposed to facilitate the end-to-end business process transformation planning from gap analyses to portfolio management as shown in Fig. 1. The proposed methodology provides a top-down approach to analyzing the business value of technology initiatives. The objectives of approach include providing visibility into project performance, helping manage a dynamic portfolio of business transformation initiatives, and monitoring financial metrics for transformation initiatives and projects. The framework consists of the four modules that are linked together.

The proposed approach starts with a business transformation analysis by using Component Business Modeling (CBM) which enables enterprise strategic design and planning. This step utilizes the CBM technique to understand the business and organization and identify business transformation opportunities. The CBM approach is useful in determining which solutions and projects to consider, and assuring that investments are classified properly and diversified across various business processes.

The gap analysis based on CBM helps the organization assess rigorously its enterprise systems and processes, and identify opportunities for improvement. Also, this top-down approach enables a business analysis for identifying "hot" components that are associated with business pain points, and various types of IT shortfalls that need to be addressed to mitigate the pain points.

Then, the solution analysis step helps discover which solution or solution portfolio in a given solution catalog supports the processes improvement opportunities identified in the previous step. A solution catalog presents a set of complete business and technology solutions for an industry in a process-oriented way.

In the next step, a value model is developed to identify and map the enterprise's key business and IT value drivers, and links them to the measurable business and financial benefits. Specifically, it quantitatively calculates the impact of multiple business initiatives at a time such as solutions to the performance of business activities and then to key performance indicators of the organization, through the cause and effect relationships over time.

Furthermore, it integrates a value model with a project portfolio to factor in financial values in selecting projects and optimizing the portfolio. Project portfolio optimization supports provision of decision support for selecting candidate investments, prioritizing transformations initiatives and projects based on their potential to improve business performance, maximizing the value delivered by initiatives and at the same meet constraints such as budget and resource, and balancing the overall portfolio with enterprise objectives.

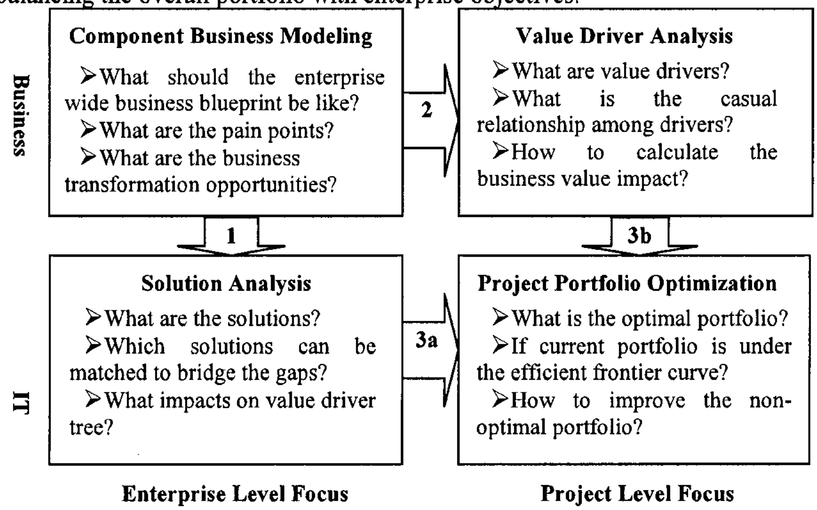

Fig. 1. Value-oriented project portfolio management

Component Business Modeling

To help determine which projects to consider, and to ensure that investments are classified properly and diversified across various business processes, we utilize the Component Business Modeling. CBM is a business decomposition methodology that has been used successfully by IBM in various engagements across industry sectors [5, 6].

CBM models a business as a set of business components. A business component is a part of an enterprise that has the potential to operate independently, in the extreme case as a separate company, or as part of another company. A business component is a logical view of part of an enterprise that includes the resources, people, technology and know-how necessary to deliver some value.

A business component map is a tabular view of the business components in the scope of interest. The columns of the table represent business competencies and the rows represent accountability levels. The business components are rectangles within the table. Normally each rectangle is within only one cell of the table. Fig. 2 shows a sample component business model for the banking industry.

Fig. 2. A component business model

Once a business component map is created, an IT shortfall assessment can be conducted to examine each key business component and then each business process within the component for improvement opportunities. Within each key component, the current systems, processes and organizations are specified. In addition, there may be more detailed specifications on the functional and non-functional features of the business components and the collaborations among components. The systems, processes and organizations can be analyzed for the cost effectiveness and business efficiency of the current state ("As-Is") and the future state ("To-Be"). The shortfall analysis of the business component efficiency and effectiveness determines if a certain technology-based reengineering exercise can help streamline the process, improve operating efficiency and optimize strategic business advantage. Generally, three types of issues tend to arise in the shortfall assessment:

Gaps: no system exists, the system lacks key functionality, or is poorly designed/uses the wrong technology for a specific component.

Duplication: multiple systems compete for the same component, typically adding unnecessary complexity/cost to development, maintenance and production.

Over-extension: a system designed to support one component is extended to help support others, for which it may not have appropriate capabilities. Furthermore, as a system gets more extensive the cost/complexity of its operation increases exponentially.

Solution Analysis

A solution catalog presents a set of business solutions for an industry in a process-oriented way. A solution catalog tree for banking industry is shown in Fig. 3.

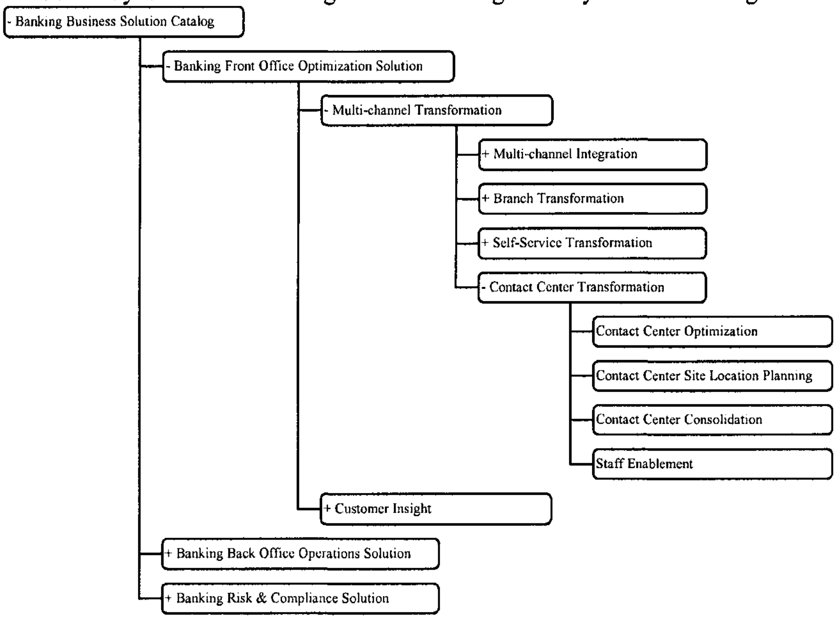

Fig. 3. A solution catalog

We use business processes within an organization to link solution technologies with the CBM map and show how various business components and processes are covered by solutions. It is designed to help visualize, plan, and implement a coherent, integrated, and comprehensive information technology solutions for an organization or enterprise. The solution catalog is represented hierarchically by a tree structure. The top level nodes represent business solution categories, the middle level nodes business solution offerings, and the leaf nodes business solution components and linkages.

The previous step of the CBM shortfall assessment identified various technology gaps in the present enterprise environment. By using the specifications of the solution catalog, this step identifies one more existing solutions that best address the shortfalls identified in the previous step, through a matching component. In order to determine the basic set of matching solutions, we compute the degree of similarity between feature values (including, but not limited to, key business metrics for improvement, e.g., number of employees, implementation costs, etc.) of the matching component and those of the solutions from the solution catalog by using a distance-based similarity measure.

Although building a complete solution catalog is costly in terms of time, money and skills involved. In fact, it needn't have the value of completely vendor-independent solution catalogs. So it can not only be determined and maintained efficiently by major consulting companies. Solution catalog is useful way to help organizations to view industry solutions that are specific to their business and paint points, plan, and implement a comprehensive, integrated, and coherent solution.

Value Driver Analysis

Traditionally, organizations have used a bottom-up approach for technology valuation. The traditional ROI analysis defines financial metrics such as NPV (Net Present Value), IRR (internal rate of return), and pay-back period. The traditional approach is hard to generalize and costly to evaluate multiple initiatives at one time, provide a complete picture of the impact of these solutions or initiatives, and determine which solutions are best.

To address this problem, our approach proposes to link characteristics and impacts of proposed solutions and initiatives to a value model, which is typically represented by a top-down structure called a value driver tree. It captures business impact at a measurable metric level and aggregates it into higher-level business values by using generic value drivers such as revenue growth, margin improvement, and increased capital efficiency.

The value driver tree provides a hierarchical structure of value drivers and metrics. The top level nodes of the value driver tree are generic value driver, such as the shareholder value or profitability; the middle level nodes are business specific value driver; and the leaf nodes are measurable operational metrics. The leaf metrics nodes are connected to the root through multiple layers of performance indicators and value drivers. A sample value driver tree is shown in Fig. 4.

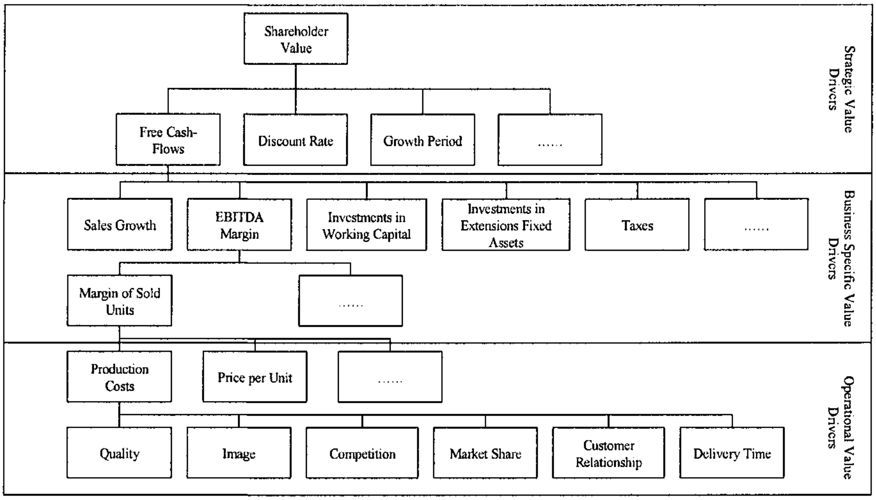

Fig. 4. A value driver tree

Before using a value driver tree to calculate the business value of one or more solutions, the causal relationship between a value driver and its children value drivers needs to be defined first. In certain cases, it is difficult to come up with quantitative relationship among a value driver node and its children nodes, because empirical data for applying regression methods is not always available. Our approach proposes a new technique referred to as "1% sensitivity analysis." The 1% sensitivity analysis is an incremental expression form to describe the impact of one metrics (cause) on another. For example, if a metric, order process time, is reduced 1%, this analysis computes how much change there will be to another metric, say, revenue. Domain experts can come up with this data by using their experience and estimation.

Because the value model is built on causal judgment, the model's assumptions must be clearly specified, so that they can be discussed, debated, and set to reflect best-organizational understanding of how the organization determines the value it creates. In a real-world situation, the value driver tree can usually be constructed in a 2-3 day framing workshop using techniques based on influence diagramming, and causal modeling.

Based on the 1% sensitivity analysis, a recursive algorithm is used to calculate the expected values of high-level value drivers affected by low-level value drivers or solutions. The value of driver y is:

$$y_{t0+1}=y_{t0}\times\Delta_y$$

where $\Delta_y=\sum\Delta_y^{(xi)}$ is the 1% sensitivity of y . $\Delta_y^{(xi)}$is the 1% sensitivity between the parent value driver y and one of its children value driver x_i, $i=1,2,3,\ldots n$. n is the number of children value drivers.

The recursive algorithm forecasts the planned solution portfolio's impact on value drivers. This activity can be repeated for a number of alternative solution portfolio candidates. It helps determine the highest-reward, lowest-risk solutions, set priorities and ensure proper resource allocation.

Portfolio Analysis

After one or more solutions are selected and evaluated by the solution matching and the value analysis, there could be several project candidates. Most organizations are constrained by resources to meet their requirements and objectives. Selecting projects to fund poses an important and hard problem. It is not as simple as ranking the proposals and funding them from the top of the list until resource is depleted. To address this problem, we use an enterprise portfolio analysis to select the optimal project mix to maximize the collective benefit, while balancing other factors such as risk, dependency, and budget. A mathematical model based on the knapsack problem [7] together with a revised dynamic programming algorithm is developed.

A standard mathematical model of the portfolio optimization problem is constructed as follows: Let P denote the set of available projects. For now, assume that the projects are independent. That is, it is reasonable to select any combination of projects and the cost and benefit of any project do not depend on what other projects are selected. Define, for each project i in the available set P (denoted $i \in P$), the zero-one variable x_i. The variable x_i is one, if the project is accepted, and zero, if it is rejected. Let b_i be the benefit of the ith project and c_i be its cost. Let C be the total available budget. The goal is to select from the available project set P a subset of projects with a total cost less than or equal to C that produces the greatest possible total benefit. The problem may be mathematically expressed as:

$$\text{Maximize } \sum b_i x_i$$

$$\text{Subject to: } \sum c_i x_i \leq C,\ x_i = 0 \text{ or } 1$$

where the notation $\sum$ denotes summing over all projects i in P.

Although the basic model is simplistic, it can be extended to handle many complexities that must be addressed in the real world. In real-world practices, the model has been extended to deal with interdependencies among projects, multi-period, and sensitivity to delay, risk, side-effects (e.g. the introduction of a new CRM solution might require additional organizational restructuring in other areas, too) etc. Here let is just take interdependencies as an example to show an extension. Examples of dependencies that may exist between projects include: project A is not funded unless project B is funded, both project A and B must be funded or neither is funded, and funding project A precludes funding project B. By adding constraints to the basic model, interdependencies among projects can be handled by groups. Groups mean alternatives can be grouped with constraints. Suppose G denotes a group of the projects with some constraints, the following constraints can be added:

$\sum xi \leq 1$, $i \in G$ (Less than or equal to 1) – at most one alternative in a group can be funded.

$\sum xi = 1$, $i \in G$ (Equal to 1) – one and only one alternative in a group must be funded.

$\sum xi \geq 1$, $i \in G$ (Greater than or equal to 1) – one or more alternatives in a group must be funded.

Based on this model, a revised dynamic programming algorithm is used to pick possible project portfolios that create the greatest possible risk-adjusted value without exceeding the applicable constraints on available resources. The set of investments that create the greatest possible value at the least possible cost are the "efficient frontier" [8]. Fig. 5 shows an example of 50 projects in a company with the efficient frontier. It lists all possible portfolios and the optimal portfolio at different given budget (i.e., cost). Portfolios along the curve are said to be efficient because the company is getting the maximum value from the available budget. Points under the efficient frontier curve represent inefficient portfolios.

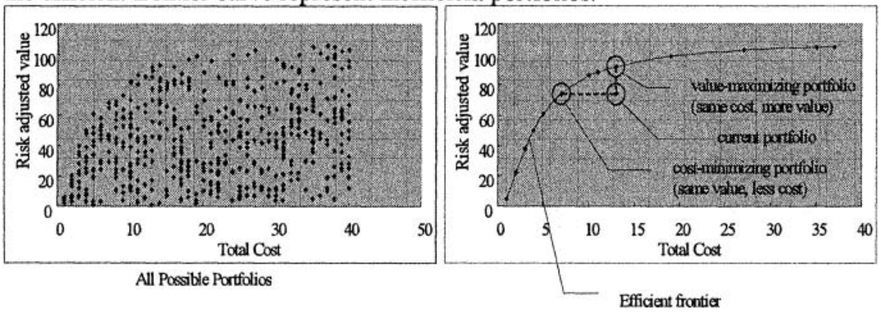

Fig. 5. Portfolio analysis and optimization

The company can also review the current portfolio of projects on or under the efficient frontier. There are two ways to improve points under the efficient frontier curve. One is value-maximizing portfolio (same cost, more value), and the other is cost-minimizing portfolio (same value, less cost). In short, the portfolio analysis and optimization can review the current portfolio and deliver the greatest margins, maintain an optimal portfolio mix considering the overall risk.

Related work

There are precursory thoughts on value-oriented IT project portfolio management found in research reports and published papers [9, 10]. For example, Tom Pisello has developed a methodology called IT Value Chain Management to optimize measures and manage the business impact of IT for all stakeholders based on their research findings on the correlation between IT spending and shareholder value. IT Value Chain Management approach quantifies technology benefits, and improves the financial justification process for technology investments, and calculates the value of specific business and IT capabilities such as faster time-to-market [11].

Also, a Forrester research report discusses "installing value-based thinking." The report describes that a strategic IT organization contributes, directly and indirectly, to the organization's ability to execute its business plan. Therefore, strategic thinking for the IT manager must include an analysis of the impact that major decisions will have outside the IT organization. This focus must be driven down through the organization so that the business implications of decisions are considered at all levels. The research firm also provides related discussion on the application of balanced scorecard for IT and value metrics for IT along with ROI analysis of IT [9].

In addition, there are numerous studies on return-on-investment, metrics measurement and analysis models. Total Cost of Ownership Model by the Gartner Group provides a deterministic ROI model for calculation designed to help consumers and enterprise managers assess direct and indirect costs as well as benefits related to the purchase of computer software or hardware. Kaplan and Norton's the balanced scorecard provides a method intended to give managers a fast, comprehensive view of the performance of a business.

Also, there are project portfolio management firms, such as ProSight Inc. [12], Planview [13] etc. Applications of project portfolio and resource management aim to help companies boost team performance, and enable IT management and others to access real-time data via dashboards for prioritization and rapid decision making.

Our approach is different from these business performance approaches in a number of ways. It provides a comprehensive value model that captures a multi-level model of value drivers associated business activities and components. Also, it departs from the traditional business value analysis, and employs a component-based model of business, which facilitates solution matching for business and IT alignment. Finally, it integrates portfolio optimization technology and value driver tree analysis to maximize the value of IT investments.

Concluding Remarks

Realization of value-based IT project portfolio management requires an end-to-end approach to identifying business components and IT shortfalls associated with business pain points; and modeling to capture and represent relationships among business components and activities, metrics, value drivers and IT solutions. This paper presented a value-oriented IT project portfolio management methodology which correlates business benefits with business processes and also with solutions, measuring and tracking value, and delivering value through business processes.

This approach consists of four modeling elements. First, component business modeling provides a new view of business, and helps understand the businesses pain points and identify gaps for transformation opportunities. Second, a solution catalog presents a set of complete business solutions for an industry in a process-oriented way. It enables to discover suitable solutions for the identified gaps and assess their impact on value drivers. Third, the value driver tree specifies multiple levels of strategic value drivers, business value drivers and operational value drivers. Finally, the project portfolio optimization selects one or more possible project candidates that will generate the greatest possible risk-adjusted value, and reviews the current project portfolio to adjust it for maximizing financial value.

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Enterprise Maturity Model –The Technology Aligned Business Strategy Model for Indian Banks

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Abstract: Public Sector Banks (PSB) in India are embarking on a comprehensive set of Information Technology initiatives. Since embracing technology alone is not enough to bring operational efficiency and profitability in the business it has become critical for PSBs to have an enterprise level strategy in which technology plans are in total alignment with business strategies. In this paper we propose an enterprise architecture which serves as a guideline for PSBs' IT strategies. This architecture is based on an assessment carried out on representative PSBs- studying their business & Technology plans, business processes and information requirements with focus on some key areas like ALM, Credit Risk Management (CRM), Investment Portfolio Management (IPM), FOREX (Foreign Exchange) etc.

Based on the assessment and best IT enabled practices in the banking industry, an Enterprise Maturity Model (EMM) has been evolved to provide banks a structured frame-work having five hierarchical layers with defined business objectives at each level starting with basic objectives like increasing operational efficiency at the bottom most layer and leading up to very strategic objectives like maximizing wealth and stakeholder value at the highest level. To meet these objectives, a set of business systems for the key areas like ALM, CRM, IPM, Human Resource Management System and Customer Information Management System have been identified whose features are also layered with well-defined functionality to aid decision-making. The other critical component of the EMM is a multi-layered Information Technology architecture to support the applications at each layer. This methodology is unique and different from existing methodologies.

1 Introduction

To remain competitive and to provide modern facilities like ATMs, Telebanking, almost all Public Sector Banks (in which the government has major stake) in India are going for Information Technology based banking solutions. The Reserve Bank of India the Federal bank in India felt that since the new technology initiatives have an impact on business processes of the bank and the fact that it's critical for banks to derive business benefits from the technology investments, it is necessary to provide a set of guidelines to Indian banks for formulating their technology plans aligned to their business plans to meet business objectives. This paper describes the Enterprise Maturity Model that provides a framework for PSBs to integrate their technology

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plans with business objectives to attain total convergence of technology and business strategies in key areas of their business. The enterprise maturity model layered into five levels of maturity also addresses human resources and customers as they are an integral part of the system [1]. The paper is organized in the following way. The need for such a model is established and the methodology used in building the EMM is discussed. Next, Executive Information Systems needed for the key areas of banking, viz., Asset Liability Management, Credit & Credit Risk Management, Investment Portfolio Management, Human Resources Information Management and Customer Relationship Management are identified and the layer wise application needs of each of the applications is presented. The final Enterprise Maturity Model along with the technology architecture is presented and the paper concludes with the expected benefits.

2 Need for such a model

The initiation of financial deregulation, globalization and open economy in late 90s has brought in the emergence of new market players in the Indian banking arena. These nimble competitors started banking in the country with technology driven banking solutions[2], brought in innovative style of banking with customers as their main focus, introduced multi-delivery channels to provide round the clock banking services and posed a big challenge to the Public Sector Banks PSB), which have been in banking business for more than half a century. It is worthwhile to note that the PSBs were using technology only for doing the branch centric operations, realized the need to opt for more technology based solutions to sustain business, retain customers and improve business prospects. Since then, the PSBs have started heavily investing in information technology.

Based on a detailed study of representative public sectors banks (visits, questionnaires, interviews) covering a detailed study of their business objectives, technology initiatives an analysis of the extent of correlation between the two initiatives (as technology is an enabler for attaining business success) revealed that: .

The banks are inducting technology at a great pace but only operational efficiency and correctness of data is being achieved in the process.

The banks need to work out more rigorously on how their technology will help them to achieve their long term business plans.

More serious need for considering the impact of technology induction on the current and future banking employees and skill sets needed for managing the banking business in the long run.

Hence it became evident that there is an immediate need to develop an enterprise level technology aligned business model, which the Indian banks can abide by. In this paper one such model called as Enterprise Maturity Model (EMM) that is suitable for the Indian banking environment is presented.

3 Procedure for building Enterprise Maturity Model

A common set of business objectives listed below have been chosen as the drivers for business success: -
Size, Growth & Mix of Business
Market Share
Sectoral allocation of Business
Geographical spread
Product/Price/Cost Leadership
Risk adjusted Performance measures
Profit optimization
Shareholder's wealth maximization and Brand Image
These business objectives translate into business strategies such as bringing down the NPAs, enlarging profitable customer base, good credit appraisal systems to safeguard the bank, profitable investment propositions etc which mandates an excellent Executive Information system for decision making. This EIS is an aggregation of sophisticated decision support systems in Asset Liability management (ALM), Credit & Credit risk management (CRM), Investment Portfolio management (IPM) and Foreign Exchange Systems (FOREX), and not but the least, an extensive customer Information management system (CIM) and human resource management system (HRM). Each of these areas i.e., ALM, CRM, IPM, FOREX, CIM and HRM is conceptually well advanced, and hence heavily depend on technology support to reap the full benefits. For example, they need a comprehensive information base related to banking, customers, and other external sources, which are to be accessed bank wide (that needs a communication network) at any point in time. Also these systems use extensively, quantitative, statistical and simulation techniques, neural networks, time series analysis, to name a few.

It is to be noted that the banks cannot implement an integrated EIS instantly. Hence it is logical to look at the ALM, CRM, IPM etc., as incremental systems, comprising of multiple layers, to be developed in the bottom up way, so as to attain the final state of sophistication in the EIS. Every level, in each of the above-mentioned systems, have well defined purposes, add value in decision making and as they grow in levels the value added and the complexity involved in the systems are higher. Each level is abstracted out with well-defined functionality in mind. As all these individual systems are to work in an integrated fashion to provide an integrated, bank level EIS, it is important to normalize the corresponding levels of each of these systems to get a single level in the enterprise level application architecture. This exercise will help in defining the required technology architecture for each of the levels to accomplish its business purposes. This involves identifying the data needs, other technology-based needs such as network connectivity, centralized or decentralized approach for data store, periodicity for data exchange etc, and arrives at common technology requirements. This is the way, the enterprise level business-technology architecture or enterprise maturity model is worked out.

4 Key functional areas in the model

4.1 Asset Liability Management

Asset Liability Management (ALM) aims at simultaneous planning of all assets and liability positions in the bank's balance sheet so that bank mitigates the risks arising out of changes in interest rates, providing adequate liquidity and enhancing the value of the bank [3]. From risk management perspective, ALM mainly handles Interest Rate Risk and Liquidity Risk in the banking book. ALM is the process of planning, organizing and controlling asset and liability mixes, volumes, yields and rates in order to achieve targeted interest margin [4]. The primary goal is to control interest income and expenses and to increase the net interest margin on a continuous basis. In order to establish efficient ALM systems banks require adequate, accurate data in timely manner which mostly originates at branch level such as Term Deposits, Term Loans, Non-maturity items in the balance sheet such as Savings Bank deposits, Cash credit, etc. . The model recommends a layered implementation of ALM functionality which is summarized in Table 1.

4.2 Credit Risk Management

Credit risk is one of the oldest risks that is faced by the banks world-wide. Since exposures to credit risk continues to be the leading driver of risk, it is necessary for banks to identify measure, monitor and control credit risk so that they can hold adequate capital against the same [5].In the past banks have faced serious risks due to lax in credit standards for counter parties and a lack of attentions to changes in economic and other external conditions [6,7]. To overcome these problems, it is essential for banks to make both qualitative and quantitative assessment of borrower's credit standing which will help them in estimating his/her repayment capacity. In Table 2, a layered Credit Risk Management Architecture is presented.

Layer Description	Data	Source & Frequency
L1- Understand the Static Liquidity Position, Interest Rate Sensitivity and Dynamic Liquidity Position Regulatory Reporting	Transaction & Account Level Data Time Series Data of Aggregate Balances, Point of time data	Branch / Head office (Fort nightly) HO / Regional offices / Weekly) HO (Fortnight/Weekly)
L2- Assess the sensitivity of earnings numbers to interest rate changes on assets and liabilities Setting-up and tolerance limits based on gaps, cumulative gaps and sensitivity of earnings (Earnings-at-Risk)	Data in Layer– I Time Series Data on Interest Rates	HO / External Data in Public Domain **Frequency** Quarterly
L3- Implementing the Economic Value Approach of Interest Rate Risk Management Valuation of assets, liabilities and off-balance sheet items Implementation of Duration, Duration Gap and Convexity Analysis	Data in Layer – I, Current Interest Rates on Assets and Liabilities for various tenors, Spot and Forward Rates	HO / Third Party Sources **Frequency** Quarterly (Q)
L4- Stress testing of liquidity and parameters rate sensitivity – both the earnings and EVE	Stress Events Stress Scenarios	Internal Data on Stressful Events - HO Generation of Stress scenarios -HO (Q)
L5- Simulation of Gaps, Earnings, EVE, Durations and Duration Gap	Input-output relationships established over time	HO Quarterly
L6- Implementation of Funds Transfer Pricing	Data in Phase – I Data on Interest Rates	HO Quarterly

Table1. ALM architecture

4.3 Investment portfolio management

Management of Investment Portfolio has become an important function in the recent past due to various reasons such as the high-profile trading disasters in the international markets, regulatory pressures to make capital requirements in tune with the risks arising out of changing market conditions, and heightened volatility of interest rates, etc. Uncertainties in the interest rate environment continue to pose immense challenge for the banks to manage risks in investment portfolio in a more efficient manner. This necessitates availability of an efficient information system that will facilitate evaluation of risk-return measures not only at the individual security level but also at the portfolio context [8]. Such system will help banks to achieve optimum total return on investment portfolio which is consistent with the risk tolerance limits placed for various sources of risks and other regulatory requirements. The layered architecture of Investment Portfolio Management is presented in Table 3.

Layer	Data	Source and Frequency
L1 : Traditional Approach of Credit Appraisal, Monitoring & Follow-up	Financial and Non-Financial information on borrowers, businesses and Industries	**Source:** Branch **Frequency:** As frequent as the requirement for monitoring
L2 : Standalone Default and Recovery Risk Assessment, Monitoring and some Elements of Portfolio Credit Risk Analysis	Facility wise data related information, transition matrices, which specify both the default and transition probability, can be estimated using historical credit rating data for various cohorts of the credit portfolio,Historical data on recovery for the defaulted.	**Source:** Branch and external databases like CMIE&, Capital Line, ICRA, CRISIL, Planning Commission, MOF or Credit Bureaus. Internal CIS database on initial ratings and subsequent rating reviews for the individual borrowers in the credit portfolio **Frequency:** Fortnightly/ Monthly / Half Yearly/ Annually As and when recoveries have been effected for the defaulted accounts
L3 : Standalone Credit Loss Risk Assessment, Loan Valuation and Some Elements of Portfolio Analysis	Individual accounts, account level information for each of the parameters mentioned in L2 in a centralized form, market rates of interest and credit spreads.	**Source:** Internal CIS database on mean default probabilities, standard deviation of default probabilities, recovery rates and credit exposures, external database on market rates of interest and credit spreads associated with each rating category **Frequency:** Quarterly/Half yearly/Annually
L4 : Portfolio Credit Risk Measurement Value at risk- and Risk Adjusted Performance	Data on industry stock return indices, macro economic variables, industry wise performance measures credit exposure data, data on proxies of default correlation and industry correlation and sector or industry wise segmentation of the credit portfolio returns and risks for each segment.	**Source:** Internal CIS database and external information like Stock Market information, Bond Data and RBI data **Frequency:** Half yearly / Annual

Table 2. Credit risk management architecture

L1: Yield Measures such as Current Yield, YTM and return measures at individual security level and at portfolio level	Individual Security-wise Data	HO **Frequency** Daily
L2: Analysis of relative attractiveness of securities to evaluate swap opportunities, Yield Curve Creation and Valuation of securities, Analysis of Market Risk using factor sensitivity measures: Duration, Modified Duration, PVBP and Convexity	Data in Layer – I RBI – NDS data NSE -WDM data FIMMDA Data Data on Credit Spreads	External Sources collected by HO Investment dept **Frequency** Daily
L3: -Implementing Volatility Based Measures of Risk – Value-at-Risk (VAR) stress testing and back-testing -Liquidity Analysis for securities and portfolio	Data in Layer – I Data on traded securities in the market Spot Rate Data – Internally generated and from external sources	HO External sources **Frequency** Fortnightly
L4: -Analysis of Embedded Options in securities -Portfolio Optimization Simulation	Data in Layer – I Internal and External Constraints Data on Yield curve Behaviour	HO External Sources **Frequency** Quarterly

Table 3. Investment Portfolio Management Architecture

4.4 Human Resource Information Management and Customer Information Management System

The introduction of technology, and the new challenges in the form of cut-throat business and challenges from the private and foreign banks calls for a change in the human resource talent management and leadership planning process. As the banks, like any corporate house, also need leaders, critical thinkers, and decision-makers at all levels, it is need of the hour to have a Human resource information system, which can help the banks, not only for managing the human resources but also to assist in creating competencies, job profiles, help in career planning (for individuals) and succession planning for the top bracket jobs in the banks.. The various levels of need in the human resource side are also included in the enterprise maturity model.

In a similar way, as the banking scenario has shifted its marketing paradigm from product centric to customer centric, having a good customer information system (CIM) has become crucial for relationship building and business expansions.

5 Enterprise Level Maturity Model and Technology Requirements

Three diagrams for EMM are presented; Individual systems normalised and synthesized, presented as **Fig.** 1. The common business objectives stated in the beginning are layered as per their realization in the EMM and a pyramidal representation of the same EMM levels is depicted in **Fig.** 2 and the final diagram for the technology requirements to accomplish the needs is mentioned in **Fig.** 3.

The individual ALM, CRM, IPM, CIM, HRM systems are normalized and the final synthesized enterprise level maturity model is presented in the diagram below.

Business layers	ALM	IPM	CRM	HRM	CIM
M5	L6 EIS	L4 EIS	L4 EIS	L3 EIS	L4 EIS
M4	L5 DSS	L4 EIS	L3 DSS	L3 DSS	L3 DSS
M3	L4&L3 DSS	L3 DSS	L2 DSS	L2 DSS	L2 DSS
M2	L1&L2 MIS	L1& L2 MIS	L1 MIS	L1 MIS	L1 MIS
M1					

Fig. 1. Normalized, synthesized individual functional area systems in EMM

IPM: L1, L2, L3, L4 refer to various Layers in Investments architecture table.
ALM: L1, L2, L3, L4, L5, L6 refer to various phases in ALM architecture table.
CRM: L1, L2, L3, L4 refer to various Layers in Credit Risk Management architecture table.
HRM: L1 – Employee Information system, L2 – Job Profiling, Competency Requirement, 360 degree assessment, Gap Identification, Redesigning Performance Appraisal System, L3 – Training and Development, Succession planning & Career development
CIM): L1 – Unique Customer ID, Start Collecting Individual Customer Information, L2 – Customer Information is available at branch level, L3 – Analyzing Branch / Region / Zonal Customer Relationship data, L4 – Customer Segmentation & Product positioning
MIS: Management Information System, DSS: Decision Support System, EIS: Executive Information System

5.1 Technology Architecture

The objectives to be attained, the kind of reports needed whether for information or for analysis or for forecasting, the frequency at which it should be generated, the data needed for it, where all they are available, multiple sites (branches) or at a centralized place, the source of data, all these factors determine the kind of technology support needed at each of the EMM layers as given in EMM **Fig.** 1. The technology requirements are presented in a pyramidal form in EMM **Fig.** 3.

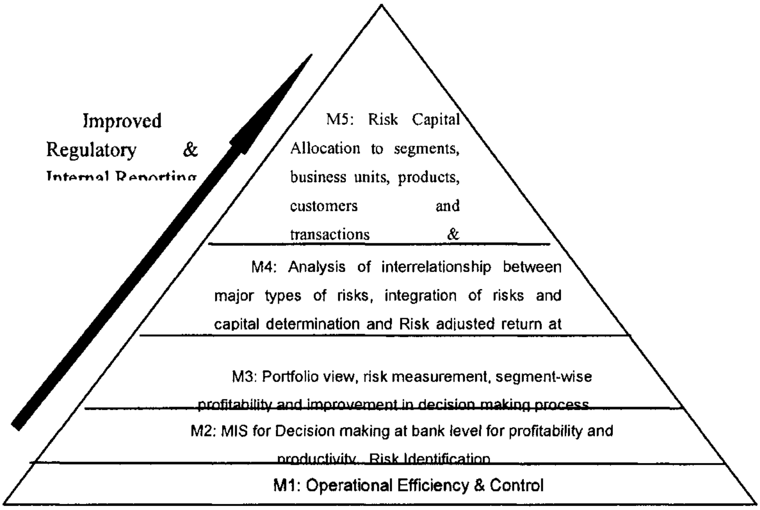

Fig. 2. EMM Business objectives

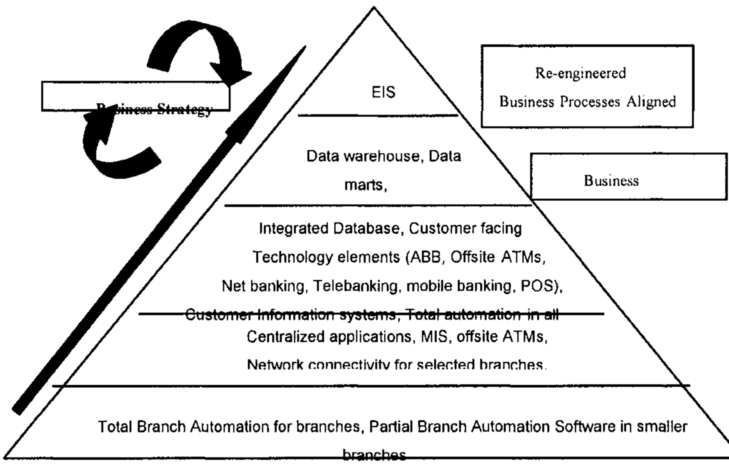

Fig. 3. EMM Technology Model

Conclusions

In this paper a new Enterprise level Maturity Model, which can be implemented in layers is proposed. The approach used in this paper is very unique in contrast to existing methodologies such as strategic alignment model discussed in [9-11]. The proposed model facilitates banks to assess the layer in which its enterprise level information systems are and formulate a strategy to evolve their information systems in a multifaceted manner. As the implementation of the EMM reaches completion, banks would also have an intelligent EIS to make the best business decisions. Further extensions to the model are underway to take care of control aspects recommended by Basel II [12].

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ERP - Change Agent or a Legacy System in Disguise: A Chinese Case

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Abstract. The paper is a report on a case study of a state-owned Chinese company. The study selected one simple business process and compared the process before and after the Enterprise Resource Planning system implementation. ERP systems promise to integrate business processes across an organization and in most cases are considered as an ideal Business Process Reengineering tool. The present study shows the impact of organizational culture on the use of ERP in an organization.

1 Introduction

Enterprise resource planning (ERP) systems are defined as "configurable information systems packages that integrate information and information-based processes within and across functional areas in an organization" [1, p. 22]. The major goal of ERP systems is to integrate and streamline business processes and their associated information and work flows [2]. Although these systems can deliver significant rewards such as improved customer service, better production scheduling, and reduced manufacturing costs, the risks related to their adoption are equally great [3]. ERP systems are Software packages which are developed on the basis of best practices promising integration across the organization. Integration, being packaged software and using best practice and the associated assumptions are suggested to be the main features of ERP systems [4, 5, 6, 7, and 8].

Davenport, Hammer and Champy [3 & 9] introduced the terminology "business process innovation" or "business process reengineering" to represent the radical change in the way "in which organizations work" compared with the incremental change of business processes in total quality management (TQM), which is the most accepted management philosophy in Japan. Gunasekaran and

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Nath [10] identified three elements in BPR: organizational restructuring, exploiting information technology, and changing the participants' behaviors.

In theory, BPR can occur without IT; however a range of information technologies can be enablers of the reengineering business process [11 - 12]. IT and BPR "have a symbiotic relationship: without reengineering, information technology delivers little payoff; without information technology, little reengineering can be done" [9, p. 5]. As well as being applied to BPR at different levels and in different areas, IT can be a constraint on BPR, mainly because the legacy systems and architecture serve local function and result in an "information Island". In addition, the process thinking and the enabling potential of IT are necessary but not sufficient in BPR. "To realign operations, administration, management or inter-firm relationships with 'process' requires a fundamental shift in the way the whole business or organisation thinks and works" [12 p.27]. It has been widely recognized that human, rather than technical barriers present the major challenges in BPR [13 - 14]. Evans [13] claims that re-engineering is not the technical, IT-driven exercise many consider it to be; rather it should incorporate three key elements: a proper strategy, the use of enabling IT and the training of staff to understand the reengineering process. People are assumed to be able to adapt quickly to new ways of doing business in most BPR cases regardless of the changes required in their behaviour or work practices [14].

Cultural differences may significantly influence transferability and success when BPR is introduced in China, although most management ideas can be commonly adopted. This cultural difference contributes to a high failure rate of ERP implementation [15]. ERP systems function, as suggested by some authors such as Brehm *et al.* [16], on the basis of some assumptions regarding the business processes and the market in which the organization operates. Cultural "fit" with ERP systems might be a problem in Asia, because the reference processes model underlying most ERP systems is influenced by European or U.S. industry/business practices, which are different from those of Asian countries [17]. As organizations are encouraged to reengineer their business processes to match "best practice" in packages, there can be significant problems associated with the reengineering of local practices and processes [18]. There are national culture and organizational culture to be considered. Hofstede [19] proposed four dimensions of national culture. "Society is seen as a hierarchical pyramid of roles which entail fairly well established norms governing how people should act and behave in relationship to people in other roles. Social hierarchy and relations of subordination and superiority are considered natural and proper" [8, p. 16].

The present study examines one case of ERP adoption in a State Owned Enterprise (SOE). The BPR through ERP adoption here refers to whether adopters reengineer their business processes to fit the software, or whether they customize the package to fit their business processes, or do both. The aim is to provide a rich picture of the change in business processes in case organizations, not to quantify the components of the studied phenomenon. The overall stance of research philosophy is the radical humanist approach proposed by Burrell and Morgan [20].

2 The Case Company – MachineCo.

MachineCo has almost 100 years history, changing from a simple workshop to a modern enterprise specialized in manufacturing specialized machines. Although MachineCo has made significant achievements since Chinese government carried out reform policy from 1978, it possesses traditional SoEs' characteristics. There are two points to be considered in MachineCo. First employees consider themselves are working for and being paid by the government. The second point to be considered here is that due to government policy, the company at present enjoys a low competition in the market. There has never been any serious competition and the profit has increased steadily in recent years. The industrial sector (machinery) the company engaged in is a very traditional sector in China. The demand increases steadily by a small rate without radical fluctuations. It seems that the government has decided to allow other companies to enter this market in near future. All MachineCo's customers are also traditional SoEs.

2.1 Adoption of ERP Systems

Through tender and case investigations of other corporations, 'Forth Shift ERP' system was employed. This system specializes in medium and small manufacturing enterprises and has gained good reputation in recent years in China. The adopted modules are production, storage management, purchasing, planning and order processing units. An ordinary department: information centre department is charge of the implementation of the system. ERP adoption process started in 2002 and the implementation went into its final phase by mid 2004. The case analyzed in this study was the purchasing process at MachineCo.

2.2 Purchasing Process at Machine Co after ERP implementation

The analysis focuses on Steps 1 to 6 of the company's purchasing process which become easier after the adoption of the ERP system because information about the required material for orders, current stocked materials and detailed data on suppliers are integrated. In Step 1, the market plan is generated by the planning module of the ERP system according to the currently received orders and product stock levels. This procedure is a complex process based on scientific calculation and prediction. Every product consists of a corresponding BOM, which provides detailed data about its consisting parts and prices. However, because it is difficult to accurately predict market demand, in Step 2 the plan produced by the ERP system is modified by users on the basis of their experience in the business environment. In most cases, the inaccurate prediction of market demand requires a manual change in the plan. In China, especially for SoEs, the decision-making process is highly influenced by irrational factors such as politics and "guanxi". MachineCo usually relies on the personal experience of employees and informal information to predict prospective orders. For example, if some signs indicate that the prices of raw material such as steel will increase in coming months, which could in turn cause an increase in the price of the parts, MachineCo increases its purchasing level. When staff in the purchasing department place orders generated by the ERP system in Step 5, they have to take non-technical factors into consideration to change the quantities ordered from different suppliers to some extent. However, if the supplier has a good personal relationship with MachineCo, the managers change the purchasing process to guarantee the desired order share for the supplier. This phenomenon is common in the Chinese business environment, especially in SoEs.

3 Discussion

Inadequate functions of the software package in quality inspection and the coding system of parts have been the major cause of delay in the implementation process. The problem has been solved with the help of the vendor by customizing relevant modules. The ERP system was implemented with the help of a consultancy company and was completed within the budget, but exceeded the planned time by one and half years. So it can be concluded that the ERP software can meet the requirements of BPR in functionality and flexibility. In addition to technical factors, the study examined the impact of environmental and organizational factors. Three "misfits" between environmental, organizational factors and ERP adoption and BPR implementation are:

- **"misfit" Between Organizational, Environmental Factors and ERP Adoption**
- **"misfit" between Organizational, Environmental Factors & BPR**
- **"misfit" Between ERP Adoption and BPR Implementation**

Since the old business processes with the constraints of SoEs, were thought to be basically reasonable, the new business processes followed the old ones accordingly. MachineCo did not change its fundamental way of doing business. The only difference between the purchasing process before and after ERP implementation seems to be the elimination of some information exchange activities with the help of ERP system. The current improvement achieved through the reengineering business processes is marginal and limited. One reason is that since ERP implementation, many processes are still undergoing optimization. The other is that MachineCo did not undertake the essential changes required by BPR, such as organizational restructuring and assessment systems redesign. The important part of any process in the case organization is the negotiations and special social relations with the management, employees, customers and the local government and this cannot be embedded into the present software package. As a result it seems that the users have found different methods to incorporate the system into their work process to simplify the access to the data. The major factor in this case has been enjoying a monopoly in the market which is changing at present. With the competition there will be a need for more efficient process and it will have a major impact on the environmental and organizational factors.

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Enterprise Information Systems for Large-Scale Engineering Projects

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Abstract. ERP systems for manufacturing sector are commercially available and research on ERP systems for manufacturing enterprises is prevalent now. However, little attention has so far been paid on how to establish ERP systems for large scale engineering projects. An ERP system for a specific engineering project is usually not available commercially. In this paper, the methods and models for establishing an ERP system for a large-scale engineering project with unique features are discussed in systems engineering perspectives. First, the necessity for establishing ERP system is analyzed; second, the methods and models for developing the ERP system are discussed; finally, the relative conclusions are given.

1 Introduction

In order to respond to the increasing competition in the global marketplace, more and more enterprises are using different kinds of tools to improve and reengineer their business processes. ERP is one of important and typical tools among them. ERP systems are developed to integrate and automate enterprises' business processes in order to maximize benefits with constrained resources. For large-scale engineering projects, ERP systems are in high demand.

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Over the last decade, there has been quite a bit of research focus on ERP systems in manufacturing enterprises. Commercial systems are available for such firms. Research shows that the major reason for implementing ERP system was for standardizing business processes and systems [1]. However, researchers have not paid much attention on how to establish ERP systems for engineering projects and it is not possible to acquire a commercially available and suitable ERP system for a specific engineering project. In this paper, from systems engineering perspectives and systems thinking, the methods and models for establishing ERP systems for large-scale engineering projects with unique features are studied. Li and Li [2] studied the integration of systems concepts into manufacturing information systems as manufacturing managers find that the tasks in manufacturing are not only their responsibility but equally lies on the shoulders of the entire organization in days of highly competitive global markets. In this paper, the methods and models for establishing an ERP system for a large-scale engineering project with unique features are discussed in systems engineering perspectives. The main reasons that systems engineering methodology are applied to establishing the ERP system are that too many details need to be considered, and complex relationships exist among them. Certain issues, such as determining the weights for resource allocation, lead to the need for employing systems engineering methods.

2 Reasons to establish ERP system

The current resource planning procedures of the project are shown in Fig. 1. In general, among resource requests from different customers, about 80% are regular requests that are expected resource demand, another 10% are temporary which are based on adjusted resource demand, and the remaining 10% are emergent ones due to urgent resource need. The resource planning department manages the requests from customers, and develops a resource plan that is based on the previous resource plan, the current resource status, and the various resource requests of the customers. The resource planning department then passes the resource plan, including customers' name, resource ID, scheduled time and date of the resources, any form of restrictive conditions for confirmed requests and so on, to the resource management department.

With the information provided by resource planning department, the resource management department decides the resource types for each application, and calculates volume of resources needed for the requests of customers, monitoring the available quantity of resources, and examining schedules for resource. Then, a short term resource schedule plan can be settled, and the resource plan is checked to see whether any conflicts exist. If one or more conflicts exist, the conflicts are dealt with and corrected manually, and the results are sent to the resource planning department for resource plan generation.

If an emergency resource application occurs that causes a conflict, the resource planning department then submits the emergency resource application to the resource management department and passes the resource plan to the main management department. In addition, the resource management department should provide information on conflicts and the resource schedule to main management department. The resource plan will be regenerated if the main management department requests to do so.

If the main management department approves the resource plan generated by the resource planning department, or receives a "no conflict" from the resource management department, then the resource planning department notifies every customer regarding the expected operation date, time, and other pertinent information. Generally, if a conflict exists among customers' resource applications, the resource plan need to be regenerated and some adjustments are needed. Emergent and/or temporary resource applications may change the predetermined resource plan and delivery date to satisfy the new requirements. It should be noted that the applications of resource should be conducted in advance because time is needed for the resource to change their status from occupied to available.

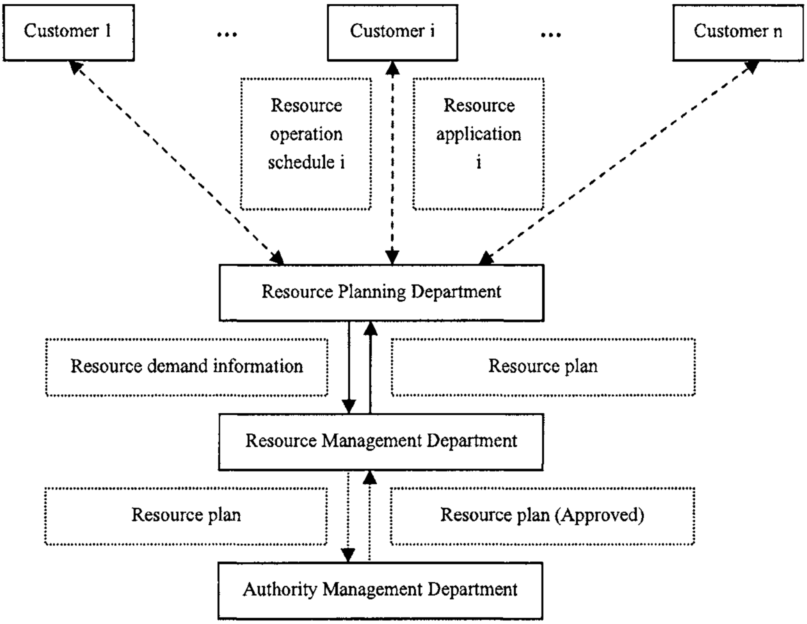

Fig. 1. Current resource planning procedures

In the above we describe the existing resource planning procedures of engineering projects that have several limitations such as:

▪ Resource planning tasks such as procedure processing, resource scheduling, plan generation, and information delivery, are not fully computerized, integrated and automated yet.

▪ Too much data or information need to be checked, such as the past resource plan, current available resource, and resource occupation during next period.

▪ Resource plan generation needs to be adjusted and changed manually when emergency and/or temporary resource applications occur.

▪ Time-consuming manual resource planning is required whenever there is a change in resource condition.

▪Those models for optimizing resource utilization have not been used. As a result, sometimes some important resource requests from customers are denied; and resources of the engineering project are not used effectively.

▪ Conflict eluding models are not well developed. For this reason, resource requests of customers are denied frequently.

3 Main Methods and Models to establish the ERP system

3.1 Reengineering resource planning procedures

The reengineered procedures of the resource planning system are shown in Fig. 2.

3.2 Optimizing models

(1) Maximizing resource utilization model

Maximizing resource utilization model is a model which can provide customers with a flexible and efficient resource plan on condition that all available resources of the engineering project are utilized properly (Fig. 3).

(2) Minimizing resource utilization model

Minimizing resource utilization model is a model that minimizing resources of the engineering project is considered on condition that all customers' requirements are met (Fig. 4).

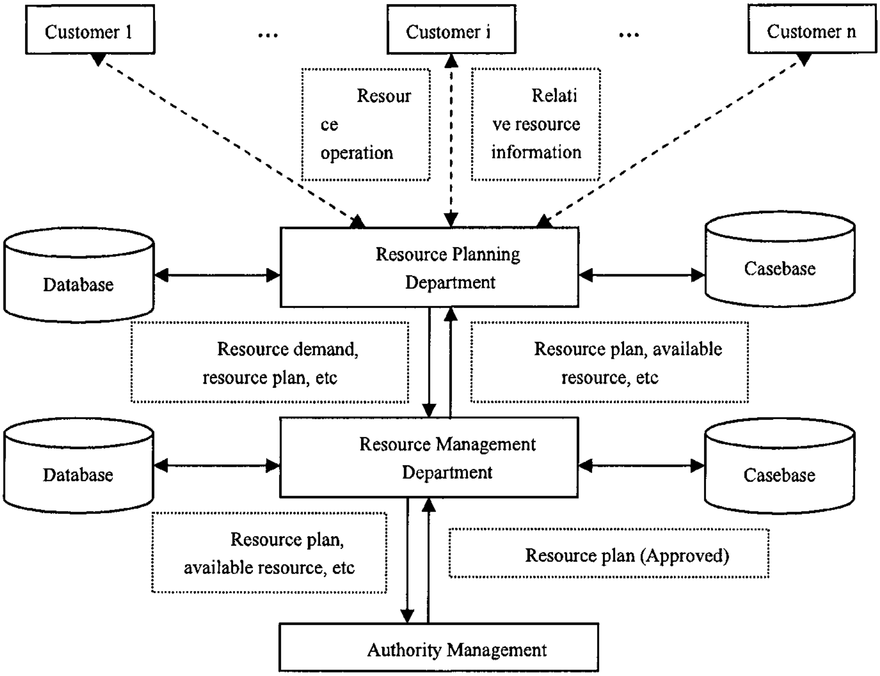

Fig. 2. Reengineered procedures

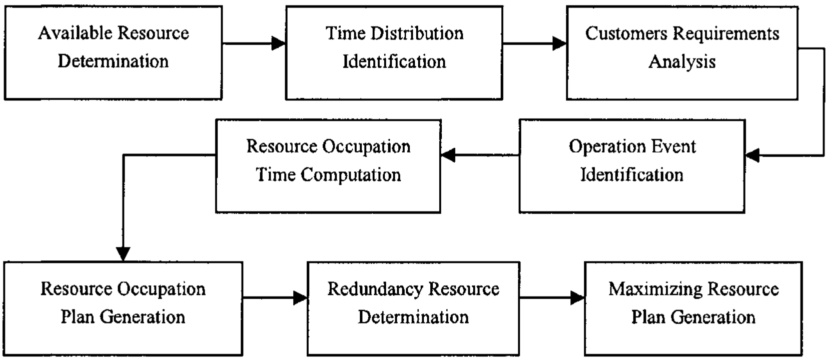

Fig. 3. Maximizing resource utilization modeling

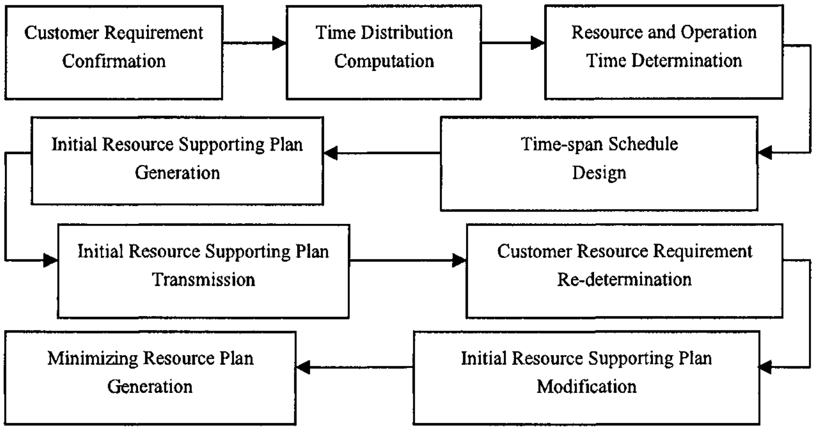

Fig. 4. Minimizing resource utilization modeling

3.3 Conflict eluding model

Conflict eluding model is used to eliminate the conflicts during resource planning process. These conflicts not only include the conflicts among resource applications from different customers, such as overlapping applications, contradictory applications, etc, but the conflicts between customers' resource applications and resource supporting capability provided by the engineering project (Fig. 5).

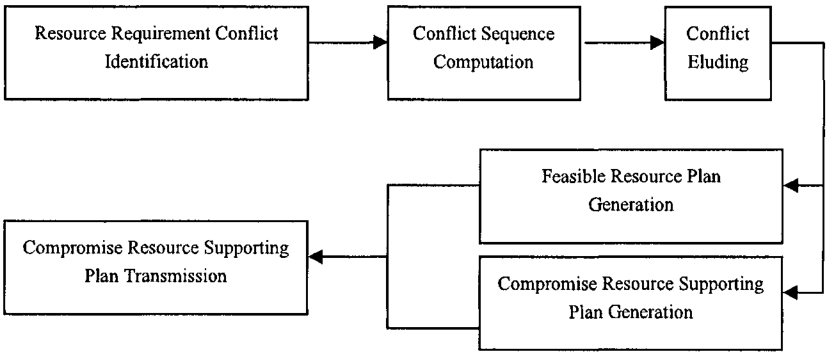

Fig. 5. Conflict eluding modeling

4 Conclusions

ERP system is an effective tool to plan enterprises' resources. It is equally true for engineering projects. Unfortunately, it is difficult to acquire a commercially available ERP system to meet all the resource planning requirements for an engineering project with unique features. ERP systems for this kind of engineering projects should be developed in house. In this paper, from systems engineering perspectives, the methods and models to establish an ERP system for a large-scale engineering project were studied and the main conclusions of the research in this paper include:

(1) To use the resources effectively and to fully meet resource application requirements simultaneously depends on using the optimized models. The pertinent optimized models of resource planning system of the engineering project, including maximizing and minimizing resource utilization models, are presented in this paper.

(2) Models to elude resource planning conflicts, for instance, the conflicts among resource application requirements of different customers and the conflicts between customers' resource requirement and resource supporting capability provided by the engineering project, are crucial for the resource planning system. The relative conflict-eluding models are discussed in this paper.

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ISRUP E-Service Framework Balanced Scorecard to Measure the Capabilities from the Methodologies, Processes, Notations, Life Cycles, and Standards

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Abstract. Despite the fact that nowadays, architectures, development processes, frameworks and technologies are maturing to be Service Oriented Architecture (SOA). Former frameworks for enterprise architecting couldn't be matched with those SOAs. Thus putting to use those frameworks to the business enterprises make IT/ICT consultants and enterprise architects encounter with some complex difficulties in the enterprise architecting projects. ISRUP E-Service Framework is proposed and developed based on SOA and RUP to converge E-Business, E-Commerce and E-Government concepts through just leveraging E-Services (especially web and grid services) by architecting the information systems in the enterprises. This paper explains the results of the benchmarks which done in between ISRUP E-Service Framework and 21 different methodologies, processes, notations, life cycles and standards pertaining to their capabilities.

1 Introduction

The Rational Unified Process is a software engineering process developed and marketed originally by Rational Software, and now IBM. It is a disciplined approach to assigning and managing tasks and responsibilities in a development

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organization. The goal of this process is to produce, within a predictable schedule and budget, high-quality software that meets the needs of its end users [1].

ISRUP is an E-Service framework for Agile Enterprise Architecting through Unified Modeling Language (UML) and RUP terminology to improve the enterprise architecture of business enterprises, ISRUP E-Service Framework has 40 enterprise patterns to apply an iterative process for continuous improvement by way of information system architecting. ISRUP E-Service framework depicted that the convergence of E-Business, E-Commerce and E-Government through just E-Services. Each enterprise that wants to be as a service requester, service provider and service broker, should apply ISRUP enterprise patterns to be prosperous. ISRUP stands on Integrated Services-Information Systems based on Rational Unified Process terminology. ISRUP E-Service framework is used by some parts of government and businesses to make informative and reusable documents as their assets. For more information please see www.isrup.com [2]. After ISRUP E-Service framework Odyssey, 5 views and 8 models of ISRUP E-Service framework are explored in the following. What comes as final is ISRUP E-Service Framework Balanced Scorecard that shows the results from benchmarking different methodologies, processes, notations, life cycles and standards.

2 ISRUP E-Service Framework Odyssey

ISRUP E-Service framework is derived from Zachman enterprise architecture framework and IBM Rational software development process. The framework mainly uses RUP and UML terminologies respecting to the enterprise architecture documentation. The framework doesn't claim to use the same terms and expressions as Zachman framework and RUP process, but according to the facts in the enterprises (especially Government and Businesses); it has tried to develop framework components with respect to the future technologies (SOA) and the past useful experiences. ISRUP E-Service Framework consists of 5 views (Stakeholder, Analyst, Architect, Designer and Developer) and 8 models (Proof, Process, Place, People, Period, Purpose, Practice, and Project (8P)) [3, 4, 5, and 6].

3 ISRUP E-Service Framework Views

The 40 enterprise patterns fit into 5 views that don't necessarily adapt with the views of other frameworks syntactically, semantically and pragmatically. These views are described as follows [7, 8].

Stakeholder View, This view addresses the activities and artifacts of the enterprise patterns from the view of stakeholders. All models are simplified and understandable for them.
Analyst View, The emphasis of the view is on requirements & requirements analysis. Analysts analyze the requirements from different aspects. The view is a conceptual view to the enterprise-wide requirements.
Architect View, Focuses on integration and homogeneity of the components in the models, in addition to this view is platform-independent.
Designer View, All the models in this view emphasize on clearance and determining the design details and generally all of the details. These details are dependent on the technology and thus they are platform-dependent.
Developer View, This view addresses implementation and test details and generally details of controlling any development in enterprise's projects and activities, especially for software development activities.

4 ISRUP E-Service Framework Models

Proof, Process, Place, People, Period and Purpose models are considered extensions of what, how, where, who, when and why in the Zachman framework, consecutively. Practice and Project models are added to the Zachman to support and leverage the experiences and resolving the problems and changes in terms of projects. ISRUP models (8P) are described in the following [3-6, and 8].
Proof Model, 5 enterprise patterns pertaining to this model emphasize on entities, persistent object, data tables and generally any kind of repository, which can be created in an enterprise.
Process Model, The enterprise patterns relating to this model emphasize on how the enterprise processes collaborate to use the enterprise resources, and especially on their interaction with elements of the proof model.
Place Model, The enterprise patterns of this model emphasize on logical and physical positions for network elements. For example buildings, rooms, floors, etc. are physical and IP is a logical position. This model addresses the way to order and organize all of the software and hardware components to take more secure advantages of information technology.
People Model, This model emphasizes on human resources and their relationship with information resources (knowledge) of an enterprise, for example; the owner of information systems and access levels are determined in this model.
Period Model, This model emphasizes on all reactions the enterprise must have toward immediately to manage internal and external events.
Purpose Model, This model emphasizes on all of the matters related to ROI, vision and generally all of the subjects relating to the enterprise goals.

Practice Model, This model emphasizes on taking advantage from success and failure experiences from people and other organizations to resolve the common problems from all viewpoints.
Project Model, This model includes the stages of understanding the problem statement, determining the projects to resolve the problems and taking advantage from external resources to simplify and speed solving problems. Subcontracting and controlling what would be outsourced are herein.

5 ISRUP E-Service Framework Balanced Scorecard

Different methodologies, processes, notations, life cycles and standards such as ITU-T SG */4 , Web Services, SOA, OMG-MDA, P of EAA, UML 2.0, UN/CEFACT-UMM, IBM RUP®, Goal UML, EUP, Zachman, GEM- MDEM, EAP, TOGAF, DoDAF-C4ISR, FEAF, TEAF, Balanced Scorecard, CMM/CMMI/ISO, Six Sigma, and Porter share common issues that in order to use them simultaneously (they are called Enterprise Patterns in ISRUP E-Service Framework). The important point is that, we'll need to integrate all of them in a holistic framework.

All above methodologies, processes, notations, life cycles and standards have been compared with together through 40 enterprise patterns of ISRUP E-Service Framework in Table 1. ISRUP E-Service Framework Balanced Scorecard (BSC) as a measurement instrument has been used to specify the importance level of all methodologies, processes, notations, life cycles and standards which they have claim on their enterprise-wide solutions, partially or completely. So the value of each cell encompasses the elements of knowledge and documentation. For each of these methodologies, processes, notations, life cycles and standards, the result of each enterprise pattern of ISRUP E-Service Framework can be assessed from 3 different situations.

1 Status 1= uncertain or not documented
2 Status 2= partly known and partly documented
3 Status 3= fully known and well documented certainly

Table 1 shows relatively the significant scores of those methodologies, processes, notations, life cycles and standards rather than ISRUPE-Service Framework score (120) in different presentations as Table 1. This benchmark shows that IBM RUP®, ITU-T SG */4, and OMG MDA have got 100, 82, and 74 marks, subsequently.

Table 1. Results of Benchmarking Methodologies, Processes, Notations, Life cycles and Standards based on ISRUPE-Service Framework patterns (ISRUP score=120)

Methodologies, Processes, Notations, Life cycles and Standards	BSC Score	Methodologies, Processes, Notations, Life cycles and Standards	BSC Score	Methodologies, Processes, Notations, Life cycles and Standards	BSC Score
IBM RUP®	100	Zachman	68	CMM CMMI ISO	69
ITU-T SG */4	82	GEM MDEM	70	Six Sigma	62
Web Services	62	EAP	56	Porter	57
SOA	57	TOGAF	57	Goal UML	72
OMG MDA	74	DoDAF C4ISR	67	EUP	69
P of EAA	64	FEAF	57	Balanced Scorecard	53
UML 2.0	51	TEAF	58	UN/ CEFACT UMM	68

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Enterprise Architecture Definition Framework for IT Service Providers

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Abstract. As Enterprises evolve, they invariably end up with heterogeneous IT systems. The software applications for the IT systems would have been deployed on multiple platforms and built using varied programming languages or packaged software. Customers require approaches to plan enterprise wide strategies that lead to scenarios of well integrated IT systems within their organizations. Suitable integration strategies have to be adopted to ensure that the systems which are currently available are well-integrated as well as enable future systems to be easily brought into their fold through seamless integration.

In order to address customer requirements for developing enterprise architectures and also to develop strategies to maintain them, customized approaches have been adopted. This resulted in the development of an Enterprise Architecture Definition Framework that IT Service providers can apply in consulting assignments. The paper presents the best practices for enterprise architecting and integration. Two case studies have also been included in the paper to illustrate the approach, one based on a native integration framework and the other based on Enterprise-Wide Service Oriented Architecture.

1 Introduction

The Information Technology services department of a typical organization has moved from playing the role of a supporting partner to that of a strategic partner.

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From the scenario of having an Electronic Data Processing Officer/Manager who would generate the required reports for the user departments we have reached a stage where large enterprises have Chief Information Officers and IT Directors to drive the IT strategies of their enterprises. Information Technology (IT) has become the backbone of almost every business enterprise. Consulting organizations are being employed to develop and setup the required applications/systems on a large scale. Hence, there is a need to provide detail to the various stake holders at a level of abstraction that they are comfortable with, when communicating with others.

Further, large enterprises would have already invested a considerable amount of resources while evolving to the current state of IT implementation. Consequently, there is a need to integrate the heterogeneous applications/systems and also to have a clear path to integrate the applications/systems that the enterprise would acquire in future.

Thus, there is a need for effective communication of the requirements of various stake holders within an enterprise and also while communicating with an outsourcing partner, when the enterprise engages an IT Service Provider. The communication would be highly effective through an Enterprise Architecture. This paper discusses an Enterprise Architecture Definition Framework for IT Service Providers.

The paper is based on customer engagements that involved recommending and providing Enterprise Architecture based solutions. In this paper, large-scale business applications built on distributed systems are referred to as "Enterprise Applications". Two customer case studies have been discussed in the paper.

The rest of this paper is organized as follows. Section 2 discusses the concept of Enterprise Architecture (EA) and its current stage of adoption. Section 3 discusses the Enterprise Architecture Definition Framework for IT Service Providers. Section 4 describes the generic approach to Enterprise Architecting and instantiates it with two case studies, one based on a native integration framework and the other based on Enterprise-Wide Service Oriented Architecture. Section 5 concludes the paper.

2 Enterprise Architecture – The concept and its current stage of adoption

Enterprise Architecture involves the integration of processes and applications across an enterprise and is a collection of architectures. It involves the gathering and documenting of AS-IS/Current state and TO-BE/Future state requirements of various stake holders from different dimensions, such as business, information, applications, infrastructure and security. In case the enterprise contains stove-pipe systems then the enterprise architecture would come up with a plan to migrate to a seamlessly integrated enterprise wide IT system, i.e. the integration architecture. The process dimension of the Enterprise Architecture would contain the roadmap to move from the AS-IS to the TO-BE scenario and also a Governance model for the architecture.

In the year 1987, John Zachman published a paper titled "A framework for information systems architecture". [6] But, it did not capture the industry's attention to the required extent for more than a decade. In an article published in 1999, Zachman enunciated why architecting did not catch industry's attention and also listed reasons why an architectural revolution was imminent for every enterprise that intended to be a player in the information age. [7] Zachman's analysis is now getting validated as a large number of players in the current scenario are adopting enterprise architecture.

Gartner, in September 2005, states "Many CIOs have established or inherited enterprise architecture programs with high hopes of improving IT by managing complexity, increasing IT agility and reducing cost and risk. These programs frequently flounder because many CIOs don't apply EA in their everyday work with the business, their staff, vendors and business partners." [10] The report identifies some drawbacks on enterprise architecture implementation by CIOs. However, the very fact that such a research was conducted illustrates how wide spread and established the titles of CIOs and the concept of enterprise architectures are in today's organizations.

3 Enterprise Architecture Definition Framework

Based on our experiences, we have formulated an Enterprise Architecture Definition Framework (EADF). The framework, like any framework, provides a skeletal structure that needs to be populated depending upon the context of the problem to which it is applied and needs to be adapted to the problem at hand. The key elements of an EADF are shown in Table 1.

The EADF provides guidance on how to develop various architectures constituting the enterprise architecture by way of drawing attention to the points that should be kept in mind while arriving at respective architectures which are shown as rows in the EADF matrix below. The various decisions related to business development and technology innovations need to be considered in a systematic manner within the framework of various architectures. Choices of methods and techniques have to be made in the context of the goals and objectives. [2]

Constituents of an Enterprise Architecture and relationship between the AS-IS & TO-BE Architectures and concerns:

As discussed in section 2, an Enterprise Architecture is made up of various architectures like Business, Information, Applications and Infrastructure Architectures. Further, each of the Architectures is related to various concerns.

AS-IS Architecture or AS-IS Artifact =
function (Rationale, Process, Actors, Information, Location, Time)

However, one may not have much control in documenting AS-IS artifacts and Architectures. The customer might not be willing to spend more time and effort in documenting the existing scenarios. The Enterprise Architect would have to use discretion in identifying existing artifacts and architectures that would be useful in documenting the AS-IS scenarios and needs to negotiate with regard to the ones which are essential.

TO-BE Architecture or TO-BE Artifact =
function (Rationale, Process, Actors, Information, Location, Time)

Enterprise Architecture needs a detailed sequencing plan to evolve the baseline architecture to the target architecture. The plan's major elements include program/business improvement IT projects and major infrastructure and technology upgrades. [14] Migration from AS-IS to TO-BE might use approaches like service-oriented architecture and building integration frameworks. The architecture governance identifies the roles and responsibilities of concerned stake holders. An escalation mechanism is planned and documented. Thus, both the model and process are captured.

Strawman Table of Contents for EA documentation and governance:

The EADF is supported by a Strawman version of Table of Contents (ToC) that would guide in documenting the important architectures of the EA. Points mentioned in the matrix have to be checked against when arriving at their respective architectures.

1. How to use this document
2. Introduction
3. Business Architecture
    a. AS-IS Architecture
    b. TO-BE Architecture
4. Information Architecture
    a. AS-IS Architecture
    b. TO-BE Architecture
5. Application Architecture

   a. AS-IS Architecture
   b. TO-BE Architecture
6. Infrastructure Architecture
   a. AS-IS Architecture
   b. TO-BE Architecture
7. Security Architecture
   a. AS-IS Architecture
   b. TO-BE Architecture
8. Integration Architecture
9. Road Map to migrate from AS-IS to TO-BE
10. Architecture Governance
    a. Architecture Governance Structure
    b. Roles and Responsibilities of concerned stake holders
    c. Escalation Mechanism
11. Appendix

Architecture or Artifact, Primary Stake-holder (s)	**Rationale**	**Process**	**Actors**	**Information**	**Location**	**Time**
Solution Overview, Program/Project Sponsor	Business goals/strategies, need for taking up the project	Processes the business performs	Organizational units important to the business	Things important to the business	Locations in which the business operates	Events/cycles important to business
Business Architecture, Business User and Business Domain Expert	A tool for visualizing how individual business processes fit into the overall value-producing chain, 'siloed' vs. 'enterprise' management.	Business Process Model	Work flow model (key stakeholders in different organizational units (OUs) and their reporting relationships, with a work-flow relationship)	Functional model, Process model, Business entities, Workflows, Key business components (functions)	Business logistics system (business locations and linkages - detailed information on different OUs)	Master schedule (including business events and cycles), investigation of suitability of service orientation
Information and Data Architecture, Business Domain Expert and Technology Expert	Development of strategies to satisfy the needs of the end users (both naïve and advanced) and the Senior Management	Identification of online queries, summary reports, queries that give intelligent reports (e.g. use of data warehouse)	Who can access the data/information, which data elements to protect and the extent of protection?	Functional Requirements which lead to identification of data elements, Data Model, Information requirements	Location of users who would need the data and information	Identification of Real time, Near Real Time and Batch Processing requirements
Application Architecture, Business Domain Expert and Technology Expert	Identification of Applications that need to be replaced and relationship between new and retained applications	How the applications interact with each other (e.g. synchronous, asynchronous)	Who should access which applications?	Names of different applications (both products and those developed in-house)	Position of applications in layers and also their geographical location	Identification of communication styles (e.g. Messaging, service oriented, etc.) between applications
Infrastructure Architecture, Technology Expert and Developer	Identification of required hardware/ software and guidance on their selection, deployment and maintenance	Load, performance, scalability and considerations like trade-off due to selection of one implementation style over other (e.g. use of tomcat vs. WAS)	User wise Access permissions for varied users, at a high level	Servers, Clients, Databases, Networks, Operating Systems	Connectivity issues for the chosen environment (e.g. bandwidth considerations)	Support for style and type analyzed above (e.g. Message Oriented Middleware like MQ Series, Enterprise Service Bus, etc.)

Architecture or Artifact, Primary Stake-holder (s)	**Rationale**	**Process**	**Actors**	**Information**	**Location**	**Time**
Security Architecture, Security Architects	To have a secure operating environment	Navigability across screens for different types of users and screen formats (e.g. presentation or UI aspects)	Identity (people) and job (work) mapping document for security	Zones of control (e.g. Insecure un-trusted & trusted and Secure trusted & un-trusted), Access Control List entries like "write access", audit trail record written for all file attempts	Security within and across locations (e.g. SSL)	Time dependent security, if any, possibly due to operations in different time zones
Integration Architecture, Designers	To develop integration strategies, for the integration of existing/retained and new applications (e.g. interface framework or SOA)	How the applications interact with each other (e.g. synchronous, asynchronous, batch), data transfer direction – in, in/out, out)	Who can access which applications?	Applications to be retained & new application(s) (e.g. comprehensive list of all external applications that need to be integrated)	Physical location of the external applications within the operating environment	Identification of Synchronous and Asynchronous interfaces

Table 1 Enterprise Architecture Definition Framework

4 Case Studies

There is no one right way or a single industry standard for defining architecture, so agreement within an enterprise is more important than theoretical perfection. [3] Based on customer engagements we have arrived at an EADF, as discussed in section 3 above. The case studies deal with the integration of information systems.

Many existing Information Systems (IS) supporting an organization's business processes, are considered "automation islands", since they cannot communicate easily with systems inside the organization and even less outside it, with external systems of clients and suppliers. In order to provide a complete, efficient and reliable support, the IS must be integrated. IS integration means to unify independent IS, with the purpose of providing shared information and give a valid support to the whole organizational process. [8]

4.1 Enterprise Architecting for a large Bank

The customer is a large bank that has grown rapidly through mergers and acquisitions. This inorganic growth has led to the bank having heterogeneous applications for the same functionality. This led to a scenario of stove pipe applications or "automation islands". The bank has decided to centralize the functionality and has identified a third party vendor who would provide an off the shelf solution.

In order to see how the entire business processes and the information/data would get integrated Enterprise Architecture was defined. Our organization had been engaged as an IT service provider to finalize the EA. In this context we used the EADF to document the EA, provide a road map and architecture governance. Apart from the offshore study an onsite visit was undertaken to arrive at the EA. Among others, the team included a Domain Architect and an Enterprise Architect.

The AS-IS and TO-BE architectures of the business, information, application, infrastructure and security were documented. The EADF was used to guide in the definition of the architectures. It was ensured that the concerns mentioned in the columns of the EADF, shown in Table 1, were part of the architecture/artifacts for each of the architectures/artifacts. Thus, for a given row, the architecture/artifacts addressed all the mentioned concerns. Further, it was ensured that there is traceability between the various architectures for a given concern i.e. as we go down a given column of the EADF, shown in Table 1, the architectures/artifacts are generally at a lower level of abstraction but there is continuity of thought process for a given concern. The standards and guidelines related to the different architectures were included in the appendix. A road map to migrate from the AS-IS to TO-BE state, and architecture governance framework were recommended. Roles and responsibilities of concerned stake holders along with an escalation mechanism, in case of deviations, were documented.

The customer had taken a decision to take the non-SOA path, as its policy is to be an early follower than to be a leader in the adoption of new or emerging technologies. Hence, a solution that involves the creation of an Integration Framework was recommended and is as shown in Fig. 1.

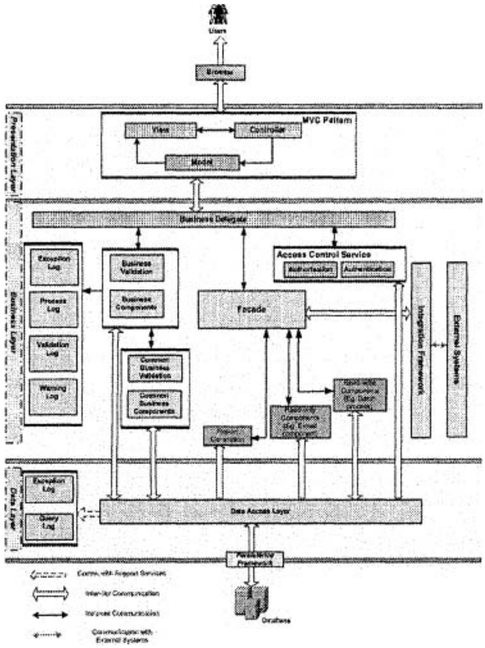

Fig. 1. A J2EE based application that would integrate with other applications through the Integration Framework

The design of the Integration Framework adopted an approach of integrating various applications in a plug and play manner.

4.2 Enterprise Architecting for a Financial Services customer

The customer is a large financial corporation. Over a period of time, it has developed and acquired varied systems that cater to the required functionality. The existence of varied legacy systems had led to a situation where it was becoming difficult to maintain them. The customer wanted a migration of their applications to newer platforms. Proactively, it wanted to have an EA that would make the systems maintainable and enable it to integrate any new technologies/applications that the customer would develop or acquire in future. An approach similar to the one discussed in the earlier case study was used to arrive at Enterprise Architecture.

As the customer was willing to adopt SOA, a solution based on SOA was proposed. Strawman architecture for enterprise wide SOA was recommended.

Subsequently, a detailed study of the IT systems was undertaken to arrive at the final recommendation.

A central aspect of Service Oriented Architectures is the loose coupling between applications (services) that are achieved when services publish their functional and non-functional behavioral characteristics in a standardized, machine-readable format as indicated in [9]. In this section, discussion is not restricted to a particular technology. A generic view of a service is considered.

The Strawman Architecture presented in this section could serve as a starting point for developing a SOA based solution for an Enterprise. Fig. 2 represents a Strawman for Enterprise-Wide SOA recommended to the customer.

It can be seen from the figure that the enterprise has several applications that need to talk to each other. A key feature of the architecture is the use of Enterprise Service Bus (ESB) that enables a smooth communication between the applications. ESB is often described as a product, especially in the marketing literature of various vendors. But, in a strict sense, ESB is an architectural style. The Strawman architecture for Enterprise-Wide SOA has the ESB as the heart of communication between applications. [1, 11, 12]

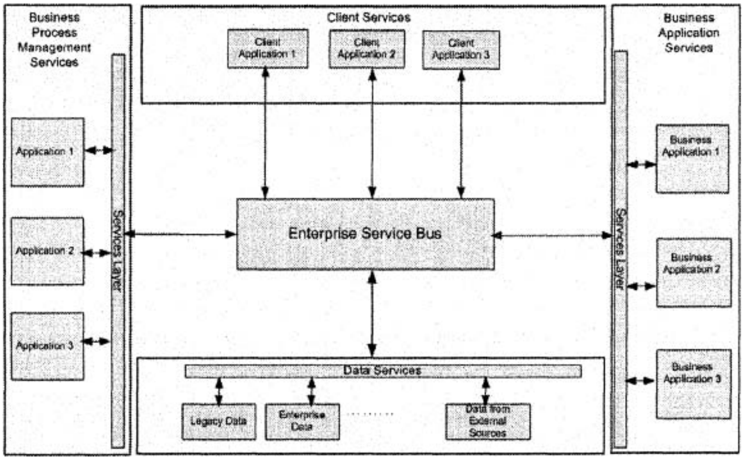

Fig. 2. Strawman for Enterprise-Wide SOA

5 Conclusions

This paper has captured experiences in providing EA based solutions for enterprise applications. The Enterprise Architecture Definition Framework enables an Enterprise or an IT Service Provider to quickly arrive at the required Enterprise Architecture definition. The strawman table of contents helps in documenting the enterprise architecture, a road map to migrate from AS-IS to TO-BE state and an architecture governance model. The SOA and non-SOA based approaches for integration that have been discussed as part of case studies provide approaches for enterprise and solution architecting of the enterprise's applications. The framework, tools and techniques discussed in the paper would reduce the time and resources required for enterprise architecting by IT service providers.

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Studies of Enterprises' Modularization Decomposition

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Abstract. "Modularity" theory has been widely applied in product design and manufacturing, system development etc., meanwhile the notion of "modularity" has been infiltrating into researches and practicalities of current enterprises theories, industrial economy as well as enterprises strategies. Thus, the concept of "modularity" is a hot topic among experts of products design engineering, economist and operating specialists. Based on modularity classification researches to global product functions, through the logical integrate analysis of function-theory-method-entity, combined with relations upon the four levels, this paper puts forward one enterprises modularity decomposition method, which not only explains the variation of enterprises' structure, but also provides research clues for enterprises' modularity integration.

1 Theory and application of "Modularity"

Aoki Masahiko takes "modular" as a semi self-restrained subsystem, constituting together with other similar subsystems by certain rules into even more complicated system or process. He calls the complex unit or system decomposing into semi self-restrained lower unit as modularization; He therefore regards modularization as an effective method [1] to solve complicated system.

In researches of modularity structure and construction, Kusiak [2] has applied elicitation diagram modular identification and put forward three modularization structure designs; Gu [3, 4] and his colleagues put forward the optimal design of the integrated modularization design based on life cycle and integrated modularization design; By function design research in manufacturing and assembling, Tsai [5] and his colleagues have obtained the optimal method of modular construction, they also arranged the modular design and manufacturing

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sequence; Salhieh [6] etc have decomposed the construction process of modular into four stages and formed modular through the connected degree of characteristic index among spare parts.

In modularity decomposition researches, mechanical engineering takes the decomposition of the system, namely products, as key to concept design. Azarm and his colleagues (1989) studied the method of component-oriented decomposition [7]. Buur (1990) studied the discipline-oriented decomposition method [8], Hansen (1995) studied the function-oriented decomposition method [9], among which the function-oriented decomposition is applicable and hence is widely practiced, while the function method tree is one of its typical representatives. This method suits both simple system and complicated system concept designs.

2 Application analysis of modularity in enterprise

Through the proportion developed by modularization unit's supplier and automobile assembling factory together(15% in North America, 52% in Japan), and therefore the finished auto costs advantage analysis, Clark and Fujimoto (1990), point out that the modularization unit is a new and efficient topic of operation pattern and unit type. They conclude enterprise operates on the basis of modularization unit, taking the entire production network as unit, not refining only within a single enterprise [10].

Through the establishment of enterprises' inner market, by market pricing method, it thus enables the intermediary products to flow within enterprises and combines enterprises' interior and exterior markets together. Therefore, modularization unit is more adaptable, directed and flexible. It requires each modularization unit in enterprise to become independent Business Entity with "Self-Organization". They are some self-existing, self-evolution and self-progressing economic entities.

In the operation level, application of modularization in enterprise mainly reflected in three aspects: First is the business modularization established on the basis of reengineering theory. Second is the capability elements modularity based on the core ability. Third is unit structure modularization on the basis of system engineering theory. So, modularization operation in enterprises can be understood from two aspects: first is to construct enterprises' unit modular by business modular and core capability, reacting swiftly to requirements of the exterior market, namely enterprise's modularization integration; Second is to decompose enterprises into some modularity units by certain structure, level and regulations and to take the business modularity and core ability modular as its content. This paper attempts to put forward an enterprise modularization decomposition method through the integration analysis of the logics among function-principle-method-entity.

3 Decomposition system of Enterprises' modularity's function-principle-method-entity

3.1. Function tree expression of enterprise

As a system, enterprise owns certain function. To take function as the abstract expression of enterprise system not only helps to summarize the diversification of enterprise entity structure, but also helps to decompose enterprise with systematic engineering method. For example, enterprise has a general function to supply product(service) to market, directed to this, there can be many different entity types of enterprise corresponding(such as productive enterprise, distributing enterprise, retailing enterprise, etc) to fulfill this total function. As an abstract concept, function can be realized by different entity objects. So, relation between function and its realized entity is one to several. In this way, it is an effective enterprise analysis method to abstract different individual enterprise systems into the function area for systematic decomposition and analysis.

We can use the function tree method in the systematic engineering principle to decompose enterprise after abstracting enterprise system to the function area, so that we can ascertain a reasonable function unit and function structure to fulfill the overall function. The function tree expression is shown in Figure 1 where OF refers to the overall function and F refers to function.

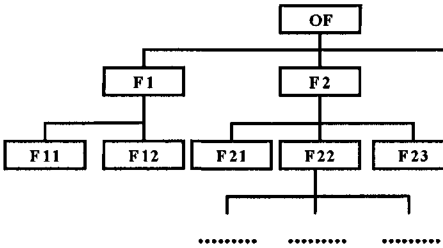

Fig. 1. Sketch Map of Function Tree

3.2 Expression of enterprise's function-principle tree

The traditional function decomposition method only conducts in the function area, there exists on the one side the difficulty of function's reasonable decomposition, and it is difficult on the other side to get the complete defined collection of sub functions. So, according to Axiomatic Design (AD) theory, to correspond principle with function and to join the function decomposition can not only support theoretically function's realization, but also ascertain the suspending stage of function decomposition through the function corresponding principle realization.

To better express and support theoretically the earlier mentioned function decomposition, reference [11] forwards the principle figure of function method tree. This paper puts forward the sketch map of the function-principle tree as shown in Figure 2: P refers to principle, OF is the root, namely the overall function to be modularized, the bottom (P11, P31, P31, P33, etc) is a series of principles. So, a function can be supported both by only one principle and by multi principles. Relation between function and principle is one to several in the same level. On the contrary, principle's produced function is relation at different levels; their relation can either be one to one, or one to several.

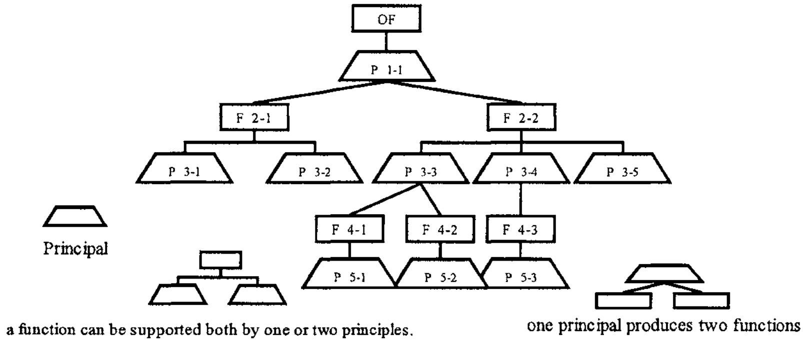

Fig. 2. Sketch Map of Function-Principle

3.3 Principle-method corresponding relation

Principle acts as functions' theoretical support while method is the practice to realize function under the guidance of principle. Obviously, one principle corresponds to several methods, that is to say, backed by one principle, one function can be achieved by different methods in various environment and background. Method is unlike function and principle, which exist level structure, it is the specific practice to realize functions, backed by one principle and in different environments and backgrounds. Method is different from function and principle existing level structure, it is the collection of specific practice and it is hard to express with level area.

3.4 Enterprise entity system tree expression

The traditional enterprise entity analysis is established on the unit modularity basis of the level structure, it is in fact a kind of systematic decomposition method, with the same principle and pattern like the function decomposition. It is actually the materialized pattern of the function, and it has the same framework of function tree.

3.5 Enterprise system function-principle-method-entity decomposition system

According to the Law [11] in the mechanical system, in the mechanical system, there exists casual relation between function and method, function is realized by method, method corresponds to a series of entities, and the entity's action result is solution to function. Putting this Law into social and economic system, this paper forwards function-principle-method-entity solution system of enterprise system modularity decomposition system.

Function system coming out of decomposing the traditional function tree is called as the function area. Also, principle and entity modular have their principle areas and modularity areas respectively, as various methods can hardly be integrated within one level; we sum up all the methods into method sets in this paper.

Directed by the same theory, under different restrictions, we can achieve function target through various methods. Law takes that a method usually corresponds with a series of entities. In this paper, we define enterprise as a modular, so enterprise is composed of related sub modular. We conclude hence that method corresponds with each sub modular in enterprise. To integrate function area, principle area, method sets and modular area together as to construct an enterprise modularity decomposition system just as what is shown in Figure 3.

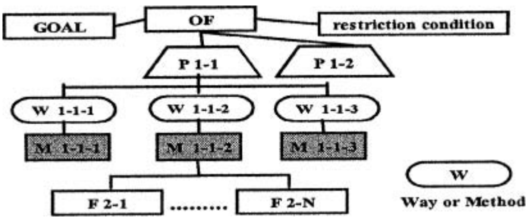

Fig. 3. Enterprise Modularization Decompositions Illustration Based on Function-Principle-Method-Modular Integration

In Figure 3, relation between the function area and the principle area is one to several; relation between principle area to method sets is also one to several. Only relation of method sets to modular area is one to one as shown in Figure 4. So, directed to this function, under the support of certain principle, with various methods, it can be fulfilled by different modular entities, this can explain functionally the diversification of enterprise structures and unit patterns.

4 Determination of enterprise function-principle-method-entity decomposition system

Within enterprises' function-principle-method-entity decomposition system, the decomposition floor issue concerning function and modular decomposition, namely the end level of enterprise modularization decomposition determination is an important content of modularity decomposition. It decides the facilitation and feasibility of bottom modular function realization after the modularity decomposition.

4.1 Floor function determination of the mechanical system

In function bottom determination of the mechanical system, Sturges [12] points out that the functional decomposition should stop when function decomposition reaches supporting functions, while supporting function is "a common model of usual component, process or sub function", yet he does not offer any supporting function sets. Kirschman [12] puts forward a systematics based on function after the analysis of various machines like automobile, driller and weeder, namely the four basic functions of movement, control, energy and connection; he describes the four basic functions with four types of languages and therefore constitutes the classification of the basic functions. Through researches of the realization method of basic functions, he sets up the method base of basic functions; any method within the base can become the bottom method of function tree and therefore may correspond directly to the bottom entity structure.

4.2 Determination of the bottom modular in enterprise system decomposition

If the specific method can correspond with the existed parts, or the designer considers the method is actually easily realized in practical systematic decomposition, then these methods are the floor methods and entity corresponding to this method can be understood as the bottom physical entity.

Each sub modular that enterprise modular gets after the modularity decomposition differs from modular in products and physical system (such as mechanical system and software system, etc), because it includes human elements. So, in enterprise modularity decomposition, determination of modular bottom may consult the determination method of function bottom in mechanical system, through the integrate analysis of function-principle-method-modular, the following flow design diagram of floor function-entity modularity is put forward, see Figure 5.

First, directed to entity system, to determine construction of system's (modular) abstract overall function, decomposing the overall function in the function area, it is obvious that there will be related principle to support it in each decomposition function level.

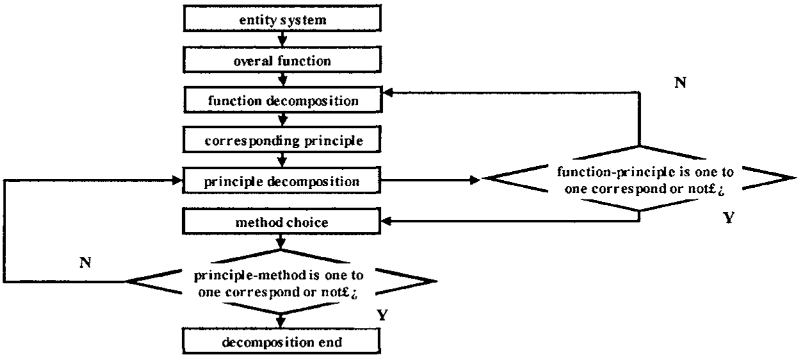

Fig. 5. Sketch Map of Floor Function-Modular Determination Process

Second, after the determination of the overall principle of the general function, find out the corresponding function supporting principle in the function area and calculate the corresponding relation between principle and function. If in the two areas, the corresponding relations are one to one, then we should choose the corresponding methods; if it is not one to one relation, and then continue the function decomposition program.

Third, judge whether principle corresponds with method one by one or not, if it corresponds one to one, then bottom method will decide, and stop the decomposition of function and modular; if principle does not correspond with method, then return to the principle decomposition program.

As this paper defines that relation between method and modular is that of one to one, so in the calculation illustration, bottom method should correspond to the bottom sub modular.

5 Modularity Decomposition Analysis of enterprise production system based on demand satisfaction principle

Production system is a sub system in the enterprise system whose main function is to produce. While products determine the production system needed, what to produce is determined according to market requirements. Satisfaction of customer demand is the supporting principle of the production system in manufacturing. Only to produce what customers need enables effective realization of the production system. This paper analyzes briefly the modularization decomposition process on the basis of enterprise production system of satisfaction principle, seen in Figure 6.

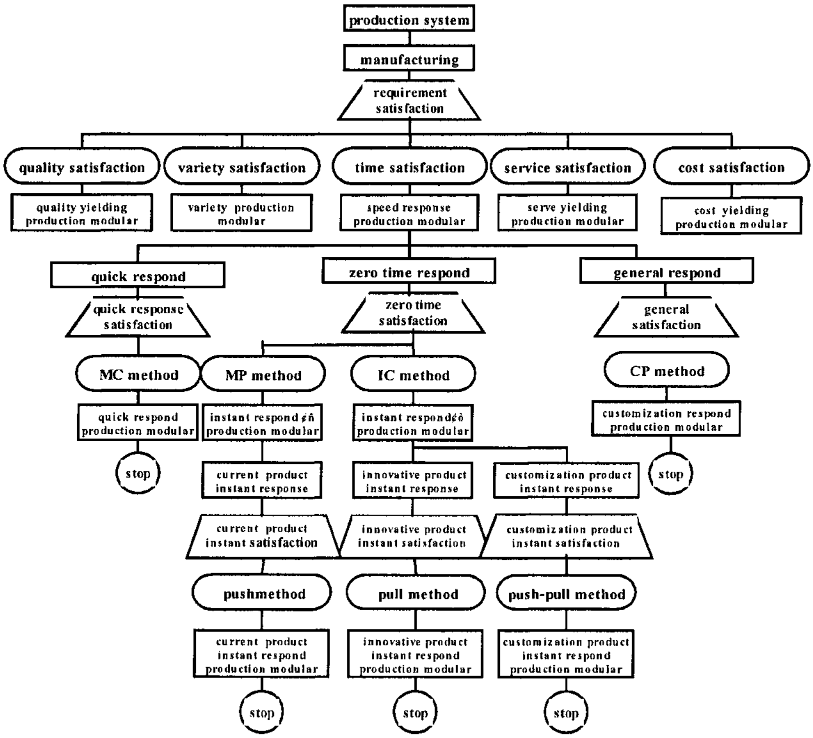

Fig. 6. Sketch Map of Modularity Decomposition of the Production System Based on Requirement Satisfaction Principle

5.1 Decomposition analysis of the first level

First, as the entity system, production system corresponds to the manufacturing as well as other related functions such as environment protection. Only the manufacturing function is studied here.

Second, realization of products manufacturing function also corresponds to supports of several principles, for example, related manufacturing technology principle, economic and management principle support, etc. In our case study, we only probe the manufacturing functions in the production system supported by demand satisfaction principle, the realization function of manufacturing products in productive system.

Third, demand satisfaction principle corresponds to several expressions: such as products' quality demand, products varieties demand, products' cost demand; products service demand, products response demand, and products quantity demand. So, the above demands can be understood as realization of demand satisfaction principle.

Fourth, each demand satisfaction method corresponds to certain sub modular of production system, for example, time satisfaction method corresponds to speed responding production modular, and quality satisfaction corresponds to production modular of quality benefits.

5.2 Decomposition briefing of the second level

According to decomposition in 5.1, the five demand satisfactions correspond to the entity system of five production sub modular, for example, quality results production modular, varieties production modular. speed responding production modular, service production modular, cost-yielding product sub modular etc(Modular in this level is the first level modular);obviously each production modular can be realized through the decomposition of the overall function. This paper decomposes mainly the speed responding product modular.

First, speed responding product modular corresponds to three realization functions: quick responding product function (for short quick correspondence), zero time responding product manufacturing function (abbreviated as zero time responding) and the usual responding function of manufacturing (abbreviated as usual corresponding).

Second, as the function realization of the next supporting principle to demand satisfaction principle, there are quick satisfaction demand principle, zero time satisfaction principle and the usual satisfaction principle, they support quick response, zero time response and the general response respectively..

Third, under the support of quick satisfaction realization principle, the productive methods of Mass Customization (MC) can be applied to realize quick response; we can also adopt the Customization Production (CP) to realize the usual response; under the support of zero time satisfaction principle, Mass Production and Instant Customization can realize respectively realization of zero time response.

Fourth, the quick response production modular can be constructed by MC production method (This modular is in the second level, the same in later discussion and thus omitted.), to realize quick respond to market requirement; CP method can construct Customization response production modular to realize the function of general market requirement; To construct I production modular by MP method construction or to construct II production modular by IC method construction can both realize the instant response market requirement.

Fifth, according to floor modular determination calculation process of enterprise system decomposition, MC Production method corresponds to quick responding production modular, the customization pattern production modular corresponding CP production corresponds is floor modular, the decomposition stops; While to the two production modular of instant response I and II corresponding to zero time response function modular, the decomposition continues.

5.3 Decomposition analysis of the third level

First, to define instant response I production modular can provide the instant response function of finalized products, Instant response II production modular can offer innovative and customized instant response functions.

Second, as the zero time satisfaction principle's next supporting realization function, they are customization instant satisfaction, innovative productions instant satisfaction and personalized instant satisfaction principle respectively, they support the customization production instant response, innovative products instant response and customization instant response.

Third, under the support of customization instant satisfaction principle, the instant response function of pushing production method to realize the customization product can be applied; Under the support of innovative instant satisfaction principle, the pull method can also be adopted to realize the instant response of innovative products; Under the support of personalized product instant satisfaction principle, the pushing-pull combined method can be applied to realize the customized products instant response market requirement function.

Fourth, through pushing production method, the instant response production method can be constructed(this model is divided into three levels, the same in later discussion and thus omitted),to realize customized product instant response to market requirement; the push-pull combination production method can construct the personalized product instant response production modular and fulfill the personalized product instant response market requirement;

As function modular corresponds one to one with the entity modular, the decomposition process of the whole production system ends. Function modularity by customer demand satisfaction principle of the final production system is: quick response market requirement modular, general response market requirement modular(modular in the second level), customized product instant response market requirement modular, innovative product instant market requirement modular and personalized product instant market requirement(sub modular in the third level).

The sub modular of production system decompositions are quick response production modular and the general production modular(sub level in the second level), customized product instant response production modular, innovative product instant response production modular and personalized product instant production modular(sub modular in the third level).

6 Conclusions

Through the application analysis of modularization theory this paper puts forward the function-principle- method-entity decomposition system of enterprise modularization, studies the floor function and the calculating process of entity modularity determination. It conducts simple analysis to modularization decomposition based on demand satisfaction principle and provides the preliminary researches for further enterprise system construction through modularity integration.

Acknowledgement

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A Multi-Layer Framework for Enterprise Application Development

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Abstract. Building Enterprise Information Systems (EIS) presents, by a structural point of view, a number of somehow repetitive tasks like programming behavior and structure for Graphical User Interfaces (GUI) for user input and data retrieving; coding verbose protocols to accessing application servers for merely input and retrieve data; coding numerous routines implementing database queries for answering several kinds of user transaction requirements, and others. For most applications, these tasks are numerous, repetitive, complex and error prone. Besides, they are very similar in most enterprise applications. This work proposes an object-oriented multi-layer framework for automating basic structural tasks for enterprise applications, freeing developers from time-consuming, low aggregated value tasks and allowing them to concentrate on the actual goal of software development: the implementation of user requirements. The framework is constructed over three conceptual layers – presentation layer, business layer and service layer – each one playing a well-defined role in the architecture.

1 Introduction

The current software development, in spite of the dissemination of object technology, did not achieve yet the goal of reducing effort on repetitive and similar development codification activities in several transactional systems, like

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data entry forms, simple queries, data access facilities and complex but repetitive operations for getting access to application servers.

In most of the current systems, all these activities are encoded *ad hoc*, in a low style of programming, not much reusable and inclined to mistakes. Additionally, the use of object-oriented (OO) programming many times only happens within "visual inheritance", in other words, the reuse of form layout templates and some basic GUI functionality. The data access classes normally are, also, encoded case by case, and they are difficult to be reused. Also, there are the particularities of different queries and the shortcomings caused by the "impedance" between OO programming paradigm and the relational paradigm.

The present proposal aims to present an object-oriented multi-layer framework for the creation of applications where the developer will focus in the problem's business rules to be solved and not in the creation of interface functionalities, database access code or formalities of the access to application servers.

Thus, the framework has reasonable amplitude, comprising: a) a MVC (Model-View-Controller) framework [1, 2] for Java desktop and several facilities and layout creators for the Swing API (Application Programming Interface); b) a set of classes that encapsulate application servers, hiding of the developer his complexities and formalities of access; c) a framework of DAO (Data Access Objects) [3] automation, so that basic accesses, of the type CRUD (Create, Retrieve, Update, Deletes), to the DBMS (Database Management System) are done in transparent and automated way.

1.1 Overview

The work described here has been implemented under the Java platform, more specifically the J2EE (Java 2 Enterprise Edition) distribution. The proposed framework intends to be extremely flexible and extensible to the use within third part products, through the development of plug-ins (there are several of them already implemented). This plug-ins take the form of adapter classes, according to the Adapter design pattern [4].

The framework offers a solution, which intends to be complete, for the presentation layer, being directed exclusively for the desktop. However, it is simple to extend it to give support, for example, to MVC mechanisms for the web, which can substitute or act concomitantly to the standard presentation in desktop.

The framework supports, at this moment, in its business layer, the use of application servers based on the JSR-19, Enterprise JavaBeans 2.0 [5]. The use of EJB 2.0/2.1 is considered widely complex and bureaucratic, and the framework automates almost all the complexity of its use, releasing developer's time for implementing business rules. The new version of the specification, 3.0 [6], however, simplifies a lot the use of EJB; support for it is expected to be provided soon.

At the persistence layer, the framework offers support to SQL-92 and to the object-relational persistence mechanism Hibernate. Specific plug-ins for Firebird and PostGreSQL DBMS are on the way.

2 Presentation Layer

In Java platform, browser-based web interfaces are well used as technology for information systems presentation. For doing that, there is an abundant offer of open-source frameworks, such as Apache Struts, MyFaces (open-source and certified JSR-127 (JavaServer Faces) implementation), Spring, WebWork, Jakarta Tapestry, VRaptor, JSenna, e-Gen and others. For a presentation layer based in desktop, however, the offer of open-source frameworks is quite reduced. Basically, we have knowledge of the MVC framework JForms, which, however, did not pass from version 0.0.1, release candidate.

Besides making possible a very richer interactivity with the user, since several interface functionalities are quite difficult – if not impossible – to be implemented in a browser, there are several reasons to develop desktop applications: visual handling of graphic elements – diagrams, graphics, images etc; distributed processing, in the cases in which it is desirable to have code running in the clients; local cache of information, to increase access performance, and others. Even traditional disadvantages, like the necessity of installing software locally in several client machines, have been significantly minimized by the use of technologies like Java Web Start.

The proposed model is an adaptation of the Model-View-Controller architectural pattern [2]. In this pattern, the View layer contains only the code for the assembly of the user interface, the Controller contains the logic for the treatment of events occurring in the system, and Model is the layer responsible for the treating and supplying data for the other application layers. The View and Controller lay on framework's Presentation Layer; Model works on framework's Business Layer.

Besides providing the construction of visions and controllers *ad hoc*, the functionalities offered by the presentation layer offer interfaces with almost functional specific characteristics, and the framework user will only extend some few hot spots.

2.1 Design Issues

The presentation layer was developed based on the Java Foundation Classes (JFC) toolkit, with emphasis in the set of functionalities known as Swing [7], the more powerful and popular graphic toolkit for desktop in Java. However, the great power provided by Swing has a high price, which is complexity, being criticized because of being exaggeratedly academic and carrying out in extreme way all the requisites of a strictly object-oriented project [8]. However, we think this is a quality, since it gives the programmer the possibility to build virtually anything in the user interface, in a strictly object oriented way.

To avoid dealing directly with Swing API complexities, the framework offers classes that work as Façades [4], hiding complexity and supplying a lighter and dry API. Therefore, one of the main requisites of the presentation layer is to use the power and flexibility of the API and, at the same time, create facilities so that the user productivity is maximized.

2.2.1. Presentation Layer Internals

Presentation layer architecture is adapted from MVC, inspired in the standard J2EE View Helper [3]. Thus, there is, for each item of interface, a controller that assumes the function of helper in the foregoing standard, assuming the tasks of process data for visualization, storing intermediary data models, and working as a business data adapter. Therefore, in the presentation layer, the hot spots consist of only a controller/helper and a viewer, that will contain only the visualization components, which are essentially *ad hoc*, and all the processing and adaptation responsibility of business data and the communication with the business layer stay with the controller/helper. Besides that, controllers and viewers abstracts classes automate, by default, repetitive tasks like reading and writing component data, allowing very little codification for the hot spot implementation in most cases.

A visualization screen, however, has not only the customized viewer, but a series of other supportive visual components, like menus, toolbars, navigators, search bars and others, that have fixed or little customized appearance and behavior. Such components are considered frozen spots, though they could be eventually extended without any type of impediment related to couplings. The communication between several visual classes that compose the frozen structure of the presentation layer is implemented by the use of the Mediator design pattern [4], making possible a decoupled communication between the components and giving, even for the frozen spots, great flexibility and extensibility.

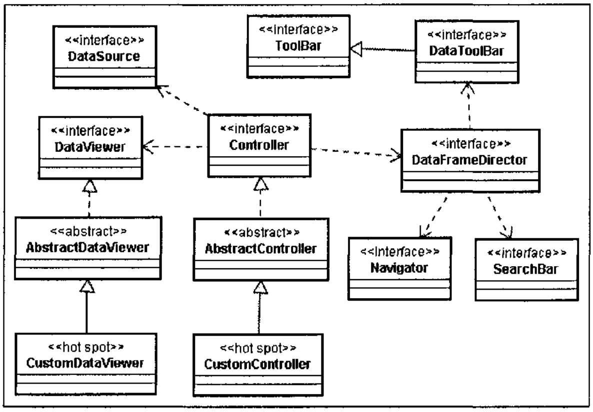


Fig. 1. Presentation layer schema

The Controller also has another responsibility in the framework architecture, which is to carry out the communication between the hot spots and the DataFrameDirector (the entity that does the mediation between the participant colleagues of the Mediator design pattern) that manages the standard components. This communication also is done in completely automated way, so that the developer of the hot spots will be able to ignore even the existence of the frozen spots. The described schema is shown at Figure 1.

3 Business Layer

The business layer is responsible for containing all application logic, in other words, it is the layer that implements the rules concerning the application domain, controlling the stream of work and maintaining the consistence of user sessions state.

The separation of business layer from other layers brings several benefits for the application, for instance, the possibility of diverse systems using different graphical interfaces (desktop and web) share the same business logic resident on a centralized or distributed repository, like an application server. But it is not only the detachment of implementation of the business layer from the graphic interface that became this kind of solution so popular and efficient in the modern object-oriented software development. The clear separation of different concerns obtained from software partition makes technical issues concerning one layer be transparent to others. For instance, in the business layer, problems as data security and concurrent transaction management must be considered by solution developers, but ignored (or, at least, minimized) by user interface designers.

3.1. Design Issues

The primary approach of the framework is oriented to reduce the complexity of J2EE architecture's distributed components development, separating the business logic implementation itself, isolating it from technological low level details.

The function of the framework is to automate the codification of the underlying server application management and the EJB component that will be installed in the server. For this goal, the framework uses a set of classes that hide from the developer all details concerning the access, from client, to EJB components and hiding the EJB classes that connect with data services to provide persistence capabilities, by example.

Repetitive tasks performed for accessing an EJB from a desktop or web application, like the adjust of JNDI (Java Naming and Directory Interface) API for searching and obtaining the home interface of EJBs running in the application server, are automated by the framework, through the use of a simple XML configuration file. An immediate consequence is to transform JNDI into a transparent service for the user. Some design patterns are used for achieve these facilities. One of the patterns used is *EJBHomeFactory* [9], whose objective is to provide a factory that will search and obtain the home object (object responsible by the EJB component life cycle management in the container, e.g., its creation or its destruction) only in the first request of the client, storing and becoming it automatically available for future requisitions. The framework makes the factory transparent for the developer, being enough that he/she informs the name of home interface to the factory. The framework will use Java's introspection mechanism for invoking the search service and creating the home object in application server, taking off an extremely repetitive and error-inclining work from the responsibility of the application developer. The class diagram that represents the described structure is shown at Figure 2.

The framework also contemplates the automation of the relationship between the EJBs and the data access service resident in the integration layer. In a multi-layer application, the business layer interacts, directly or not, with the persistence services for storing and retrieving data. The architecture of framework intended to automate CRUD operations, because these operations are recurrent in all applications that need to persist data, becoming primordial to hide from the developer the task to define and handle the linking between the two layers for these kinds of operations. For achieving this objective, *Session Façade* [3] design pattern was implemented in the framework to interact with another J2EE design pattern, *Data Access Object* [3]. The DAO pattern belongs to the integration layer and is responsible for controlling the framework's persistence mechanism. The only task reserved to developer is to inform to *façade* what DAO will be instantiated and, according to its polymorphic behavior, all CRUD operations provided by DAO will be immediately available to the business layer and, consequently, to the presentation layer. Other benefit offered by automation of the *façades* is the encapsulation of EJB architecture technical details, e.g., the handling of exceptions referring to network communication, reducing once more the developer responsibilities with non-trivial technical issues related to the use of J2EE technology.

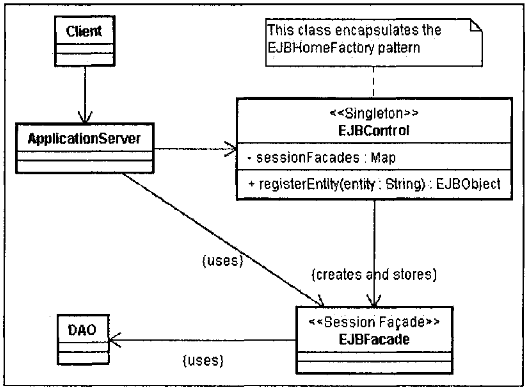


Fig. 2. EJB Interfacing Scheme Class Diagram

3.1.1. Data Transport and Decoupling

All data transport between layers, in this framework, is performed by objects that implement the *Value Object*, also known as *Transfer Object* [3], that are objects containing the same data of business objects, but only acessor members. Here, the main objective of the use of *ValueObjects* is to remove the direct dependency of presentation and persistence layers related to the domain application model.

4 Persistence Layer

The persistence layer is a highlighting point in the architecture of any application with needs to store and retrieve data, even if it is contained in DBMS, XML files, serialized object files, and LDAP repositories. For each data access mechanism, the variety of APIs that support it becomes more and more abundant and diversified. In the case of relational DBMS, there are many solutions, like J2EE CMP entity beans, the Hibernate framework for object-relational mapping, or even the direct use of JDBC or the underlying DBMS' API.

It's very natural that in this so complex and sensible piece of the application, there is an evolution of APIs for increasing the productivity and the facility of implementing the permanent storing devices. Besides, handling legacy data schema concurrently with new data schema is commonplace. Thus, it is extremely important the existence of a very weak coupling between the persistence mechanisms and the rest of the application. In this way, any future changes, even caused by the natural evolution of APIs or by the replacing of a solution, have very low (or, preferentially, none) impact in the rest of the application.

4.1. Design Issues

Aiming for the objectives of low coupling and high cohesion in the persistence layer, ensuring the maintainability and the portability of the remaining architecture and preserving the freedom of the developer in adopting various data persistence solutions, the framework adopts a sophisticated interface schema. Many design patterns are widely implemented in this layer to ensure the necessary flexibility, facilitating the operations on this admittedly heterogeneous system structure, beyond centering the access to its functionalities.

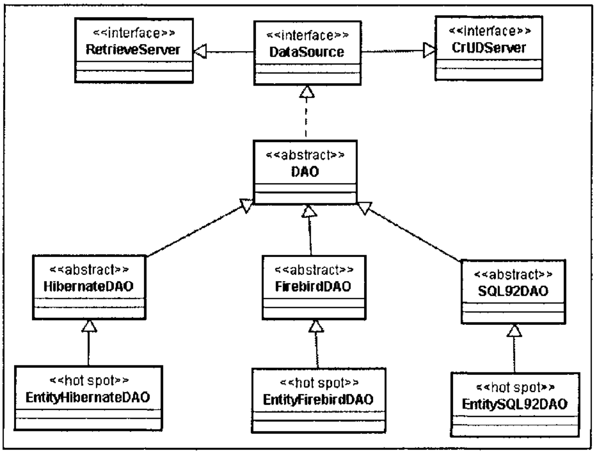


Fig. 3. Framework's data access architecture

On top of data access architecture's hierarchy, we have CrUDServer and RetrieveServer interfaces. Both interfaces comprise the four basic functions of the persistence layer, known as CRUD – create, retrieve, update and delete data. The CrUD server interface is responsible to provide operations for three of four persistence functions – including, updating and deleting. The CrUDServer interface has a lowercase "r" in its name for expliciting the retrieve operations are not defined in this interface. All three operations take as parameter a Value Object, representing the persistent entities of the system. The RetrieveServer interface provides operations that comprise almost all searching possibilities that an application can need, through the use of auxiliary classes representing the full set of relational algebra operations (select, project, union, intersection, difference and Cartesian product) [10], but under a higher and object-oriented abstraction level. This makes possible that all queries be requested, at presentation level, only in terms of objects and its attributes. Consequently, all queries are generated dynamically from the relational algebra encapsulator objects, with no need for creating *ad hoc* querying methods on DAO classes, except for very special cases. The schema containing the described interfaces is shown at Figure 3.

The DataSource interface extends CrUDServer and RetrieveServer, being a starting point for the components that will handle all persistent operations present in these two interfaces. These interfaces are fundamental for the framework, due to their presence on the other layers of the architecture, do not restricted to persistence layer. This happens because the CRUD operations are requested by the application user start from the presentation layer and pass through the layers until achieve the persistence layer for executing the required operation. To reach this goal, it was adopted the *Chain of Responsibility* design pattern [4], whose advantage is to provide a low coupling level between an object that sends a request and the receiver one. In the particular case, the sender objects are resident on presentation level and the receiver objects belong to persistence level. From the graphical interface to the persistence services, the request goes through all layers.

4.1.1. Data Access Objects' (DAO) role

Among the DAO implementation possibilities, the framework adopted a factory strategy for Data Access Objects, whose implementation is based on the *Abstract Factory* design pattern [4]. This pattern is convenient because its objective is to deal with a hierarchy of classes composed by a set of subclasses with a parent class in common. In that way, the framework automates and speeds up the implementation of the DAOs, defining the main methods that will have to be considered by the developer for the correct communication between the actual layers in the whole architecture. The factory responsible for creating, effectively, the correct DAO in the application business layer, according to the design pattern Abstract Factory, will have to be implemented by the developer, since each application will define, in a unique fashion, its set of applicable DAOs.

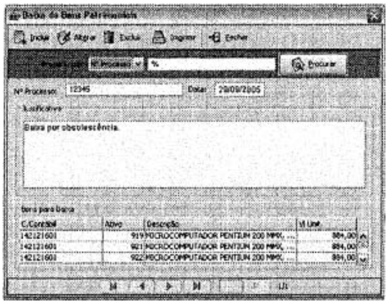
5 Case Study

The framework has being developed on context of an enterprise application for a public university in Brazil. All features explained already were implemented and they are working at production. Figure 4 shows an example viewer and the controller code manipulating all frozen spots and hot spots, including the data obtained from a database.

In the presentation layer, for each CRUD screen, the developer will create a panel containing data components (through programming, tools or IDEs). The framework provides a set of programmed components to perform several kinds of validation, like dates and personal document numbers. These components can be easily extended or customized according to the developer needs.

The controller, that also will be unique for each CRUD screen, will contain a small quantity of code to register the data components that will be automatically managed by the framework. These components, after being registered, have their behavior determined by the framework in a transparent way, thus the control of the edition mode, reading, color, among others, of the components in the diverse screen states (e.g. data inclusion, edition or browsing) is exclusive responsibility of the framework, do not having need of application developer interference. The controller class can be defined programmatic, or through a simple XML file, according to the programmer convenience.

Another controller responsibility is to inform the class of the persistent objects that will be used in the process. From this information, the framework makes possible the interaction of the presentation layer with the business and persistence layers, in order to automate the CRUD operations. With that, the screen does not be concerned of how data will be obtained or treated in the application, since the framework standardizes the procedures of obtaining, manipulating and recording these data in the persistence layer.



```
public class BaixaBemController extends
    AbstractController <BaixaBemViewer> {
    public BaixaBemController(BaixaBemViewer viewer) {

        super(viewer);
        this.addModel(this.getViewer().getModel("nrDoc",
            ModelFamily.DOCUMENT), "N° Processo");
        this.addModel(this.getViewer().getModel("data",
            ModelFamily.DOCUMENT), "Data");
        this.addModel(this.getViewer().getModel("just",
            ModelFamily.DOCUMENT), "Justificativa");
        this.addModel(this.getViewer().getModel("bens",
            ModelFamily.TABLE), "Bens para baixa");
    }
    protected Class<? extends ValueObject> getVOClass()
    {
        return BemPatrimonialVO.class;
    }
    public String getFrameTitle() {
        return "Baixa de Bem Patrimonial";
    }
}
```

Fig. 4. A viewer and its controller

6 Conclusions

The strong interlayer decoupling guaranteed by the framework, beyond the evident and well-known advantages of low coupling [11], avoids dependency of providers, when it allows the different layers of framework are used in independent way, being able to work together with another supplier products. For instance, the connector architecture allows the presentation layer to have its role played for MVC web frameworks, in place of the default desktop presentation of framework.

Moreover, the automation of the tasks related to data manipulation is a very valuable factor for productivity increase and software maintainability, releasing developer time for modeling and implementation of the user business requirements.

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Reuse Software Architecture through Dynamic Composition

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Abstract: With the mature technology of software component and software architecture, software reuse has achieved significant progress. However, dynamic reusing software architecture such as in the condition of changing requirements under non-stopping condition at runtime remains a challenge. Reflection is the ability that a system performs the computing about itself. Based on reflection, in this paper, a reflective architecture RSA4RDC was constructed to support architecture dynamic reuse, and also the design framework, primitives, and process were illustrated.

1 Introduction

Software reuse refers to the process during similar or identical software products used repeatedly in multiple software producing or process. With the emergence of software architecture, the component technology came out and become mature, software reuse has achieved significant progress.

However, dynamic reusing of coarse-grained elements, such as software architecture, still does not have much. Traditionally, reusing software architecture is done at design phase: according to the requirement of the system, designers reuse the architectural constituents by incorporating the existing elements into the architecture. However, with respect to the systems which are non-stopping, having change

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requirements, and have to evolve continuously [1], the design phase and running phase are overlapping. Traditional reuse method is insufficient to deal with such condition.

The common way to deal with the system with continuous evolving architecture is to define the possible evolving strategy at the design phase of architecture. At run-time, the system will execute the architecture evolution automatically while the evolving conditions are satisfied. But such approach could not be used in the system with changing requirement at run-time. Because the changing requirement is not predictable, it could not be considered at design phase.

Focus on these issues, this paper proposed a design and reuse architecture method at run-time, which called reuse software through dynamic composition. The research work was based on reflection mechanism; it provided an approach to reuse architecture constituents by manipulating architecture. Based on reflective, it uses the meta-information about the architecture to provide the designers and tools with the operation and process of reusing architecture.

In this article, we constructed architecture---RSA4RDC (Reflective Software Architecture for Reusing SA through Dynamic Composition) to support dynamic composition reuse of the architecture at design time, provided a framework and process of reuse through dynamic composition in RSA4RDC, in this article, a simple case was given to illustrate on how to use the framework and process..

This paper is organized as follows: Section 2 describes the model of reflective architecture for reuse through dynamic composition, specifies the elements of architecture. Section 3 illustrates the framework, the operation primitives, and process for reuse. In section 4, an example is given to illustrate how to use the framework and process to gain a new system in runtime. And in section 5, a conclusion is given by comparing some relative research work.

2 RSA4RDC

2.1 Reflective Software Architecture for reuse

In order to redesign the architecture at run-time, we need explicit data structure to represent and control of the run-time architecture of the system. Explicitly representing the design information of architecture could support the architecture design at run-time. For this end, our approach is to construct a reflective architecture for reuse through dynamic composition: RSA4RDC.

Reflection is the ability that a system performs the computing about itself [2]. In a software system, reflection has enabled a program to access the internal structure and behavior of itself, and to manipulate its own structure and modify its own behavior in runtime. Thus software system could adapt itself to the changing conditions, which has more flexibility for the system.

Introduction reflection mechanism into architecture, a reflective architecture which could perform the computing about itself is constructed [3 - 5]. RSA4RDC is a kind of reflective architecture that used for dynamic reuse; it split a system into two parts explicitly: one is base-level architecture which executes business process; the other is meta-level architecture which monitors base-level architecture. By using the reflection, the whole software system could dynamically changes at run-time. So we also could design the system through dynamic composition architecture constitute. Figure 1 represents the structure of RSA4RDC.

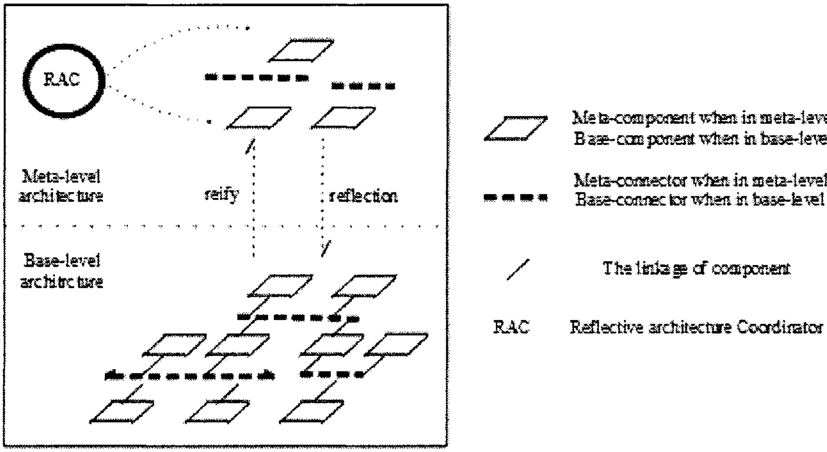

Fig. 1. The structure of RSA4RDC

Comparing to the non-reflective architecture, component/connector in non-reflective architecture has their counterpart in the base-level of RSA4RDC, and meta-component/meta-connector in meta-level of RSA4RDC. The meta-information of the base-level architecture could support the management and manipulation of the reuse process of base-level architecture. Therefore at the design-time, by separating the concerns, it could help us to do the design at different abstractions and simplify the design and promote reusability.

2.2 RSA4RDC base-level architecture

The base-level architecture is the space of implement business requirement, which is about the assignment of responsibility of the system. It is composed of components and connectors, component is the basic unit to implement the functions, while connector is an explicit entity which binds the component together and plays the role of coordination between components [6].

2.3 RSA4RDC meta-level architecture

The meta-level architecture is the space of monitor base-level architecture, which could obtain the base-level architecture information such as constitute, topology, linkage and runtime information, and also could new, delete, replace of constitute. It provides designers with the information when they are reusing the architecture and its constituents at architectural design phase, and also provide architect and tools with a standard interface to use base-level architecture.

The meta-level architecture is composed of meta-component, meta-connector and RAC (Reflective Architecture Coordinator), meta-component and meta-connector are composed of two parts: first, they represent the meta-information of the elements in base-level. The meta-information includes basic meta-information and purpose-specific meta-information. (1) Basic meta-information: describing the basic information about elements in base-level, such as the id, name, methods etc of component and connector. (2) Purpose-specific meta-information (such as reuse, evolution, refinement): in meta-level architecture, elements in meta-level can not only monitor the run-time properties of the elements in base-level, but also manipulate the adding, deleting and replacing of the elements in base-level, thus controlling the evolution, refinement and reuse of the system. Towards these purposes, extended meta-information is needed, these purpose-specify meta-information should be represent in them. Second, change the base level architecture such as new, delete and replace of them based on some strategy.

RAC is used to describe the reflect/reify strategy between base-level and meta-level: the base-level architecture and meta-level architecture in the reflective architecture are mutually interactive and interacted, and their interaction should be guided by certain strategy, such as under what condition the meta-component sends the modification or replace operation to base-level. It receives the request that modifying the design at run-time from the user, and then modifies the meta-level architecture, and finally reflects the resulting meta-level to the base-level architecture.

3 The Framework and Process for Reuse through Dynamic Composition

In order to meet the requirements such as non-stopping, changing requirements and continuously evolving, based on reflection, we propose a framework and process for reuse a RSA4RDC through dynamic composition of large coarse element such as component and connector, Figure 2 is design framework for dynamical reuse.

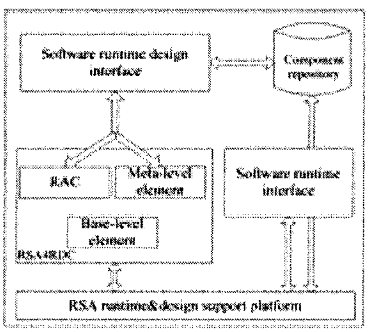

Fig. 2. Dynamic Reuse Frameworks

3.1 Reuse Design Framework

This reuse design framework differs with common software because that by using reflection, software is designed at run-time, and the design is taking effect at run-time and finally verified.

This framework includes following parts: (1) a running interface of the program: it can be executed directly during the reuse process, and the resulting architecture can be verified in the running interface, (2) a design tool: through this tool, designer can design the running architecture, (3) reflective architecture of software system: it is RSA4RDC designed by design tool and verified by running interface; it is the output of the design/verification activity, (4) a component repository: it provides reusable components and connectors, as well as the design information of these elements, (5) a runtime and design support platform: it provides a infrastructure for the design and running of RSA4RDC system; translates the operation of the design into the RSA4RDC and takes effect, and then executes the new system.

3.2 Reuse Design Primitive

In the reuse design framework, we define some primitives for design. Below are the main design primitives for meta-architecture for add, delete, replace of meta-elements:

(1) find(element, condition): the operation is to retrieval component or connector which conforms to the input condition from component repository. "element" is component or connect, "condition" prefer to the condition that element satisfy, and this operation return all results that coincidence with "condition".

(2) add(element): This operation is to add meta-components and meta-connectors into RSA4RDC system.

(3) delete(element): This operation is to delete meta-component or meta-connector that no long used from RSA4RDC system, after this operation, the argument "element" will no long exist in system, and the link to other element will be unlinked.

(4) replace(oldelement, newelement): This operation is used to replace an oldelement with newelement.

RSA4RDC meta-level architecture monitor base-level component, connector and the linkage between them, below are the main design primitives for monitor the base-element of meta elements:

(5) instance: instances a component or connector, this means add new element in base-level.

(6) delete: delete an element not used in base-level architecture.

(7) changeMethod: modify element method in base-level.

(8) link: link an element to another that existed in base-level.

(9) unlink: unlink a linkage that existed in the base-level.

(10) addStrategies():This operation is to add evolution strategy according to business requirement. A RSA4RDC is a system that has evolution ability according to evolution strategies, the strategies can be predefined when the system first design,

and also can be added when the system is running because the needs of business requirement. For example, in a CS system, when concurrency Clients number exceeds a given amount, the QoS (Quality of Service) is decreased. In order to increase QoS, we can add a strategy below to gain the aim.

While (S.activestate=T and S.responsetime>10s) replace(S, S_{fast})

(11) execute: Only through this operation can all design activities above take into effect. After this, we can get a new redesign RSA4RDC system.

3.3 Reuse Design Process

In order to get a new system in runtime, designer adds, deletes, replaces components, connectors, links and evolution strategies in design interface, the process mainly includes:

(1) Retrieval reusable element. It is the activity that retrieval and obtains component and connector needed from component repository through tools in design time.

(2) composition/modify/verify software system.

In this project, we develop a simple platform that provides dynamic composition design in runtime. Figure 3 is a screen-snapshot of the design interface: in this platform, we could add/delete/replace meta-component, meta-connector, define the meta-relation of elements between base-level and meta-level, and the linkage of components and connectors, add the evolution strategies of software system. After finish the design of system, click the execute button, the design platform can execute the design. And the system can dynamic take into effect in runtime. In section 5, we use the interface to design a new CS system.

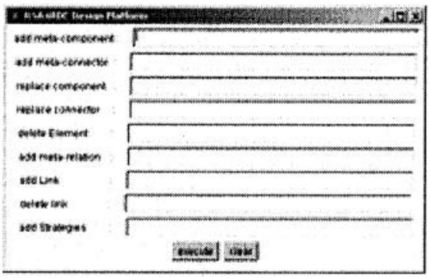

Fig. 3. Reuse Design Snapshot

4 Case study

Considering a CS system, we define C is a client that asks server S to calculate an input formula. And we let the origin system is a simple CS system which can only do addition and subtraction operations. User requests calculation form C and S provide the calculation service, and send answer back to C. Figure 4 and Figure 5 is the runtime snapshot of the simple CS system.

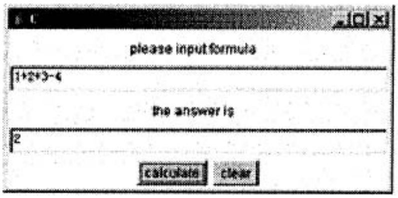

Fig. 4. C Component Runtime Interface

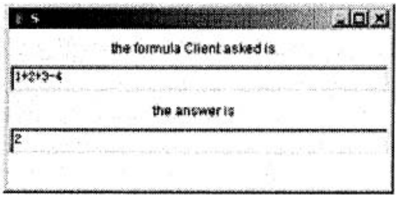

Fig. 5. S Component Runtime Interface

In non-stopping runtime, customer requests to add the security communication between S and C component, and he also wants server providing multiplication and division function. Figure 6 is the CS base-level architecture transition graphic.

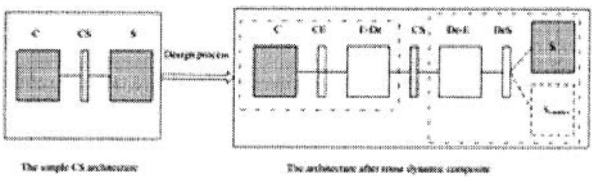

Fig. 6. The CS Base-Level Architecture Transition

As the security, we add an E-De component which can encrypt the request formulas, and decipher the answer which server have calculated, a De-E component which decipher the request formulas which encrypted by E-De, and encrypt the answer which S or $S_{complex}$ component calculate. And we also need add CE and DeS connector which connect C, E-De and De-E, DeS respectively. As the complex calculation includes multiplication and division operations request includes multiplication and division, we need to add $S_{complex}$ component to the system. And also we need to add evolution strategy that replace S component with $S_{complex}$ when the input formulas includes multiplication and division operations. In order to attain the new system, In RSA4RDC design platform, the design activities is below:

In add meta-component input box, we input metaE-De, metaDe-E;

In add meta-connector input box, we input metaCE, metaDeS;

In add meta-relation input box, we input CE, metaCE; E-De, metaE-De; De-E, metaDe-E; DeS, metaDeS;

In add Link input box, we input C, CE; CE, E-De; E-De, CS; CS De-E; De-E, DeS, DeS, S;

In add delete link input box, we input C, CS; CS, S;

In add Strategies input box, we input "if(C.formulas.includes(multiple) or C.formulas.includes(division), then replace(S, $S_{complex}$) ".

At last, we click the execute button, and the system runtime&design platform can take the design into effect in runtime: through the reflection mechanism, meta-component and meta-connector can reflect into base-level, and create new component E-De, De-E, $S_{complex}$ and connector CE, DeS, the link can change into the new linkage, in the end, the CS software architecture changes into a new CS system with evolution ability and security function.

5 Related works

Dynamic software architecture is a hot area in software engineer academic and industrial community. In this field, there are some relative research works below:

Pila [7] is a reflective ADL with dynamic ability, it enforces compositionality. And it has been designed with formal languages based on process algebras, especially CCS [8], Pilar defines s set of primitives to make use of the reflective capabilities. The basic primitives are Avatar(α), Reify(ρ), Destroy(δ). In Pilar, connectors are just as meta-level components. And a component is defined as either a collection of interfaces or a configuration of component instances (composite component). Each interface is segmented in ports, defined as the interaction points published by the component. Each component has at least one interface.

ArchWare [9] applies an innovative approach to the architecture-centric model-driven engineering of software systems that sets the "ability to evolve" as its central characteristic. Evolution arises in response to changes to requirements as well as to run-time feedback. In order to achieve this goal, ArchWare develops an integrated set of architecture-centric languages, such as ArchWare Architecture description language, Architecture Analysis Language, Architecture Refine Language. And it also develops an IDE, which includes support formal architecture description, analysis and refine, and also code generation.

Darwin [10] is a language for describing hierarchic configurative structures. It is used to describe and control the configuration structure of a program. It provides the ability of dynamic aspects of configuration as well as static aspects. A Darwin architecture can be used both to compose component implementations to build a system and/or compose LTS (labelled transition systems) specifications of component behaviour for system property analysis.

PKUAS [11] is design and implementation for a reflective component operating platform, it based on componentized structure, PKUAS introduces SA as the global view of the whole reflective system. As a J2EE-compliant application server, it can reflect both the underlying platform and EJB components. It provides management tool and evaluates ability through reflective middlewares.

Comparing to these works above, differently, we mainly concern on software architecture dynamic reuse design and analysis. Through define RSA4RDC---a reflective architecture which can provide dynamic composition ability, combining with reflective mechanism for Reflective software architecture, we can retrieval reusable element from repository, composite them together and change evolution strategies from a running system dynamically. By this mean, we provide a solve method for designing and analysis large, complex, non-stopping and continual requirement changes system.

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On Managing the Enterprise Information Systems Transformation: Lessons learned and research challenges

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Abstract. Contemporary standardized Enterprise Information Systems, like SAP or Oracle, are increasingly setting the agenda and the pace for the development of almost any organization. Most organizations today are required not only to establish effective business processes but they are also required to accommodate for changing business conditions at an increasing rate. The major vendors are proposing new breed of technology, sometime denoted extended ERP or ERP/II. Consequently the time is ripe to reflect on the status of Enterprise Information Systems and their application in practice. This paper reflects on the lessons learned from managing the Enterprise Information Systems transformation and outlines future challenges for research on Enterprise Information Systems. The paper concludes that the ERP industry has a significant and increasing impact on enterprises due to the EIS enable transformation of the business. Consequently, the practical implications of these results are the continued management of EIS, after going-live, but most important, EIS research need to refocus and embrace this new tendency. The paper takes an exploratory perspective on managing the EIS transformation by examine the evidence from the experience gained in seven different Danish organizations. The paper finally outlines the critical implications for research in EIS.

1 Introduction

Contemporary standardized Enterprise Information Systems (EIS), like SAP or Oracle, are increasingly setting the agenda and the pace for the development of almost any organization. Few IT innovations have had as much impact on business organizations in recent years as the Enterprise Resource Planning (ERP) systems. ERP systems are standardized software packages that can be configured to manage every aspect of an organization within any business.

It is estimated that organizations worldwide have spent around USD18.3 billion every year on ERP in recent years [1]. The adoption of ERP is often explained as phases or waves [2]. During the first phase of ERP, the organizations struggle to implement ERP and get the internal processes in place. There has been a lot of interest in and critique of ERP based on the experience from this phase, but recently attention has now shifted from implementation issues towards post-implementation issues. During a "second wave" implementation the organizations deploy their new systems in order to create and sustain competitive advantage.

Most organizations today are required not only to establish effective business processes but they are required to accommodate for changing business conditions at

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an increasing rate. Many business processes extend beyond the boundary of the enterprise into the supply chain and the information infrastructure therefore is critical. The rationales of integrating ERP and SCM have been explored by Tarn, Yen and Beaumont [3]. They conclude that the industrial trend is that ERP is becoming a subclass of a much larger and broader enterprise business system or in more general terms Enterprise Information Systems (EIS).

A recent published survey shows that the factors most associated with achieving value from ERP are integration, process optimization and use of the ERP systems in decision-making [4]. Davenport and Brooks [5] argue that ERP systems are internally focused, but the greatest impact of ERP is felt in the supply chain.

Today nearly every business relies on their Enterprise Information System for process integration and the future generations of Enterprise Information Systems will increasingly be driven by business process models [6].

Consequently, businesses must face up to the continuing challenge of balancing the transformation of the organization towards processes in the supply chain driven by an ongoing change in the standard EIS and emerging business disruptions.

This presents a major managerial challenge. This paper takes an exploratory perspective on managing the EIS transformation by examine the evidence from the experience gained in seven different Danish organizations. In the next chapter the paper establishes a framework for understanding the Enterprise Information Systems transformation and then the paper presents an analysis of the cases. Finally the paper summarizes the lesson learned and discusses the implications for future research.

2 The Enterprise Information Systems transformation

The notion of standard EIS/ERP systems has developed drastically during the last five years due to the impact of the web technologies, among other things. In order to fully comprehend the systems it is necessary to look at the industry in a 50-year retrospective.

The industrial Enterprise Resource Planning (ERP) market showed a positive growth in 2003 after years of decline, precipitated by the Y2K craze. The worldwide market for ERP solutions to discrete and process manufacturers was USD 9.10 billion in 2003 and is forecasted to be over USD 12.00 billion in 2008, growing at a Compounded Annual Growth Rate (CAGR) of 5.7 per cent over the next five years, according to a recent ARC Advisory Group study.

The concept of EIS has often been explained through the evolution of ERP [7-9]. The concept of Enterprise Information Systems (ES) has evolved over almost fifty years, driven by the changing business requirements, new technologies and software vendors' development capabilities.

ERP is a standardized software package designed to integrate the internal value chain of an enterprise. An ERP system is based on an integrated database and consists of several modules aimed at specific business functions.

The ERP II concept is a vision originally conceived by Gartner Group in 2000. Gartner Group, who also tagged the ERP concept, define ERP II as "a business strategy and a set of industry-domain-specific applications that build customer and shareholder value by enabling and optimizing enterprise and inter-enterprise, collaborative-operational and financial processes"[10].

ERP II includes six elements that touch on the business, the applications and technology strategy: (1) the role of ERP II, (2) its business domain, (3) the functions addressed within that domain, (4) the kinds of processes required by those functions, (5) the system architectures that can support those processes, and (6) the way in which data is handled within those architectures. With the exception of architecture, these ERP II elements represent an expansion of traditional ERP [10]. ERP II includes [11]: Supply Chain Management (SCM); Customer Relationship Management (CRM); Supplier Relationship Management (SRM); Product Lifecycle Management (PLM); Employee Lifecycle Management (ELM) and Corporate Performance Management (CPM). So in conclusion, ERP II is essentially componentized ERP, e-business and collaboration in the supply chain.

Throughout the ERP industry this new philosophy of ERP and e-business has been gradually incorporated into the ERP systems and the system architectures were redesigned and modularized, e.g. like SAP intends it with the NetWeaver platform, like Oracle intends with the Fusion platform, and like Microsoft intend with their Dynamics platform. Therefore the contemporary standard systems do incorporate ERP II. The ERP industry survived the challenge and recent market analyses do not render any signs of market fragmentation.

Today all the major vendors have adopted the ERP II concept, either partly or fully. The evolution is driven by emerging business requirements and new information technology as it has been argued in the preceding chapters was the case of the evolution of ERP.

It has been argued that people, structure, realignment and change management will prove more important to fulfilling the ERP II vision [12]. In all the cases in this study the process change was the main driver of the second-wave projects and most important, the ERP II concepts has enabled the transformation of the ERP systems into general EIS driven by process models [6].

2.1 The ERP market and the adoption of ERP

The ERP market and the vendors are important not just because of their systems, but because their research reports and the vendors' consultants have an enormous impact on the business decisions made in companies adopting ERP. The ERP market is however quite complex for the following reasons [13]:

First, The ERP market is not well-defined. Sometimes it includes all kinds of enterprise application software and sometimes only ERP. The total 2002 revenue of the ERP vendors was USD 20 billion according to AMR Research, but the total ERP spending may be 5-10 times higher.

Second, there are significant commercial interests in defining, segmenting and measuring the market. The authoritative sources of market sizes and segments are large research organizations such as Gartner, IDC, AMR Research or Forrester.

Third, the market is quite dynamic. The vendors are constantly merging and consolidating. Since the Gartner Dataquest report was published, Peoplesoft bought

JD Edwards, Oracle bought Peoplesoft and Microsoft acquired Encore and tried to buy SAP. Finally the systems are constantly developed, and some of them are discontinued.

A different perspective on the ERP market is the enterprise perspective: what systems do they have, what do they invest in, and when do they acquire or update their systems?

A recent survey on ERP in large Danish Enterprises [13] concluded that (1) ERP has become a pervasive technology; (2) ERP has become a contemporary technology; (3) the ERP market has matured; and (4) the dominant ERP strategy is still the single vendor strategy. The study was based on telephone interviews with ERP managers in 88.4 per cent of the top-500 enterprises in Denmark.

ERP has been adopted by Danish enterprises in general. 93.4 per cent of the large companies had an ERP of some kind, and 13.6 per cent of the enterprises had more than one ERP system. Only 6.6 per cent of the companies have not adopted ERP, their financial performance is poor, and their number is decreasing.

ERP is the pervasive infrastructure because it is so widely adopted. Based on the high percentage of adopters and based on the non-adopters' accounts we conclude that ERP as a technology is a prerequisite to run any business, and that it should be considered an infrastructure rather than a new technology.

ERP is a contemporary technology because the installed base is renewed frequently. Based on the average age of the systems (2.8 years), it is concluded that the ERP technology now follows the normal IT lifecycle. There are differences, however: the in-house developed ERP systems are still to be considered a legacy technology. The overall conclusion is that the latest releases and technologies are available to in the enterprises and is waiting to be used.

ERP adoption is stable, because the market is consolidated. Based on the adoption level, the vendors' market shares and the average systems' age, it is concluded that the ERP market has matured. Indications are that we end up with one (SAP), maybe two or three major vendors, a handful of global vendors, and a small number of vendors specializing in specific industries or countries. A similar pattern was found among the systems suppliers and implementation consultants. This was further reinforced by the fact that on average ERP investments are below 1 per cent of the revenue. However, it can not be concluded that the ERP market is no longer innovative.

ERP adoption is converging towards a dominant design due to the facts mentioned above. Only 13.6 per cent of the companies use more than one ERP vendor. This indicates that the businesses pursue a "single-vendor" strategy rather than a "best-of-breed" strategy. Consequently, the new ERP II functions are provided by the major vendors' systems, and add-on modules or third part bolt-on systems may only have a limited scope. This may imply that supply chain planning will be dominated by, e.g. SAP APO (Advanced Planning and Optimization) modules, and consequently that the reference models provided by the major vendors will be the future supply chain templates. This might imply that the variety in the applied logistics concepts is reduced to the standards defined by the major vendors. However, it can not be concluded that inter-organizational integration will be much easier with enterprises using the same platforms.

The general conclusions of the survey is that large companies now have a common platform based on the large vendors (in particular SAP) and that the platform is kept up to date with the most recent release.

2.2 A framework for EIS transformation

ERP enables close cooperation among supply chain partners facilitating supplier-customer interactions and minimizing transaction costs [3]. However, there is a risk of ERP actually hampering progress in SCM [14]. Nonetheless, it is becoming clear that the greatest impact of, and payback from, EIS is in SCM [4].

ERP researchers recognize the time-gap between impact and effect [15]. The benefits from EIS implementation are best understood in a lifecycle perspective. Several authors applied a lifecycle view on ERP implementation [16]. The proposed lifecycle models [9, 17, and 18] all emphasize the pre-implementation phase, have fewer details on the post-implementation phase and almost nothing on the use of EIS. Ross and Vitale (2000) describe an ERP journey as a prisoner's escape. The last stages: continuous improvement and transformation are sometimes referred to as second wave or the post-implementation stages. It is in the post-implementation stages we find the impact of ERP in the supply chain.

Table 1. Overview of the cases, Adopted from [19]

Context	**Problem**	**Solution**	**Issues**
Lego Company	Inability to change due to Legacy system complexity	Quick small scope SAP implementation	New adaptive supply chain strategy
Municipality of Copenhagen	Ineffective administrative procedures	Oracle implementation using two waves	Decentralized IT competencies
Martin Professional	Legacy systems and new management	Rapid Baan implementation	The need to enhance functionality
Dell Computer	Failed SAP ERP project	EIS based on EAI backbone	World class make-to order process
Hydro Automotive Structures	Complexity of group SAP	In-house development based on MBS Axapta	Industry requirement for "track'n trace"
Bang & Olufsen	Heavy customized legacy system	SAP implementation with "best practice"	Support of planning process
Fritz Hansen	Increasing number of supplier due to outsourcing	EIS platform based on "best-of-breed"	Effective relationship mgmnt with suppliers

3.1 Cases

Lego Company is the well-known toy manufacturer. Before launching their ERP project Lego had a large number of legacy systems throughout their supply chain. The ERP project was accelerated due to poor financial results of 2000. One of the reasons was the inability of the existing supply chain to adapt to market demands. The major part of Lego's annual sale to consumers takes place at Christmas. With the existing supply chain set-up, Lego was unable to respond to market dynamics. During 2000 a large-scale project aimed at replacing the existing systems with a custom -built ERP system based on standardized global processes and Oracle was introduced. By the end of 2000 the project was abandoned and replaced with a new project based on standard SAP. This project was concluded successfully in 2001 with a new ERP platform called LEGO Light. This project was followed by a number of second wave projects aimed at improving process effectiveness. Lego top-management has highlighted ERP with an IT and process-governance structure, which include sourcing considerations. The new projects are driven by the people from the ERP implementation team by with an emphasis on the combination of process development and IT.

The *municipality of Copenhagen* (KK) is one of the largest organizations in Denmark with 43.000 employees (FTE). KK implemented Oracle almost ten years ago. The first wave was oriented primarily towards the back-office function of financial control. In 2001 KK initiated a second-wave project aimed at e-procurement and project management, among other things. One of the challenges was that these projects touched on the more marginal actors in the supply chain. For instance actors like small daycare centers and their suppliers, who previously acted independently from KK, were now included in the scope of the EIS. KK approached this project by setting up a team focused on process development – not as an IT implementation project. Consequently the change was managed as a learning process, but following the standardized new EIS processes. This enabled KK not only to implement the new modules but also to unleash the energy of new ideas for improvement.

Martin Professional develops and manufactures intelligent lighting for the entertainment and architectural markets. The founder of Martin, a charismatic entrepreneur was replaced by professional management in 1999 when the success and growth was about to choke the company. Since the existing legacy systems (very rudimentary systems) could not cope with Y2K, an ambitious plan for implementing a new ERP platform based on Baan was launched in 90 days. With some disruption the ERP system was in place throughout the group by the end of 2001 when Martin started their venture into second generation projects. This, of course, included new modules but also a lot of different "best-of-breed" systems, like Business Intelligence (BI), Supply Chain Management (SCM) and many others. It also included the implementation of a different ERP platform (Axapta) in the sales companies forcing Martin to reconsider and unify their EIS architecture. One of the problems is integration issues when deploying more platforms.

Dell took a different approach to integration in the supply chain. Dell set out early in the nineties with an ambitious SAP project. In the mid-nineties Dell abandoned the ERP path after some heavy investments resulting only in a functional HR system. Dell developed a new strategy called G2 where they specified the architecture of the EIS in Dell's supply chain. The essence of this architecture is an EIS based on Enterprise Application Integration. The outcome of this strategy is Dell's ability to rapidly deploy new business models and closely coordinate and integrate with partners in the supply chain.

Hydro Automotive Structure (HAS) is a first-tier supplier in the automotive supply chain. HAS is part of the Hydro Group; they develop and manufacture aluminum components for the automotive industry. As a supplier HAS have limited influence on the business model and must conform to the requirements of the dominating actors. In 1999 HAS replaced an old industry-specific system and was facing a group policy on SAP as a preferred vendor. Due to the cost and resource requirements of a SAP project, HAS selected Axapta from Microsoft Business Solutions and a small local consulting company to run the implementation. After a long-winded implementation process, the system was operative in 2000 and HAS started their quest for process improvements. Today they have developed a high-performing, integrated supply chain and they are, for example, able to track and trace every piece of material. A lot of the process improvements are actually not a result of the ERP system (e.g. KANBAN) but HAS are convinced that the ERP system has provided the platform for the improvements.

Bang & Olufsen (B&O) is a manufacturer of high-end audio/video equipment for the consumer market. B&O has been through a long phase of process improvements due to a near-fatal financial situation in the eighties. This includes outsourcing a high number of activities and therefore B&O depend quite heavily on their supply network and have developed exceptional partnerships with suppliers and customers over the years supported by in-house developed IT systems. Y2K made B&O decide to replace their customized legacy system with SAP. The implementation of the finance and HR modules went very well but logistics and production planning presented considerable problems. B&O developed "Mass-Customization"-inspired processes for manufacturing customer-unique products, and the implementation of SAP would jeopardize this process. When B&O had to make a stock announcement on an expected loss due to problems with SAP, they got SAP's full attention leading to the development of a B&O solution which later became part of the standard system. Today B&O is a happy SAP user seeing it as a strategic platform for B&O's development. Recently they have started integrating the supply chain planning further by using the APO (Advanced Planning and Optimizer) module.

Fritz Hansen (FH) is a manufacturer of exclusive design furniture. The furniture includes designs from architects such as Arne Jacobsen and Piet Hein. FH has used Movex, an ERP system from Intentia, since 1993; in 2000 they decided to upgrade their systems. FH used to be a traditional furniture manufacturer but due to the success of designer furniture they were forced to outsource a number of activities. Also they put an emphasis on demand management. Consequently supply chain coordination was high on the agenda, and modules like product configuration and supplier management were critical to FH. FH's EIS ended up as a combination of an

ERP system, a CRM (Customer Relationship Management) system and a data warehouse. As a consequence of the new EIS platform FH has been transformed from a traditional manufacturing company to a decentralized, process-oriented organization where collaboration takes place across the entire supply chain. In particular the use of smaller suppliers to create flexibility is mainly a result the ERP platform.

3.2 Lessons learned

The cases are alike in the sense that the motivation for introducing ERP was almost identical. Y2K combined with a need for a common platform drove management to move into ERP. Also the expected benefits from ERP conform to Ross and Vitale's motivations for ERP[18]. The cases also report on serious stabilization issues, for some organizations it was measured in years, but the cases render interesting insight into the post-implementation stages.

The research literature on implementation e.g. Ross and Vitale[18] has little details on their "transformation stage" and none of the companies in their study felt that they had yet transformed themselves. In a workshop for logistics managers in large Danish enterprises the relationship between ERP and SCM was emphasized. The observations were quite similar to those in a Dutch Delphi study[14]. The managers responsible for the supply chain pointed out that although the ERP systems were the key to future supply chain developments the inherent inflexibility of ERP was also a major roadblock for SCM initiatives.

The organizations' general reflection was that the second-wave projects were oriented towards process improvements, and therefore the organizational dimension is emphasized. A second observation is that the second-wave project took the organizations places they never intended to go. The second generation projects were aimed at the supply chain but the new EIS suddenly opened roads that the organizations initially did not consider. Their new ERP systems became instrumental in this change.

This suggests a more subtle relationship between the business, the EIS, and the supply chain processes, where the EIS holds the potential to leverage (or to destroy) business opportunities. Consequently, the time is now ripe for a new management perspective on EIS.

3.3 Implications for managing Enterprise Information Systems

Enterprise Information Systems are under constant development. Current ERP systems reflect fifty years of aggregated business requirements and innovations. Future EIS, ERP II or whatever they evolve into, will continue this evolution. Consequently the contemporary standard systems from one of the major vendors will include extended functions for integration supply chain processes. Based on the retrospective analysis it is also feasible that future critical requirements will be provided in the standard systems and thus will be made available to existing users as a part of normal upgrades.

Based on the survey data it can be concluded that large enterprises have the most recent EIS from the major vendors. Also the age profile of the installations can lead to the conclusion that EIS is a technology that is kept up-to-date with the most recent release. Then it is feasible to deduce that the overall EIS architecture is determined by the architects of the major vendors.

The case studies exemplify the impact of EIS architecture on the supply chain. The cases all illustrate the staged development approach. A few years after the initial ERP implementation effort, when the ERP infrastructure is in place, the focus of the development extends into the supply chain. The driver of this change is effectiveness in the supply chain, which is very specific to the organizations, but information-based collaboration is central to all the cases.

These arguments suggest that many organizations are facing transformation triggered by EIS adoption. This transformation is a new kind of IT diffusion process based on standardized EIS and "best-practice" processes. Until now, mainstream ERP research has mainly focused on isolated issues in this transformation. The new diffusion process goes beyond the traditional system lifecycle thinking, and the implementation phase is just an intermezzo in the transformation. What is proposed here is that the enterprise transformation is considered in relation to the ERP market and the evolution of EIS.

The implications of the EIS transformation for practice are enormous. If the technology and processes acquired by the EIS impact the supply chain, managing the transformation is of strategic importance. This paper therefore proposes a new area of management, EIS Management and Innovation. Except during implementation, IT and ERP is not considered top management issues, and supply chain development is considered logistics and operations management responsibility. This paper suggests that SCM and ERP are to be considered in tandem. EIS Management and Innovation is a new challenge and an issue that needs to be brought to the attention of top management.

Another issue is EIS as a source of process innovation. Before acquiring an ERP system, an organization typically spends a good deal of resources in evaluating the suitability of the standard processes of the system and the strategic match. What happens after a few years? The new releases are accepted more or less as a routine or based on operational criteria. Who is responsible for the strategic evaluation of the new features, and who initiates a decision to discontinue an EIS? This should be the challenge of the EIS Manager.

4 Conclusions

The paper proposed that EIS implementation based on standardized EIS and "best-practice" processes lead to a new management challenge: Enterprise Information Systems Management and Innovation. The argument is rooted in seven case studies, a survey on ERP adoption and a retrospective analysis on the development of EIS. The paper discussed the emerging issues and the implications for management.

Having reviewed the ERP research literature little support for this new challenge has been found, and we propose that EIS management and innovation is explored and put on the research agenda.

This paper contributes to ERP research by exhibiting the importance of ERP management. The paper draws a direct line from the achieved benefit in the supply chain, second-wave ERP projects to ERP implementation and to EIS development. Consequently ERP can be considered a source of innovation in the supply chain.

The research implies that the ERP industry itself is to be considered an object for further research. The ERP industry contributes significantly to the value chain and to EIS transformation of the enterprises.

ERP research has not dealt explicitly with this diffusion process. Many authors have dealt with ERP implementation, a few authors have dealt with the ERP journey, but no one has considered the EIS transformation process in all entire aspects. Many enterprises are now organizing their ERP activities towards second-wave projects. This will present many new practical challenges as well as research challenges. In future managers must be prepared to manage EIS – or the large vendors will set the agenda for them.

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Critical Success Factors for ERP Deployments

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Abstract. As pre-packaged multi-module software solutions, Enterprise Resource Planning (ERP) systems do not necessarily satisfy by default the needs of the entities where they are deployed, and require customization and sometimes additional development in order to satisfy the end-users' requirements. Due to several reasons, many ERP implementation projects are geared towards failure, out-of-budget deployments, implementations unable to deliver the expected functionality or, in the best of cases, delays. As a consequence, the study of implementation success has become a relevant research issue in the ERP field. This article contributes to this subject by presenting a novel taxonomy of the critical factors that can lead to thriving ERP projects, gathering information from ERP implementations in the private, public, and international sectors.

1 Introduction

Enterprise Resource Planning (ERP) systems are commercial-off-the-shelf (COTS) tools implemented as multi-module application software geared towards the integration of business processes and functions within and across functional areas in a company or organization. ERP applications are configured, customized, and commonly extended (through additional development or third-party add-ons) in order to match the organizational processes and needs. ERP suites usually support several business activities such as, for example, administration, finance, marketing, sales, manufacturing, and distribution.

A useful step in the planning of an ERP implementation is the identification and categorization of the critical success factors (CSF) of the project. The CSF approach was proposed by Rockhart [1, 2] based on the work of Daniel on success factors [3]. Multiple classifications for CSF have been proposed in a wide range of areas, such

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as, for example, security management, strategic management, e-commerce, and technology selection. The uniqueness of each ERP implementation, the specific functional matching of ERP applications capabilities and business needs, the emphasis of ERP developers on the requirements of entities in the private sector, and the large number of deployment failures, demand a specific approach for the organization of CSF in ERP implementations.

With this intention, this study proposes a different categorization of CSF in ERP deployments, classifying them by organizational type (private, public, and international) and doing a separate CSF analysis for each. The division of CSF as presented in this article had not been done before, to the best of knowledge of the author.

The remainder of this article is structured as follows. A categorization of CSF in the private, public, and international sectors is introduced in Section 2. Concluding remarks are presented in Section 3.

2 Critical Success Factors

Critical: crucial, decisive, indispensable, vital. *Success:* accomplishment, achievement, triumph, victory. *Factor:* agent, component, constituent, element. *Critical success factors* are key areas of performance that are essential for the accomplishment of a mission or project, i.e., the fields in which satisfactory results ensure the attainment of goals [4, 5]. Although most managers may implicitly take into account these areas in directing their operational activities, these elements provide a common point of reference for the entire organization or enterprise (e.g., in an ERP deployment) when they are explicitly identified [5].

2.1 Previous categorizations of CSF in ERP projects

Former studies on CSF for ERP usually proposed the categorization criteria of CSF as one of three major types. *Perspectives*, different points of view have been used to separate CSF, such as the nature of the ERP implementation process (see, e.g., [6-8]); *project implementation*, the factors are classified according to the project implementation phase (see, e.g., [9, 10]); and *no criteria*, some researchers have simply enumerated their CSF without any categorization (see, e.g., [11-13]).

2.2 A categorization of CSF for ERP by organizational types

In order to classify the different CSF, it was decided to identify the major entities and elements that participate in an ERP implementation: *Company, organization, or institution* where the deployment takes place; *software integrator*, a third-party that may take the responsibility of setting up the ERP application (replaceable by an internal team); *software application*, the ERP suite; *project*, the planned undertaking for the implementation; and *other stakeholders*, any third-party that participates or influences the outcome of the ERP deployment.

For the private field, information was gathered through a documentary examination that included sources that reported on direct experience [6, 8, 11, 14-17]. Likewise, a literature review was the source for the public field analysis [13, 18-21]. In order to determine the CSF for ERP implementations in an international environment, members of the internal ERP deployment teams of six international organizations were contacted.

The separation of CSF by organizational category presented in Table 1 facilitates to identify the factors that are common to all types of implementation, and also to find those that could be unique to a given organizational category. Only the factors that were most commonly presented or that seemed to have the most impact were included. An empty cell means that the factor was not observed in the analyzed implementations for the given organizational division.

In the private field, the most relevant factors were the end-user training, the management support, and the project planning/organizational change. In the public sector, communication and management support were the most important elements. In the international arena the project staffing was identified as the most significant factor, followed by the end users.

When performing an entity/element assessment across organizational types, the most relevant element was, as expected, the implementation project, followed by the company, organization, or institution where the deployment takes place. Although the most important elements were always the project and the organization, the remaining three elements have a unique order in each one of the organizational categories under analysis. This could confirm our hypothesis that the division by organizational types is a useful classification criterion for CSF in ERP implementations, but this conclusion requires further validation.

3 Concluding Remarks

Proposing specific CSF by organizational types offered the advantage of using the fact that ERP applications are developed focusing mostly on the private sector as an intrinsic element during the CSF assessment. Furthermore, it also allowed us to take into consideration the fact that resources, structures, and organizational cultures are generally unique in each organizational category.

In our analysis, no major differences were identified across the organizational types taken into account, although only 53.57% of the factors were common to all categories and 28.57% were unique. Surprisingly, some issues that could be considered as important were regarded as irrelevant, e.g., communication in the international case or the business needs in the public one. In general, end users, project staffing, project planning, management support, organizational change management, and the project team were the most relevant factors in the implementations analyzed. The elements project and organization accounted on average 77.93% of the CSF.

Table 1. CSF in ERP deployments by organizational type

Entity/Element, CSF	Private	Public	Intl.	Average
PROJECT	52.00%	56.67%	51.16%	53.28%
Staffing/casting	5.33%	6.67%	13.95%	8.65%
Project management/planning	8.00%	6.67%	6.98%	7.21%
Organizational change	8.00%	6.67%	4.65%	6.44%
Internal project team	4.00%	3.33%	9.30%	5.55%
External project team	5.33%	3.33%	6.98%	5.21%
Communication	5.33%	10.00%		5.11%
Project objectives	5.33%	3.33%	4.65%	4.44%
Project management team/Steering Committee	4.00%	6.67%	2.33%	4.33%
Business justification	2.67%	6.67%	2.33%	3.89%
Documentation		3.33%		1.11%
Risk management	2.67%			0.89%
Project Sponsor/Champion	1.33%			0.44%
COMPANY/ORGANIZATION	32.00%	23.33%	18.60%	24.65%
End users	14.67%	3.33%	9.30%	9.10%
Management support	10.67%	10.00%		6.89%
Technology	5.33%	3.33%	2.33%	3.66%
Business needs	1.33%		4.65%	1.99%
Organizational culture		3.33%	2.33%	1.89%
Political structures		3.33%		1.11%
SOFTWARE APPLICATION	8.00%	6.67%	16.28%	10.32%
Software capabilities	4.00%	3.33%	4.65%	3.99%
Flexibility	2.67%	3.33%	4.65%	3.55%
Interface with legacy/other systems	1.33%		6.98%	2.77%
SOFTWARE INTEGRATOR	2.67%	10.00%	9.30%	7.32%
Customization	1.33%	6.67%	4.65%	4.22%
Fit-gap identification capabilities	1.33%	3.33%	4.65%	3.11%
OTHER STAKEHOLDERS	5.33%	3.33%	4.65%	4.44%
Knowledge from past deployments	1.33%	3.33%	2.33%	2.33%
Keeping of internal project team			2.33%	0.78%
Troubleshooting	1.33%			0.44%
Multi-site issues	1.33%			0.44%
Performance measures	1.33%			0.44%

As major open issue remains the improvement of our proposal, for example, by diminishing the number of factors or by including an additional layer, such as the project stages, or by including direct feedback from software providers and integrators. Furthermore, even though the results of our study were gathered from real deployments, the validation and application of our conclusions are still to be seen in future ERP implementations.

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Improving the Accuracy of Execution Data of ERP Systems: A Case Study in the Zongxin Telecom Corporation

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Abstract. The poor accuracy of the execution data (AoD) is often seen as a common symptom of unsuccessful enterprise resources planning (ERP) implementation. Finding ways to achieve high AoD is therefore an important and pressing issue for ERP practitioners. This paper describes an AoD improvement project in Zongxin Corporation (China). The approach taken in this project has been to better define AoD and to measure it with the use of five indices including data coincidence, completeness, timeliness, reliability and logical consistency. Five influencing factors of AoD have been identified by examining the current AoD problems of the ERP system implemented in Zongxin Corporation. They include management commitment to and policy on the management of enterprise information, effectiveness of training, the competence of the ERP solution providers, the reliability of the system, and the duration of concurrent running of new and legacy systems. These factors are related to the AoD indices through the development of a structural model, and the cause-and-effect relationships for improving AoD in ERP implementation are established. A relationship matrix between the influencing factors and the AoD indices is established for use in AoD control. The five factors are further explored as controllable and uncontrollable factors in improving AoD. Based on these models, process improvements for AoD are carried out, key control points are identified, and best practices are introduced and reinforced. This paper will also elaborate on the issues relating to ERP training, system reliability and transition

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period, with both new and legacy systems in operations. Ways to improve the effectiveness and to reduce vulnerability will also be discussed.

1 Introduction

The successful implementation of an ERP system should lead to considerable benefits for firms entering the e-business field. Unfortunately, a very high failure rate of ERP system implementation (ESI) has deterred potential users from using this important e-business tool. There are several reasons for the frequent failures of ESI; low accuracy of the execution data (AoD) is considered as one of the most common reason. Many examples of failed ESI due to poor AoD can be found, with many firms experiencing considerable frustration during their ESI, and having no other choice but to abort their ERP systems. Therefore, resolving the problem of low AoD seems to be of fundamental importance during the early stage of an ESI.

This study is based on an ESI case in the Zongxin Corporation (ZXC), a major manufacturer of telecom equipment in China. They considered implementing an advanced ERP system to order to enhance its supply chain capabilities. During the planning stage of its ESI project, the company spent considerable resources examining alternative ERP solutions from various vendors. However, unsatisfactory AoD during the project go-live stage presented major problems and critical issues for ZXC. To resolve such critical issues, a solution for enhancing AoD was developed by the authors and will be described in the sections that follow.

2 Review of Literature

Researchers in the field of ESI seem to have paid comparatively little attention to AoD when compared to the other factors that lead to effective ESI. Most authors have focused on the indirect factors such as a change of business processes [1, 2], top supervisor support [3-5], training [6, 7] and cultural factors [8, 9]. On the other hand, AoD, which is critical for successful ESI, has not been adequately addressed, with only a small amount of published literature addressing the role of data accuracy in information systems. An example is Stephen [10], who analyzed the tradeoff between data accuracy and the performance of databases. He defined data accuracy as the relevant error between memory data value and true value. Robertson [11] developed an automated data collection model for simulation and the improved the methodologies and mechanisms of selection of potential key data sources. Thomas and Yang [12] proposed a semi-structure constraint-based wrapper specification and verification for enhancing data accuracy in cooperative information systems. While these contributions deal with the data accuracy of database from various perspectives in different fields, it is apparent that they lack a systematic approach to achieving data accuracy in ESI.

3 ERP in the Zongxin Corporation and the low accuracy of AoD

3.1 Outline of the Zongxin Corporation

ZXC is a leading Chinese manufacturer of telecom equipment. It sells three series of products including wireless equipment, networking facilities, and consumer products such as mobile phones. ZXC also provides various solutions and high quality services for users located in many parts of the world. The company is now in the process of expanding its international telecom operational business (e.g. system equipment of mobile phone, personal hand-phone system (PHS), WLAN and BWA). In the mobile communications area, ZXC has complete production systems for CDMA, and GSM from 2G, 2.5G and 3G products.

3.2 ERP Systems Implementation in ZXC

In the early of 2000's and in response to the then increasing competitive environment worldwide, ZXC decided to adopt an ERP solution to integrate its production, market, purchasing and financial management operations. And so provide an information platform on which to build a unified database and data sources to support the group's business across several countries and regions. The whole business processes and information management ranges right through from order receipts to sales services.

The characteristics of ZXC's business processes were analyzed and investigated and the capabilities of ERP vendors and consultants were thoroughly studied. The Oracle Application ERP and Henkel Technologies were selected as the vendor and the consulting company respectively. Based on the guidelines for ERP implementation and the conclusions reached by both of the project implementation team and consultants, 6 months would be required before the system could go live.

After the system was up and running, various implementation faults appeared which aggravated as time went on. These faults can be divided into the following four general categories:

(1) Accounting faults: All accounting data came from records of past activities. However, in practice, such data was only "re-recorded", instead of being captured at the time when the business transactions took place. As a result, errors propagated and proliferated from one department and to all involved in those transactions. For example, if an invoice was generated in the finance department and if the shipment

data had not been recorded in the database, the submission of the invoice could not be made because the related shipment records for the new process were missing.

(2) Faults arising from incorrectly using ERP modules: For example, in using the sales order modules, sales staff (usually with self-interest) did not follow the rule of submitting all customer information to the ERP project team. The customer's information, therefore, was not recorded in the database and sales orders could not be issued in the correct way.

(3) Faults due to erroneous data: Financial processes were usually arranged at the end of a series of transactions. Normally, errors arising in prior processes will not be allowed to pass through the financial process. However, if an error was uncovered at the financial process, rectifying such erroneous data at such a late stage would be out of the question. To effectively rectify the problem, the only approach was feedback from earlier processes. This in turn would significantly delay the overall time for completing the process and at the same time a large amount of junk data was generated.

(4) Operational faults: Many operational problems were identified in various departments. Some could be attributed to ignorance of the important business processes, while a mixture of other problems were due to the heterogeneous configuration of software solutions and data.

3.3 Accuracy of AoD in ZXC

The most acute among the numerous problems in the implementation of ERP at ZXC were mainly as a result of low AoD and executive data. Although two months had passed since implementation, the executive data extracted from the system generally exhibited low quality as follows:

- Contract data error

Out of a total of 120 purchase orders generated within one month were examined, only 21 (17%) were recorded in the system. As the remaining purchasing orders were not created and issued on time, the raw materials required for them were unable to arrive on time and be received by the warehouse. Consequently, it was not possible to release raw material to production due to missing related records in the raw material warehouse; and consequently no finished products could be received by warehouse, and finally no finished products could be sold.

- Ordering error

There were 926 basic sales orders throughout the year. However, only 734 (79%) of them were recorded in the system. There were 231 confirmed sales orders in the month under investigation, but only 67 of them were recorded. Such incomplete sales information resulted in a host of related problems such as: money paid for returned goods could not be correctly refunded customers; although the finished goods had been received by the warehouse, the accounting system's inability to record this transaction on time affected production; and low accuracy of sales orders also resulted in the system's inability to issue invoices after the goods had been delivered.

- Inaccurate production and cost information

In order to investigate the AoD of ESI, the discrepancies between data recorded in ERP and data obtained from actual production system were compared, see Table 1. Information relating to the tasks and costs of production task was explored. Production tasks could be divided into two categories according to whether their production costs can be derived from standard cost data used by ZXC or required special consideration. Moreover, since operators did not perform tasks according to ERP specification, cost errors for standard finished products were created (Table 1) and errors in production cost would inevitably lead to the errors in sales costs.

Table. 1 Error Ratio of Production Task and Production Cost

Item	Index	Standard task	Non-standard task	Total task
Production task	Record of task in ERP system	86	44	130
	Actual task in production system	269	143	412
	Error ratio	32%	30%	32%
Production cost	Amount of products in ERP system at correct cost	124	52	176
	Amount of actual products	269	143	412
	Error ratio	46%	36%	42%

- System bugs

There were 102 sales orders recorded in the system during the month, which included 35 "virtual orders". Such virtual orders were generated to resolve bugs in the system. For example, if a virtual order was generated in a designated warehouse, errors in product delivery should appear. The occurrence of such an error would stop further operations, which in turn invoked quick fixes such as a virtual shipment or a virtual return to deal with the error. Such errors and related actions further aggravated AoD in related activities.

- Invoice errors

183 invoices in the module of receivable management in the month were examined. Of these, 54 errors relating to taxation were found in invoices. Moreover, incorrect data in invoices were due to the numerous human errors. To deal with these erroneous invoices, a series of hedge invoices were generated and this measure resulted in the inflation of unnecessary information.

- Inventory data errors

At the end of the month, there were over 200 codes of finished products in inventory. Unfortunately, every inventory code was found to be different from the one recorded in the system. The ratio of accurate data of inventory-checking was almost zero.

- Delaying of production task record

There were 412 tasks completed and received in warehouse during the month, and 78 of them (on average) were duly recorded in the system everyday. The ratio of timely updating of accounting records after task completion and warehouse receipt was 19%.

- BOM errors

5 outdated BOM were uncovered in the system because the updated versions had not been properly maintained. This inevitably led to successive errors in production, material release, and cost management.

The primary objective of ESI is to create an effective database in which accurate information of purchasing, production and sales activities becomes available online. This aspect is the crucial to achieve clear visibility in the extended enterprise and to synchronize the enterprise-wide transactions. Unfortunately, this object can easily and often be defeated by data that are flawed with errors, delay in data input, etc. AoD is susceptible in many ways, some of which are inadvertent and comes as "natural" because of the user's ability to come to terms of a new way of working. Sometimes "errors" are a result of a need to explore (play) the system in order to correct other errors. The large volume of junk data entered into or generated by the system are not easy to identify and removed. Worse still, such cleansing is not always possible because of the enormity of the task involved in detecting the numerous production tasks, orders, and manual replenishment and reverse invoices, and to systematically delete them.

The low AoD in ZXC prevented top supervisors from getting the necessary data from the system for making correct and timely decisions, resulting in a negative impact on production.

4 Analysis of the Factors and the Relationship Model for AoD

4.1 The Indices of Accuracy Data

AoD can be generally defined as the ratio of correct data to the total recorded data in an ERP system over a defined period of time. Our investigation of the problem suggests that ways to enhance AoD rest on achieving the data properties of coincidence, completeness, timeliness, reliability and logical consistency, which can be defined as follows:

- Coincidence: the data recorded in system is the same as the actual data.

- Completeness: the data recorded in system is complete and there should not be any missing or redundant data.
- Timeliness: real-time recording of any data required in processes.
- Reliability: ensuring system is safe and reliable and all the required maintenance-related functions are performed punctually.
- Logical consistency: that there are no logical errors in data used by the system.

Five indices were developed based on the above five properties.

4.2 Critical factors for AoD

Based on the analysis of the AoD phenomena in the ZXC case, several influencing factors for AoD in ESI have been proposed including management commitment and policy, system reliability, competence of ERP solution providers, training effectiveness, and duration of concurrent running of new and legacy systems. These factors could be divided into two groups including the system factor and human factor. The structure of model was shown in Fig. 1.

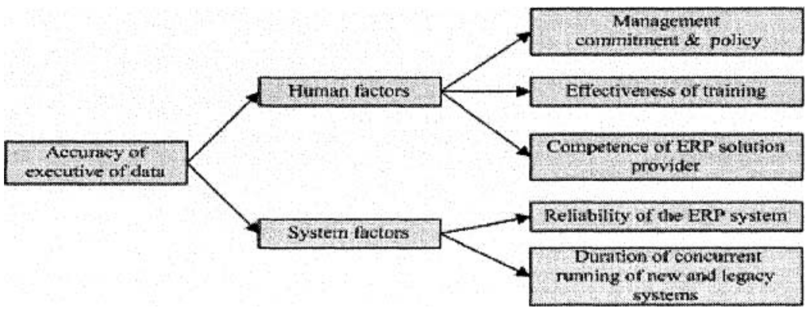


Fig. 1. Critical factors for AoD in ERP system implementation

The five influencing factors for ESI could be further elaborated by a fishbone diagram, see Fig. 2.

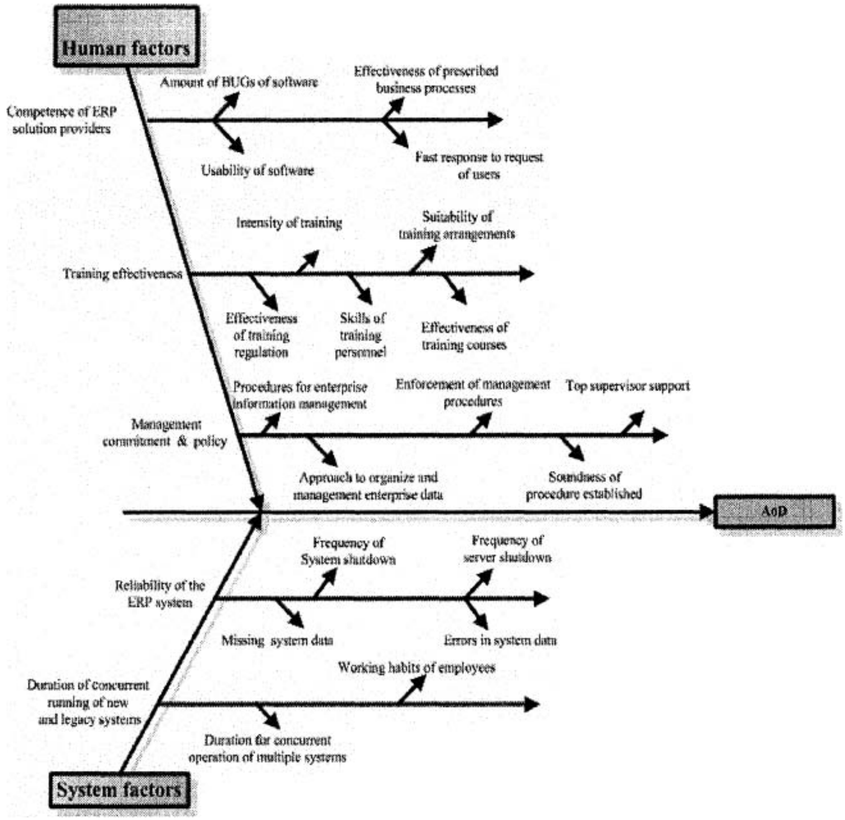


Fig. 2. Fishbone diagram of factors for AoD

- Management's commitment in and policy on enterprise information management include measures to establish clear and rational procedures for information management. The management will need to consider the rationality of organization planning of fundamental data, the execution level of planning and regulation, and top supervisor support for ERP implementation.

- Effectiveness of training program includes the qualification, experience and mentoring or coaching skills of the training personnel; the effectiveness of training courses, the suitability of training arrangements, the effectiveness of training regulations.

- Competence of ERP solution provider. The choice of a suitable ERP solution provider contributes critically towards the success or failure of the ERP implementation project. Its competence (or lack of it) is highlighted by the bugs contained in the software, the effectiveness of the prescribed business processes, the usability of software, and it response to request of users.

- The reliability of the ERP system is mainly demonstrated by the frequency of shut-down of system, the frequency of shut down of the server, missing system data and errors.

- Duration of concurrent running of new and legacy systems. After the new ERP system is operated online, usually the legacy information system could be made use of for a period at the same time which will affect data completeness and timeliness.

4.4 The Relationship Model between Indices and the Factors relating to AoD

Based on the analysis of the indices and the impact factors of AoD in the above sections, the relationship model between the indices and the impact factors was developed, see Table 2.

Table. 2 The Relationship Model between Indices and Impact Factors (√- Controllable; x-Non-controllable)

Category	Factors	Sub-factors	Indices of AoD				
			Coincidence	Completeness	Timeliness	Reliability	Logical consistency
Human	Management Commitment & Policy	Procedures for enterprise information management	√	√	√	√	/
		Enforcement of management procedures	√	√	√	√	/
		Approach to organize and management enterprise data	√	√	/	/	/
		Soundness of procedure established	√	√	/	/	/
		Top supervisor support	√	√	√	√	/
	Training effectiveness	Suitability of training arrangements	√	√	√	√	√
		Effectiveness of training regulation	√	√	√	√	√
		Intensity of training	√	√	√	√	√
		Skills of training personnel	√	√	√	√	√
		Effectiveness of training courses	√	√	√	√	√
	Competence of ERP Solution Providers	Usability of software	x	/	/	x	/
		Amount of bugs of software	/	/	/	x	x
		Fast response to request of users	/	/	/	x	x
		Effectiveness of prescribed business processes	/	/	/	x	x
System	Reliability	Frequency of system shutdown	/	/	/	/	x
		Frequency of server shutdown	/	√	√	/	/
		Missing system data	/	/	/	√	/
		Errors in system data	/	/	/	/	√
	Concurrent running of new & legacy systems	Duration for concurrent operation of multiple systems	/	√	√	/	/
		Working habits of employees	√	√	√	/	/

In Table 2, the drivers of AoD are further divided into two groups: one includes the controllable factors and the other the uncontrollable factors. The controllable factors will be further discussed in the next section.

5 Analysis of the Controllable Factors of AoD in ERP Implementation and Related Strategies

5.1 The Measures for Improving AoD

5.1.1 Management commitment and policy

The effectiveness of enterprise information management practices can be significantly improved with the establishment of reasonable and acceptable procedures for information management, for the enforcements of established procedures, for the support of top supervisors, and for process improvement and optimization.

a. Procedures for information management for ERP

A major requirement of AoD is the development of regulations for critical work at various points in the business processes, which can include critical control points such as warehouse-out, warehouse-entry, staff requirements, staff of record, etc.

b. Enforcing the procedures

The procedures on information management laid down by management must be effectively enforced. To achieve this, a committee has been set up which is responsible for weekly evaluations of performance in carrying out these procedures. Losses incurred due to looseness in enforcing these procedures are assessed and ways to better enforce these procedures are explored.

c. The support of top supervisors

In order to get the support of top supervisors in the ZXC company, two measures were been taken. First, during the stage of implementation of online operation, the consultants were required to provide sufficient training to top supervisors, so that they could overcome the technical and psychological barriers in using the ERP system. Second, the supervisors were encouraged to develop competence in using ERP tools such as information query via interfaces of ERP system, allowing them to make inquiries on the operational situation of the firm at any time. When the top supervisors appreciate the benefits brought about by the ERP system, they will obviously give more support to the ERP implementation. Top supervisors are thus encouraged to change their passive attitude towards the system and to become proactive in supporting AoD. Moreover, top supervisors will eventually influence lower level staff to also promote and support AoD activities and the ERP system.

d. Process improvement and optimization

The proposed operational procedures and processes for information processing aim at improving data coincidence and data completeness. For example, after re-designing some warehouse processes and reinforcing operational procedures, receiving activities and shipping activities will not be performed until the required documents are available.

5.1.2 Factors relating to training and improvement measures

According to the learning curve theory [13], training has a great impact on the effect of learning. It is also always necessary to reward effective learning during a training program. It is always constructive to motivate staff, and so prevent them from developing negative attitudes to learning when setbacks and frustrations encountered. It should be made clear that through continuous learning, they would be able to overcome the declining stage and shift to the improving stage of a learning process, as shown in the classical learning curves.

5.1.3 Factors relating to the reliability of system and improvement measures

The reliability of the system was improved through the following measures:

- The security control of the ERP data: hardware, human factors, catastrophes, design and maintenance.
- The equipment of the ERP system: hardware, human factors, catastrophes, pilferage and sabotage.
- The communication system: network, viruses, software, and communication transmission;
- The database management of the ERP: human factors, viruses, theft, authorization.

5.1.4 Solution for the concurrent operation of multiple systems

In the ZXC case study, both the new ERP system and the legacy systems (e.g. NOTES) were used concurrently for 4 months. This resulted in an adverse effect on the coincidence, the completeness, and the timeliness of the data. In order to solve the problems resulting from the simultaneous operation of new and legacy systems, the company decided to accelerate the phasing-out of the old legacy systems, and within two months the ERP system was able to run independently, producing a noticeable improvement in the AoD of system.

5.2 Effect Analysis of the Improvement Measures

For the ZXC project, the related measures were implemented using the above procedures and methods of solutions, and subsequently, the AoD of system was found to have improved on all the five critical indices.

5.2.1 The effect on coincidence

Data coincidence for sales orders was found to have increased from 80% up to 97% (Table 2), for production tasks versus cost order it improved from 30% to 93% (Table 3), and for manual-invoicing versus system-invoicing it also improved from 77% to 96% (Table 4).

Table. 2 Coincidence of Sale Orders

Sale order	Amount of charge up (Time)	Amount of error charge up (Time)	Coincidence
Before improvement	35	7	80%
After improvement	32	1	97%

Table 3. Coincidence of Production Task vs. Cost Order

Production task vs. Cost	Amount of task (Time)	Amount of error cost (Time)	Coincidence
Before improvement	88	62	30%
After improvement	76	5	93%

Table. 4 Coincidence of Hand Invoice vs. System Invoice

Hand invoice	Amount of charge up (Time)	Amount of error charge up (Time)	Coincidence
Before improvement	26	6	77%
After improvement	23	1	96%

5.2.2 The effect on data completeness

After the program, a noticeable improvement in data completeness was observed. Data completeness for material release per month was found to have increased from 43% to 94% (Fig.3).

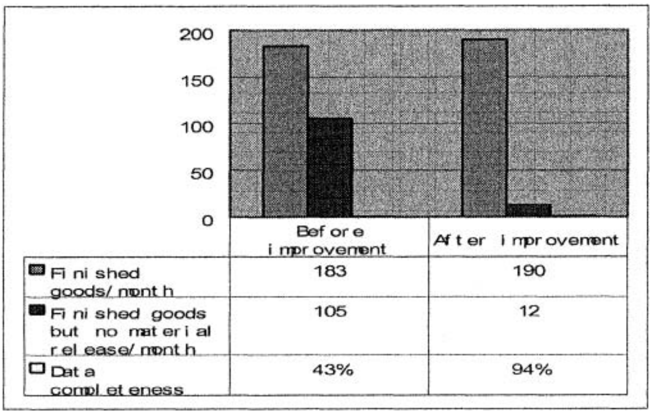
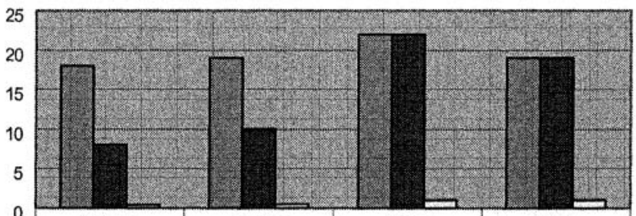


Fig. 3: Improvement of integrality of material release per month

For contracts it increased from 29% to 100%, for production tasks per month it improved from 30% to 100%, for purchasing orders per month it increased from 17% to 100%, and for return of goods from contractors per month it improved from 23% to 78%.

5.2.3 The effect on timeliness of data

Data timeliness of materials release on any work day has improved from around 48% to virtually 100% (Fig. 4). The timeliness of entry into the finished products warehouse on any work day has also improved form from around 15% to almost 100%. By controlling the related factors, the timeliness of the data used in the ERP has considerably improved.



	Before improvement 1	Before improvement 2	After improvement 1	After improvement 2
Amount of real business	18	19	22	19
Amount of charge up	8	10	22	19
Timeliness at the day	44%	53%	100%	100%

Fig.4. Improvement of timeliness of material release

5.2.4 The effect on reliability and logical consistency

ZXC has adopted a series of measures to enhance the reliability and logical consistency of the data. These measures include validation of user identity, authorization control, data protection, hardware investment, system update, and system training and so forth. Also, users of the system and consultants are strictly forbidden to transfer information of their accounts to outsiders. As a result, AoD has shown major improvements. The frequency of network breakdown has also fallen from around 5 times to only 1 per day. The logical data faults resulting from network breakdown have also decreased from several dozens to almost zero.

6 Conclusion and Further Work

We believe that AoD is the most critical issue in the successful implementation of ERP, an issue that not been addressed sufficiently by researchers. The work described in this paper has, though somewhat preliminary, has managed to contribute to and highlight the issue of AoD. The definition of AoD has been refined through the use of the five indices of coincidence, completeness, timeliness, reliability and the logical consistency of data. These indices provide a means for assessing AoD in ERP implementation projects and are related to factors that have a clear influence AoD. Based on the proposed relationship model, approaches to the control of AoD by focusing on other controllable factors plus other process improvement initiatives have been implemented. Experience with the ZXC case suggests that the methodology developed is effective in improving AoD. It has also improved effectiveness of the enterprise information management practices, the quality of related training, and the reliability of system.

Future work is expected to focus on refining the logical relationships between the indices of AoD and the related factors, possibly by adopting a more quantitative approach involving Varimax correlation analysis and Logistic regressions analysis.

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Developing a Practical Framework for ERP Project Implementation: A Proposed Research Design

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Abstract. The implementation of Enterprise Resource Planning (ERP) systems is famous for mismanagement, unfulfilled expectations, and even outright failure. While some organizations undertaking this effort manage to report on-time schedules, intact budgets, and systems capable of providing measurable value to the organization, this is the exception rather than the rule. The objective of this research project is to focus on organizational reliability. This paper will delineate a proposed research design that will enable one to quantify the impact of organizational factors on ERP projects. Those factors will be classified in five broad categories: risk factors, expectations, resources, organizational competence, and consequences. The benefit of this research will be threefold: 1) to assess organizational readiness for undertaking an ERP project, 2) to identify areas of weakness within an organization, and 3) to predict with confidence the outcome of the ERP project in terms of common project metrics (budget, schedule, system capability, etc.). In practice, this would enable ERP project managers to possess a comprehensive understanding of project vulnerability and allow them to strengthen areas of weakness prior to project implementation.

1 Introduction

The worst kept secret in IS might be that management of complex systems such as ERP systems possesses enormous potential for mismanagement, unfulfilled expectations, and outright failure.

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While some organizations manage to report on-time schedules, intact budgets, and systems capable of providing measurable value to the organization, those that fall woefully short are much more prevalent. Researchers [1] have identified many real world examples of ERP projects that have experienced difficulty. Those difficulties can cause significant problems for the companies that depend on them.

This research project will focus on organizational reliability. Sullivan and Beach's [2] model of how High Reliability Organizations (HROs) manage complex systems, provides a novel method of representing the dynamics of managing complex systems, sometimes in hazardous environments. Factors that impact these projects can be categorized into five broad categories: risk factors, expectations, resources, organizational competence, and consequences. Using HROs as an example of a consistently effective management environment, and overlaying critical success factors for ERP implementations found in the literature, a representation of an effective ERP implementation is proposed. Conversely, it is expected that this same method can be applied to represent ineffective ERP implementation.

The objective of this paper is to outline a proposed research design that will lead to the ability to quantify the impact of organizational factors on ERP projects. Ultimately, an analysis of a significant volume of statistical data regarding the outcomes of ERP projects and the impact of particular factors on project performance will be required.

The benefits of this research for practitioners will be the ability to assess organizational readiness for undertaking an ERP project, identify areas of weakness, and predict with a degree of confidence the outcome of the project in terms of common project metrics such as budget, schedule, and system capability. This would enable ERP project managers to better understand project vulnerability and strengthen areas of weakness prior to project implementation.

2 ERP Systems and Outcomes

ERP systems are comprehensive packages of software solutions that integrate all business processes and organizational functions to define a holistic view of the business from a single information architecture [3]. These systems are comprised of customizable, standard application software modules that integrate business solutions for core business processes and administrative functions [4].

Further, they provide comprehensive integrated business functionality using a state-of-the-art IT infrastructure [5] that can improve the information flow within organizations significantly [6]. In addition, they also provide the capability to improve core business practices, such as human resources, manufacturing, marketing, and finance. This is accomplished by standardizing business functions based on best business practices [7, 8]

ERP implementations require skillful management. In summarizing the recommendations of other researchers as to how ERP implementations should be managed, a list of critical success factors has been compiled. Table 1 reflects the general categories of those factors and the authors who provided the findings.

Included in the table are critical success factors identified by SAP [9], a vendor of ERP systems.

Table 1. Critical Success Factors for ERP Implementations by Author

	CRITICAL SUCCESS FACTORS							
Authors	**Strategy**	**Technology**	**Organizational Culture**	**Management**	**Human Resources**	**Structure**	**Organizational Learning**	**Operational**
Al-Mashari et al. [10]	Effective planning can enable key business imperatives Align business strategy with IT strategy	IT mission to provide technically enabling and supporting infrastructure	Effective change management	Top management involvement and commitment Effective leadership	Management of employee skills and competencies Team building Training	Adequately address necessary changes to organizational structure	Measurement techniques that enable decision making that move business competitively forward	
Umble et al., [11]	Clear understanding of strategic goals	Organizational change management		Top management commitment, excellent project management Performance measures	Quality implementation team Training			Data accuracy, multi-site issues
Matwani et al. [12]	Strategic initiatives	IT leveragability, knowledge sharing	Cultural Readiness Change and process management	Process measurement metrics, feedback loops, quality control tools, and documentation			Learning capacity	
Shang and Seddon [13]	Strategic, geared toward business growth	IT infrastructure, increase capability, reduce cost		Managerial decision making, planning, performance improvement, organizational change			Business learning	Operational efficiency
Meyers et al., [14]	Broad and strategic decision processes	Technology fit to organizational skills	Constructive cooperation, intra- and inter-industry networking	Project management Communication	Education and training Motivation	Adaptive and flexible structure, strong communication	Knowledge transfer	Joint product development.

		Technical capabilities		skills	Commitment	mechanisms across structural boundaries		
SAP [9]	Clear project goals, scope, objectives, and measurements		Keep the organization informed	Executive commitment and active participation Executive alignment Empower team member to make prompt decisions	Qualified people on the project	Willingness to adapt. Centralize team members for better team work.	Monitor performance using Key Performance Indicators (KPI).	Comprehensive risk assessment. Include quality assurance plan. Be consistent with best practices.

Despite the recommendations of how ERP projects should be managed, failure among ERP implementations has been widely documented [7, 15, 16, and 11]. Langenwalter [17] reported that ERP implementation failures range from 40 percent to over 60 percent, while Ptak [18] suggests that ERP systems that failed to provide the expected Return on Investment (ROI) are as high as 60-90 percent. These statistics are comparable to the Standish Group's [19] findings where they reported that as much as 83 percent of all IS/IT projects encounter some significant difficulty or failure. Clearly, success rates for ERP outcomes are consistent with historical patterns of IS/IT project performance. Thus, while not all ERP implementations are failures, the problem is still chronic.

The impact of an ERP implementation failure can be significant, since the cost of these systems is often in the hundreds of millions of dollars. In extreme cases, it can even threaten the financial viability of the organization.

3 Characteristics of HROs

The above withstanding, Roberts and Bea [20] suggest that some organizations have been very successful in their implementation of complex systems (e.g., those controlling nuclear power stations and chemical processes.). These organizations, by the very nature of what they do require a high degree of reliability from their systems, procedures, and people.

HROs operate in an environment where the tolerances for error are extremely slim. Roberts [21] identifies what it means to be a HRO by posing the question, "How often could this organization have failed with dramatic consequences?" If failure could have occurred many thousands of times, the organization is highly reliable. Another characteristic of HROs is that, "performance reliability rivals productivity as a dominant goal" [21].

Sullivan and Beach [2] suggest that it is the ability to balance capability and risk in the face of high consequence that separate HROs from traditionally less critical organizations. The Sullivan-Beach Model (Figure 1) provides an illustration of the dynamics of managing complex systems in HROs using a scale to represent the weight of risk and the required weight of capability to counteract that risk.

Failure occurs when risk, comprised of expectations and risk factors, outweighs an organization's capability, comprised of resources and organizational competence. In such cases the scale tips out of balance, and consequences follow.

Bilateral relationships in this model exist between expectations and consequences, as well as expectations and resources. Additionally, a one-way relationship between consequences and organizational competence exists. Expectations and consequences are related in that the consequences for failure are consistent with the degree of missed expectations. For example, a delay in

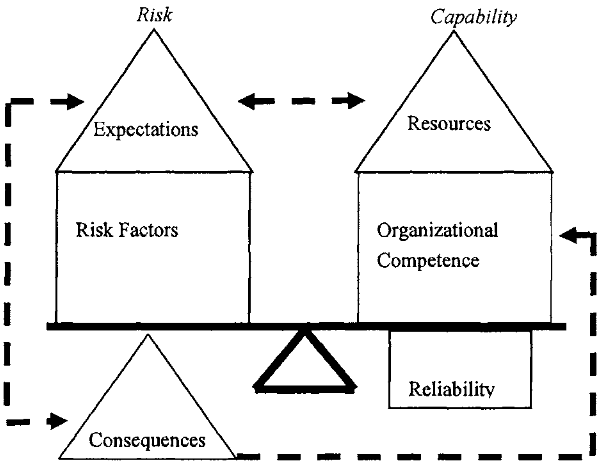

Fig. 1. Conceptual Model for How HROs Manage Complex Systems

launching the space shuttle by one day violates an expectation that the shuttle program stay on schedule. However, the consequences of failing to meet this expectation are minor. Higher order expectations include returning the shuttle and its crew safely to earth. Failing to meet those expectations involves severe consequences [2].

The relationship between expectations and resources is demonstrated when stakeholders (government agencies, for example) provide resources to a project. Certain expectations, or a return on investment, accompany those resource commitments. Conversely, if resources are withdrawn, project managers will insist that stakeholders lower their expectations, or failure will result. Similarly, if expectations increase, managers will demand additional resources [2].

Finally, the one-way relationship between consequences and organizational competence is best described as organizational learning. When HROs fail, an investigation follows, and what is learned contributes to changes in policies and procedures that increase organizational competence so that a particular type of failure does not occur again [2].

4 Commonalities between HROs and ERP Systems

ERP systems have become the norm for medium to large companies. Thus, there is a real need to improve the likelihood of ERP implementation success. Based on the Sullivan-Beach Model, HROs share considerable commonality with ERP implementations:

- complex, highly integrated, systems,
- significant resource investment,
- high expectations for success,
- risk factors that threaten success,
- significant consequences for failure (i.e., punitive, financial, etc.),

ERP and HRO systems have similar factors that influence their success. System complexity, resource commitments, high expectations, and risk all interrelate in the environment of these systems.

5 Research Design

The environment of IS project management is complex, with a broad range of interacting variables. The proliferation of ERP systems requires a study into the factors that influence the success of these complex projects in order to both identify areas for potential failure, and quantify their impact. This will provide a method of evaluating organizational readiness and forecasting project performance in advance. Obvious benefits to organizations include identifying weakness and risks that threaten the success of the initiative, and mitigating them before they impact the project.

From these observations, questions arise that will require further empirical study.
"Can a correlation between success factors and impact on project performance be reliably quantified?"
"How can factors of organizational readiness for an ERP implementation be quantified and used to predict project performance?"

Effectively studying a topic this complex will be difficult if only a single measurement tool were to be used. This research design will propose using a combination of methods that will approach the data from multiple perspectives, each designed to provide a specific insight into the topic. This framework will incorporate a combination, or triangulation, of qualitative and quantitative methods.

Researchers [22, 23] have consistently noted the benefits of triangulation. Frankfort-Nachmias and Nachmias [24] define triangulation as the "use of more than one form of data collection to test the same hypothesis within a unified research plan". The author further adds, "To minimize the degree of specificity of certain methods to particular bodies of knowledge, a researcher can use two or more methods of data collection to test hypotheses and measure variables; this is the essence of triangulation" [24]. A summary of this research design is provided in Table 2.

Table 2. Research Design Summary

	Research	*Scope*			
Phase	*Depth*	*Breadth*	*Source of Data*	*Type of Analysis*	*Purpose of Analysis*
1	Low	Very High	Published Literature	Literature Review	Exploratory: Identification of scope of system development failures, historical practices, relevant issues, and success factors.
2	High	Low	Interview	Analysis across organizations	Theory formulation: Identification of relevant forces (technical, managerial, procedural and organizational culture) affecting project outcomes. Identify success strategy effectiveness. Identification of deviation points of system development planning that invite failure. Compare and contrast HRO and commercial ERP development environment.
3	Medium	High	Survey Data	Statistical Analysis	Confirmation: Validation of theoretical constructs over larger population.
4	Very High	Very Low	Practical Application	Evaluation of feedback	Test and Evaluation: Validate ERP factor valuation framework through application in practice.

5.1 Literature Review

This research began with a review of published literature in order to establish relevant issues and relationships that influence system development in general, as well as that of HRO and ERP systems. This review supported the findings of Sullivan and Beach [2] and the developmental model they posited. Consequently, we will use this model as a basis to proceed. This process establishes a theoretical underpinning for the remainder of the research.

5.2 Qualitative Exploratory Phase

The interview process will provide a method of extracting the experiences and observations of the participants involved in developing these systems. While interviews provide limited breadth, they allow a high degree of depth and detail into this area of research. This process will involve a small number of participants, approximately twenty interviewees. Interview data will be processed in order to identify the major issues that affect system development outcomes. The information gleaned in this exploratory phase will form the basis of the instrument created in the confirmatory phase.

5.3 Quantitative Confirmatory Phase

Once the major issues are identified, a survey instrument will provide a method of validating the existence and influence of these issues over a larger population of participants. A statistical analysis of responses will allow correlations to be drawn between success factors and ERP project performance metrics.

5.4 Practical Application

The practical applications of this research are significant. The objective is to obtain the ability to predict project performance in advance of the project so that weaknesses can be identified and corrected before they impact the project. The ability to make a correlation between factors that contribute to success and failure of ERP projects with a quantifiable impact on project metrics will be valuable to ERP vendors, consultants, and their clients. As the impact of these factors becomes known, it is expected that an assessment of organizational readiness could provide an estimate of budget and schedule overruns. It is hoped that the resulting framework will enable an environment of trial *without* error.

The obvious benefit of having the capability to estimate project performance before it begins is that corrections can be made to organizational weaknesses before they impact the project. Further refinement of this knowledge over time can lead to contributions in other areas of system development as well.

6 Development of a Practical Framework

6.1 Training

Organizations that seek to develop success-oriented professionals to participate in ERP projects could emphasize the importance of effective project management using examples from this research. Training programs provide an opportunity to instill not only effective management practices, but organizational philosophy and culture. Organizations could understand how projects result in failure and what each factor costs.

6.2 ERP System Managers

As a practical solution to improve the long history of failure with ERP systems, managers might realize organizational benefits where in the past they experienced difficulties. Project personnel could be held accountable for project performance, since they would have advanced notice of risk factors and organizational weaknesses in advance of the project. One lessen learned in HROs is that accountability tends to drive higher levels of performance.

6.3 ERP Vendors and Consultants

By incorporating techniques developed in this research project, ERP vendors and consultants will enhance their credibility with clients. As the findings from this research are refined over time, it will reinforce the correlation between project factors and the impact on project metrics.

7 Conclusions

ERP systems have a high potential for mismanagement, unfulfilled expectations, and failure. While some organizations manage to get it right, many fall short. Researchers have written much about success factors and techniques for improving project outcomes, yet millions of dollars are lost to inefficiency and ineffectiveness in managing ERP projects.

Using Sullivan and Beach's [2] model representing the dynamics of how HROs manage complex systems, the objective of this research project is ultimately to put a price tag in misalignment with established success factors for ERP projects. To accomplish this, interviews will be used to perform the exploratory data collection and identify major themes in this area. Then, survey questionnaires will provide quantitative data over a larger population. Statistical analysis will establish the degree of correlation between project factors and project performance metrics.

The benefits of this research for practitioners will be the ability to assess organizational readiness for undertaking an ERP project, identify areas of weakness, and predict with a degree of confidence the outcome of the project in terms of common project metrics such as budget, schedule, and system capability.

The industry benefits resulting from an effective framework for system development based on the experiences of HROs would likely include:

- Understanding the origins of factors that lead to comprehensive system failure.
- Learning how theoretically harmless anomalies can develop into significant threats.

- Learning to proactively identify and correct adverse symptoms early in the project rather than reacting to their future effects.
- Developing project management techniques that prevent the emergence of these project threats.
- Understanding the effects of organizational culture on individuals' motivations concerning his/her responsibilities to the organization.

With the proliferation of vastly complex ERP systems, organizations need to be aware that failing to follow effective system development practices can result in mortal financial injury for even the most affluent corporations. The ERP development industry has strongly suggested that organizations be open to modifying the way they do business in order to align themselves with industry best practices.

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Renovating Information Technology Infrastructure to Effectively Provide E-Services

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Abstract. Most times the provision of e-government services is dealt with independency of the legacy system itself. As more complex transactional services are provided to the public and the degree of on-line interaction between e-government service users (Internet) and legacy system users (Intranet) increases, the integration between e-service provision platform and existing legacy information system becomes a one-way direction. Although current technological trends as the J2EE architecture and web service platform promise the seamless integration of any type of system, this is not always true. In this paper we discuss the implications of such integration and the strategic decisions made regarding legacy system renovation.

1 Introduction

In order to take advantage of their assets, more and more governments take advantage of information and communication technologies (ICT) and the continuing expansion of the Web and started e-government strategies to renew the public sector and eliminate existing bureaucracy and therefore reduce costs [1, 2]. It is obvious that governments and governmental institutions are the most complicated organizations in the society providing the legal, political, and economic infrastructure to support the daily needs of citizens and businesses [3]. Majority of

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Internet users believe that their government is doing a good or excellent job developing online resources that allow them access to information and conduct online transactions with the government [4].

Markellou et al. [5] proposes that for the implementation and successful operation of e-government, the proper design, which will be the basis in order to receive a series of strategic, administrative and operational benefits, is necessary. The application of e-government in the public domain can be gradually performed in fourteen levels, easing the adjustment of the traditional governmental model to the electronic one. Depending on the maturity and the resources of each governmental authority, the authority is level categorised and the bottom levels may gradually be applied. This allows the unobstructed flow of information from/to the public sector and gives the possibility not only to the citizens but also to the businesses (private sector) to acquire better access in the services that state provides. The Hellenic Ministry of Economy and Finance and especially its General Secretariat of Information Systems (GSIS) has applied the fourteen levels approach [5] in order to provide e-services to citizens and businesses. In this paper, we discuss the case of reengineering existing legacy information systems in order to effectively support e-services. Problems rose from the operation of existing legacy and e-service platform are discussed. Subsequently, the new e-government portal characteristics are presented and the requirements and decisions made for renovating existing legacy system are presented.

2 Existing Legacy and E-Services Platforms

The organization supports more than 350 regional offices all over Greece. The current version of the legacy information system is based on the client-server model and is fully functional since the early nineties. All application logic is programmed within the client platform (heavy client – light server model), while data is distributed in "local" database servers located in each regional office. A Central database is supported in GSIS for data synchronization and lookup purposes. It also facilitates computation of statistics and data maintainability and security. The information system can be characterized as the legacy system of the organization, since no services can be provided without accessing it. Most data related to a specific citizen are maintained as local data in his/her regional office. Local data are asynchronously replicated in the central database using a transaction management system (TMS). The central database provides the overall view of each citizen's record. This three-layered hierarchical architecture is a typical one for client-server systems built in the nineties. Although it works efficiently, it has some drawbacks, since updating local data from another regional office or providing e-services through the Internet becomes a complicated task imposing restrictions. Client workstation support is also expensive since a large amount of software products must be installed/updated in each workstation. Thus, local support must be provided in all regional offices regardless of their size.

Current e-services imitate existing bureaucratic procedures and are based on an off-line policy. This means that although citizens initiate a request using an e-service available through the WWW, they still have no feedback about the progress of a case plus the uncertainly that creates the lack of a contact in person. The necessity to assure maximum data privacy, security and integrity in combination with the existing technology capabilities resulted in implementing them in an independent development platform and run-time environment. These services operate since the late nineties. The process of data exchange between the e-services platform and the internal legacy information system is carried out through manual procedures, using intermediate backup media or occasional short-time network links. The fore-described policy has a number of side effects. The most important is the frequent inconsistency between the two databases' data and the significant delays for the dispatch of certain procedures. Other side effect is the uncertainty that human interference causes.

3 E-Government Portal

GSIS provides a new e-services environment through an e-government portal. The main target of the portal is to minimize the need of citizens' presence in regional offices and intents to deal with all the drawbacks mentioned in the previous section. The intention for this new environment is to serve citizens so as to be able to carry out more than 90% of their common procedures, which take place at a regional office, through the Internet. The new system will be based on a uniform development and run-time environment based on the J2EE architecture. Application software is generated using open tools and solutions, like XML and Web services. The portal should facilitate on-line transactional services and ensure on-line access to the databases of the legacy information system. A number of issues are also dealt for the completeness of the new system. User certification and authorization, security, data integrity, confidentiality and other issues are under consideration and will be solved during the implementation of the system. The most significant characteristics of the new e-services that affect the existing legacy information system infrastructure are:

Single, real time registration and authentication. Since all services will be hosted at the same environment (application, web and data base servers) it is easy to ensure common registration and authentication procedures.

Provision of most of the services offered in local branches. The idea behind this vision is to offer citizens and businesses the ability to carry out their common obligations and claims for a case percentage more than 90%. That means that regional offices will receive fewer citizens in person and only for special and non-standardized cases.

Enhanced security. A present open issue-challenge is security assurance through the Internet.

Improved Response Time. All e-services are expected to have a quick response time to the end user. That means that all back office processes and internal communication must be optimized. Exception for this demand is network transfer time because of its dependence to the user's connection type with the Internet.

Added-Value Services. The new generation of an environment, like the one we are discussing here, couldn't continue adopting the existing approach by just imitating standard bureaucratic procedures. It is time for it to offer added-value services, upgrading the relationship of citizens with government and, in our case, with the financial authorities.

Powerful User Support. The referring variety of target groups for the new e-services platform signifies the variety of regarding user knowledge about the use of a personal computer and/or the utilization of the Internet. In order to support a significant number of users with limited IT skills, the responsible authority has to organize an efficient support mechanism for them.

Interoperability. It is crucial for the implementation of one-stop points-of-service that make it easy for citizens to access high-quality government services.

Internal Connectivity. In order to achieve the fore mentioned requirements - characteristics, the new e-services portal must communicate with the existing legacy information system in a more frequently basis supported by enhanced security mechanisms. The ultimate scope is to implement a real time communication and synchronization between the two systems, even to integrate them into one single system, addressed to both internal and external (Internet) users.

4 Renovating Legacy Information System

The current version of the legacy information system is based on a distributed client-server model, where database servers are maintained in all regional offices and a central database is supported in GSIS for data synchronization and lookup purposes. After ten years of successful operation, GSIS obtained funding for hardware replacement of existing hardware platforms. In the following, we discuss the requirements impose the renovation of the legacy information system, the decisions made and benefits and drawbacks of the solutions adopted.

The current version of the legacy information system was built having in mind the fact that most citizens expected to be serviced in their local regional office. In an attempt to simplify procedures and minimize bureaucracy, it was decided to encourage citizens to ask for services in any regional office regardless of their local office. Thus, database synchronization becomes far more complicated and should be performed on-line.

The central e-government portal facilitates e-services to citizens allowing them to complete most common transactions (more than 90%) without visiting any office. The Web Service interface facilitates other public organizations to safely access the system. Thus, the number of citizens visiting local offices to complete their cases is decreasing and, thus, the usage of the legacy information system. It is expected that the number of citizens visiting regional offices will be decreased 30% within the first year of the portal's operation. Furthermore, in order to provide on-line transactional services, the portal should obtain secure access to the legacy system databases. This can be accomplished by interacting with Central Database, since both are hosted in the Data Center of GSIS. Thus, on-line bi-directional synchronization of local and central databases on the legacy system is a hard constraint in order to ensure consistency.

In order to effectively support both systems (e.g. the portal and the legacy system), GSIS should be able to apply the same policies and minimize maintenance cost. Thus, the following factors should be considered:

Unify the infrastructure supporting both systems
Obtain a central administration policy and minimize administration cost
Minimize training cost to support both systems

GSIS decided to explore redesigning the architecture of the legacy information system by adopting modern technological treads as server-based computing and light clients. It was decided to explore whether the already obtained funding for hardware replacement and application maintenance could be used for this purpose.

One of the major dilemmas faced was whether applications should be rewritten to facilitate a web interface to end-users or whether a remote program execution platform (e.g. CITRIX [6]) should be used to execute existing applications. Furthermore, GSIS should maintain two different development environments (a J2EE-based one for the portal and the existing form-based one) for the same system. Both portal and legacy system support almost the same functionality, since the portal supports about 80% of the transactions supported by the legacy system. The cost of maintaining such applications proved to be less than the one for existing form-based environment. Although the "actual" code implementing portal e-services could not be used to replace existing legacy applications, unifying the development environment for both systems promotes code reusability and simplifies code maintenance.

The following decisions were reached:

1. Replace distributed databases of residential offices with a central one hosted in the Data Center of GSIS.
2. Support server-based computing and benefit from the fact that all server equipment is consolidated in the Data Center.
3. Rewrite most applications of the legacy information system to facilitate a web interface based on J2EE architecture.

The cost of rewriting legacy application code and maintaining the system for one year proved to be the same as the cost of maintaining existing applications for three years. This cost includes basic existing application maintenance with no additional application development. GSIS decided to adopt this policy and freeze the functionality of existing legacy applications for two years. It should be noted that only the user interface part of applications is rewritten. The cost of purchasing hardware to implement a central solution proved to be 20% less than local server replacement cost. Thus, it was decided to maintain existing servers of two more years and also initiate procedures for obtaining new hardware. It is estimated that hardware maintenance cost will be decreased, although not considerably.

5 Conclusions

The provision of on-line transactional e-government services drastically affects underlying legacy information systems, since it imposes new functionally requirements to it. GSIS ensured funding for hardware replacement (server infrastructure supporting databases in regional offices and the central database) and applications maintenance for the existing legacy systems for two years. Exploiting the same funding, it was possible to redesign the system architecture and rewrite applications of the legacy information system to facilitate a web interface based on J2EE architecture.

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The Timeless Way of Building REA Enterprise Systems

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Abstract. In a continuously changing business environment, the need for more flexible enterprise systems has been recognized by many. Different solutions are being suggested to improve the adaptability of enterprise systems, including model-driven architectures and reflective systems. A model-driven architecture starts from an enterprise schema that formally defines the business activities of a company. This schema is then progressively transformed into more implementation-specific models until source code is generated [1, 2]. Changes in business practices are accommodated by enterprise schema updates that are then automatically propagated into software code. Reflective systems record enterprise schemas explicitly so that they can be manipulated at run time [3, 4]. A reflective system is more flexible since the definition of the enterprise schema and its integrity rules can be configured external to the execution of the program [5]. The expected benefits of reflective systems include improved adaptability, semantics, and reusability. On the other hand, their design is substantially more complex, and the execution of applications built with such systems is slower since the definition of the enterprise schema needs to be interpreted. A timeless REA enterprise system integrates ontological specifications as part of its reflective architecture. The Resource-Event-Agent (REA) enterprise ontology [6, 7] is strongly rooted in accounting and economic theory and addresses the issue of what phenomena should be captured in an enterprise system. In addition, it provides structuring guidelines on how economic phenomena should be assembled into business process and value chain specifications [8]. This paper explores the reflective architecture, design, and operation of timeless REA enterprise systems. We first describe the integration of ontological specifications as part of reflective enterprise systems. Next, we use claim management and cost calculation examples to illustrate how the ontological specifications can be employed for the design of reusable, ontology-driven applications.

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Development of Enterprise Information System Using Business Component-Based Approach

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Abstract. Facing the great challenges from various changes, the traditional enterprise information system is becoming obsolescent. The timely response to market changes has become the competitive advantage. In this paper, business component-based development of modern enterprise information system is studied. Based on the business component and its technology, business component-based software development process is proposed. A clustering algorithm is used to identify the business components from requirement model and a rules library is used to assemble the business components to a business application. Component-based hierarchy architecture of enterprise information system is established, which are software infrastructure layer, middleware container layer, business entity layer, business process layer and application interface layer. The business component-based enterprise information system has the rapid reconfigurability, reusability and extensibility to adapt itself to the changes of business environment.

1 Introduction

In the 21^{st} century, enterprise confronts the great challenges from unprecedented and abrupt changes, including economic globalization, saturated market and rapid IT progress. Under the pressure of market competition, the timely response to market changes becomes the competitive advantage [1]. The enterprise information system

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must have the characters of rapid reconfigurability, reusability and extensibility to adapt itself to the changes of business environment.

The object-oriented technology is primarily adopted in the development of enterprise information system [2, 3]. However, the enterprise information system based on O-O technology needs to open the source code of reusable object to system developer, which belongs to the white-box mechanism [4]. In order to reach the black-box reuse, business component-based approach is proposed and currently used in enterprise information system [4, 5]. Such technology hides the implementation process of function, and only provides interface publicly to implement the development and reconfiguration of system. With the integration, dynamic and reconfigurability, business component-based development approach has been the popular approach to software development [6].

The aim of this paper is to develop the enterprise information system using business component-based approach. Section 2 introduces the concept and characteristic of business component technology. Section 3 describes the business component-based development approach and its two main stages: business component identification and business component assembly. Section 4 uses business component-based approach to develop enterprise information system and the component-based hierarchy architecture of enterprise information system is established. Section 5 summarizes this paper and draws conclusions.

2 Business Component and Business Component Technology

2.1 Business Component

A software component is defined as the independently developed and deployed software unit having well-defined interfaces to perform specific functions [7]. A business component represents a software implementation of an autonomous business concept or business process. It is composed of all software components necessary to express, implement, and deploy a business component as an autonomous, reusable element of an information system [8].

The business components are the autonomous, independent and large granularity software units and easy to assemble into business application to implement the real world business concepts [7]. Furthermore, the business components can be reused in the same or similar domains. They export functionality to their environment and may also import functionality from their environment through well-defined interfaces.

Business components vary from traditional reusable software artifacts, such as code segments and objects [9]. In the granularity level, the traditional reusable artifacts are the low-level technical-oriented representation of the domain, while components are intended to provide a high-level business-oriented representation of the domain. Moreover, a component is a self-contained executable program to provide a specific service and has an interface to communicate with other components.

2.2 Business Component Technology

Business component technology is the new progress of component technology. It has four primary characteristics [10]:

(1) Advancing the industrialization of software production

Business component technology provides the theory and the technology for the industrialization of software production.

(2) Saving the time and cost of software development

Using business component technology, the software development stages are completed in parallel way with high efficiency.

(3) Minimizing the gap between the business and the technology

The business component is a combination of business object and component. It is convenient for the smooth transition from business architecture to technology architecture.

(4) Supporting the rapid reconfiguration of information system

Business components are assembled into the full-scale business application. By means of plug & play, business components can be reconfigured as the business changes happen.

3 Business Component-Based Development Approach

3.1 Component-Based Software Development Process

Component-based software development (CBSD) is an emerging paradigm of software development [6]. Component-based development approach is thought to be the latest outcome to tackle software crisis [11]. It advocates an approach that the designer can identify the components that satisfy their business requirements from business components and assemble them into full-scale business applications [6].

As shown in Fig. 1, component-based software development process consists of two main stages: component fabrication (building the business components) and application assembly (building a business application from components) [9].

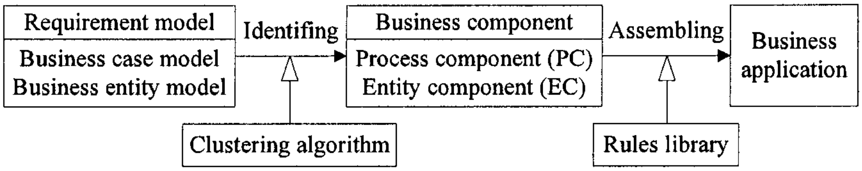


Fig. 1. Component-based software development process

3.2 Business Component Identification Using Clustering Algorithm

The component fabrication stage of CBSD consists of various phases. Business component identification is recognized as one of the greatest important phase of component fabrication stage [9]. Here, a clustering algorithm is used for identifying the components from a requirement model, which has been done using an object-oriented approach UML.

The unified modeling language (UML) is a visual and graphical modeling language. It can analyze and design the object-oriented system. The requirement model based on UML consists of business case model and business entity model. The core contents are business cases and business entities [11]. The goal of business component identification is to determine the high cohesive and low coupling business components from business cases and business entities of requirement model.

The clustering algorithm is a new multivariate statistical analysis method. It groups the data objects into the different clusters. The data objects of the same cluster have high similarity while the data objects of the different cluster have distinct difference. The cluster algorithm is described as follows [11, 12]:

(1) Denoting all the samples as a set, $X = \{x_i \mid i = 1, 2, \ldots, n\}$. Where n is the number of samples.

(2) Determining the computational methods of R_{ij}, which denotes the relationship strength of the samples x_i and x_j.

(3) Computing the value of samples' relationship R_{ij} and establishing the relationship matrix D.

(4) Selecting appropriately a minimal value of samples' relationship R_{min} as a criterion to execute the clustering process. If $R_{ij} \geq R_{min}$, group the samples x_i and x_j into the same cluster. If the samples x_i and x_j belong to the same cluster and the samples x_i and x_k belong to the same cluster, group the samples x_i, x_j and x_k into the same cluster.

The requirement model based on UML is taken as the data source of clustering algorithm samples, and all the samples grouped into the same cluster can be transform a business component.

UML use case diagram and activity diagram are used to describe the business case model. The business components identified from business case model are called the process components (PC), which are the encapsulation of business process and business rule [11]. The business cases are recognized as the samples set. Three relationships may exist between two business cases. These are include, extend and generalization. If there is no relationship between the business cases x_i and x_j, R_{ij}=0.

UML class diagrams are used to describe the business entity model. The business components identified from business entity model are called the entity components (EC), which are the encapsulation of business entity and business rule [11]. For computing the value of relationships between classes, static and dynamic relationships are used. Static relationships are computed based on the associations between classes and the dynamic relationships are computed based on use cases diagram.

The value of the static relationship RS_{ij} between classes x_i and x_j be defined as follows [9, 11, and 13]:

$$RS_{ij} = \sum_{y \in Y} (U_{yi} \cdot U_{yj} \cdot W_y) \qquad (1)$$

Where Y is the relationship set of business entities. U_{yi} and U_{yj} are Boolean variables. If the relationship y contains classes x_i and x_j, $U_{yi} = 1$ and $U_{yj} = 1$. W_y is the static association weight and has the different values according to the different relationship.

The value of the dynamic relationship RD_{ij} between classes x_i and x_j be defined as follows [9, 11, and 13]:

$$RD_{ij} = \sum_{z \in Z} (V_{zi} \cdot V_{zj} \cdot W_z) \qquad (2)$$

Where Z is the set of use cases. V_{zi} and V_{zj} are Boolean variables. If the use case z uses classes x_i and x_j, $V_{zi} = 1$ and $V_{zj} = 1$. W_z is the weight of the use case z, which is based on the criticality, frequency or any other considerations.

The total value of relationships between two classes is computed as follows [9, 11]:

$$R_{ij} = RI_s \cdot RS_{ij} + RI_d \cdot RD_{ij} \qquad (3)$$

Where RI is the importance to static and dynamic relationships and $RI_s + RI_d = 1$.

3.3 Business Component Assembly Based on Rules Library

Application assembly is the second stage of CBSD. It is to build a business application from business components, which are identified from a requirement model using a clustering algorithm. In the domain engineering, business components are organized to implement the realistic business process based on rules in the domain rule library [10, 14].

Business process can be represented formally as follows [10, 15]:

BP = {Name, Business component, Rule}

Where Name is the business process's name, Business component = (Name, Function, Code, Input, Output), and Rule = (Rule name, Key-point, Algorithm).

Key-points are the business components that are determinative to the execution of business process. Business component is triggered by key-point of the business process and organized by algorithm to build the realistic business process.

In the business component assembly based on rules library, the algorithm is defined by the associated set between the business components as follows [10, 15]:

$\Omega = \{\rightarrow, \wedge, \vee\}$

Where "$\rightarrow$" is sequential relationship, "$\wedge$" is parallel relationship and "$\vee$" is choice relationship. As shown in Table 1, the associated operations, such as And-split, And-join, Or-split and Or-join, can be described with the above three relationships.

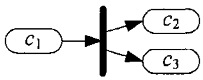
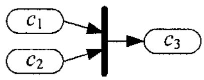
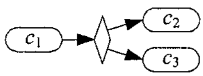
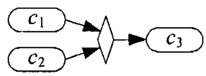
And-split: $c_1 \rightarrow (c_2 \wedge c_3)$

And-join: $(c_1 \wedge c_2) \rightarrow c_3$

Or-split: $c_1 \rightarrow (c_2 \vee c_3)$

Or-join: $(c_1 \vee c_2) \rightarrow c_3$

Table 1. Associated Operations of Business Components

And-split	And-join	Or-split	Or-join
			

Business rules are described in ECA (Event-Condition-Action) mechanism. The event is the reason of action, condition is the constraint of action, and action is an execution process of operation. Universally, business rules can be described as follows [15]:

rule <rule name> [(<parameter>, ...)]

when <event expression>

if <condition i> then <action i>

end-rule [(rule name)]

Rule library consists of meta-data set and rule set [10]. Meta-data set describes rule name, meaning, origin, format, purpose and so on. It provides the method of rule access and search. Rule set is a set of domain business rules to describe the content of rules. It consists of business key-point set and algorithm set. Key-point set is a sequential list set of business key-point in business process. Algorithm set is a sequential list set of operator corresponding key-point. As shown in Fig. 2, while the management-scheduling center calls a rule, a key-point list and corresponding several operators are called simultaneously [10, 15].

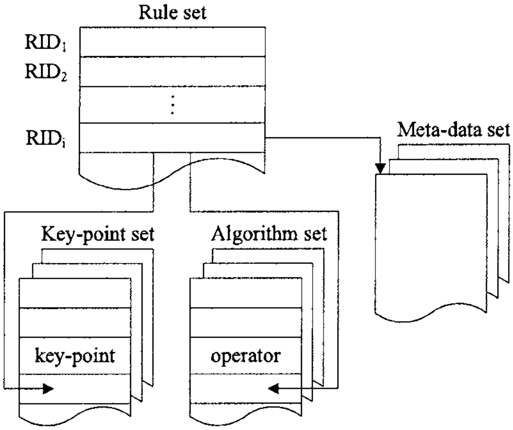


Fig. 2. Business rules library

4 Business Component-Based Development of Enterprise Information System

Development of enterprise information system is to build a business application using business component-based approach. The architecture is a crucial product in software development and can provide guidelines and supports for business components design, including identification and assembly. It is also the center of the component-based software development [10].

At present, hierarchy architecture is one of the universal architectures of enterprise information system. It places the different characteristics of system into the different layers of architecture and each layer provides a service to the layer above and serves as a client to the layer below [16]. Based on the existing references [10, 11, and 16], component-based hierarchy architecture of enterprise information system has five layers from bottom to up, which are software infrastructure layer, middleware container layer, business entity layer, business process layer and application interface layer, as shown in Fig. 3.

The software infrastructure layer consists of operating system (OS), data base management system (DBMS) and network and provides a basic environment on which the while information system runs. The middleware container layer offers a software-bus mechanism and the business components can plug onto the software-bus to realize plug & play. The business entity layer contains the entity components (EC), which are the encapsulation of business entity and business rule. The business process layer contains the process components (PC), which are the encapsulation of business process and business rule. The application interface layer contains the interface components to meet user interface requirement and trigger business event of business process. The various enterprise information systems can be developed and reconfigured on the basis of the above component-based hierarchy architecture.

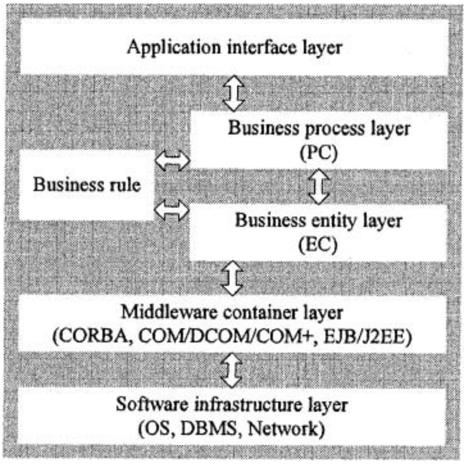


Fig. 3. Component-based hierarchy architecture of enterprise information system

5 Conclusions

In order to meet the requirement of business environment changes, enterprise information system must have the characteristics of reconfigurability, reusability and extensibility. In this paper, business component-based approach is used to develop enterprise information system. The business component-based software development process contains two main stages: component fabrication and application assembly. The former is to build the business components using a clustering algorithm and the latter is to build a business application from components using a rules library. The component-based hierarchy architecture is established for development of enterprise information system. With the rapid development and maturation of the standard of middleware such as CORBA, DCOM and EJB, business component-based software development will have been widely applied to develop the reconfigurable enterprise information system.

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Reconfiguring Business Process for Enterprise Information System Based on UML and Polychromatic Sets

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Abstract. Reconfigurability is one of the intelligent characteristics of enterprise information system. It is also a key factor that influences an enterprise to response to market changes and wins a global competition. In this paper, business process reconfiguration for enterprise information system is studied to support the rapid changes in business environment. Firstly, UML and polychromatic sets are united based on their advantages and disadvantages, and a business process reconfiguration method is proposed. Secondly, the main contents of business process reconfiguration for enterprise information system are detailed, which includes the model of business process based on UML, the translation from UML activity diagram to PS contour matrix model, the analysis and reconfiguration of business process and the implement of information system. Finally, an enterprise information subsystem of spare parts requisition is provided for application and validation of the proposed method.

1 Introduction

Under the environment of economic globalization, modern enterprises face the various changes from themselves and outside. In order to win the competition, enterprises must have ability to reconfigure their business process to adapt themselves to such changes [1]. However, traditional enterprise information systems are developed according to the special industries, special market environments, and special business process [2]. If the customer requirement and business process happen to change drastically, the quondam information system doesn't work

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normally. Therefore, enterprise information system that supports business process and business rule must have the reconfigurability to response to market changes [3].

In 1993, Hammer and Champy first proposed the concept of business process reengineering (BPR). They defined business process reengineering as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance such as costs, quality, speed, and service [4]. Business process reconfiguration is regarded as a revolution of development of enterprise information system and can reduce the cost and improve efficiency remarkably [5].

There are many business process reconfiguration methods for enterprise information system, such as Petri net, UML and IDEF [6-9]. Each method has its own advantages and disadvantages. Generally speaking, these methods can be classified into two types: the formal method and the graphical method. The formal method is precise and its model is easy to realize in computer language. But it is difficult to understand and read for non-specialists. The graphical method is explicit and its model facilitates the description of business process. A wide range of software packages and tools support the development of graphical model. However, the graphical method lacks of accuracy and preciseness.

Enterprise business process is highly dynamic and distributed. A formal but easy-to-understand method is needed for reconfiguring business process for enterprise information system. In this paper, we present a business process reconfiguration method based on UML and polychromatic sets (PS) theory. For non-specialists, this integrated method is the graphical representation and easy to understand and popularize. Moreover, it has the firm mathematical foundation and the abundance of analysis methods.

2 Business process reconfiguration method

The key idea of polychromatic sets theory is to utilize standardized mathematical model to simulate different objects, such as product, design process, manufacturing process and manufacturing systems [10-13]. Polychromatic sets theory has the significant progress and advantage in problem formalization [11]. However, if polychromatic sets theory is used directly to model the real system, the application developer must have profound field knowledge.

Unified modeling language (UML) is universally acknowledged as an international standard in the software industry and convenient for transition from UML model to program coding (such as Java and C++) [14]. Yet, UML is not a formal modeling language. It suffers from a lack of precise syntax and semantics [15]. The model defined by UML is lack of the rigorous, effective verification and analysis. The model cannot be simulated until it is realized, and its modification and improvement are difficult to accomplish.

Based on their advantages and disadvantages, we propose a new business process reconfiguration method, which unites UML and polychromatic sets theory and has a well-defined mathematical foundation and an easy-to-understand graphical feature. As shown in Fig. 1, the business process reconfiguration method contains four primary steps as follows:

Step 1. The visual modeling stage based on UML. According to the business requirements, basic model primitives and basic model constructs of UML activity diagram are used to describe and design the business process and UML activity diagram model is established.

Step 2. The mapping stage from UML activity diagram to PS contour matrix. The goal of transformation UML activity diagram model into PS contour matrix model is to analyze and modifying the UML activity diagram model.

Step 3. The analyzing and reconfiguring stage based on PS. With the rigorous mathematics foundation, polychromatic sets theory has power to analyze and reconfigure the business process formally. UML activity diagram model is modified and improved on the basis of analysis results.

Step 4. The implementing stage in computer programming language. The modified UML activity diagram model is implemented in Java or C++ and the information system is developed.

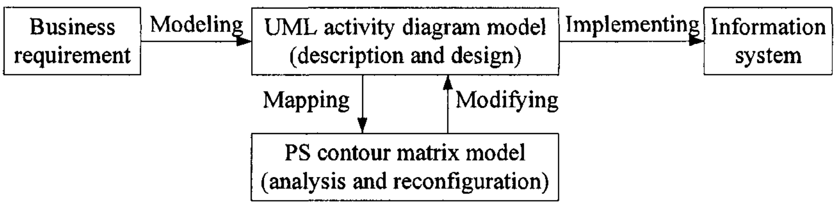


Fig. 1. Business process reconfiguration method

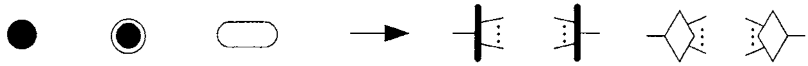
3 Business Process Reconfiguration for Enterprise Information System

3.1 Model of Business Process Based on UML

Unified modeling language (UML) is not limited to software development. Some of UML views can be used in enterprise modeling, business engineering, and process analysis and system configuration [16]. UML activity diagram can be applied in business process reconfiguration for enterprise information system. It has powerful capability to describe the activity execution sequences of business process and express the basic model constructs: sequence, parallel, choice and iteration.

Table 1. Basic Model Primitives of UML Activity Diagram

Nodes			Interrelations				
Start node	End node	Activity node	Link arc	And-split	And-join	Or-split	Or-join



3.1.1 Basic Model Primitives

UML activity diagram has two kinds of basic model primitives, as shown in Table 1.

(1) Nodes: start node, end node and activity node.

(2) Interrelations: link arc, and-split, and-join, or-split, and or-join.

3.1.2 Basic Model Constructs

The above basic model primitives of UML activity diagram can constitute four basic model constructs, as shown in Table 2. The basic model primitives and basic model constructs of UML activity diagram can constitute any complicated business process model.

3.2 Translation from UML to Polychromatic Sets

In UML activity diagram, basic model primitives are nodes and interrelations. The combinations of any two nodes (a_i, a_j) are recognized as the elements of PS and the interrelations between the any two nodes $F_k(a_i, a_j)$ are recognized as the contour of PS. The PS contour matrix model $[(A\times A)\times F(A)]$ is established as shown in Fig. 2. Where, $a_i, a_j \in A$. $(A\times A)$ is Cartesian product of the nodes set A and itself. $F(A) = (F_1, F_2, F_3, F_4, F_5)$ are all possible interrelations between the any two nodes. These are link arc, and-split, and-join, or-split and or-join.

	F_1	F_2	F_3	F_4	F_5
(a_1, a_2)	1				
…		1			
(a_1, a_n)					
…					1
(a_i, a_{i+1})	1				
…				1	
(a_i, a_j)			1		
…					
(a_i, a_n)		1			
…					
(a_{n-1}, a_n)				1	

Fig. 2. PS contour matrix model

3.2.1 Interrelations Rules

(1) If $F(a_i, a_j) = 1$, the interrelation exists between the node a_i and the node a_j.
(2) If $F_1(a_i, a_j) = 1$, the interrelation of the node a_i and the node a_j is link arc.
(3) If $F_2(a_i, a_j) = 1$, the interrelation of the node a_i and the node a_j is and-split.
(4) If $F_3(a_i, a_j) = 1$, the interrelation of the node a_i and the node a_j is and-join.
(5) If $F_4(a_i, a_j) = 1$, the interrelation of the node a_i and the node a_j is or-split.
(6) If $F_5(a_i, a_j) = 1$, the interrelation of the node a_i and the node a_j is or-join.

3.2.2 Constructs Rules

(1) If $F_1(a_i, a_j) = 1$, the node a_i and the node a_j constitute sequential construct.

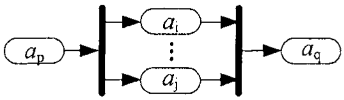
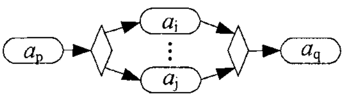
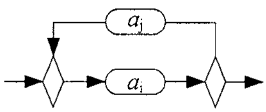
(2) If $F_2(a_p, a_i) \wedge F_3(a_i, a_q) \wedge F_2(a_p, a_j) \wedge F_3(a_j, a_q) = 1$, the node a_i and the node a_j constitute parallel construct.

(3) If $F_4(a_p, a_i) \wedge F_5(a_i, a_q) \wedge F_4(a_p, a_j) \wedge F_5(a_j, a_q) = 1$, the node a_i and the node a_j constitute choice construct.

(4) If $F_4(a_i, a_j) \wedge F_5(a_j, a_i) = 1$, the node a_i and the node a_j constitute iterative construct.

Table 2 shows four basic model constructs of UML activity diagram and their PS contour matrix modes.

Table 2. Basic Model Constructs and Their PS Contour Matrix Models

Basic model constructs	UML activity diagram	PS contour matrix
Sequential construct		$\begin{array}{c\|ccccc} & F_1 & F_2 & F_3 & F_4 & F_5 \\ \hline (a_i, a_j) & 1 & & & & \end{array}$
Parallel construct		$\begin{array}{c\|ccccc} & F_1 & F_2 & F_3 & F_4 & F_5 \\ \hline (a_p, a_i) & & 1 & & & \\ (a_i, a_q) & & & 1 & & \\ (a_p, a_j) & & 1 & & & \\ (a_j, a_q) & & & 1 & & \end{array}$
Choice construct		$\begin{array}{c\|ccccc} & F_1 & F_2 & F_3 & F_4 & F_5 \\ \hline (a_p, a_i) & & & & 1 & \\ (a_i, a_q) & & & & & 1 \\ (a_p, a_j) & & & & 1 & \\ (a_j, a_q) & & & & & 1 \end{array}$
Iterative construct		$\begin{array}{c\|ccccc} & F_1 & F_2 & F_3 & F_4 & F_5 \\ \hline (a_i, a_j) & & & & 1 & \\ (a_j, a_i) & & & & & 1 \end{array}$

3.3 Analysis and Reconfiguration of Business Process

PS contour matrix model not only describes whether the interrelation exists in any two nodes of UML activity diagram, but also represents concrete kind of interrelation existing in any connected two nodes. Further, PS contour matrix can be extended without limit to describe any complex business process. With PS theory operational ability and existing algorithm, the business process model can be analyzed and reconfigured formally. Fig. 3 shows the path-searching algorithm of business process mode. Using this algorithm, all possible activity paths can be found out and the business process can be analyzed, improved and reconfigured.

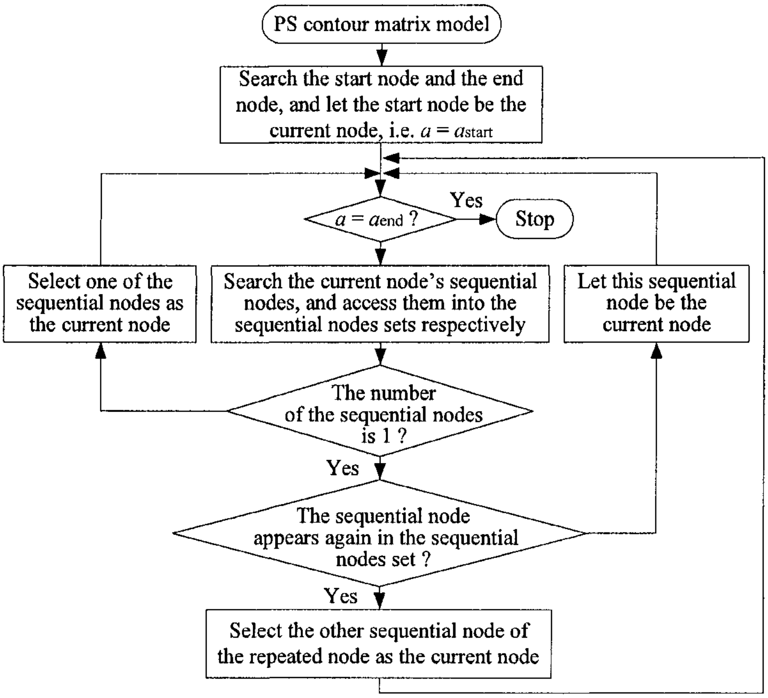


Fig. 3. Path searching algorithm of business process model

4 A Case Study

An enterprise information subsystem of spare parts requisition is used to illustrate the effectiveness of the proposed method [17]. Fig. 4 shows UML activity diagram of the spare parts requisition. The meanings of the activities codes are shown in Table 3.

Table 3. Meanings of the Activity Codes

Activity a_i	Meanings of activities	Activity a_i	Meanings of activities
a_1	The start node	a_7	Inquiring market information
a_2	Filling in requisition	a_8	Virtual node
a_3	Examining requisition	a_9	Approving requisition
a_4	Virtual node	a_{10}	Creating purchase document
a_5	Filling in specific requisition	a_{11}	The end node
a_6	Collecting requisitions		

(1) According to the interrelations rules and constructs rules, UML activity diagram is mapped into PS contour matrix model, as shown in Fig. 5.

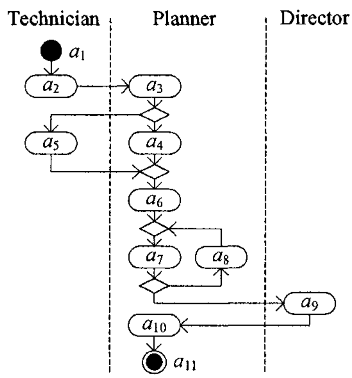


Fig. 4. UML activity diagram model

	F_1	F_2	F_3	F_4	F_5
(a_1, a_2)	1				
(a_2, a_3)	1				
(a_3, a_4)				1	
(a_3, a_5)				1	
(a_4, a_6)					1
(a_5, a_6)					1
(a_6, a_7)					1
(a_7, a_8)				1	
(a_7, a_9)				1	
(a_8, a_7)					1
(a_9, a_{10})	1				
(a_{10}, a_{11})	1				

Fig. 5. Corresponding PS contour matrix mode

(2) Using the path-searching algorithm of business process mode, four activity paths are found out as follows:

$P_1=\{a_1, a_2, a_3, a_4, a_6, a_7, a_9, a_{10}, a_{11}\}$;

$P_2=\{a_1, a_2, a_3, a_5, a_6, a_7, a_9, a_{10}, a_{11}\}$;

$P_3=\{a_1, a_2, a_3, a_4, a_6, a_7, a_8, a_7, a_9, a_{10}, a_{11}\}$;

$P_4=\{a_1, a_2, a_3, a_5, a_6, a_7, a_8, a_7, a_9, a_{10}, a_{11}\}$.

(3) Determination of the time consuming of all activities, the execution probability of the split link and the time consuming of all activity paths as shown in Table 4.

Table 4. Computing Results of Parameters

Activity a_i	Time consuming t_i	Interrelation $F_k(a_i, a_j)$	Execution probability m_{ij}	Path P_v	Anticipant time consuming T_v	Anticipant execution probability p_v
a_1	0					
a_2	10	$F_4(a_3, a_4)$	0.9	P_1	56	0.27
a_3	10					
a_4	0					
a_5	5	$F_4(a_3, a_5)$	0.1	P_2	61	0.03
a_6	16					
a_7	8					
a_8	0	$F_4(a_7, a_8)$	0.7	P_3	64	0.63
a_9	4					
a_{10}	8	$F_4(a_7, a_9)$	0.3	P_4	69	0.07
a_{11}	0					

The anticipant time consuming of business process is computed as follows:

$$Z_1 = \sum_{v=1}^{4} T_v p_v = (56\times0.27+61\times0.03+64\times0.63+69\times0.07) = 62.1$$

(4) Analysis of the business process and identification of improvement opportunities.

In Fig. 4 and Fig. 5, the planner needs to enquire market information repeatedly, until the parts parameters meet the technician's requirements. The computer suggests that the operator should reconfigure the process. The market information of parts is classified into two kinds of catalogues, namely the generic parts catalogue and the specific parts catalogue. The technician enquires directly the parts catalogue accessed in database. This reconfiguration avoids the negotiations between the planner and the technician.

(5) Modification of the UML activity diagram model and repetition of the procedure from (1) to (3).

Fig. 6 and Fig. 7 show UML activity diagram model after modifying and its PS contour matrix model. In Fig. 6, the meanings of the activities codes are shown in Table 5.

Table 5. Meanings of the Activity Codes after BPR

Activity a_i	Meanings of activities	Activity a_i	Meanings of activities
a_1	The start node	a_5	Approving requisition
a_2	Filling in generic requisition	a_6	Creating purchase document
a_3	Filling in specific requisition	a_7	The end node
a_4	Collecting requisitions		

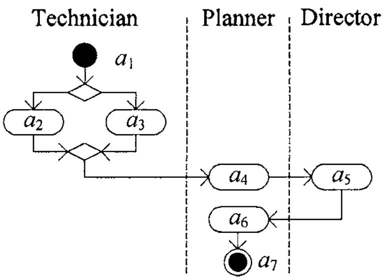


Fig. 6. UML activity diagram model after BPR

	F_1	F_2	F_3	F_4	F_5
(a_1, a_2)				1	
(a_1, a_3)				1	
(a_2, a_4)					1
(a_3, a_4)					1
(a_4, a_5)	1				
(a_5, a_6)	1				
(a_6, a_7)	1				

Fig. 7. PS contour matrix model after BPR

Using the path-searching algorithm of business process mode, two activity paths are found out as follows:

$P_1=\{a_1, a_2, a_4, a_5, a_6, a_7\}$, $P_2=\{a_1, a_3, a_4, a_5, a_6, a_7\}$.

The time consuming of all activities, the execution probability of the split link and the time consuming of all activity paths are determined as shown in Table 6.

Table 6. Computing Results of Parameters after BPR

Activity a_i	Time consuming t_i	Interrelation $F_k(a_i, a_j)$	Execution probability m_{ij}	Path P_v	Anticipant time consuming T_v	Anticipant execution probability p_v
a_1	0					
a_2	10	$F_4(a_1, a_2)$	0.9	P_1	32	0.9
a_3	5					
a_4	10					
a_5	4	$F_4(a_1, a_3)$	0.1	P_2	27	0.1
a_6	8					
a_7	0					

The anticipant time consuming of business process after modifying is computed as follows:

$$Z_2 = \sum_{v=1}^{2} T_v p_v = (32\times0.9+27\times0.11) = 31.5$$

We can see that there is no activity loop in the new business process of spare parts requisition and that the anticipant time consuming of the business process is reduced from 62.1 to 31.5.

5 Conclusions

Reconfigurability is one of the intelligent characteristics of enterprise information system. In the paper, a new business process reconfiguration method for enterprise information system is proposed. It unites UML and polychromatic sets theory and has a well-defined mathematical foundation and an easy-to-understand graphical feature. Using the proposed method, business process is analyzed quantitatively and the key bottlenecks and improvement opportunities are identified to reconfigure the business process for enterprise information system. An enterprise information subsystem of spare parts requisition is used to illustrate the effectiveness of the proposed method. Results show that business process reconfiguration can reduce the cost and improve efficiency remarkably and enterprise information system is reconfigurable enough to rapid changes.

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Extending the Enterprise: An Evaluation of ERP and EAI Technologies within a Case Study Organisation

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Abstract. It is widely understood that both Information Technology (IT) and Information Systems (IS), provide great benefits in improving the visibility of supply and value chains within and across organisational boundaries. Those enterprises which can realise the benefits of extending their core business processes outwards to clients and trading partners, will be able to create unique supply chain-dependent products and solutions. Thus, such business infrastructures have enabled organisations to expand and improve the effectiveness of their enterprise. One method to achieve this, has been to integrate Enterprise Resource Planning (ERP) systems with web-based and other IS systems, using Enterprise Application Integration (EAI) technologies. This paper seeks to investigate those factors which contributed to a case organisation's extended enterprise experiences, by using extant ERP and EAI implementation IS evaluation criteria; and by placing the research results within the context of applicable IS research techniques in the area.

1 Introduction

Much of the benefits attributed towards adopting Information Technology (IT) and Information Systems (IS), centre on the ability to speed up decision-making, improve process productivity and efficiencies and increase the level of control available to management. The joint effects of market globalization and competition that is ever more sophisticated is urging producers, distributors and vendors to integrate their operations, in order to maintain competitive advantage. Companies that are successful with Supply Chain Management (SCM) increasingly have to compete on their ability to work rapidly with customers and trading partners (Boyson *et al.* [1]);

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as we; as optimizing the interface between IT/IS and humans (Willcocks and Sykes [2]), in order extend the reach of the organization towards becoming a "Digital Enterprise" (Tapscott *et al.* [3])

This paper seeks to assess and analyse how technological and organisational factors occur within the context of an extended enterprise context. By using data from a case study organisation, the authors focus on both system as well as process behaviours. As is well known and understood within the qualitative information systems research community, the application of a case study context provides the researcher with access to a protocol and coding methods which allow feature-rich behavioural, organisational and process-related data to be harnessed and gathered (Orlikowski and Baroudi [4], Walsham [5] and Yin [6]). By assessing the case organisation's attempts at implementing an extended enterprise approach, the authors seek identify key factors for carrying out research in this area of MIS.

2 Research Approach

The rationale behind this research was to investigate and highlight those technological and organisational aspects of implementing an extended enterprise, by carrying out a case study analysis on an organization embarking upon such a project. The authors now define the research approach employed in terms of the background, data and focal theory relating to the topic.

2.1 Background Theory: the Extended Enterprise

The concept of an extended enterprise is congruent with the idea of a Virtual Organisation. As such, the underlying notion is that of a business entity which exists as a so-called "borderless" form, having access to people, process and technological resources which may or may not be rooted in physical, i.e. geographical space (Goldman *et al.* [7]). Hence an extended enterprise can be said to comprise of three aspects: a set of extended business relationships across and between an organisation's customers and suppliers (Malone *et al.* [8]); a business ecosystem which belies a set of business processes (Tapscott *et al* [3]), which is underpinned by a networked supply chain, which require the integration of inter-organisational systems (IOS). Hence, the authors suggest that the fundamental components of extended enterprises rely heavily upon both Enterprise Resource Planning (ERP) and Enterprise Application Integration (EAI) technologies (Linthicum [9]).

Figure 1 shows a model of these facets. This highlights business-to-business / business-consumber (B2B / B2C) architectures, which provide communication and automation of business processes across and between enterprises (Daniel and Klimmis [10]); Digital Marketplaces (DMP) which are a collection of B2B vertical/horizontal supply chain intermediaries (Strader and Shaw [11]); and ERPII, which is an externalisation of an organisation's SCM, Customer Relationship Management (CRM) and ERP functionalities (Bakht [12]).

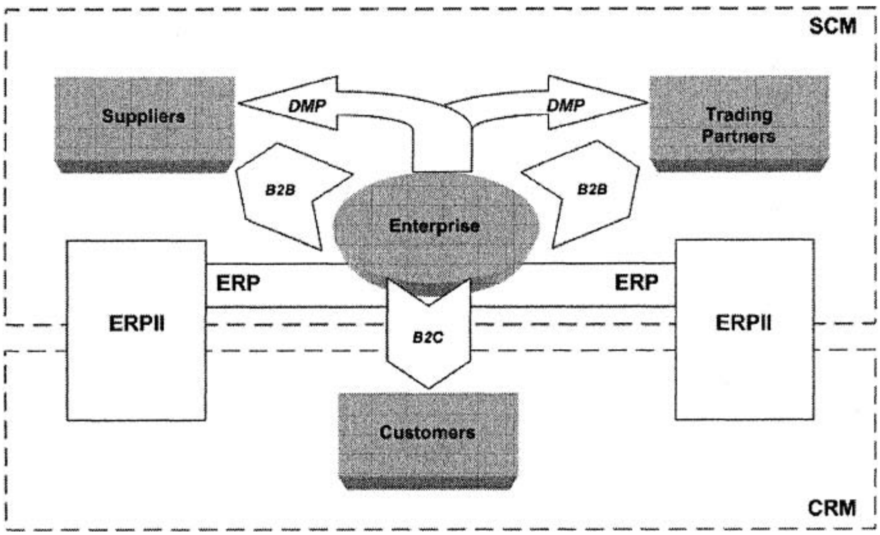

Fig.1 A model of Extended Enterprise components

2.2 Data Theory

The authors are primarily concerned with analyzing human factors in relation to organizational systems, in terms of an empirical case study approach, where the primary units of analysis will be via narrative discourse and discussion. The authors believe this can be achieved by applying a range of ERP and EAI evaluation criteria: 4 business-based (actor) models from the ERP literature (Akkermans and van Helden [13]; Dalal *et al.* [14]; Lee *et al.* [15]; Swanson [16]); and 7 technology-based (network) models from both the ERP and EAI literature (Al-Mudimighi *et al.* [17]; Brehm *et al.* [18]; Linthicum [9]; Parr and Shanks [19]; Schmidt [20]; Themistocleous *et al.* [21]; Themistocleous [22]). This is in the vein of the taxonomical approach to Information Systems Evaluation as defined by Irani and Love [23] and in the importance that should be given to identifying those emergent aspects of supply chain management as highlighted by Sherif *et al.* [24]. Hence, the research methodologies employed within the extant MIS literature on this subject, tend to focus on and support the integrative nature of the impact of technology upon people and processes. In so doing the authors seek to not only analyse the case company's experiences in the light of evaluative models but thenceforth compare and extract those details from the case company, which can aid the MIS researcher in investigating this field further. This will be achieved by a brief comparison of this data via the lens of organizational, socio-technical and systems theory components.

2.3 Focal Theory

The theoretical stance taken by the authors in this paper, is that of providing a view into the richness of the exogenous / endogenous relationship of humans and the systems they interact with. This is achieved through using a socio-technical lens, in the guise of the application of Actor-Network Theory (Tatnall and Gilding [25]). This is in order to relate the (albeit loose) network of heterogeneous sociological and technical actors within the given extended enterprise context. This context of social factors within the IS setting, is as favoured by and noted by Orlikowski and Baroudi [4], Lamb and Kling [26], and Nichols [27] – all who suggest using multiple modes of analysis within complex organizational settings. As Rose [28] notes, the advent of this particular lens allows for a more convenient operationalisation of the concept of Giddens' "structural agency" (Structuration), making the relationships between agents and the context within which they exist, based upon an interpretivist epistemology.

The underlying research method used is that of the case study type (Yin [6]) following an Empirical, Interpretivist philosophy (Klein and Myers, [29]). The data collection procedure followed all the major prescriptions within the literature for doing fieldwork research (Walsham [5]; Yin [6]; Fiedler [30]). This was applied within the overall context of the normative Information Systems Evaluation (ISE) literature, which suggests that the primary reason why organisations fail to realise benefits from their IT/IS investments lies with a lack of understanding with regards to the evaluation of human, organisational and technology perspectives (Irani and Love [23]). The authors sought to gather primary data (via a semi-structured interview and participant observation protocol) and secondary data (via organisational reports, memos and archived material). One on one interviews and discussions were conducted with the Chief Executive Officer (CEO), Chief Operating Officer (COO), Chief Technology Officer (CTO) and Chief Financial Officer (CFO), as well as two managers from the IS department. This interviewing technique was carried out in the manner of that proposed by Tan and Hunter [31], using 'probe' questions as suggested by Shaughnessy and Zechmeister [32]: i.e. an extended interview where responses were fed back to the interviewee, allowing for the resolution of research biases from the interviewer. Numerous secondary data sources were also used, such as internal reports, budget reports, archived documentation and filed accounts that were later transcribed. The findings are subsequently presented using a narrative mode of analysis, which has over the years become popular within the field of IS (Orlikowski and Baroudi [4]; Walsham [5]). Hence, given this contextual background, the case detail is now presented.

3 Case Detail

The case company investigated is an internationally renowned Global industrial products company (herein known as Company X), specialising in industrial control, workshop scheduling, safety, control systems and software. Company X boasts a range of global clients and suppliers across manufacturing, pharmaceuticals, process automation, computer software / hardware and systems integration. At the time of conducting the research, Company X had approximately 15 IS product lines feeding into production planning and fulfilment processes, involving a tight integration with core ERP. Senior management realised, that if by integrating information across and within their industrial automation software product line, via a core ERP package, potentially both suppliers as well customers could be able to see the state of the order, build, design, forecast, production and control cycles more easily. Hence, an extended enterprise. For trading partners of the case organisation (resellers and external strategic alliance partners) sales level information would be required to be shared and seen. This would encompass sales contact, product and support / maintenance information. Customers of Company X would also be able to access and demand a range of services, products and information via so-called "shopping cart" functionality; sales order and shipping information; and on-line help. Management instigated an EAI programme to enhance the integration between the organisation's order entry, planning, production and order tracking and logistics technologies. Under the auspices of the CEO and board, the project would involve the delivery of an internal "B2B portal" concept. This would be carried out using Baan as the core manufacturing process ERP system in order to aggregate planning and fulfilment information for customer orders, in effect embracing both partners and customers (as shown by Davis [33]). Thus, by integrating both core CRM, ERP and SCM components of their enterprise, both manufacturing and shipping operations can be combined in a single manner (i.e. once again, in an ERPII sense). Although Company X had enthusiastically highlighted and began working on this initiative, it did not fully realise the effort that was involved.

From the outset and as a result of an internal IT audit, the organisation unwittingly faced the prospect of upgrading and maintaining its current SAP R/3 product internally, which was nearing its license re-purchase state, and was therefore looking to be a significant cost outlay. Crucially, Company X decided to adopt Baan not only as their own internal core ERP, but also as the basis of their software products also. This was because the module architecture fitted its discrete manufacturing processes better. As such, senior management persisted in making a switch to Baan ERP, given its stated aims at the behest of the managing director. The apparent disregard for the inherent risks associated with moving away from core SAP ERP and the vigorous and aggressive timescales suggested by senior management, did not take into account the change management issues which would be encountered.

For all company admissions about involving stakeholders, partners and even external systems integrators, the reality of executing the project plan meant that Company X effectively ignored such external involvement (as can be seen in the project plan itself). Thus, considerable effort had to be expended in order to integrate and consolidate the core business process applications (not least of which, was replacing their existing ERP package, SAP, with Baan). As an ensemble effort, the application development and rollout of the system was scheduled to be delivered within an aggressive timeframe of 12 months. The initial scoping and definition of the integration effort required, took 6 man months alone to complete. Such estimates were driven and mandated by senior management, with a disregard for the active and necessary involvement of technical and operational IT/IS managers within the divisions concerned. The Chief Financial Officer (CFO) also commented that unless costs were also not tightly controlled, such a strategic project could easily come off the rails. As such, the proposed B2B portal concept and EAI implementation was shelved after a period of 6 months as it became clear, that the successful adoption of Baan internally in order to achieve "reference site" status, was not achievable. Also, product line heads (such as for Enterprise Management and Automation) were also concerned about the extent of effort required in order to integrate and standardise their product lines with Baan (which had not even been fully implemented as a core ERP within the company). Company X therefore was left with the task of continuing with attempting to replace its SAP ERP with Baan ERP – focussing all its efforts on completing an ERP as opposed to ERP-EAI integration programme (ultimately returning back to utilising its core abilities). In summary, their experiences were as follows:

- Little understanding of the level of complexity involved in replacing SAP with Baan;
- Change management / process re-organisation, not understood by management;
- Difficulty in managing both the operational business and the strategic initiative at the same time.

4 Case Analysis

In order to understand the case organisation's experiences, the authors now apply evaluation models from the ERP and EAI research literature in order to ask: can we learn anything more by applying the evaluation models?; and can we identify any aspects which can assist in forming a research agenda in the field?

4.1 Evaluation of the Extended Enterprise implementation

The selection and approach of the given literature-based methods attempted to balance both those organisational with technical factors in order to draw conclusions from the symbiotic nature of man and system in this regard. The results are shown in Table 1 and are now discussed in further detail.

In terms of "old economy" processes, it is immediately clear that models T.g and O.a (ERP tailorability and pre-modelling) were not apparent at all, and that the B2B portal platform was not going to be considered for low transactional liquidity. Conversely, it appears that there was greater concentration around models T.a, T.b, T.f, O.b and O.d (EAI process steps, EAI interconnections, ERP implementation approach, Organisational impact of enterprise integration ERP implementations and

IS innovation level, respectively). This was in terms of technology considerations; whilst in terms of business (and hence actor) components, there was an emphasis on planning and control, internal focus, and limited user involvement. Overall there appears to have been a general concentration around procedural capabilities, and hence existing skills and experience (although the slightly below average result of model T.d belies a lack of deep integration skill).

The view of the organisation's ERP implementation lifecycle, was short to medium term, and as defined by model T.e, the implementation path taken was strategic only (not operational or tactical), the focus being on finding a rapid solution without much thought for the practicalities of the implementation. At the same time however, the organisation was attempting to go beyond this level of capability in terms of embracing and capturing the spirit of "new economy" tools, technologies and paradigms. Here it can be seen that there was a general lack of understanding and recognition of an ERP implementation approach (model I.f), and gravity of the number of EAI interconnections required (model T.b). This further highlights the lack of understanding given to the impact of the ERP system (O.b). For all company X's views and ideals on creating a borderless, connected enterprise network with its supplies, partners and customers, the breadth and depth of its business processes was also negated by their implementation approach also.

As noted, there was little user involvement and appreciation of a multi-dimensional (or rather, multi-contextual) view of the plan-source-make-move lifecycle envisioned by the firm. Furthermore, concepts of agility, flexibility and high transaction liquidity although mandated, were not evident in the design and implementation of the B2B portal. Hence as can be seen there was a greater desire to concentrate on those technology aspects of ERP tailorability and enterprise modelling (model T.g and O.a, respectively), but this could not be realised due to a lack of thoroughness in models T.b, I.f and O.b (EAI interconnections, ERP implementation approach and Organisational impact of enterprise integration ERP implementations, respectively). Company X faced / instigated a dichotomy in how it viewed its business processes. Again this emphasises the fact that due to limited user and stakeholder involvement in the implementation of the given B2B portal, and an over-reliance on using existing technologies, the goals of achieving the whole business perspective, customer-centric organisation were never fully realised (although, as we know, they were articulated as such by senior management).

So it could be said that strategic goals were trying to be achieved at the expense of tactical and operational considerations. Likewise, in network (technology) terms, there was a preference/desire to address the tailorability of the new ERP (SAP) alongside attempting to be innovative and design the processes around the system (models T.g, O.d and O.a respectively). At the other end of the scale, it can be seen that there was less reliance and importance given to the ERP implementation approach to be used (model I.f), along with the organisational impact of the given system (model O.b) and finally the level of adoption of the resulting implementation (model T.c).

Table 1. Analysis of integration approach, using ERP and EAI evaluation models

Type	Description	Result in Company X	Significance	Type	Context
T.a	***EAI Process Steps*** **(Linthicum [9])**	EAI process steps carried out in order: 1, 5, 7, 2, 3, 4, 6, 8, 11, 9, 10, 12	EAI Implementation process was out of sequence (as compared to Linthicum)	EAI	TECHNOLOGY
T.b	***EAI Interconnections*** **(Themistocleous *et al.* [21])**	105 interconnections required across 15 subsystems	High magnitude of interconnections to develop in the time period given		
T.c	***EAI Adoption model*** **(Themistocleous [22])**	Run the business, cut costs, some internal resistance / pressure	Barriers and internal pressures outweighed benefits to be gained (little experience of full scale integration also)		
T.d	***EAI Lifestyle evaluation*** **(Schmidt, [20])**	10 out of a maximum of 25	According to the rating scale, this defines an organisation with solid / mature EAI capability (does not necessarily equate with *ability*)		
T.e	***ERP Implementation Strategy*** **(Al-Mudimighi *et al.* [17])**	Strategic and Tactical aspects considered only	Little or no consideration of operational effects on business to meet 12 month milestone	ERP	
T.f	***ERP Implementation Approach*** **(Parr and Shanks [19])**	High budget and short timelines; motivated by operational (data visibility) and strategic (responsiveness) factors	Change continuum experienced in the company was more akin to a vicious circle (sic), as opposed to a smooth change		
T.g	***ERP Tailorability*** **(Brehm *et al.* [18])**	Type 2 company profile: See Figure 7 for detail	Too much customisation required to meet needs		
O.a	***Pre-Modelling of the IS enterprise*** **(Dalal *et al.* [14])**	No modelling carried out – implementation began almost immediately	Little or no thought given to the design and impact of the technology on the business processes within and across the organisation	**Process Design**	ORGANISATIONAL
O.b	***Organisational impact of enterprise integration ERP implementations*** **(Lee et al [15])**	Process Integration with level of High BPR; High resistance to change; Decentralised business processesl short internalisation period	Management interference and reliance upon technology delivering the solution, rather than working with and steering the IS organisation to achieve the goals	**Change Management**	
O.c	***CSFs for Communication and Collaboration in ERP*** **(Akkermans and van Helden [13])**	Management support, team competence, clear goals & objectives, interdepartmental communication, vendor support, dedicated resources	Strong communication (from management), weak collaboration (from teams)	**Collaboration**	
O.d	***IS Innovation level*** **(Swanson [16])**	3c (out of a maximum of 5c)	Short / medium term view of Innovation: emphasis given to know-what rather than know-how. Little or no support from other innovation levels also.	**Innovation**	

Model O.c shows that there was strong communication but weak collaboration. Again, as similar to the result of model T.g, only a handful or project success characteristics were applied, at the expense of others which were not immediately evident. So in the case of Company X, although factors relating to management control, communication and overall support for the programme were evident, it is important to highlight those CSFs which were not found, such as: interdependent co-operation; management of expectations; existence of a project champion; careful package selection; user training; education on new business processes; business process re-engineering; choice of a technical architecture; change management; and the use of consultants (and other professional services). In short, Company X decided to "go it alone" on this initiative, and as a result, it took on a large effort in technical and organisational change which could not be sustained with the resources it had in place. Coupled with the high level of management interference (as shown in model O.b), there was a great amount of communication from senior and middle management, but little collaboration amongst the individual software divisions that had to integrate their systems together. This was also exacerbated by the lack of a cohesive group business structure to facilitate effective collaboration and discussion (as highlighted earlier). This led to what Akkerman and Van Helden describe as a vicious circle: poor communication, begetting poor collaboration, leading to a "spiral" of failure. Therefore, there was little understanding of the impact on the firm's people and how the step-change in technology would affect their processes.

4.2 Researching the extended enterprise: a synthesis

Company X tried to employ an internal B2B type architecture, in order to realise the goal of an extended enterprise. In other words, it attempted to implement a combined approach to extend and integrate a base-level ERP system to encompass CRM and SCM functionalities, through an application integration approach: hence ERPII. Indeed, the vague and wanton usage of the term B2B by Company X as relates to this specific integration programme, was something of a misnomer as there was no external integration carried out during this phase. This was purely an internal EAI scheme (i.e. intra-enterprise application integration), but couched by management in the terms and language of contemporary business information systems terminology. Although this might have been, as Dixon and John [34] state, a synergistic affect of articulating IT needs, this confused the technical issues around the exact needs and requirements of the integration to be achieved. Because it was trying to extend the capabilities of the underlying Baan ERP, Company X was unwittingly involved in attempting to carry out an ERPII-type implementation: but using traditional ERP and EAI techniques to do so.

Furthermore, the case study analysis has highlighted several necessary precedents for enacting an extending enterprise initiative, in the application of an ERP/EAI evaluative lens. It is quite clear that there was a distinct lack of planning involved; a lack of consultation with intended supply chain stakeholders being impacted (suppliers, trading and alliance partners); there was no supporting collaborative effort to get cross-divisional software teams and groups to actively approach the integration effort together; the company was effectively attempting to address internal integration issues – but not providing or planning for a complete B2B solution (between itself, its suppliers, partners and vendors); and a high degree of complacency in terms of Company X underestimating its technical capability in an area in which it had little or no experience, of replacing its existing ERP system (i.e. SAP for Baan). In short, there was a lack of cohesiveness in bringing together resource complementarities (collaborative opportunities and processes), org design (decentralisation with re-integration), ent IS, relationship management (governance, contracts and incentivisation) and sustained competitive advantage (IT as a valued resource). Hence, it can be concluded that achieving an extended enterprise is a difficult and complex exercise and requires at the most fundamental level, a consistent commitment to stated goals and objectives of an underlying, disintermediating, yet flexible business model across supply chain stakeholders. The linkage between this strategic and operational view of the firm as noted by Constantinides [35] is hence critical to extended enterprise success.

Whilst the case study methodology applied in this paper did reveal and highlight significant technological failings, the results of the evaluation show that there was an inherent human aspect of the programme undertaken. This therefore highlights the usefulness and appropriateness of the case study approach employed, similar to that reported by Kumar and Crook [36] who suggest that empirical analysis of such organisational contexts, allows for the identification of inter-organisational conflicts. The relevance and understanding of all aspects of supply chain management, from sales order fulfilment right through to third and fourth-party logistics, is becoming increasingly important for MIS researchers and practitioners. The authors also believe that a continuing development of inter-disciplinary knowledge transfer, is vital to extending the debate and discussion of such disintermediating technologies and concepts as the Extended Enterprise. As the cursory survey of the literature in Table 1 shows, there is a wide spectrum of research techniques that cover all aspects of this area. Hence the study of extended enterprises themselves should tend towards a multidisciplinary approach to capture such facets, as Chiasson and Davidson [37] as well as Sherif *et al.* [24], note in using IT artefacts and resource complementarities within a socio-technical context.

Hence in order to address and realise the nature of such a business strategy as the extended enterprise, the authors suggest viewing the continuum of issues as reported in the given case study, in terms of a multidisciplinary approach. Indeed, as the results in Table 2 show, the application of a technology prototyping or enterprise model would have been useful in order to emote and elucidate the implementation aspects of such a strategy (as has been noted by Lin *et al.* [38]). Furthermore, although the case study approach taken by the authors within this article has sought to capture a sense of the impact of such an initiative, the wider implications of management behaviours and organisational actions, needs to be placed within a longitudinal context. This could likewise be achieved by extending the period or scope of study outwards across all supply chain participants, employing an even deeper level of analysis. This in-depth evaluation of supply chain participants could possibly be achieved by applying a hybridisation of a case study and action research, via a socio-technical lens, in order to relate supply chain people, processes and technology factors together.

5 Conclusions

This paper has outlined and discussed how an industrial automation company, attempted to transform itself into an Extended Enterprise, through the introduction of a combined ERP and EAI approach. The authors applied a number of ERP/EAI evaluation models in order to highlight the approach taken by the organisation, in the context of a socio-technical stance (considering both human and systematic facets). Thus, it was found that an extended enterprise implementation requires a holistic approach to People, Process and Technology (in terms of supply chain participants; value chain integration; and ERP/EAI implementation). The authors suggest that future research in the area of extended enterprises / virtual organisations, within the context of implementing IT/IS, should attempt to uncover such facets, possibly via applying a hybrid approach to uncovering both socio-technical and institutional factors, as outlined in terms of the extant literature in Table 1. Indeed this requires knowledge an insight from experts across a number of connected fields (sociologists, MIS, supply chain included), using an empirical and qualitative lens, within a longitudinal timeframe. Hence, the authors also agree with Rose [28] in that a combined approach of Actor-Network Theory with the operationalisation of structural agency theory (Structuration) may help to provide a deeper insight into the thetic and antithetic aspects of inter-organisational systems, and their related processes. In doing so one can gain a better understanding of this emerging field and its boundaries.

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Mappings from OWL-s to UML for Semantic Web Services

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Abstract. As a member of resources on Semantic Web, Web Services become increasingly important to realize accurate composition for interoperation between human beings and information systems. In order to address the need for semantic annotation of existing Web Services, a special UML profile can be built upon UML metamodel and MMFI4Ontology Registration for Semantic Web Services described with OWL-s. Then the mappings from OWL-s to UML are defined in detail to indicate that our UML profile and transformation rules can be used to represent services with UML activity models. Efforts on our UML profile and further mappings can enrich the semantics of ubiquitous Web Services, facilitate services modeling for domain experts and make it easy to update current tools for supporting growing services on semantic web.

1 Introduction

As a crucial force of the next generation web, Semantic Web Services are raised to discover and access ubiquitous service resources in a more easy and accurate way. For this purpose, semantic markup of Web services, user constraints and Web agent generic procedures should be involved to augment the capability of conversation between human beings and information systems, together with the interoperation among systems [1]. As the base of information sharing, accessing and reuse, ontology is deemed as the key technique to provide rich semantic annotation and explicit interpretation. With the significant demands in academia and industry, ontology can be used to capture the semantics of various sources and give them a concise, uniform and declarative description. Either web sites or Web Services tend to employ ontology for service description and classification [2].

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In the family of ontology description languages, OWL (Web Ontology Language) [3] proposed by W3C (World Wide Web Consortium) has become the most popular one for diverse applications based on ontologies. OWL is tended to provide a standard specification for various resources on the web, from entities to services. Owing to the important role that services play, a specific OWL profile for Web Services (OWL-s for short) is designed as an extended ontology language to reflect the fact that it provides a standard vocabulary that can be used together with the other aspects of the OWL description languages to create service description [4]. Since both OWL and OWL-s are based on the syntax of XML (eXtensible Markup Language), it is difficult for common customers to use them conveniently. Furthermore, OWL-s based applications lack sufficient supports from existing modeling tools, especially the ones with friendly interfaces and simple operations. Different from OWL and OWL-s, UML (Unified Modeling Language) has been regarded as the standard modeling language in software engineering. It has received wild attention, acceptance and tool support due to its visual views and easy manipulation. Analysis on those two languages gives rise to a hotspot of current research, i.e. to establish transformation between them and update existing UML tools for Semantic Web Services. If so, service access, service invocation and other web applications can be promoted greatly.

This paper contributes to extending basic activity elements in UML 2.0 standard [5] and grouping them as a UML profile for Semantic Web Services. In this profile, a common registry structure from Framework for Metamodel Interoperability: Metamodel for Ontology Registration (MMFI4Ontology Registration for short) [6] is also combined to register ontologies related to Web Services. Further mappings are then defined to convert Web Services described with OWL-s into UML Activity Diagrams. In terms of our profile and mapping rules, Web Services on Semantic Web can be represented graphically and embraced with more existing tools, which might promote discovery and invocation of OWL-s based Web Services for different needs.

This paper is organized as follows: Section 2 introduces OWL-s briefly; Section 3 provides a specific UML profile for Semantic Web Services; in Section 4, mapping from OWL-s to UML is specified by detailed rules; Section 5 exemplifies how our mapping rules fit the specific cases; Section 6 covers related work, followed by conclusions and future work in Section 7.

2 Overview of OWL-s

OWL-s is proposed by W3C as a particular OWL profile for Web Services on Semantic Web. It supplies semantic and functional description of services and automation services tasks including discovery, invocation, composition and interoperation [7]. In general, an OWL-s based description of Service represents reference for a declared Web Service, which contains three essential parts as follows:

- ServiceProfile gives the advertising information of services, with respect to relevant information of service provider, service requester and service itself. Service shows what it does by presenting a ServiceProfile, so ServiceProfile will be necessary for customized service discovery and location.
- ServiceModel describes the function of services and specifies how to use them. Service is described by ServiceModel, including the trigger condition, the steps it should follow, the results and the corresponding effect as well. In those three parts, ServiceModel is of quite importance and complexity.
- ServiceGrounding is supported by Services and specifies the means by which users can access to a specific service. In contrast to ServiceProfile and ServiceModel, ServiceGrounding concentrates on concrete realization of service, rather than its abstract representations.

Those three parts are the main components of upper ontology of services, which provide an overall description, especially functional description, for Web Services and the details on their executable processes. As such, OWL-s can be used to represent semantics of Web Services by means of this uniform mechanism.

3 UML Profile for Semantic Web Services

To make use of Web Services, it is necessary to provide the description of services and the means by which they are located, selected as well as composed. In this section, a particular UML profile for Semantic Web Services will be established on two existing metamodel standards.

The first one is UML 2.0 standard, in which three extension mechanisms, i.e. stereotype, tagged value and constraints are offered for new model elements based on existing or defined ones. Stereotypes define how to extend defined metaclasses for specific domains. Tagged values refer to the new values of properties. And constraints describe restrictions that applied to existing metamodel elements. A UML profile represents a set of extended elements for a specific scenario. Considering Semantic Web Services, referred elements mainly come from Kernel package, Action package and Activity package of UML metamodel.

Table 1. Mappings for Semantic Web Services

Element in OWL-s	Metaclass in UML	Type of extensions
Service	Class	stereotype
Service Profile	Class	stereotype
Service Process	Class	stereotype
Service Grounding	Class	stereotype
presents	Association	stereotype
describedBy	Association	stereotype
supports	Association	stereotype
Category	Comment	tagged value

On one hand, the main structure of Web Services can be represented by extended metaclasses from Kernel package, in which classes, properties, associations and etc. are covered. In our UML profile, stereotypes can be respectively marked to "Service", "Service Profile", "Service Process", "Service Grounding" and the relationships between them to generate a Class Diagram of Web Services. Mappings for Semantic Web Services and corresponding extension mechanisms they adopted are listed in Table 1. On the other hand, Web Services concentrate much more on dynamic activities, including service discovery, invocation, composition and interoperation. As a result, metaclasses from Action package and Activity package should also be employed, as the blue parts in Figure 1 shows.

The second standard is ISO MMFI4Ontology Registration, which is provided as a common framework to register ontologies, manage corresponding evolution information and enable semantic interoperation between them. MMFI4Ontology Registration contains a language-independent structure with three layers to capture basic semantics and structure of ontologies that is Ontology-Ontology Component-Ontology Atomic Construct [8], In our proposed framework, Ontology consists of Ontology Components and Ontology Component consists of Ontology Atomic Constructs. Under the guidance of this framework, ontology can be registered to annotate Web Services, even be employed to classify services and promote applications based on them. In Figure 1, Category of services can be addressed by a registered ontology in MMFI4Ontology Registration.

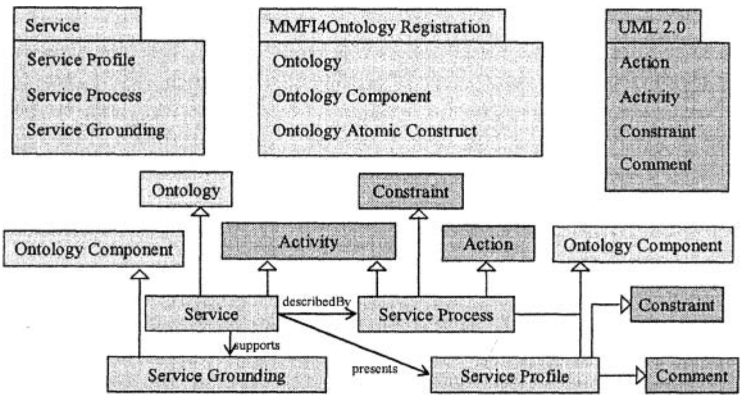

Fig. 1. UML profile for Semantic Web Services.

Based on the proposed UML profile for Semantic Web Services, the main concepts and properties in Web Services can be represented semantically. However, Figure 1 only illustrates the relations between Web Services and activity description part of UML 2.0 standard in brief. Further details will be discussed in Section 4.

4 Mapping from OWL-s to UML

It's widely known that essential elements, including static structure diagrams and dynamic behavioral diagrams are provided in UML 2.0 standard for domain modeling. Although description of services involves descriptions for entities and processes, more attention will be paid to service processes in this section. That is, detailed mappings rules will be defined here to specify transformations from OWL-s process model to UML dynamic diagrams.

Generally speaking, services refer to a group of processes or activities that will be executed in a certain sequence. According to the proposed UML profile for Semantic Web Services, services as a whole can be first represented as a stereotyped complex activities. Since a service consists of atomic processes and other composite processes, both Atomic Process and Composite Process in OWL-s should be represented as activities with respective stereotypes. Correspondingly, inputs and outputs of those activities are mapped to InputPin and OutputPin from UML Action package, while preconditions and their effects are referred to logical representation with restrictions. Trivial extended elements in our UML profile for ServiceProcess of Web Service are shown in Table 2.

Table 2. Mappings for ServiceProcess

Elementin OWL-s	Metaclass in UML	Type of extensions
process.SimpleProcess	Activity	stereotype
process.CompositeProcess	Activity	stereotype
process.AtomicProcess	Activity	stereotype
process.preconditions(s)	Constraint	constraint
process.input(s)	Action.InputPin	stereotype
process.output(s)	Action.OutputPin	stereotype
process.effect(s)	Constraint	constraint
process.parameters	Activity.Parameter	stereotype
process.condition	Constraint	constraint
process.collapseto	Association	stereotype
process.expandto	Association	stereotype

As far as composite process is further concerned, it is decomposable into other composite process or atomic processes, and the decomposition is under the guidance of different control constructs, such as process.sequence, process.split-join, etc. Then various kinds of activity nodes can be marked with stereotypes to represent Control Constructs and their subclasses in OWL-s, as Table 3 lists. For example, both the metaclass iterate and its two subclasses are mapped to LoopNode in Activity model here. Notice that no mapped notation is found for process.any-order now.

In terms of mapping rules specified in those two tables, Semantic Web Services described with OWL-s can be transformed into respective UML Activity Diagram. Only mappings from OWL-s to UML, rather than both-way transformation between them, are discussed in this paper. The basic idea of transformation may be helpful for the next study on transformations from UML to OWL-s.

Table 3. Mappings for Control Constructs in ServiceProcess

Element in OWL-s	Metaclass in UML	Type of extensions
process.sequence	Activity.SeqenceNode	stereotype
process.choice	Activity.DecisionNode	stereotype
process.split	Activity.ForkNode or/and Activity.DecisionNode	stereotype
process.split-join	Activity.ForkNode or/and Activity.JoinNode	stereotype
process.any-order	Not Mapped in Activity Model	None
process.if-then-else	Activity.ConditionalNode	stereotype
process.iterate	Activity.LoopNode	stereotype
process.repeat-while	Activity.LoopNode	stereotype
process.repeat-until	Activity.LoopNode	stereotype

5 Example

In this section, a simple example is demonstrated to show how those mapping rules can fit for converting a specific OWL-s service description into a UML activity diagram when a real case is taken into account. The exemplary service introduced here is called BravoAir Reservation, which is provided by W3C in [9].

Based on the OWL-s specification, BravoAir reservation service consists of its own profile, process and grounding. The names of these three components and the relationships between them are specified in the following fragment documents. Following the mapping rules proposed in Table 1, we can easily generate the corresponding class diagram in Figure 2 to describe overall structure of BravoAir reservation service.

```
......
  - <service:Service
rdf:ID="BravoAir_ReservationAgent">
  <service:presents
rdf:resource="&website#Profile_BravoAir_ReservationAgen
t" />
  <service:describedBy
rdf:resource="&website#BravoAir_ReservationAgent_Proces
sModel" />
  <service:supports
rdf:resource="&website#Grounding_BravoAir_ReservationAg
ent" />
</service:Service>......
```

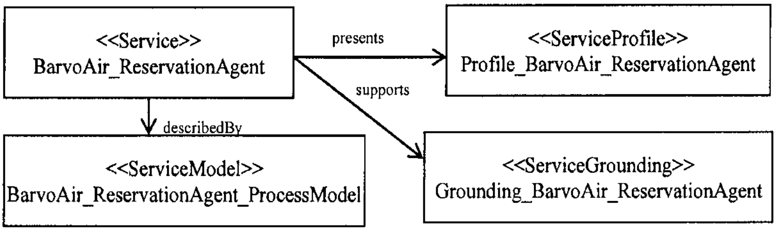

Fig. 2. UML class diagram for BravoAir reservation service

After the overall representation, we will concentrate on how to present activities in BravoAir_ReservationAgent_ProcessModel. BravoAir_Process is the core process in this process model. It contains two atomic processes GetDesiredFlightDetails and SelectAvailableFlight, along with one composite process named BookFlight. In terms of our UML profile and mapping rules proposed in Section 3, an activity diagram of BravoAir reservation service can be generated, as the right part of Figure 2 suggests. In this figure, all the processes in BravoAir service, including composite processes and atomic processes, are represented as different activities. The relevant inputs, outputs and other parameters are merged into corresponding control flows.

Meanwhile, Figure 2 also illustrates a general conversation named BravoAir Reservation Agent Process. First the GetDesiredFlightDetails is called. Its outputs involve airports, preferred time, round trip, etc. AvailableFlightItineraryList_Out then will be generated as one of the inputs of BookFlight. It's known that the outputs of Login, one of the sub-processes of BookFlight, indicate whether the user's details are confirmed or not. Correspondingly, the UML DecisionNode control flow construct is introduced here as a conditional choice to tell whether the BookFlight conversation can be implemented successfully according to defined sequence in the service. If all the input details are correct, the selected reservation will be confirmed and return an appropriate response that the customer will succeed in having a seat.

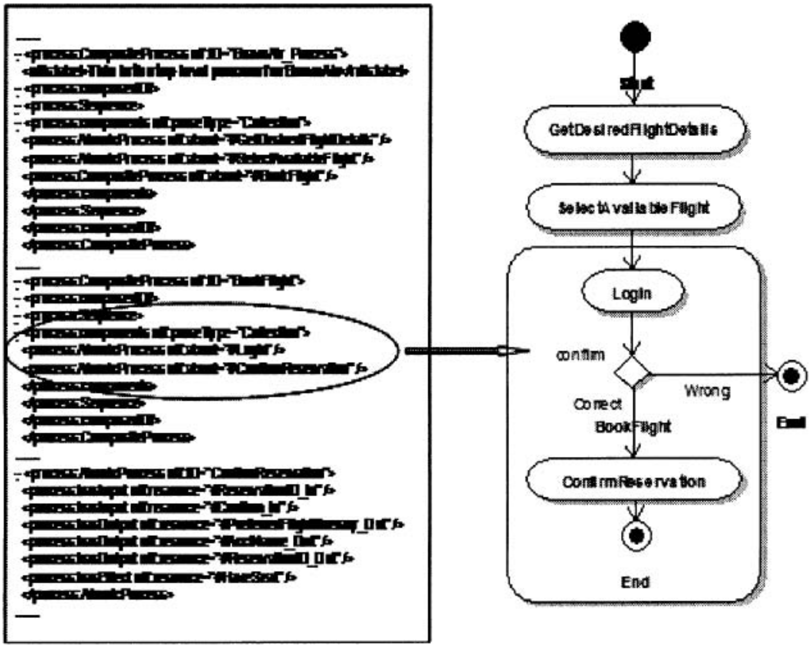

Fig. 3. Activity Diagram for BravoAir Process

6 Related work

Web Service Description Language (WSDL) is proposed by W3C to provide a model and an XML format for describing Web Services [10]. Till now, many tools have been developed to support and generate specific WSDL documents. However, poor semantics is attached to WSDL documents since they always work at syntactic level. Then misunderstanding might be caused by ambiguous descriptions. To handle with this problem, WSDL-s [11] is raised as semantic annotated WSDL to add semantics to existing description mechanism. Though both OWL-s and WSDL-s can be used to describe Web Services on Semantic Web, the former is of richer expressiveness than the later when semantic representation is taken into account. Moreover, domain experts and ending users may prefer OWL-s rather than WDSL during the process of specifying domain concepts and the relationships between them.

Web Service Management Framework- Foundation (WSMF-Foundation) is designed by Hewlett-Packard Company to make use of Web Services to provide the management interfaces to manageable resources [12]. WSMF builds upon the existing Web Services techniques, such as WSDL and SOAP [13], to define methods for Web Services management. But the basic foundation of WSMF, XML syntax and relevant standards, is of insufficient semantics. It will give rise to the fact that WSMF lacks of more powerful methods of discovering new manageable resources on Semantic web. Based on our UML profile for Semantic Web Service, WSMF can be similarly enhanced in expressiveness of semantic representation and capability of dynamic operations as well.

Ontology Definition Metamodel (ODM) [14] is proposed by Object Management Organization (OMG) to provide metamodels of the most popular ontology description languages and mappings between them, covering both ways syntax transformation between OWL and UML, etc. However, corresponding mappings in ODM only concentrate on the transformations from/to UML Class Diagram, Activity Diagram or other kinds of dynamic diagrams are beyond the scope of current version of ODM. In this paper, our UML profile for Semantic Web Service and mapping rules focus on the relations between OWL-s and dynamic parts of UML standard, which is stronger than ODM standard in expressiveness capability to some extend.

7 Conclusions and Future Work

In this paper, a UML profile for Semantic Web Services is established on the basis of two existing standards: UML 2.0 standard and MMFI4Ontology Registration. UML metamodel provides infrastructure elements and three extension mechanisms. And MMFI4Ontology Registration is reused to associate semantics with extended representation of Web Services, so that those registered ontologies can be used for further semantic interoperation based on them. Then detailed mappings are defined to convert OWL-s description of web services into corresponding UML activity diagram, covering respective mapping tables for OWL-s process model and its control constructs. Under the guidance of our profile and one-way transformation rules, not only can Web Services be annotated semantically, but also customized services might be generated with graphical representation by specifying those UML-based modeling methods.

In the near future, further efforts will be made on mappings from UML to OWL-s to supplement current transformation rules. In addition, we'll pay more attention to the research regarding dynamic composition of Semantic Web Services based on UML metamodel, followed by preserving semantic consistency in the case that ontology is of great importance.

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A Tourism Resources Integration Mechanism based on XML and Web Service

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Abstract. To tackle problems such as isolated data islands in tourism as so much assorted data should be processed, it is constructed a platform that can share data and information of tourism resources. XML and Web Services are getting more and more attentions in many fields such as enterprise, e-government and so on as their great expressive ability in data and services. In this paper, the integrated tourism data processing platform based on XML and Web Services is described. Compared with others, it is efficient as semi-structured data description is convenient and simple for data processing, sharing and exchanging. Then, a case study is described to illustrate how the integration mechanism can be applied in practice. At last, some open issues and future work are discussed.

1 Introduction

Tourism is a mushroom industry today, but how to use tourism resources reasonably and efficiently to develop tourism industry in a more profitable way; and increase the ratio of tourism resources usage [1] are the key problems confront us. The degree of using information technology in many enterprises is not high, and some one are only portal web site of their company, lacking of basic business service such as transaction processing system, management information system, not to mention decision support system. One reason is that the information platform is designed on independent planning and isolated implementation mode, there existing much differences in data format, data storage and system platform between so many departments, and it may be very difficult to implement data sharing and exchanging

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with each other for so much assorted legacy systems with people's not inclination to change them.

With this situation, it is very important to develop an open application platform for data exchanging and collaborative application across several business domains. This schema is not an application infrastructure which is only used for present data integration and sharing, and it is an integration standards and solutions for data exchanging which are compatible for all relative tourism organizations. Any application, if its application schema is based on the normalizations, which have been designed for all entities such as enterprise, government or travel agency, it may need only some degree of alternation of existing application for applying into the whole collaborative system, which could share information and exchange data resources.

Web Service that is based on SOAP (Simple Object Access Protocol) represents the future application direction of distributed computing technology. Combined with XML, Web service consists of so many distinguishing features such as operating system independent, high efficiency and convenience in use, and the ability of communications across platform and firewall [2-4].

Under this computing environment, all resources published in standard description language are distributed, and it is a real collaborative platform with the advantages of platform independent. And this paper is under the research about collaborative environment based on XML and Web Service.

The outline of tourism resources integration could be drawn as following: the infrastructure of collaborative work based on Web Service technology is presented first; then the ontology of tourism information resources based on main techniques and standards such as SOAP, XML, UDDI, WSDL and WSLF is described [5-7]; on the basis of these, tourism information resources are integrated, and the standards of various tourism resources are given. At last, it will be realized the goal of unified standards, united construction, information complementation and data shares.

On the research of Web Service and workflow [8-10], they are integrated into applications in tourism seamlessly. As the undividable part of web service infrastructure, XML is integrated into the web service collaborative workflow and supplying information service for the whole collaborative platform. Therefore, it completes the data sharing and information exchange of tourism information resources; accelerates the development of information intelligent island, and realizes the agility, standardization and normalization of information service.

The rest of this paper is structured as follows. Section 2 will give background information about tourism information resources sharing and exchanging. In section 3 we will describe how tourism information resources can be integrated based on XML and Web Service. Section 4 will give a case study, which illustrates how the integration mechanism can be applied in practice. Finally, in Section 5 we will discuss some open issues and future work, and conclude the paper.

2 Background

There is a need for tourism resources web services based on xml when applying search about a travel scenario to get the tourism information such as air, spot, hotel etc and save it to local database for private use. In fact, it is not easy to complete this task as all the information given about the research may be described in some different way, and it is not convenient to process for local use. For example, if search "hotel", "jiuzhaigou", "phone", the information found may be expressed in some different way and format. Some provides the zone code such as "0837-7734xxx", and some other may not provide it as "7734xxx". On the other way, this information is described in web page as a text format that is not structured and not convenient for local use such as saving and processing. In addition to this, the same data may be drawn in several methods. For example, phone may be given as "phone" or "telephone" and this will bring misuse and promiscuous. If all hotels present their information in standard way, e.g. phone use telephone to present the number by a web service and all the information is shown in a structure way such as XML, it will be simple and easy for using and processing.

Lara mentions web services oriented specifications such as DAML-S, OWL-S and industry web services standards such as WSFL, BPEL4WS, and BPML [11]. Singh [12] discusses the workflow composition of services as a community of services providing using shared information in a convenient way. Paper [13] gives UDDI registry that can be used in Hotel Reservation registering their offerings as web services. It is investigated that integrating web service using the basic workflow patterns as defined by van der Aalst [14]. On-line businesses are beginning to adopt a developmental paradigm where high-level component-based services and semantic web services [15] are becoming sufficiently modular and autonomous to be capable of fulfilling the requirements of other businesses. In paper [16], it is described that Input/Output Messages of multiple services should be transformed into independent ontology, and then consensus ontology is used to help integrate these messages. This consensus ontology is decomposed into the Value_Names. Thus services incorporate the integrated knowledge that may be used by other entity. Zeng [17] conducts research that uses Unified Modeling Language (UML) state charts and agent-oriented methods for declarative peer-to-peer service composition that is useful for web services to be integrated into a composite one providing a unified service.

Later in this paper we will show how can integrate heterogeneous legacy system into a standard one in data format and to be easy for information communication and exchange.

3 Tourism information resources integration based on XML and Web Service

As the key technology for multi-point data exchange based on Internet, XML is very suitable to interchange business data across many sorts of enterprises/applications.

Some companies such as IBM, Microsoft, and DevelopMentor etc collaboratively constituted Simple Object Access Protocol (SOAP) specifications. SOAP is based on XML and maintains the openness and extensibility of description. It used application protocols based TCP/IP such as HTTP, SMTP, IMAP4 and POP3 etc, and be compatible with present communication infrastructure.

As Web protocols are standard, the language to be used for program and the platform the web service is running on are not important. Using HTTP protocols to communicate applications can across firewall without affecting it in low degree. It also provides the interactive communications with other services over network.

XML is discovered to be excellent and much suitable for B2B applications. B2B e-commerce depends on frequent exchanging of business information between many enterprises, and it flows smoothly between various enterprise applications. And completely developed B2B e-information flow can reduce greatly the degree of human working. In addition to this, it can improve the efficiency of transactions and obtains more business opportunities for enterprises.

Data exchange center is fully based on Web Service and. SOAP as the basis of secure communication, XML as the technology of data exchange across platforms, .net as the technology of application realization across platforms, and set up the data share standards for each level of tourism applications.

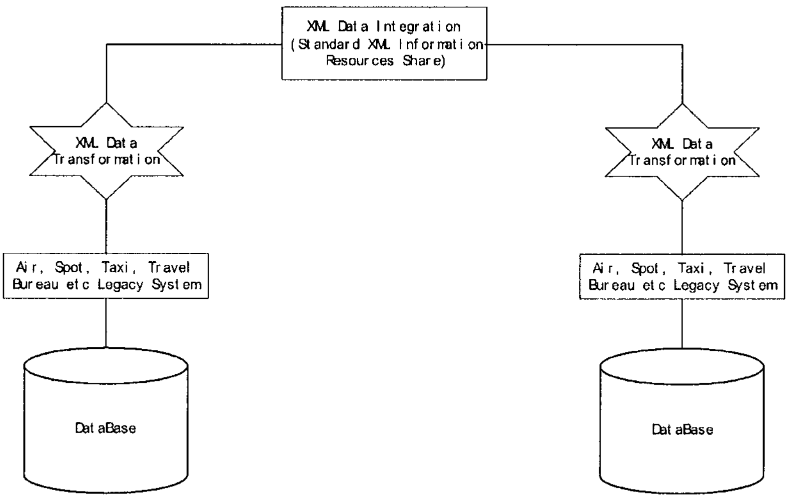

Fig. 1. Travel information resources data integration by XML

Fig 1 shows the diagram of tourism information sharing flows. The system consists of the follows. Service provider presents their services in Internet that can be searched by customers. When a user selects the service, his or her requests will be sent in XML format by SOAP to the service provider. And this service and client's request are described in standard xml format. As provider may use his own legacy system which service is drawn in private ontology that is not compatible with

standard xml format. Therefore, the request expressed in standard xml format will be translated into local xml format by xml-mapping.
Then, the service provider application executes the query by customer's demands that are now given in local xml format. When this completed, the result of query is presented in local xml format. If it is prompted to customer, he or she may not recognize it cause of different xml format contained different ontology. Thus, the request should be translated into standard xml format by xml-mapping again. The result of query that meets customer's demands will be responded to customer in standard xml format by SOAP, and formatted in XSLT to be in standard display format. As in standard xml format, the user can understand the information easily and convenient for his/her use.

When the user gets the information in standard xml format, and he/she can store the query result in his or her private xml format for future use. As the result is in standard xml format, it should be translated into the customer's local xml format by xml-mapping. Thus, it is compatible with the user's legacy system.

It consists of the following parts:

- WebServices1()
    Inputs: xml request based on standard request xml schema;

    Outputs: xml response based on standard response xml schema;

- WebApplication1()
    Inputs: user input information,

    Process: invocating the corresponding web service, and get the show information to be displayed

    Outputs: shows request response information.

    The data flow is as follows:

    Customer's request is in:

    XML request document and schema based on Standard schema;

    After strand->local XML-Mapping, it is shown in:

    XML request document and schema based on Local schema

    Carrying out query and finished, the result will be described in:

    XML response document and schema based on Local schema

    After local-standard XML-Mapping, it is shown in:

    XML response document and schema based on standard schema

- WindowsApplication2
    Inputs: XML response document and schema based on standard schema

Process: transfer the document to be xml document based on local schema, and write to local database;

Outputs: xml document based on local schema

The information exchange and share center is based on XML and Web service as their semi-structured data expressive ability and convenient way in usage. And their ubiquitous services bring more and more organizations to join to this platform. On the basis of it, one-more, more-one and more-more sharing mode takes effect. It will be widely used in tourism for its service platform that integrates tourism data and tourism services which as shown in Fig. 2.

Fig. 2, the travel information resources share platform integrates information of hotel, airlines, travel agency, taxi, traveler, spot and travel bureau together and implements the data sharing and information exchanges. It is the tourism data sharing and exchanging center. Information provided by any entity (e.g. a Hotel) can be used in horizontal industrial networks (other hotels) or vertical industrial networks (travel bureau, airlines, travel agency, traveler etc).

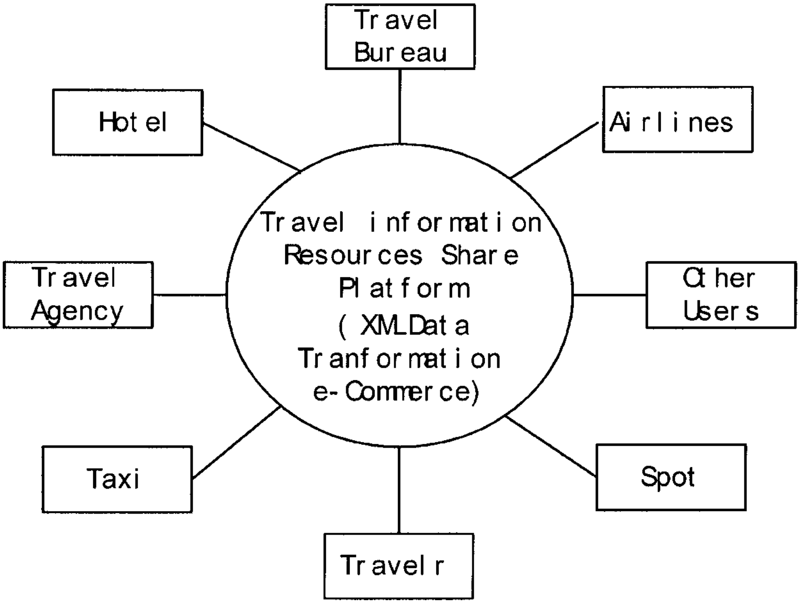

Fig. 2. Travel information resources share platform

4 Example scenario

We develop an application system shown in Fig. 3. Customers visit the hotel web service page and send their request. The request is formatted in xml standard document and schema. Before sending to the background web application1 for performing the request, it can be prompted to customer in XSLT for confirming his or her request. Then the web application1 will do xml-mapping translating request xml document in standard xml schema to request xml document in local xml schema; performing the customer's request – querying the provider's database to get the response document expressed in local response xml schema; and do second xml-mapping translating response xml document in local xml schema to response xml document in standard xml schema.

The web application1 (Containing web service application) will send response xml document to the customer and displayed by XSLT. The customer can do xml-mapping translating response xml document in standard xml schema to response xml document in his/her local xml schema, and saves it to customer's database for future use.

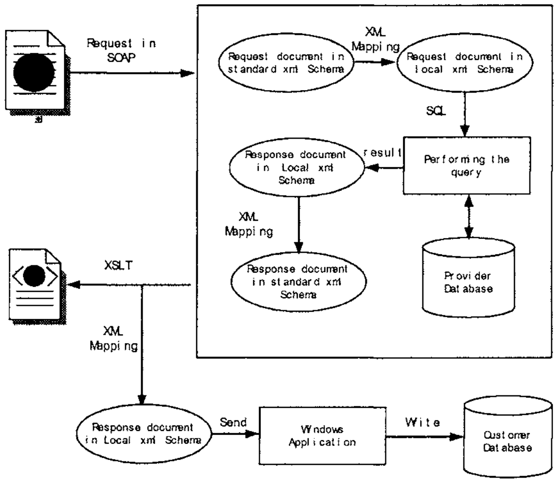

Fig. 3. Tourism resources integration based on XML and Web Service

5 Conclusions

As tourism is developing in mushroom way, it grows up accompanying multi-assorted data such as air, hotel, taxi, and so on. In order to use these information resources, an integration platform based on xml and web service is constructed with the aid of MS Visual Studio .net. Compared with others, it realizes information sharing and exchanging, and be convenient to be used. At the future research, we focus on the integration mode with the adaptive workflow to cooperate with all relative tourism organizations such as hotel, air, and scene spot for data sharing and information exchanging. In addition to these, it may be another valuable research direction tourism information change management.

Acknowledgments

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Exploitation of Semantic Web Technology in ERP Systems

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Abstract. Until recently existing technologies enabling the integration of enterprise systems, use very few of the capabilities of modern research. For example, the activity of finding services, which should deliver expected enterprise functionality, has to be driven by humans. The process of assembling pieces of functionality into complex business processes also involves human interaction. The semantic web technology can be used in the context of an ERP to enable the lacking automation process. This technology can significantly contribute to overcome the deficiencies rooting from the heterogeneity of information contents and semantics generated from various sources. A challenge in Enterprise Information System is the detailed capture of activities and process information. The semantic integration of Personal Information Management Systems could be regarded as a first step towards the modernization of ERP applications. We also describe the opportunities of significantly improving business security by using ontologies. The use of ontology concepts of the Semantic Web can be regarded as an essential step in the evolution of Service Oriented Architectures for ERP applications.

1 Introduction

Enterprise Resource Planning (ERP) is a business management system that integrates all facets of our business including marketing, finance, inventory control, material ordering, production planning, manufacturing, testing, sales, delivery, and after sales customer support. Today the ERP systems have become modular and configurable to suit our needs. In ERP environment software applications perform

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business tasks in a modular way depending upon the choice and nature of our business. Practically these modules are concerned with separate domains and are guided by human experts in those domains. The ERP is supposed to work for the achievement of common goals of the company. Different modules require different vocabulary and concept hierarchy. Nevertheless they must interact with each other for transforming the customer order into profitability.

Some of the major investments a company need to do even after deployment of ERP solution is to invest a lot on software customization, training of personnel, integration and testing of different modules, data conversion and analysis. Yet after considerable post-deployment time the profitability seems far away. The main responsible factors are the heterogeneity of information contents and the semantics generated from various sources like customer requirements, vendors, regulation bodies, and company's internal departments (mentioned at the beginning of Introduction section). *These problems can be significantly addressed by exploiting semantic web technology in ERP systems.*

The Semantic Web is a web of data that will enable machines to comprehend the data. Until recently the information available on World Wide Web is solely human understandable. The goal of Semantic Web is to change this information into Knowledge resources. In the Semantic Web the information will have a well defined meaning and this will enable the computers to know how to process the information. Next generation of World Wide Web will be greatly affected by this new evolving technology and it is clear that this will have tremendous economical impacts. It is important to note that the semantic web technology can also be used in a localized context such as ERP for our organizations, yet giving an edge to be in a state of readiness for integrating and sharing our business as specific web services to outside world.

In Semantic Web the information model is represented as a graph with nodes representing the resources using unique identifiers called *Uniform Resource Identifier (URI)* [1], and the edges representing the relationship between them with the help of properties for a specific domain of discourse. Resource can be anything such as a person, a document, a product technical drawing, a testing tool specification, a business process or a service which is further described at the specified address pointed by the URI. The representation between the nodes and the edges is formally specified in a machine processable way which can also be shared globally by virtue of its URI and an agreed upon schema. The formal information representation is made using *Resource Description Framework (RDF)* [2] which defines an XML syntax for RDF in form of *Subject-Predicate-Obje*ct triples. The richness of the knowledge base is further enhanced by describing inference rules with the help of *RDF Semantics (RDFS)* [3] and making it sharable by using *Web Ontology Language (OWL)* [4]. The information thus represented is a "*specification of a conceptualization" or ontology* [5]. In simple terms it is a set of shared vocabulary, arrangement of related taxonomy, and the definition of axioms to specify the relationships between them. Once the triples are expressed in RDF, then these can be accessed programmatically by the software *agents* designed to carry out certain *services* over the web. The service description about how it runs, as well as the explicit logic to describe consequences of using the service are also made machine-readable [6]. The theoretical flexibility to make shareable ontologies on a global scale poses many challenges in merging, integration and versioning of ontologies that are not completely solved so far. However, by making use of suitable *ontological commitments* the ontologies can successfully be made sharable in the concerned domain such as an organizational ERP system. Ontological commitments are agreements to use the shared vocabulary in a coherent and consistent manner [5].

2 State of the Art and Current Works

There are an increasing number of efforts to integrate Semantic Web based solutions in business. Especially there have been many advances in *Business to Business (B2B)* integration via Semantic Web Services. To quote an example the *Digital Enterprise Research Institute (DERI)* tries to address intelligent Web Services upon Semantic Web technologies [7]. Unlike the current web service technologies which provide limited support in mechanizing service recognition, service configuration and combination (i.e., realizing complex workflows and business logics with Web services), DERI focuses on service comparison and automated negotiation of services. In a business environment, the vision of flexible and autonomous Web service translates into automatic cooperation between enterprise services. Any enterprise requiring a business interaction with another enterprise can automatically discover and select the appropriate optimal Web services relying on selection policies. Services can be invoked automatically and payment processes can be initiated. Any necessary mediation would be applied based on data and process ontologies and the automatic translation and semantic interoperation.

Another yet more important activity is creating upper ontologies for the problem domain. ERPs are an example where a lack of common comprehensible standards and ontology has contributed to massive failures [8]. Since technical terms are often unclear, and not described in the language of business, many inter-organizational negotiations are ambiguous. Therefore, without an upper ontology the global communication between businesses is not possible. One such model which was originally designed for accounting is *Resource-Event-Agent (REA)* business model. Later REA business model was extended for supply chain management [9]. The key extension was the Dependent Demand relationship as defined by Manufacturing *Resource Planning (MRP)* systems [9]. As a semantic Web, the REA model makes it possible to link economic events together across different companies, industries, and nations. The semantic types of these links are activity-to-activity or agent-to-agent or person-to-person, not just company-to-company. This means that each individual in a REA based supply chain can be linked directly to every other individual.

SCOR+ is another more specific ontology for the description of business processes which has been developed based on *Supply Chain Operations Reference model (SCOR model)*. The SCOR model is a process reference model that has been developed and endorsed by the Supply-Chain Council as the cross-industry standard diagnostic tool for supply-chain management. SCOR enables users to address, improve, and communicate supply-chain management practices within and between all interested parties [10]. SCOR model can define the supply chains, measure its performance, and benchmark it against industry standards. This model defines the supply chain in terms of processes, performance metrics, and best practices. It has already been used and extended to develop an ontology for supply chain simulation modeling [11]. SCOR+ is directed towards overcoming the limitations of the basic SCOR model through an easy to use ontology based tool that enables an automated and comprehensive definition of the Supply Chain at any level of detail. SCOR+ captures all the constituent parts of the Supply Chain at four different levels which are, the supply chain level, the enterprise level, the element level, and the interaction level [12].

3 Business Opportunities with Semantic Web

The most obvious application of Semantic Web in business field is changing the web to a processable resource for machines. In this section we will inspect the possible uses of Semantic Web technology in the fields of Business and Economics. The information which is available on Web today is mostly produced to be human-understandable. The process of changing this information to Knowledge is time and budget consuming. On the other hand the policy makers need to have access to the last updated information and usually the human-based method of information processing is not economical.

Living systems have different characteristics like self-regulation of processes, reproduction and growth [13]. Nevertheless, these relevant characteristics could be envisioned in a semantic way in business knowledge management. Ontologies of business items grow and reproduce new ones with processes and services. These ontologies include information about our business objects such as business partners, suppliers, customers, persons, places, organizations, events and business processes. This could be of great importance in office systems including *Customer Relationship Management (CRM)*, e-business and *Supplier Relationship Management (SRM)*.

In the physical world, entities are usually interconnected, either by physical or by semantic means. In the latter case, the semantic meaning is added by human interaction (in an abstract sense) with the physical world. Business items in our case can be understood as information entities (in some cases they are representations of such physical entities) stored according to ontologies in a semantic database, which are connected to other information entities according to their semantic meaning. Also ontologies 'live' in a way, as they develop and modify permanently during the system and business lifetime.

Current Web technologies are highly efficient in processing data for human reception, i.e., the transformation from data to information. However the 'generation of meaning' is up to the human. A great deal of effort has already been made, and work is still going on to represent semantics explicitly on the Web. This is required to give computer systems the capability to enhance preprocessing of huge amounts of data for the user. It becomes more important as the 'awareness radius' of the contemporary knowledge worker and consumer is continuously increasing. This, results from the observation, that users do not limit their information search to specific data repositories, like searching for an address or an event in a calendar any longer. The availability of databases under common or similar interfaces (like web-pages) creates the demand to express more complex queries demanding information aggregated from many different systems using different semantic concepts.

3.1 ERP Implementation

Business analysis and Business reengineering is embedded in a complex web of relationships that determines processes and methods in ERP implementation. An ERP implementation process relies on large databases and their interrelations that are often managed by human knowledge and interactions. Some of these relationships are strongly coupled to and affected from contextual parameters like country-specific policies. Migration of existing context attributes and applying them to business entities is a big challenge. Another important issue is keeping track of changes and adopting the business processes, which is not easy with the existing ERP solutions.

During an ERP implementation phase the business engineer should make some critical decisions about business objects and methods to be used. Also the business criteria and requirements should be considered and checked at all phases of business evolution. These represent a heterogeneous, dynamic, and frequently ill-structured set of informational resources, thus frequently exacerbating the efforts for designers and planners to identify, obtain, and process information in an effective and timely manner.

In the real world the product lines usually require high technological and maintenance intensive assets. In addition the experience of employees and their know-how is the most critical success factor. Regarding these facts, the changing of company's strategy and product portfolio is a long term issue that must be planned after intensive marketing and feasibility studies. Management and analysis of such huge amount of data without a deep understanding of the problem domain is nearly impossible. On the other hand mastering the disparate domains of expertise is a challenging and time consuming issue. For example in the absence of an ERP system the business analysis engineer or business analysis engineering group should take the followings under control:

- Currently used software applications in the company; there may be some heterogeneous applications that do not talk to each other
- Keeping track of customer orders from acceptance to fulfillment
- Managing the interdependencies of complex Bill of Materials and product structure
- Supply chain and interactions with suppliers and transportation infrastructure

The above functionalities can be implemented in the following service groups:

- Object specifications
- Requirements and regulations
- ERP software features and asset specifications

Each of the above mentioned categories may be defined in terms of Ontologies. So at analysis time the business engineer could be aware of the consequences of the decisions made. The following scenario depicts the situation better.

Consider that a business process should be analyzed and mapped to a new ERP solution. The business engineer may explain the business process in terms of ontology and annotate it using some terms. In the next step the annotated object will be matched with an ERP process and also all pre conditions will be extracted from relevant regulation ontologies (safety regulations, material regulations ...) and checked. So by capturing the knowledge of problem domain the business engineer will be able to consider all requirements and the whole ERP implementation process will become more reliable.

3.2 Use of Ontology-based Personal Information Management Systems

Another challenge in Enterprise Information System is the detailed capture of activities and process information. ERP systems usually define a predefined sequence of activities which are in turn used to do process calculations. However, often the predefined concepts are not optimal and sometimes ambiguous in capturing the business activities. The question is how precise is the knowledge which is being captured automatically. Frequently, humans need to jump in, interpret the activities and modify the concerned process. A lot of knowledge still resides with experts, as tacit knowledge which has not been captured in a machine processable way due to lack of available technology. Now using ontologies, we are in a position to represent the expert's concepts in a formal way. The ambiguous processes can now be stated explicitly, and then can be read and processed by machines.

The time spent by a resource in a business process is crucial in calculating the overall product costs. The precise tracking of human resource time consumption is generally not possible. Consider the scenario where a marketing staff member might be talking on telephone to production staff for acquiring some useful information while preparing the tender documents for a new project, or customer support staff talking to him / her about an existing project. Apart from spending time in conversation, the production staff member starts a sequence of post-conversation activities to fulfill the query such as to consult the internet etc. Generally these intermittent requests from other departments are not tracked as far as the identification of the project and the time spent is concerned.

In our ontological personal information management system SemanticLIFE [14] we are capturing the information coming from different data sources. The different data sources are emails, process data running on your computer, your web browsing history, contacts in your address book, appointments in the calendar, chat sessions, file system monitor. Also we are in the process of implementing other data feeds like telephone log. The information is stored according to trivial ontology for each data source. In next step, domain ontology is made to interconnect these data sources according to the different types of user queries. Manual annotations and to some extent automatic associations are possible by using available metadata in incoming information items. For example it is possible to identify the project related with the web pages you visited for searching material about a technical query from your marketing counter part. The association is made based upon the following:

a. The Project ontology describing the project plan, resources, assignments, allocations, costs etc
b. The data feed ontology describing the individual data feeds, their attributes
c. Extraction of key words, and key concepts like time, location from the captured data feed
d. Mapping the instance of ontology from step b, onto entities from step a based upon key words from step c

A sample of our project ontology is as follows:

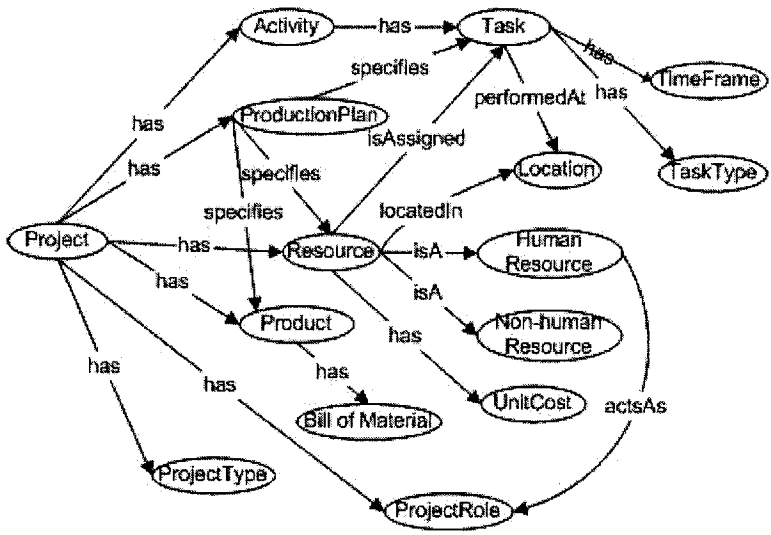

Fig. 1. Project Ontology

3.3 Business Security

As the closed domain of organization's applications opens to the outside world, there will be a growing need for enforcing complex policies whose satisfaction is not easy to manage via traditional security methods. By considering the fact that the average business loses three to six percent of annual revenue due to fraud, it goes without saying that the ERP security is of great importance. Enforcing context-sensitive policies in open domains requires the ability to opportunistically interleave policy reasoning with the dynamic identification, selection and access of relevant sources of contextual information. This requirement exceeds the capability of decentralized trust management infrastructures proposed so far, and calls for privacy and security enforcing mechanisms capable of operating external services [15].

On the highest level the security requirements of a typical business process can be broken down to "*Task level security*" and "*Process level security*" [16]. The task level security needs an "*access security model*" to define the constraints and access to system modules. On the other hand process security requires a "*business security model*" that may overlap with the access security model. Semantic Web paradigm may be used to address the complexity of our security models. As a first step, the structure of business (organization) may be captured in an ontology which essentially involves business actors. In the second step, the business processes and activities are modeled and expressed in another ontology schema.

To give a concrete example; an enterprise may have (among other activities) projects and processes. The first step is, to define ontology for these types of activities. For example, a project has a project manager, who is a person. A project consists of tasks that may have some subtasks. Tasks may be dependent and each task has attributes like start date, end date, man hours and so on. Each project must be authorized by a board of directors, the finance department and so on. The same has to be done for the process specification. A process has a process owner, has tasks, and so on.

Further more the actor's ontology should be defined that is essentially a map of the company's organizational chart plus description about customers, associates, business partners and may be system web services. As a matter of fact, all persons, organizational units or systems that have an active or passive role in a business activity must be taken into consideration.

After this the connection between the actor ontology and the organization/activities ontology can be formally described and this will be used to determine access control logic. For example one could define, that a person who is a director, has "read" access to all objects that are defined in the activity ontology except the ones that are private property of some other person [17].

3.4 Sharing Business Processes

By evolution of Service Oriented Architectures the outlook of the business is entirely changed. The processes and services are no more limited to an organization but they may be used internally by other systems and externally by business partners to automate and compose a business solution. Integration and process automation are two of the most important issues facing organizations today. By providing a standards-based approach to integration, the Web services and services-oriented architectures have provided significant help in addressing these challenges. However, Web Service standards apply at the syntax level of service interface specification and do not capture service semantics.

Web Services are the basic blocks of such collaboration environments, and an expert may compose useful scenarios by combining well-suited sets of Web Services. Still the person, who chooses the Web Services and chain them together, should be familiar with specific knowledge of domain services. Also, the expert should be familiar with Web Services at both syntax and semantic level. On the other hand as the number of available Web Services increases, it becomes more and more critical to have automated systems to help us identify the services that match specific requirements. Finding suitable Web Services depends on the metadata presented by Web Service providers including description of Web Services and their capabilities.

Ideally the Web Service descriptions should be machine interpretable to automate the service discovery and service composition scenarios in an unambiguous way. Adding Semantics to Web Services for presenting requirements and capabilities of Web Services is essential for achieving certainty and machine-interpretability. Semantics define the meaning of terms, such as the meaning of parameters or business objects and the meaning or intent of an operation. Semantics are often described in ontology as a formal and unambiguous definition of terms and their relationships. Typically, ontology includes a set of inference rules to allow reasoning on the concepts being defined.

Currently the Web Service Description Language (WSDL) [18] is used to syntactically describe the structure of a Web Service. Semantic Web Service standards leverage the capabilities of WSDL by providing a mechanism to annotate the capabilities and requirements of Web services with semantic concepts referenced from a semantic model. This mechanism will annotate the service and its inputs, outputs and operations. Additionally, it will be able to specify and annotate preconditions and effects of Web Services. These preconditions and effects together with the semantic annotations of inputs and outputs enable the automation of the service discovery process.

4 Conclusions and Future Work

The evolution of Semantic Web has opened a new window in IT and specially data engineering fields. During last few years most of Semantic Web related standards and specifications are elaborated and gradually it has attracted the attention of IT industry for developing enterprise solutions based on Semantic Web. ERP systems are a huge application area where the explicit use of semantics can make a significant difference in terms of company's productivity and increased revenues. The investigation is made as to how the semantic web technology can be useful in this domain. Also, the new challenges with its adoption in terms of security and privacy of enterprise information are explored. A solution is proposed using different ontologies for data sources, business processes, and security and privacy policies.

The work is still under progress by enhancing our prototype SemanticLIFE towards collaborative environments and providing semantic feeds for enterprise systems.

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An Extended TAM for Subscribers' Adoption of Mobile Data Services Provided by Wireless Communication Systems

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Abstract. Wireless communication systems are one kind of EIS (Enterprise Information Systems) for mobile carriers. One of the major applications of wireless communication systems is to provide mobile data services to subscribers. Why do subscribers use mobile data services? The answer is crucial to the improvement of wireless communication systems. This study applies TAM (Technology Acceptance Model) and mobile subscriber experience factors to predict subscriber's acceptance of mobile data services. The proposed model was empirically evaluated using survey data collected from 802 mobile subscribers. The results reveal that subscribers' perceived ease-of-use and innovation experience are the main reasons to influence their intention of using mobile data services, subscribers' perceived usefulness and brand experience are the key factors to change their attitude toward using mobile data services. Overall, considered direct and indirect effects, subscribers' voice experience and innovation experience are the most important factors influencing their intention of using mobile data services. The implication and the future work of this study are discussed.

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Skeleton of a Supervisor for Enterprise Information Systems

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Abstract. We describe the key elements of a working program which can assist in the overall management of the information resources of an organization. This program can reason about the relationships between components of an EIS, and concludes that a problem exists when those relationships become abnormal. This program can also reason about the behaviors of the components of an EIS, and concludes that a problem exists when those behaviors are abnormal.

1 Introduction

One of the ultimate goals of enterprise information systems (aka enterprise resource planning systems) is to develop and/or coordinate systems such that the conglomerate of the information resources of an organization works together for the good of the organization in the best of possible ways. This entails that information is timely and accurate, and more importantly, that the digestion and dissemination of that information occurs at the most appropriate of times in the most appropriate of ways.

To assist in this goal, we propose an architecture for a high level reasoning module that will sit on top of an enterprise information system (hereafter, EIS). Such a module can reason about the relationships among components within a system. It can also reason about the behavior of the components of a system. If either the behavior or the relationships vary from accepted norms, then a problem within the system is detected.

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We make the simplifying assumption that an EIS that is composed of many components. It is assumed that these components communicate with each other and with our program via message passing. (The actual mechanism by which our program receives information is immaterial.) The purpose of our program is to identify problems within the EIS. These problems can be with either the software or with the data. Problems are identified when messages conflict with each other, or when messages conflict with the program's beliefs.

1.1 Programming Tool: Answer Set Programming (SMODELS)

The basic strategy is as follows. An agent architecture is used to represent entities, their interrelationships, and their actions. In the example presented here, the only action is that of transmitting a message. These details are represented in a logic programming paradigm, called Answer Set Programming, which is more clearly specified as A-Prolog [1, 2]. A-Prolog can be viewed as a purely declarative language with roots in logic programming [3, 4], the syntax and semantics of standard Prolog , and in the work on nonmonotonic logic [5]. The inference engine used is SMODELS. This inference engine is aimed at computing answer sets (stable models) of programs of A-Prolog [6, 7]. This paradigm is very powerful in that it can represent multiple views of the world. This is important, because in the presence of uncertainty, the ability to postulate different ways that the world could be is very important. Not only can we represent different ways of perceiving the world, but we can also reason about those differences. Further, this paradigm allows the software to introspect with respect to its own beliefs.

1.2 Knowledge Representation Tool: Action Language Formalism

We are using specific action language formalism. This action formalism is very powerful in that it allows us to reason about prerequisites to actions, consequences of actions, co-requisites of actions, mutual exclusivity of actions, and sequences of actions. It also allows us to represent and reason about time. For example, things that are true in one moment of time, may or may not be true in another moment of time. Not only can we take time into account in our reasoning, but we can combine this with our introspective ability, and determine what was believed at some time in the past. We can also project into the future. This ability to predict is essential. In fact, one method of detecting problems is the fact that present observations may not match our earlier predictions. Further, predicting future actions allows us to identify potential opportunities for problems, allowing us to take proactive action.

To adequately represent and reason about these actions, we use the family of action languages [8, 9] originating with the action language A [10]. These languages encapsulate the significant issues broached by situation calculus [11], a formalism developed to deal with time-varying variables (called fluents.)

The structure of this paper is as follows. First, we present a very simple problem that the program is trying to solve. Next, we discuss elements of a working program to detect problems with regard to our simple scenario. This presentation is followed by a discussion of the results of the program.

2 Illustrative Problem

A very simple problem has been designed to demonstrate some of the techniques that will be followed. In this simple scenario, there are 3 entities. The only actions these entities can perform are communicating messages. (This is not a limitation; it serves only to simplify the problem.) A bias that is purposefully designed into the software is that it assumes that fewer problems are preferred over more problems. That is to say, when faced with competing explanations of the world, favor the explanation(s) in which there are fewer entities experiencing a problem. This matches our intuition.

3 Discussion of the Program

The program has the following structure: the objects of the domain, the background theory of the domain, and general rules of inertia. The objects of the domain are: time periods, and their general relationships to each other; entities; messages transmitted by the entities; fluents (time-varying variables); and actions that can be performed. The background theory of the domain consists of dependencies among the fluents, and causal laws. Causal laws state the impact of actions. The general rules of inertia are used to define what remains constant between time periods, and to define what changes between time periods.

3. 1 Description of objects in the domain

The objects of the domain are: the time periods involved, the entities, the messages the entities transmit, valid truth values, fluents, and the actions that can be performed. The first statement below defines the number of time periods that will be reasoned about. The second statement defines those time periods as integers between 0 and n. The third statement defines a total ordering upon the time periods, and defines what time periods are next to other periods.

```
const n=10.
time(0..n).                                   1)
next(T1,T2) :- time(T1),                      2)
      time(T2),
      T2 = T1 + 1.
```

This last statement defines that time period T2 immediately follows time period T1. Time T1 is next to time T2 if both T1 and T2 are time periods, and time T2 equals time T1 + 1 time unit. Note that in this definition, next is not symmetric. That is, while T1 is next to T2, the reverse is not true. (Next means "subsequent", not "adjacent".)

Other objects in our domain which we need to represent include the entities we are reasoning about, the messages that are transmitted.

```
entity(e1).                                                    3)
message(m1).                                                   4)
```

In the process of transmitting the message, the entity also relates his/her belief in the truth of the message. For example, "the forecast for today is for severe thunderstorms, but I don't believe it will rain at all." Therefore, in order for a communicator to express belief or disbelief in a proposition, true values need to be objects of our domain. Those truth values are defined with statements such as the following.

```
truth_value(1).        %% 1 represents "true"                  5)
```

Background knowledge is given by a collection of domain dependent fluents. A fluent is a time-varying variable. An example would be something like the president of the United States. This same term has different denotations at different moments of time. For instance, reagan = president(usa) can be true or false depending on time. If this question is asked with respect to 1980, the answer would be yes. If this question is asked with respect to 1990, the answer would be no.

In the next three rules, inertial fluents are being described. Domain dependent fluents do not have to be inertial, but are described as such for simplification. A fluent is inertial if its truth value stays the same unless it is changed by an action. For example, if the light is on, it remains on until an action changes that fluent. Such actions might include: turning the light off, turning the circuit off, or a power outage. As example of this definition is the following.

```
fluent(i,f1).                                                  6)
```

A fluent is described by two parameters, as in fluent(i,f1). The first parameter identifies the type of fluent. The second parameter identifies the fluent itself. There are two values for type of fluent: i means the fluent is inertial, and n means the fluent is not inertial. We described inertial fluents above. A fluent is not inertial if it is true only for the time period in which an action affected it. For example, if at time T1 my daughter said that she loved me, the fact that that message was uttered is true only for time T1. It is not true that she uttered that at time T2 UNLESS she uttered it again.

This example also demonstrates another issue. With the utterance of that message, two fluents were affected. I learned something about my domain from the message: the fact that my daughter loves me. This is an inertial fluent, and would remain true through all successive time periods unless an action changes that. The second fluent affected by this example is the fact that the message was uttered. This is a non-inertial fluent, and is true only in time T1, unless it is uttered again.

The fluent described next, received(M,A,Truth_value), says that the system received a message M from entity A with some truth value. That is, entity A says that message M is true (or conversely, false). A Truth_value of 1 means true, and a Truth_value of 0 represents false. Notice that this fluent is not inertial. Receiving a message at time T does not imply receiving the same message at time T+1.

```
fluent(n,received(M,A,1)) :-  entity(A),                    7)
                    message(M).
```

The example presented here is very simple, and is used to illustrate our approach. The example consists merely of entities transmitting messages. At this point in the discussion, it would be natural to expand the domain by defining actions which would allow entities to achieve some collection of goals. A general scenario would be to plan and execute actions to achieve those goal(s), and to modify those plans according to information received from the entities. It also would be reasonable to allow us to request certain types of information from the entities, etc. For the moment, these actions and goals will be ignored. For the purposes of the example, only one action will be introduced. The following rule defines that action as that of transmitting a message. This rule states that entity A transmits message M with truth_value V. Stating this in the language of fluents, A says that fluent M has truth value V.

```
action(issue(A,M,V)) :- entity(A),                         8)
          message(M),
          truth_value(V).
```

3.2 Background theory of the domain: dependencies among fluents

The foregoing discussion concludes the presentation of those types of rules which define the objects of the domain. The second major portion of the program is the background theory that is needed to reason and act in this environment. This additional background consists of: (a) dependencies between fluents, and (b) dynamic causal laws. Some dependencies will be domain dependent, and others will be domain independent. Dynamic causal laws describe actions that may be performed in the environment. They specify prerequisites to actions, consequences of actions, actions that may be performed in parallel, and actions that are mutually exclusive with each other. The following two rules specify the domain dependent dependencies for the example.

```
holds(m2,T,0) :- time(T),                                  9)
```

```
        holds(m1,T,1).

holds(m2,T,0) :- time(T),                                          10)
        holds(f1,T,1),
        holds(m3,T,1).
```

The basic form of the holds predicate is holds(Fluent, time, Truth_value). Hence, holds(m2,T,0) means that fluent m2 is false at time T. Similarly, holds(m1, T, 1) means that fluent m1 is true at time T. The first rule states a dependency between two fluents: fluent m2 and fluent m1. It states that m2 and m1 CANNOT be true at the same time. The second rule creates a dependency between three fluents: m2, f1, and m3. This rule states that at a point in time, if f1 is true, and if m3 is true, then m2 MUST be false.

The next fluent dependency rule is the following:

```
holds(M,T,V) :- time(T),                                           11)
       entity(A),
       message(M),
       truth_value(V),
       holds(received(M,A,V),T,1),
       not holds(problem_entity(A),T,1).
```

This rule states that the information received from entities that are not known to be problem entities is to be believed. The form of negation here, not, is weak negation. It is not known for a fact that entity A is not a problem entity. However, there is not any evidence to believe that entity A is a problem entity, therefore that entity is to be given the benefit of the doubt. To not do so would place us in a state of paralysis: we would never act until we were absolutely certain of all the facts. Unfortunately, real life rarely is so simple.

Note that according to rule 21, we believe precisely what the entity informs us of. In the example just given about rain, the entity informed us that he/she/it does not believe the message. This is signified by the variable V in the formula holds(received(M,A,V),T,1) of rule 21. Looking at the head of the rule 21, this same V is the truth value we assign to the fluent representing the message. In this case the meaning is that we adopt the entity's belief as our own belief.

Rather than believing what an entity transmits, we could take the posture of doubting what an entity transmits. Here is an opportunity for greater generalization. In what kinds of situations should information from an entity/person/source should be distrusted? Perhaps the person (entity) is unqualified to speak about a subject. So, strictly speaking, there is not a problem with the entity, yet there is reason to not believe the message without further investigation.

3.3 Background theory of the domain: dynamic causal laws

We have been discussing the lengthy and very important topic of background theory needed to reason and act in this environment. We mentioned that there are two broad components to this: dependencies between fluents, and Dynamic causal laws. We have just finished discussing dependencies between fluents, and will now discuss dynamic causal laws. Recall that dynamic causal laws deal with the actions of the domain, fully specifying their impacts and their relationships to one another. Normally, it is this section that is the most important and most lengthy of the two. However, since there is only one action in the example, this incredibly important section may seem trivial.

```
holds(received(M,A,V),T2,1) :- next(T1,T2),                12)
                entity(A),
                message(M),
                truth_value(V),
                occurs(issue(A,M,V),T1).
```

If the message is issued at time T1 then it will be received at time T1+1. The occurs predicate means that the action occurred at time T1.

3.4 Laws of Inertia

The rules of inertia are used to define what fluents remain unchanged from one time period to the next. Inertial fluents remain unchanged unless they are specifically impacted by one or more actions. These rules are a standard part of any action theory. One of the rules of inertia is the following.

```
holds(F,T2,1) :- next(T1,T2),                              13)
        fluent(i,F),
        holds(F,T1,1),
        not holds(F,T2,0).
```

3.5 Program execution: rules for detecting problems

The following two rules are used to discover problems,. The first rule declares that it is possible for any entity to be a problem entity. The second rule states that it is desired to conclude that an entity is a problem entity only if we are forced to conclude this by the facts of the program.

```
{holds(problem_entity(A),0,1) : entity(A)}.                                14)
minimize{holds(problem_entity(e1),0,1),holds(problem_entity(e2),0,1),  15)
        holds(problem_entity(e3),0,1)}
```

The first rule is a choice rule. Roughly speaking {p(X): q(X)} says that an answer set A of the program containing this rule may contain an arbitrary subset p of q, i.e. an arbitrary collection of atoms p(t1),...,p(tn) such that for every i, q(ti) is in A. For instance, a program

{p(X) : q(X)}
q(a)

has answer two sets {q(a)} and {q(a),p(a)}. In the case of the first answer set, the arbitrary subset chosen was the empty set, hence only q(a) appears in the answer set. In the case of the second answer set, the arbitrary subset p of q chosen was p(a). There are no other arbitrary subsets. Choice rules can be viewed as shorthand for a fairly large number of normal rules. They allow shortening the program and thereby improving its efficiency.

4 Program Execution

This final section shows a series of executions of the program. At the end of each execution, the program will print out the fluents that are true. The execution of the program starts with a very simple case, and produces very clean, intuitive results (Execution 1). Building upon this example, a contradiction will be introduced, which suggests problems (Execution 2). However, the source of problems is not clear, so multiple models of the world will be maintained to account for the uncertainty that is introduced. This ability to represent multiple views of the world is unique among the techniques of artificial intelligence, and is provided solely by the semantics of logic programs.

This execution will then be expanded with additional information which allows the software to very clearly identify the source of problems (Execution 3). This additional information illustrates nonmonotonic reasoning: in step 2 it will be believed that one of two entities are equally likely to be the problem; in step 3 that previously held belief that one of the entities is possibly the problem will be withdrawn .

4.1 Execution 1: E1

Let us say that initially fluent f1 is true, and fluent f2 is false. The values of other fluents are unknown. Our starting values are stated as follows.

holds(f1,0,1).
holds(f2,0,0).

The program will execute for 1 time period and display the fluents which are true at that time. Let us say that E1 = "entity e1 says that message m1 is true". This is denoted by the following rule:

occurs(issue(e1,m1,1),0).

This rule states that at time 0, it happened (occurred) that entity e1 issued message m1. Entity e1 believes that message m1 is true. If the program is run, the following will be displayed.

Stable Model: holds(m1) holds(f1) holds(received(m1,e1,1))

holds(m1) is true by rules 12 and 11. holds(f1) is true by rule 14. holds(received(m1,e1,1)) is true by rule 12. This result is as expected. This basically says that what was true at the beginning (f1) is still true, a message was communicated, and that message was received.

4.2 Execution 2: E2

Now, let us try a different execution, E2. E2 will be the same as E1, except that it has an additional action: "e2 says that m2 is true". So, the rules to embody this execution are as follows:

holds(f1,0,1).
holds(f2,0,0).
occurs(issue(e1,m1,1),0).
occurs(issue(e2,m2,1),0).

According to rule 9, message m1 and message m2 CANNOT be true at the same time. Hence, either entity e1 is wrong, or entity e2 is wrong.

It is expected to learn that either entity e1 or entity e2 is a problem entity. The software will in fact return two models: one in which entity e1 is a problem entity, and the other one in which entity e2 is a problem entity. This is precisely what would happen in the real world. We are faced with a contradiction (m1 and m2 cannot both be true), and lacking any more information, the strongest position one could logically take is to believe that at least one of the entities is a problem entity. The software has performed as expected and desired.

4.3 Execution 3: E3

Let us consider yet another execution of this program, E3. E3 will be the same as E2 with the addition that "e3 says that m3 is true". The rules that would embody this execution are:

```
holds(f1,0,1).
holds(f2,0,0).
occurs(issue(e1,m1,1),0).
occurs(issue(e2,m2,1),0).
occurs(issue(e3,m3,1),0).
```

In the previous execution, E2, there was a contradiction, and there was equal reason to believe that either entity e1 or entity e2 was a problem entity. There was no additional information to solidify our suspicions, therefore we were left in the position of believing that either one of them could be a problem entity, but we could not determine which one with any degree of certainty.

In another execution of the program, consider that we have the same information as before, but with the additional information that "e3 says that m3 is true". The same contradiction exists as before, yet it can now be firmly determined which entity is the problem. Rule 10 says that if f1 and m3 are true, then m2 cannot be true. This is combined with rule 9 that says that m1 and m2 cannot both be true. Hence, it is now believed (without contradiction) that entity e2 is a problem entity.

5 Expanding This Work

We could log observations to endow the module with the ability to learn patterns of communication for the various entities. This might help identify intermittent problems vs. persistent problems. This might also lead to proactive solutions if certain causes for past problems recur.

We should expand our list of actions. A very complex arsenal of actions which interrelate with each other would be interesting. We could make predictions about the consequences of actions, and observe whether those predictions came true. A significant arena of enhancement would be in defining what constitutes a "problem". That is, forms of problems in addition to inconsistencies (and discrepancies between predictions and observations) need to be identified, along with appropriate solutions. As an example, we could model and analyze more deeply the relationships between components. Abnormalities in those relationships could be considered problems. In the scenario here, a problem was defined as an inconsistency caused by a message. An example of a problem in which there is not an inconsistency would be a situation where there is an increase in the purchase of raw materials at the same time in which there is a reduction in cash flow (thereby exacerbating the cash flow problem.)

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Study of Personalized Trust Model in Enterprise Computing Environment

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Abstract. The increasing popularity of resource exchange through peer-to-peer networks has encouraged the development of ways to support distributed and heterogeneous enterprise computing. Unfortunately, the prospect of distrust attracts agents seeking to weaken the network by propagating fraud and bad services, that is, establish the trust mechanism of the P2P network. Based on recommendation, a number of computational trust and reputation models were proposed for resource-sharing network based on agents. This paper presents a recommendation-based trust model, which utilizes theory of collaborative filtering and social network. Compared with existing trust model, this model has two main features. First, it eliminates malicious recommendation by evaluating credibility of recommender. Second, it adjusts calculating of path weight, while combining trust path, which addresses the problem of subjectivity in path weight initialization. Finally, comparing with Beth model based on eBay's data, the result shows the feasibility and effectiveness of this approach.

1 Introduction

The rapid development o of internet and enterprise computing has stimulated the use of resource sharing and exchange using peer-to-peer (P2P) networks in distributed and heterogeneous enterprise computing. However, the accessibility of these systems makes them vulnerable to malicious users wishing to poison the system with corrupted data or harmful services for personal. The lack of trust mechanism has resulted in large numbers of frauds and bad services [1].

Many research groups and organizations have proposed trust models based on recommendation, applied in resource sharing service of the P2P pattern successfully. In recommendation-based trust model, recommending trust coalition of trust path is the key best of all. Analyzing existing recommend-based trust model, there have

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been a great deal of efforts in trust quantification, but still not enough on trust transmission.

The Beth [2] model utilizes probability to model subject trust in brief and synthesize recommendation-based trust by getting mean, which can't reflect truth of the trust relationship. The model by Rahaman [3] just figures out the transmission rule and calculating formula of trust degree. So it can't deduce recommendation-based trust. There are also many other scholars, who adopt variant means to measure and deduce the trust relationship, for example the Bayes network [4], rough set theory [5], evidence theory [6,7], social network analysis [8], probability [2], etc. However, all these models have some problems in the aspect of trust transmission. There exist many limitations in trust coalition, which mostly include the high subjectivity in setting weight, difficult to reflect the trust reality and unable to eliminate negative impacts of malicious recommending.

The objective of this study is to apply recommendation theory to trust calculating. In the social network, trust relationship is the key of users' human relations and the trust degree of two strangers is usually decided by recommendation of other users. This paper presents a recommendation-based trust model, which utilizes theory of collaborative filtering and social network.

2 Recommendation-Based Personal Trust Model

In our model, users will select those who have transaction history with unknown user and has close trust scenario and trust tendency as the recommender of that unknown user. Then based on the recommendation of above recommender, users can build parallel trust network and incorporate trust paths, finally get the personal evaluation of unfamiliar user's trust.

Following is the sequence of our model: 1) indirect trust computing.2) trust path deduction. 3) trust path amalgamation. 4) trust computing of unfamiliar user.

2.1 Indirect Trust Computing

Aiming at the limitation of model proposed by Beth [2] and Yu [7], the paper sets the maximum length of a trust path as 6 according to Six Degrees of Separation suggested by social psychologist Stanley Milgram [5], which cuts down the time of traversing in trust paths, therefore, raises computing efficiency and strengthens explainability of trust model by using existing research of sociology theories.

Definition 1 The direct trust τ_i^j, which user i hold about user j is given by

$$\tau_i^j = \frac{\sum_{k=1}^{num\_trans(i,j)} \rho^{num\_trans(i,j)-k} \cdot \overline{f}^k(i,j)}{num\_trans(i,j)}, \tau_i^j \in [0,1] \quad (1)$$

Where, $num\_trans(i,j)$ denote the transaction time, ρ $(0 < \rho < 1)$ denote the time attenuation factor, and $\overline{f}^k(i,j)$ denote average reputation feedback.

Definition 2 $WS(j)=\{x|\exists x\in x_k \wedge x_k \in X\}$ denote the witness set of user *j*, user *x* who satisfies $x\in x_k \wedge x\in WS(j)$ is defined as witness *x* in trust path x_k.

Definition 3 If there exist a trust path $x=x(i,o_1,o_2,\cdots,o_k,\cdots,o_{l-1},j)$, of which o_k is the *k*th recommender in trust path x, then the direct trust $\tau_i^j(\tau_j^i)$, which user *i(j)* holds about user *j(i)* in trust path x, is given by

$$\tilde{\tau}_i^j=\prod_{k=1}^{l-1}\left[CR_1(o_k)\cdot CR_2(o_k)\cdot \tau_{o_{k-1}}^{o_k}\right]\cdot\left[CR_2(o_{l-1})\cdot \tau_{o_{l-1}}^{o_l}\right], \tilde{\tau}_i^j\in[0,1] \quad (2)$$

$CR_1(\cdot)$ denote credibility of recommendation information, which is given by

$$Cre(x)=\sqrt{\frac{(\lambda-1)^2+1-(l-1)^2}{(\lambda-1)^2+1}}, \lambda\geq l\geq 2 \quad (3)$$

Where, λ denote the longest trust length, l denote length of trust path x.

2.2 Trust Path Deducing

To evaluate trust degree of user *j*, user *i* need search recommender of user *j* within own trustable user set *TN(i)* or selected recommender's trustable user set *TN(.)* first of all, then seek trust paths whose length is shorter than 6 between user *i* and user *j*, finally computing the direct trust $\tilde{\tau}_i^j$ that user *i* holds about user *j*, according to formula (1). If length of trust path is bigger than 6, there doesn't exist any trust path between user *i* and user *j*, in other words there doesn't direct trust between user *i* and user *j*. Algorithm 1 gives the implementation of above trust path deducing.

2.3 Trust Path Combination

Definition 4 Supposing that there exist m trust paths $x_1,x_2,\cdots,x_m$ between user *i* and user *j*. If $x_i\cap x_j\neq\phi$, trust path x_i and x_j is defined as parallel trust path.

Currently the common means of trust path combination system mainly includes arithmetical average [1], weighted average [9] and weight based etc [10]. Above-mentioned means all have limitations, such as excessively simple operation and overly sharp subjectivity while weight setting etc. In order to resolve above-mentioned problem, the Beth model adopts equally deducing number to combine trust paths. However, it doesn't consider the distortion problem of recommended information while combing trust paths. Therefore it will bring about computing deviation of recommending trust. The paper introduces recommendation information credibility therefore and steers an improvement to the Beth model.

Let x_j denote the jth trust path, the formula to combine trust path is given by

$$V_{com}=\sqrt[n_i]{\prod_{j=1}^{n_i} Cre(x_j)\cdot V_{ij}} \quad (4)$$

2.4 Unknown User Trust Computing

Based on means proposed by Beth, the paper presents a modified means to compute unknown user's trust degree, by adopting the credibility of recommendation information. Direct trust $\tilde{\tau}_{com}(i,j)$ that user i holds about unknown user j is given by

$$\tilde{\tau}_{com}(i,j) = 1 - \prod_{k \in WS(j)} \sqrt[n_k]{\prod_{l=1}^{n_k} Cre(x_{k,l}) \cdot (1 - \tilde{\tau}^{j}_{i,k,l})} \tag{5}$$

Where, $j.k.l$ denote witness k of user j, $k.l$ denote the lth trust path whose terminal node is k, n_k denote the number of trust paths whose terminal node is k.

3 Experiment

We used Lucking-Reilly's eBay data set [11]. He collected 2439 transaction data between June 12th 1999 and August 4th 1999. Table 1 shows the data description. There are 1026 unique users, which forms a virtual social networks G.

Table 1. Data Description

Variable	Amount	Average amount of transaction partner number	Average transaction number	Average transaction price ($)
Buyer	691	2.043	3.530	134.078
Seller	380	3.716	6.418	222.439
Double as	45		4.8	249.832

3.1 Single User Experiment

We choose a buyer named *cobra76* from 691 buyers randomly. As shown in Fig. 1, comparing with Beth model, our model' error is smaller than Beth's. The reason is that our model computes trustworthiness. Our model can not only improve computing efficiency, but also overcome malicious recommenders' negative effect on trustworthiness computing. Moreover, when combining trust path, we incorporate credibility of trust path into our model to reduce computing error aroused by recommend information dissipation. Thus, it enhances our model's precision.

3.2 Multi User Experiment

We choose one buyer (or seller) for each credit rank from 691 buyers randomly, then use our model and Beth model to compute given users' trustworthiness separately and compare two models' error (as shown in Table 2 and Fig. 2).

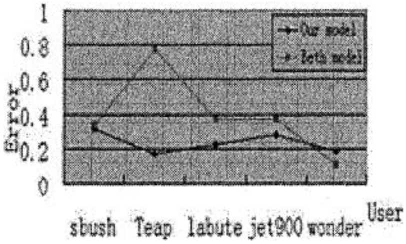

Fig. 1. Trustworthiness Computing Error

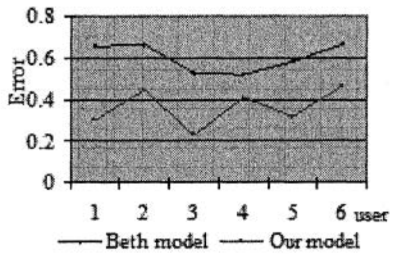

Fig. 2. Trustworthiness Computing Error

Table 2. Computing Error Comparison

User No.	Chosen user	Credit rank	Beth model		Our model	
			Average error	Total error	Average error	Total error
1	shoalscoins	1	0.6567	0.6011	0.3033	0.3624
2	juee	2	0.6617		0.4443	
3	goodealcoins	3	0.525		0.2313	
4	epach29601@aol.com	4	0.5222		0.4129	
5	bbfinethings	5	0.5797		0.3182	
6	alscoin@home.com	6	0.6612		0.4644	

As shown in table2, our model's total error is 36.24, which is smaller than Beth's (60.11%). It indicates that our model is more feasible and precise than Beth model. And the results demonstrate that building given users' social network is an effective method to measure trustworthiness about strangers.

4 Conclusions

Aiming at the scarcity of personality in existing trust model, utilizing the theory of social network and collaborative filtering, the paper designs a recommendation-based trust model. The later experiments indicate that comparing with Beth model, this model is available and feasible.

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An Integrated Information System for Financial Investment

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Abstract. With the globalization and integration of world financial markets, the success in information system has become a critical issue for financial investment institutes in financial service sector. Information system support has started to encompass the whole range of operational and decision-making activities in investment and financial industry. In this study, we take the challenge by integrating artificial intelligent techniques into the framework of the financial management information system. Particularly, we address the effectiveness of neural networks based trading strategy decision support system and discuss how it could be integrated into the information system to improve uncovering accurate trading signals and maximizing trading profits. In addition, we also analyze the investment firms' complicated and dynamic environment, where the sources of information for trading decision making comes from, and show the advantage of artificial intelligent techniques in dealing with such nonlinear and complex information. The results obtained from this study demonstrate the potential value of neural networks in financial management information systems, by discovering patterns and trading signals in noisy and dynamic financial data and by integrating with other decision support systems in making a more optimized trading strategy.

1 Introduction

Under the environment of globalization and integration of world financial markets, the success in information system has become a critical issue for financial investment institutes in financial industry. The diversity and complication of domain knowledge existing in modern financial market makes it very difficult for investors

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to make correct investment decisions efficiently, since transaction speeds have become much faster nowadays. Therefore, there is a great necessity for developing a set of financial management information system for supporting decision-making and implementing optimal trading strategies in financial investment [1, 2].

Financial investment is a knowledge-intensive industry. Under the fast development of information and electronic transaction technologies, large amount of financial transaction data and market information have been collected in the last decades and the emergence of knowledge discovery technology sheds light toward building up various financial investment decision support systems [3]. Data of financial investment markets are essentially noisy and dynamic time-series which bring more challenges than the traditional discrete data for uncovering the hidden knowledge for trading decisions [4]. It's the highly dynamic and risky nature of modern investment environment that calls for applying some new technologies in dealing with such noisy and non-linear data and information in financial markets. Artificial Intelligence technology, especially Artificial Neural Networks, a computing system containing many simple nonlinear computing unites or nodes interconnected by links, are well-tested method for financial analysis on the financial markets [9]. Therefore, for non-linear trading signal prediction and trading decision support system the key is that they include artificial intelligence techniques like neural network, fuzzy logic, genetic algorithm and so on [5, 6]. In this research we integrate an artificial neural network based investment decision support system into the framework of enterprise financial management information system and show how it take the advantage of abstracting underlying nonlinear financial relationships for trading signal prediction and how it is integrated with other decision support and trading systems to enhance the accuracy and efficiency of the enterprise information system on the whole. By abstracting appropriate trading rules based on predicted trading signals and further reconfirmed with the results form other investment decision support and trading systems, neural network based decision support system could add value on the enterprise investment information system and enhance both its accuracy and efficiency on the whole.

The paper is organized as following: Section II analyzes the complex and dynamic financial environment for the financial investment institutes; Section III introduces the process of integrating the neural network based decision support system into the framework of enterprise financial investment information system; Section III provides some analysis on the integrated information system and draws the conclusions.

2 Analysis of the Financial Environment

With the development in advanced information technologies, modern financial market has became more and more dynamic and efficient in the sense of intra- and inter- market information exchange and transformation. As shown in Fig. 1, there are four main interconnected entities that make up the macro-architecture for the information system of the financial markets: Interlinked financial markets, market participants, public information, and government regulators. It is the information exchange and interactions based on the transferred information among these four interconnected entities under this framework that dynamically and continuously determine the market price and the tendency of the market index. Particularly, there are mainly six pairs of interacted relationships under this framework:

1) Financial Markets and Market Participants: It's through the market trading system that market participants directly (institute trader or investment broker/dealer) or indirectly (through broker/dealer) make transactions on the financial markets. The transactions ordering and quoting information update the financial market information system continuously and instantly reflected on the market board information and thus released as public information. On the other hand, based on both historical and live data from the financial markets, the market participants adjust their market expectations and market trend prediction for their future transactions.
2) Financial Markets and Public Information: continuously updated financial market board information, primary market news, secondary market movements and other macroeconomic or regulation news are the main sources for the public information. Reversely, released public information can affect financial market by changing investors' market expectations and by influencing the policy of market regulators.
3) Market Participants and Public Information: market participants can contribute to public information by their transactions on the first and secondary financial markets. On the other hand, the released public information can influence the market participants' market expectations, trend predictions and even trading strategies.
4) Market Participants and Government Regulator: government regulators can regulate the activities of market participants by limiting their over speculating and market making transactions to stabilize the financial markets. On the other hand, government regulators can also influence market participants' market expectations and transactions through monetary or fiscal policies. Reversely, market participants can influence the government regulator's policy by public information that reflecting the current market status and investors' expectations.
5) Government Regulator and Public Information: government regulators can directly influence the public information either by monetary policy from Central Bank or by fiscal policy from Treasury. The public information after releasing of these policies that reflecting both the macroeconomic status and market expectations can reflect the results of the government policies and thus influence the policy makers' decisions on future policy adjustment and regulations.
6) Government Regulator and Financial Markets: government regulators can influence financial markets either by regulating the market activities of speculators and arbitrageurs or by affecting market participants' expectations through monetary or fiscal policies. The financial market status resulting from the government regulations reversely can influence the government future decisions on policy making.

From the above description, we can see that modern financial market is a highly dynamic and integrated information exchange and market price determining system. It was within such system that the financial price and trading volume information, market expectations, public and macroeconomic information and government regulations are continuously exchanged and interacted. It was under such dynamic mechanism the financial market system's functions are efficiently optimized.

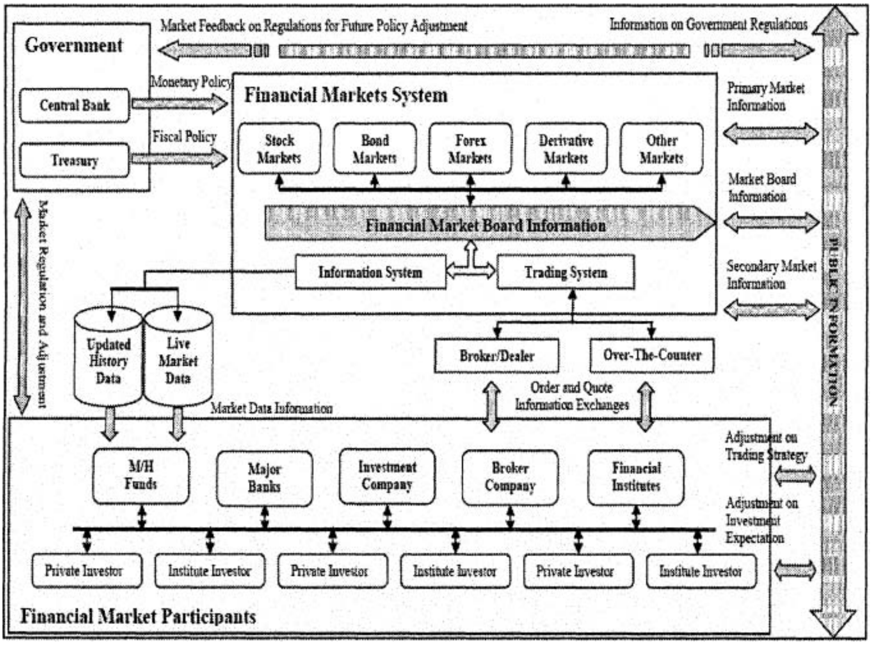

Fig. 1. Architecture of Information Systems in Financial Markets

Under such complex environment, the key to success, or even survival, for financial investment institutes is to integrate artificial intelligence techniques based investment decision support system into their enterprise investment information system. With machine learning, artificial neural network models the underlying nonlinear relationships among the entities of financial markets and allows appropriate learning, expression and presenting for better decision-making purposes [7].

3 Integrated Enterprise Investment Information System

There are number of approaches within the literatures which deal with applying artificial neural networks techniques to investment and trading decision support systems. Although there appears to be no formal segmentation of these different approaches, we classify them into four categories [8]:

1). Time Series Forecasting – predict future data points using historical data sets. Neural networks are used in the DSS to predict the base financial time series data (e.g. price, index and return) or financial indicators derived from the base data. Many trading signals are based on the predicted financial indicators that frequently used in technical analysis.
2). Pattern Recognition and Classification – attempts to classify observations into categories, generally by learning patterns in the base data or indicators. Applications involves the detection of patterns and segregation of predicted base data or indicators into 'buy', 'sell' or 'hold' categories of trading signals based on the trading strategies of the investors. For the fundamental analysis, neural networks can also be used in the DSS for financial distress and bankruptcy prediction as well as for credit rating.
3). Trading Strategy Optimization – based on the predicted financial price, indicators, recognized financial patterns and trading signals, neural networks can determine the optimal point at which to enter the transactions under the appropriate trading strategies.
4). Hybrid – this category was used to distinguish research which attempts to exploit the synergy effect by combining more than one of the above styles.

In this study, we would integrate all these features of artificial neural networks into the process of investment decisions support system and fully take the advantage of neural network in dealing with nonlinear financial information. In another words, we will use a hybrid neural networks based decision support system and further integrated this DSS with other traditional DSS in the whole process of operational and decision-making process of the Enterprise Investment Information System. The traditional decision support systems for financial investment is mainly based on such linear forecasting techniques like ARMA modeling, logit estimation MACD technique models and naïve strategy. Fig. 2 provides architecture on how to integrate the artificial intelligence technology into the framework of enterprise financial investment information system. Specifically, neural networks can improve the performance of the information system in each of the following procedures:

Step1: Predictions. The integrated information system in this procedure will use forecasting techniques to predict the future values of price or indicators. As mentioned above, neural networks have advantage comparing with other traditional forecasting techniques in recognizing the underlying nonlinear relationships in the complex financial information thus can make more accurate predictions on both future prices and indicators. In this procedure, both the neural network and traditional techniques based DSS will make their own predictions.
Step 2. Trading Rules. System in this procedure will generalize some trading rules and thus trading strategies based on the historical and predicted market value and indicators. Trading strategies are a way of implementing a set of mechanical trading rules to determine when to buy and sell a set of instruments. Trading strategies

enable the investor to develop a systematic approach to trading, test how a system does in the past, and use signals from the system to place trades into the future. With machine learning, neural networks could learn the patterns in the financial price and indicators and generalize more reliable trading rules than traditional techniques [9]
Step 3. Backtest and Trading Rules Optimization. System at this procedure would backtest and compares all the trading rules generalized from both neural networks and traditional techniques based DDS and choose the optimal trading rules for future processing. At the same time, recursive mechanisms would be applied to adjust the settings of neural networks and new trainings and predictions are conducted based on the adjustment.
Step 4. Trading Signals and Transactions. System at this procedure will generalize trading recommendations categorized into 'Buy', 'Sell' and 'Hold' to the human expert or traders of the investment institute. While, these automatically generalized recommended trading signals are based on the system generalized 'optimized' trading strategies, the system users or the traders can make decisions by their own human judgment based on the system forecasted indicators or patterns.

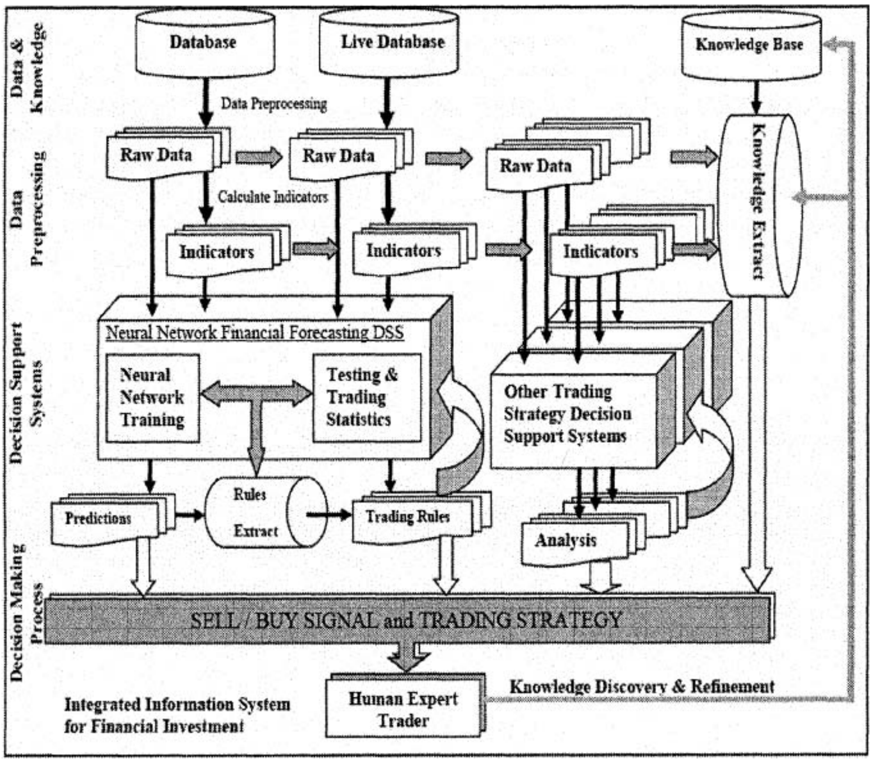

Fig. 2. Integrate Artificial Intelligence DDS into the Framework of Enterprise Financial Investment Information System

Such a hybrid investment information system used will lead to investment results that could not have been obtained using only conventional techniques.

4 Conclusions

Under current complex and dynamic financial environment, efficient financial investment information system has became critical for the success or even survival of the investment institutes. Data of financial market is essentially noisy and nonlinear time-series which brings more challenges than the traditional discrete data for uncovering the hidden knowledge. In this study, in order to overcome the above challenges, we integrate the artificial intelligence technique based DSS into the framework of enterprise investment information system to improve its performance by discovering patterns and trading signals in noisy and dynamic financial data and by integrating with other decision support systems in making a more optimized trading strategy. In particular, among the results obtained we can mention the following:

1). By the detailed analysis on the inter-relationships among the main financial market entities, this study provided the financial investment institutes a dynamic and comprehensive architecture of the interconnected financial market environment.

2). This study provided a classification of neural network advantages in the aspect of investment decision support applications and further integrated these advantages step-by-step into the framework of enterprise investment information system.

The results obtained from this study demonstrate the potential value of neural networks in financial management information systems.

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OSS and ERP Systems: Likeness, Difference and Reference

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Abstract. With similar motivations and functionalities, ERP and OSS play the same role as integrated IT platforms in manufacturing and telecommunication operations respectively. However, business processes, supply chains and resources in these two industries differ significantly. Therefore, OSS becomes the IT platform for telecommunication operations, and thus rejecting ERP's proclaimed universal applicability among all industries. However, as numerous similarities exist between ERP and OSS systems, valuable experience from ERP's research and development could still be applied to those of OSS.

1 Introduction

Enterprise resource planning (ERP) systems may be regarded as one of the most innovative developments in information technology (IT) of the 1990s [1]. Although the market of ERP continues to increase [2], its application concentrates in manufacturing and related industries [3].

As a high tech service industry, telecommunications closely combines business processes and IT applications, for it is very important to use IT support systems to improve operators' competitiveness. However, while there is a vast requirement for IT systems among telecommunication operators, the application of ERP systems is still limited to telecommunication equipment manufacturing. On the other hand, ERP solutions for telecommunications operators by SAP, Oracle/PeopleSoft and SSA are more similar to customer relationship management (CRM) systems instead of ERP systems.

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Provided by TeleManagement Forum (TMF), operations support system (OSS) is the mainstream technology to support large-scale network's operation, maintenance and management and is adopted by more and more telecommunications operators.

Some people view ERP as the mapping of all processes and data of an enterprise into a comprehensive integrated computer software, as well as the key element of an infrastructure that delivers a solution to businesses of multiple industries (including telecommunications) with very different characters [4]. Therefore, some scholars believe the term ERP is too narrowly focused, and suggest to replace the term ERP with the term business system (BS) [5] or enterprise-wide planning of resources [6]. On the other hand, some scholars consider ERP as the development of IT support for manufacturing, with the basic thought as supply chain management [7]. This second opinion probably better explains why ERP so far has not become the basic software system for telecommunication operators, for supply chain management is not the key character of telecommunication operations.

Although OSS has been widely accepted by telecommunication operators, much remains to be done, especially academic research in OSS. By analyzing above issues, this paper compares the similarities and differences between OSS and ERP systems. Their similarities may lend experience from research and application of ERP to those of OSS, while their differences may explain why telecommunication operators choose OSS instead of ERP systems.

2 The Concepts of ERP and OSS

As the first approach to combine business management and IT concepts [8], ERP systems are comprehensive software packages that integrate the complete range of a business processes and functions in order to present a holistic view of the business from a single information and IT architecture. Most ERP systems automate corporate core activities such as manufacturing, human resource, finance and supply chain management [7].

OSS generally is a term for the collection of all support systems required to run a telecommunication operators' business. Its four functions can be characterized by operation support, business support, resource support and system support [9]. Operation support system consists of CRM, operation analysis and decision support, office automation and human resource management etc. Business support system includes marketing & sales, call center, service fulfillment, order management and billing etc. Resource management system has network resource management, operation information management, customer basic information management and customer service information etc. Similar to any other systems, system support system deals with log file, system parameters, etc.

3 Similarities between ERP and OSS

Although ERP and OSS are different, they have some similarities.

3.1 Similar implementation motivations

Motivations of ERP and OSS both concentrate on common platform, cost reduction, better customer service and process reengineering.

- Common platform: uniform software platform is the most important motivation of the implementation of both ERP and OSS [10, 11].
- Cost reduction: cost reduction through operation automation is the common goal of ERP and OSS [10, 12].
- Better customer service: rapid development and timely deployment of new services are both important in ERP and OSS [10, 13].
- Process reengineering: business process integration is the concern of both ERP and OSS [10, 14].

3.2 Similar characteristics

Modularization, business process-specific, integration and management thought are the main characteristics of both ERP and OSS.

- Modularization: Most available ERP packages are structured into different modules [10], typically including accounting, human resource, manufacturing and logistics. The structure of OSS systems is modularized according to the telecommunication operation as well.
- Business process-specific: Each module is business process-specific. The use of ERP is associated with business engineering (BE) and the optimization of business processes [10]. OSS realizes the end-to-end customer business operation processes, which will inevitably bring business process reengineering as well [15].
- Integration: An ERP system creates an enterprise-wide transaction structure by integrating modules, storing and retrieving processes of data, management and analysis functionalities [10]. On the other hand, as the goal of OSS is to improve the quality of customer service, it effectively integrates the sub-systems of all business sections into a single system as well.
- Implementation of management: Both ERP and OSS are not merely software systems, but are the implementation of management. Therefore, successful ERP and OSS systems are not a choice of software packages, but are the implementation of competitive strategy, corporate culture, business process reengineering (BPR), management support, training, etc.

3.3 Similar roles

It can be seen from the concepts of ERP and OSS that they are both integrated software solutions to enterprises, although ERP systems are mostly for the manufacturing industry while OSS is usually for telecommunication operators. In general, ERP and OSS systems are both the most important software platform in these enterprises, and both significantly increase their competitiveness. In this sense, OSS is the ERP system for telecommunication operators.

4 Differences between ERP systems and OSS

On the other hand, the reason that telecommunication operators choose OSS instead of ERP systems lies in the difference between ERP and OSS.

4.1 Different operation process

If an enterprise is considered as a system, its operation is considered as a process which transfers internal resources of this enterprise into products needed by its market under certain conditions.

For manufacturing industries, input of the operation process is raw material. The enterprise gets raw materials from suppliers, turns them into all kinds of fittings through machining, puts the fittings into production lines according to a fixed procedure, and finally makes the finished product enter customer market. Information flow, material flow (logistic) and financial flow run through this process.

Fig. 1 shows this operation process. Demand information flows from the customer market into the direction of supplier market, and affects the decision of each step. This causes the output of the enterprise system close to customer's requirement. Material flows from the supplier market into the direction of customer market and makes a value-added process. The financial flow exists within the material flow. The material flow is central to the entire process, although the other two are also important.

As for telecommunication operation, output of the enterprise is information services instead of tangible goods, while input of the operation process is service requirement information from its customer market. According to service requirements, the telecommunications operator invests in and builds its networks in order to meet these requirements. These new businesses are packaged to be service product, which then is sold to customer market.

Fig. 2 presents this process. Service flow, information flow and financial flow are the basic flows in telecommunications operator's operation process. Customer requirement information flow begins at customer market, and ends at the first step of operation process. The service flow begins at the second step and ends at customer market. The financial flow goes with service flow. Obviously, the core flow is service flow, while its efficiency is very important to compose the core competitiveness of this telecommunication operator.

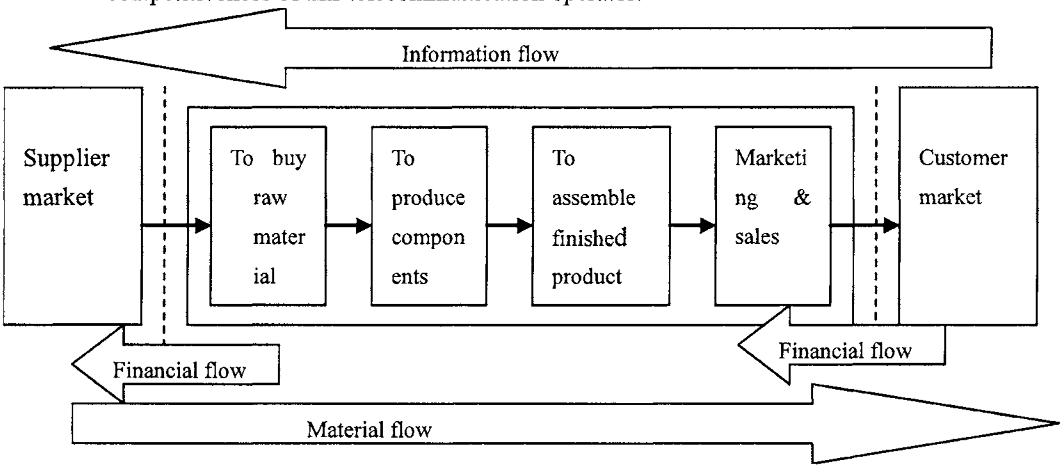

Fig. 1. The operation process of manufacturing enterprise

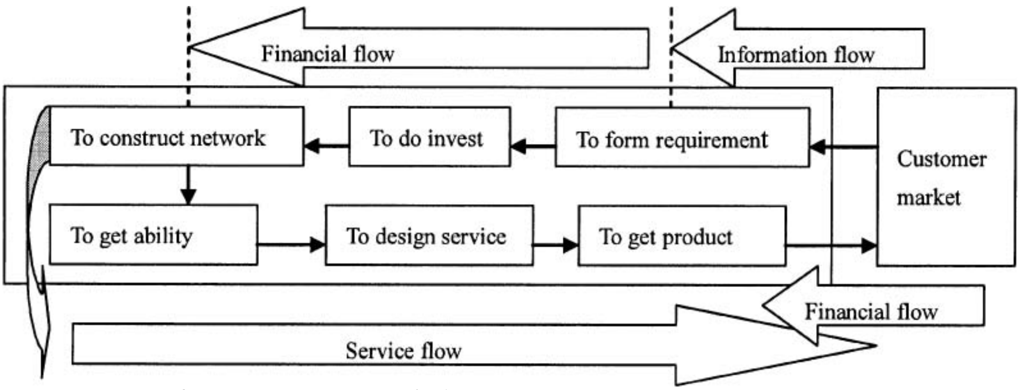

Fig. 2. The operation process of telecommunication operators

One of the most important OSS packages is eTOM, which specifically deals with customer service flow. This confirms OSS is effective for supporting service flow, while ERP systems primarily deal with material flow.

4.2 Different value chain

Both ERP and OSS must support the value chain of the enterprise in order to enhance its competitiveness. However, different value chains require different IT platforms.

Porter's value chain model is widely used in manufacturing industry. In this model, inbound logistics, operations, outbound logistics, marketing & sales and service are the primary activities, while procurement, human resource management, financial management, technology development and corporate infrastructures are the support activities. All these activities together provide customer value. Porter's value chain model is shown in Fig. 3.

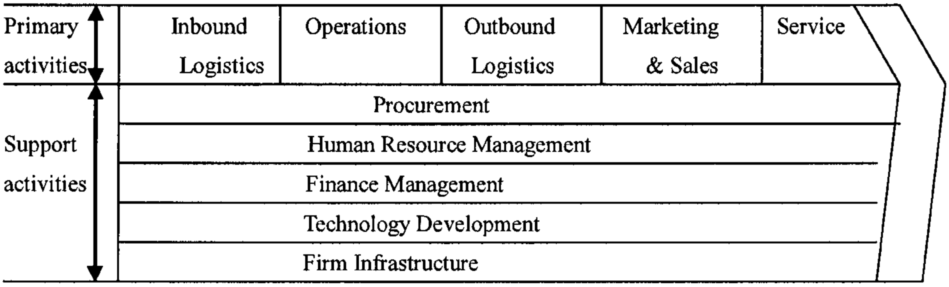

Fig. 3. The value chain model of manufacturing enterprise

Instead, the value of a telecommunication operator is created by its operation management. Primary activities include new service development, engineering construction, network resource management, network maintenance, billing management, order management, marketing & sales and customer services [12]. Support activities are technology development, human resource management, financial management and corporate infrastructures. **Fig. 4** shows the value chain model of a telecommunication operator.

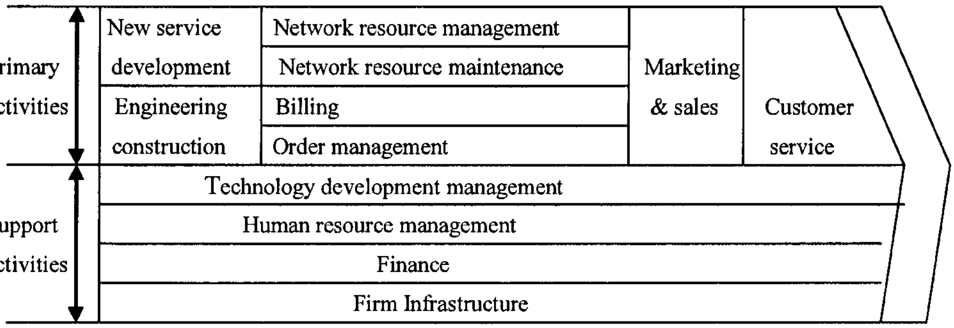

Fig. 4. The value chain model of telecommunication operator

Activities related with material flow play a central role in the value chain of manufacturing, while there are few material related activities in a telecommunication operator's value chain. Instead, they are replaced by network resource management, network maintenance and billing management, which are entirely different from manufacturing.

Because the value chain model of telecommunication operation is different, ERP systems have limited support to its primary activities. On the other hand, the eTOM model includes almost all the activities in the value chain of a telecommunication operator. This makes OSS the IT platform for telecommunication operators.

4.3 Different resources management

Enterprise resource refers to all resources supporting its business operation and strategy implementation, including human resource, capital resource and infrastructure resource, whereas infrastructure resource includes not only buildings, equipment, etc., but also large scale software systems. An enterprise-level IT platform should manage enterprise resources efficiently.

Comparing a manufacturing enterprise and a telecommunication operator, the most different resource is infrastructure resource. Multiple networks constructed for various services are the core resource for telecommunication operation. This network resource does not exist in manufacturing, so that corresponding modules neither exist in ERP systems. Resource support system is one of the four software packages of OSS, and the network resource management is one of the core functions of resource support system. Therefore, from the resource management view, OSS becomes the integrated IT solution for telecommunication operators.

Problems often complained about ERP systems include limited functionality, lack of decision support, lack of extended enterprise support, implementation and upgrade difficulties, and high total cost of ownership [16]. However, these are not the main reason that telecommunication operators do not choose ERP systems. Instead, differences in operation processes, value chain management and resource management are the real reasons.

Some ERP vendors provide specialized ERP systems for telecommunication operators. However, they are only pieces of application software to parts of the operation management. As core functions in ERP systems do not support the core operation flow, core value activities and core resources, ERP systems cannot become the fundamental software platform for telecommunication operators, while only OSS can play this role.

4.4 Different development entities

In addition to the above, as OSS development requires in depth knowledge of the telecommunication operation, its development is usually conducted by telecommunication operators themselves or in close corporation with system developers. This is in sharp contrast with ERP, where enterprises often outsource such developments to system developers or procure ready-made systems.

5 Applying ERP experience for OSS development

As ERP has a longer history and broader application than OSS, it has accumulated more experience in its research and development that can be utilized for those of OSS. A taxonomy framework of ERP research was presented by AI-Mashari [17]. Based on the similarity and differences between ERP and OSS, we get the following taxonomy of OSS research:

- Software platform research: NGOSS, eTOM and methodological aspects are three hot research areas.
- Business process research: Business process management is one of the most important areas of research in OSS.
- Implementation research: The implementation of OSS is an important area of research although little work is done so far.
- Management research: Dramatic changes occur in the telecommunication industry and much work needs to be done in performance management, investment management, knowledge management, etc. [18, 19]. Consequently, changes need to be made in OSS while much remains to be done.

Different from the research taxonomy of ERP systems [17], supply chain reengineering does not appear in the taxonomy of OSS research. Taxonomy of OSS research is as shown in **Fig. 5**.

OSS Research	Software platform	NGN & OSS; eTOM & OSS; NGOSS; Methodological aspects of OSS; OSS in IS curriculum, etc.
	Business process	Process-based IS Analysis & Design management; Standardization & Flexibility; Business process management, etc.
	Implementation	Training & Teaching OSS; Technical aspects of implementation; Successful & Failed implementation; Benchmarking best implementation; Role of IS function in implementation; OSS for other business, etc.
	Management thought	Performance management; Invest evaluation; Knowledge management; Risk management; Change management; Deploy strategy; Project management infrastructure; OSS & competition, etc.

Fig. 5. Taxonomy of OSS research

As can be seen, most areas in the taxonomy of OSS are not fully studied, while much work has been done in most areas of the ERP research taxonomy. Therefore, although not be listed in this paper, it is obvious that, excluding a few areas such as NGN, NGOSS, etc. that are specific to OSS, research experience of ERP in most areas can be utilized in corresponding research areas of OSS.

6 Conclusions

Service flow instead of material flow; service value chain instead of production value chain, and network resource management instead of material resource management, all these industry specific characters make OSS the platform of choice for telecommunication operators. In comparison to the taxonomy of ERP research, taxonomy of OSS research is also provided in this paper. However, on the other hand, due to numerous similarities between ERP and OSS systems, research in these two areas can learn from each other.

Through this comparative study of ERP and OSS, it can also be concluded that ERP systems are not universally applicable to all industries although it is commonly deployed in manufacturing. For specific industries, ERP's accessory modules are often modified in order to build specific ERP systems while its core modules are left intact. However, for industries with characters vastly different from manufacturing, for example telecommunications and the electric power industry, ERP's core modules need to be modified or replaced by completely new modules. In this case, ERP systems are hardly ERP anymore, unless all the systems that can provide an integrated enterprise solution are defined as ERP systems. However, under this definition, OSS is exactly the "ERP" system for telecommunications operators, while the original ERP system can no longer play the role as ERP.

In general, OSS not only works for telecommunications, but also for other industries whose characters resemble telecommunication operation with network resources, service flow and value chain instead of material flow and production value chains. Examples of these include large power plants [20], traffic management [21], etc. [22], although some modification could be necessary in order to make OSS industry specific.

This paper attributes to "ERP for various businesses" in the taxonomy of ERP research [17]. As the authors just analyze telecommunications industry, it is difficult to answer how far can ERP systems extend? It is important for clarifying the concept and definition of ERP systems. System methodology is useful for this research. But in this paper, it is not expressed due to the aim of the authors. This is the limitation of this paper and is one of the future research directions.

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An E-Activities Platform to Support SMEs

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Abstract. E-activities are considered a very powerful tool for the strengthening of enterprises and enterprising in general. They include among others, e-learning, e-government, e-commerce and e-business, which are the main e-activities that directly interest the enterprises. This article presents and describes a compound e-government environment-application that is addressed to enterprises, which incorporates e-learning and training activities within the enterprises on issues covering ICTs and e-activities. Moreover, particular emphasis is given to the exploitation of the Internet technologies and e-commerce from the enterprises in order to exploit the various forms of e-commerce and e-promotion of their products. For example through B2B transactions (Business to Business), there is the potential of reducing the operational expenses for the procurement cycle for their products. Furthermore, through B2C transactions (Business to Consumer), there is the potential to promote worldwide the products and services of the SMEs and finally, through e-advertisement there is the opportunity to exploit the Internet as a promotion medium for the activities of the SMEs. The environment covers all the aforementioned e-services and offers educational e-content for them. Finally, this article presents the electronic infrastructure that was developed in the framework of a relevant European project (Leonardo Da Vinci) for the supporting of e-activities in the field of enterprising and SMEs.

1 Introduction

The issues for governments are to foster appropriate business environments for e-business and ICT uptake (e.g. to diffuse broadband, enhance competition), and target program to overcome market failures to the extent that they are needed in particular areas (e.g. skill formation, specialized information) [1].

More and more governments are using information and communication technologies and especially the Internet or web-based applications, to provide

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services among governmental agencies and citizens, businesses, employees and other non-governmental organizations [2 - 5].

On the other hand, Information and Communication Technologies (ICTs) and e-business applications provide many benefits across a wide range of intra- and inter-firm business processes and transactions. ICT applications improve information and knowledge management inside the firm and can reduce transaction costs and at the same time increase the speed and reliability of transactions for both business-to-business (B2B) and business-to-consumer (B2C) transactions. In addition, they are effective tools for improving external communications and quality of service for established and new customers [6 - 8].

Furthermore e-learning and e-services are the Internet sectors which have a continuously increasing growth rate. The business community is the community which has taken advantage of e-learning services the most, mainly for staff training reducing hence, the training cost. In addition, the business community has taken advantage of e-commerce (B2C) to penetrate the global market and of e-commerce (B2E) to handle and improve employees' management, e-advertisement and to promote the companies' products and services [9 - 14].

The way such organizations cultivate learning and how they retain knowledge is fundamental to the success of organizations in the knowledge economy. E-learning can aid an organization to develop its knowledge base [15, 16]. E-learning is instructional content or learning experience delivered or enabled by electronic technologies. For e-learning to become a core part of the training strategy of organizations, the latter need to be clear of the business benefits it delivers [17 - 22].

There is no doubt of the e-learning industry's aggressive growth, nowadays. Enlightened executives are not considering e-learning an isolated activity, but rather, a piece of the overall business strategy. Hewlett-Packard's learning portal, @hp, handles HR, administrative and training functions for more than 90,000 employees around the world. Course offerings range from IT courses to leadership development courses. The greatest business benefits to be documented are a significant reduction in paperwork and faster decision-making by employees [23]. However, research indicates that instructor-led training is still the most popular and most used training method within organisations [13, 24].

2 System Analysis

2.1 3-tier Architecture

The environment's modularity and flexibility are based on the widely adopted 3-tier model. This architecture ensures the effective management of resources, the best data range, and security. The architecture includes the following tiers: presentation, application and data management. The middle or application tier is responsible for the presentation of data to the users while the third or data management tier deals with the management of the database transactions. Moreover, the middle tier limits the user access to secure data, enforcing the system security.

2.2 Environment Tools

The environment includes tools that offer flexibility and adaptability depending on their use. The design of these tools was based on the existing web services, such as discussion forums [25], chat, message box, e-libraries [26], which are widespread in the public web community. These tools are distinguished into two groups: ''informative'' and ''communicative''. On the one hand, the ''informative'' tools include services related to the educational material and its presentation. On the other hand, the ''communicative'' tools include services that allow the communication of different user groups (users belonging to a different session level).

The environment offers the possibility of management of these tools according to the user groups' permission. More explicitly, the ''informative'' tools include the following: list of courses, list of educational material, examples, exercises, multiple choices, glossary, references, web Links, e-library, announcements. Respectively, the ''communicative'' tools include: discussion forums and message boxes, video and audio conferences and chat. Finally, it must be noted that the environment relates the tools to the educational material courses according to the specific user level permissions. These levels are analyzed in the sections to follow.

2.3 User Levels

Four user levels are distinguished (Fig. 1) in the environment. In each of them different supporting tools exist. Depending on the corresponding use, these levels have also a different role: administrator, instructor, student and unauthorized user. Each of them interacts with the other through the ''informative'' and ''communicative'' tools related to each level.

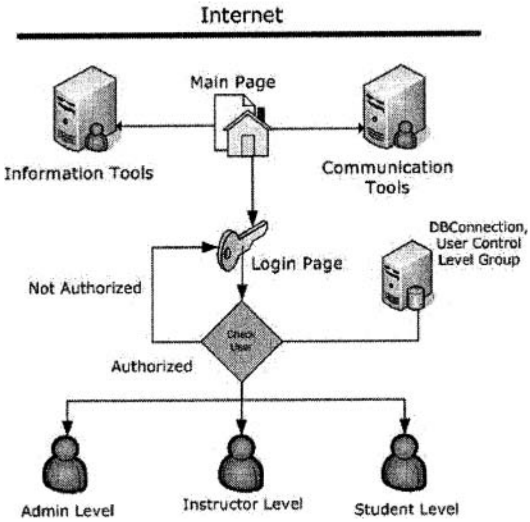

Fig. 1. The user-level diagram

3 User Tools and Services

3.1 Administration Tools

The environment provides administrative e-services and e-activities that are separated in three groups as follows: management of general services, of ''informative'' services and of ''communicative'' services (Fig. 2). The transactions executed in each group concern the retrieval, insertion and update of the corresponding data. More explicitly, the ''general services'' group of e-services and e-activities includes management of the data structures of: news, events, announcements and the user. The management of the ''informative'' e-services and e-activities is of major importance, as it enables the administrator to determine the type and number of seminars, classes, courses, instructors and students.

The ''communicative services'' group includes services through which the administrator can manage: announcements, the e-library of courses and the discussion forums between instructors and students. Moreover, through certain services the administrator communicates with each of the instructors separately.

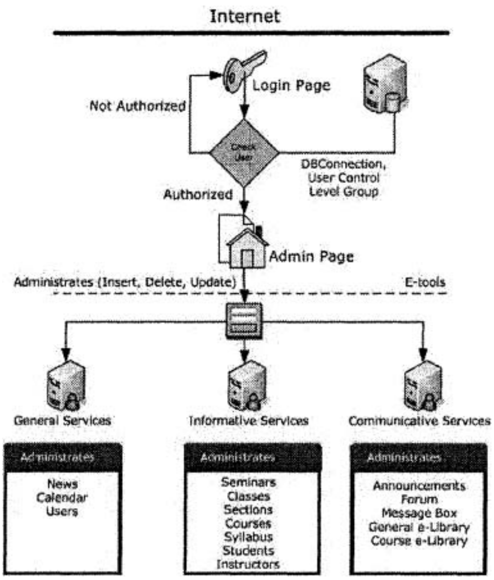

Fig. 2. Administrator Level Diagram

3.2 Instructor's Tools

The tools and e-services help the instructor to organize the course in a way that will help the students-employees in the direct comprehension of the course. The instructor can manage the courses' accompanying material (Fig. 3). Finally the tools and e-services enable the instructor to perceive the learning weaknesses of his/her students, and to select the education process of each course. More explicitly, the instructor's tools and e-services can be separated into three groups as follows: general e-services that include management tools of news, events, profile, courses retrieval/search, syllabus and educational material. The second group includes tools and e-services that allow the fast access to the consulting material, which includes: examples, exercises, multiple choices, glossary, references, web links, e-library, announcements, solutions of exercises, discussions between students and instructors.

The third and more basic group of the instructors' tools and e-services is the one that enables the instructor to build and manage the educational material of his courses: the educational material (chapters, sub-chapters, paragraphs), the accompanying material (examples, exercises, multiple choice, glossary, references, web links, e-library, announcements), the discussions between his/her students on the answers of questions, the discussions with his/her students on the practical application of the educational subjects and finally, his/her message box from the personal communication with the administrator.

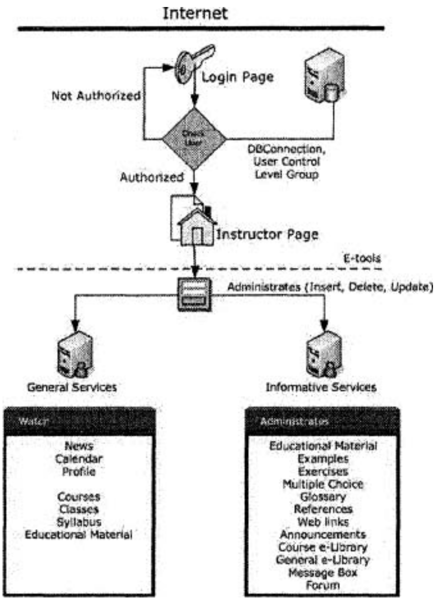

Fig. 3. Instructor Level Diagram

3.3 Student Tools

Through a user friendly and direct way, the environment enables the student-employee, via the usage of a set of e-services and e-activities, to have access to the total amount of the educational material with final aim, the acquisition of knowledge (Fig. 4).

The students' tools and e-services can be separated into two groups as follows: general e-services that allow the fast access to: news, events, courses, syllabus, and to educational material. The second group includes tools and e-services that allow the fast access to the consulting material: examples, exercises, solutions of exercises, multiple choices, glossary, references, web links, and e-library. What is important in this group is the possibility of communication with the instructor via the discussion forums.

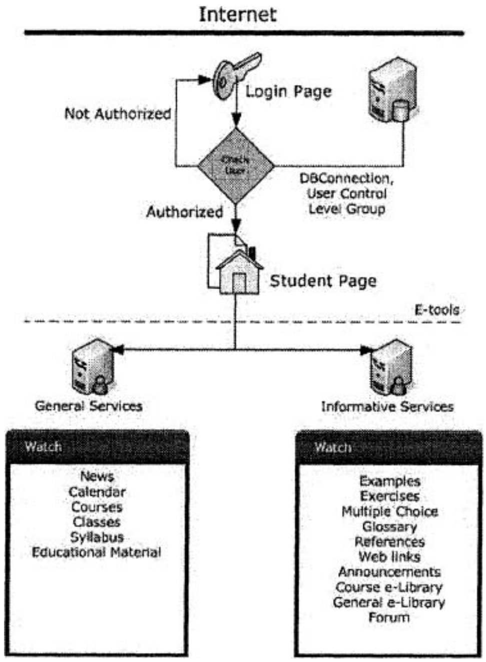

Fig. 4. Student Level Diagram

Moreover, the student-employee has access to the answers of his/her questions but also discusses with the instructor the practical application of the theoretical subjects. Finally, the environment aims at the biggest possible parallelism of education in the traditional classroom, with the education in a virtual classroom.

4 Importance of E-Services and E-Learning in SMEs

The importance of e-services and training via e-learning methods to company competitiveness and employee motivation has been highlighted by many researchers [27, 28]. Some of the most outstanding advantages are:

To the company:

- Flexibility in responding to contextual changes
- Timeliness of adaptation to normative and contractual purviews
- Labour and organisational quality
- Resource optimization
- Maximization of profitability
- Greater competitiveness

To the employees:

- Capitalization and certification of the worker's own competencies
- Acquisition of new competencies
- Transferability of new competencies
- Increased value of the worker's own role
- Greater personal motivation
- Greater knowledge of the worker's own role

Furthermore, e-learning promises to provide a unique experience that accommodates the three distinct learning styles of auditory learners, visual learners and kinaesthetic learners. E-learning also offers individualized instruction, which print media cannot provide, and which instructor led courses allow clumsily and at great cost.

Some of the most outstanding advantages to the trainer or organization are:

- Reduced overall cost is the single most influential factor in adopting e-learning. The elimination of costs associated with instructors' salaries, meeting room rentals, and student travel, lodging, and meals are directly quantifiable. The reduction of time spent away from the job by employees may be the most positive offshoot.
- Learning times reduced, an average of 40 to 60 percent
- Increased retention and application to the job averages an increase of 25 percent over traditional methods,
- Consistent delivery of content is possible with asynchronous, self-paced e-learning.
- Expert knowledge is communicated, but more importantly captured, with good e-learning and knowledge management systems.
- Proof of completion and certification, which essential elements of training initiatives, can be automated.

Along with the increased retention, reduced learning time, and other aforementioned benefits to students, particular advantages of e-learning include:

- On-demand availability enables students to complete training conveniently at off-hours or from home.
- Self-pacing for slow or quick learners reduces stress and increases satisfaction.
- Interactivity engages users, pushing them rather than pulling them through training.
- Confidence that refresher or quick reference materials are available reduces burden of responsibility of mastery.

5 Case Study

The presented infrastructure was developed and used in the framework of a European project 'Leonardo Da Vinci', in order to support the development of e-enterprising within SMEs in a number of countries in Europe and to strengthen the interaction between education and initial training. These countries include Greece, Italy and Poland and all the corresponding data analysis was provided in the corresponding languages. The SMEs that were involved were activated in the areas of Furniture-Wood-House Furnishings, Mechanics and Shoe-Industry. They were informed on issues of development of innovative methods and training products that aim to strengthen the professional training's contribution with final aim the improvement of enterprising, through the promotion of a new training culture within the SMEs.

6 Conclusions

Investment in people is a key differentiator between successful and unsuccessful organizations. In general, E-learning and e-services is a facilitator for organizations to keep up with changes in the global economy. Traditional training methods alone are no longer able to satisfy the demand for the continual updating of employee's skills and knowledge [15,18].

This paper presented an e-activities environment based on a generic and easily adapted architecture. The e-learning tools implemented were based on e-learning standards in order to be used for e-content authoring and management. The system architecture conforms to the principles of interoperability, user-friendliness, interactiveness, and flexibility. The presented environment was adapted to the needs of SMEs in new technologies issues as well as in e-activities such as e-business, e-commerce, e-management and e-advertisement. By training SMEs in the aforementioned issues, they simultaneously become more competitive in the enterprising area, the enterprising increases and consequently, so does the economy.

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An Integrated Information System for Route Inspection in Manufacturing

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Abstract. Medium and small equipments in manufacturing are numerous, various and dispersive, so route inspection is the best method to acquire their condition information for its flexibility and low costs. In this paper, an integrated information system for route inspection is constructed to achieve distributed information acquisition on a large scale and centralized information management in a well order. Firstly, the information transfer model of route inspection is erected to describe information demands of route inspection participant. Then, several key problems, such as the instrument for information acquiring, information administration mode, interaction mode and security, are resolved respectively. Finally, three units, workstation, server and client are developed to acquire, manage and utilize the information. They are integrated into a whole system called MTREE, which has been applied into several steel enterprises successfully.

1 Introduction

Due to the crucial effect of equipment running condition to industry manufacture and profit, computer has been widely used to manage the equipment condition information. Many systems are developed to enhance the efficiency of equipment management and have achieved plentiful success application. But the condition information is not isolated, it contacts with other information closely, such as maintenance plan, spare part storage, production schedule etc. So the integration of condition management becomes a new research issue. In 1999, the ARC Advisory Group originated the terminology "Plant Asset Management" (PAM) [1] to describe systems specifically intended to enable the full scope of asset management function in a plant. The primary elements of such a system include condition monitoring,

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maintenance management, and reliability management modules with integration to one another and to further support the enterprise resource plan (ERP). A framework for intelligent e-maintenance system [2], which provides web-enabled maintenance service by equipment manufacturer, is presented. Depending on the integration of information system, customers i.e. the equipment users can pay their attention only to making the production. Such new ideas are put forward in succession, but most of them are not realized yet because of some unresolved problems, foremost of which is the overall acquisition of condition data.

The condition management is the basis of whole equipment information management. Its function includes acquiring the condition data and utilizing the data effectively. According to the acquisition mode, the condition management system is classified as online, portable and route inspection, and applied in difference instance [3]. The online system monitors the key equipment, the portable system is used to analyze the fault broken out, and the route inspection system, which is implemented by inspector's periodic data acquiring, is adapted to for the dispersive medium and small equipments. For mastering the multiform equipment condition roundly, these three modes must cooperate closely. However, due to the shortage of technique and platform support, the development of route inspection is slower than the online and portable. It is an obstacle to establish the integrated condition management system for enterprise.

In this paper, a whole system, which consists of three units, workstation, server and client, is established to resolve the management problem of route inspection information in manufacturing. The content of the paper is laid out in 6 sections with this section as the introduction. The characters of condition information acquired by route inspection are investigated in Section 2. Section 3 erects the information transfer model, which analyzes the information demands of different user. Section 4 and 5 describe the system design in some emphases and the system construction respectively. Finally, the application instance is introduced in Section 6.

2 The characters of condition information acquired by route inspection

There are a large number of the medium and small equipments in the industry enterprise. The online and portable systems can't inspect them continuously due to the expensive costs. So route inspection is the best data acquisition method for them. Moreover, the condition information of the medium and small equipments is various. Some are measured by special instrument, some are read from the meters on the equipments and others are observed and recorded by inspectors. Therefore, it is difficult to acquire the information on a large scale. At present, only the important data is collected, and other secondary information is ignored. When the technician and manager judge the equipment condition, a new task has to be arranged to acquire more detailed information over again. On occasion, the technician cannot help analyzing the condition in worksite. On this account, the efficiency of inspection is low and the safety of equipment running can't be guaranteed.

To actualize the route inspection, the workstations, whose responsibility are acquiring the condition information and dealing with ordinary maintenance affair, are setting in the workshop, and the equipment is allotted to certain inspector. Since everyone pays attention to the own responsibility, condition information is only mastered by collectors. If the others want to obtain correlative information, they must communicate with the inspector by oral or written report. But the expression style of different technical fields has some diversity, sometime it perhaps causes misunderstand. In the other hand, the information can't be transferred timely. Under the circumstance, the condition information acquired by the route inspection is isolated and can't be used in a high level.

As a result of the inspected equipments' spreading out on every work site, the periodic acquisition is executed by workstation dispersedly. This distributed characteristic makes trouble to the enterprise information integration, whose target is managing and sharing the data and service in whole enterprise. At present, there are two faulty management modes. One gives priority to the workstation. The information is only saved in the workstation and the condition management is carried on independently. The superior department only checks the result of workstation. This mode is unfavorable to the global administration, which deals with the harmony of workstation or workshop. On the contrary, the other mode thinks much of the uniform administration. The inspection plan is set and executed uniformly, and the condition information is applied in certain technical department. By this mode, the administration load is centralized and the flexibility of route inspection is lost. Therefore, new management modes should be brought forward to solve this conflict.

3 The information transfer model of route inspection

In workshop, methods, such as observing, vibration or noise measuring, oil sample analyzing and whole performance evaluating etc, are utilized to inspect the equipment. So numerous information including appearance, vibration, temperature, metal residua and control parameter are acquired and analyzed to identify equipment condition. The information is classified into three types: measurement information, display information and observation information. The measurement information includes vibration and temperature signal, which are acquired easily and sensitive to the equipment abnormality. The display information includes performance and process parameters, which is displayed by the meters on the equipments. The observation information includes observation results, which describe some appearance characteristics of equipment by some terms, such as clean, dirty, incline, in repair, etc.

The participants of route inspection include data collector, plan administrator, diagnosis technician and equipment manager, and they belong to the workstation, technical office and manage section of workshop or head office respectively. The condition information flows from the bottom department to the upper department, and is appended new content continuously by every layer. According to the flow process, a general information transfer model is erected as shown in Fig. 1. In workstation, the plan administrator creates inspection plan and arranges the data collector to acquire three types information periodically. If the condition can't be identified correctly due to the low technique level, the information is transferred to technician office and analyzed by the diagnosis specialist further. The workstation reports equipment abnormality, inspection arrangement and achievement to the workshop. Combining the reports with diagnosis conclusion and repair advice, which is presented by diagnosis technician, the workshop can organize the maintain work, or dispose new inspection task. In this way, the condition management is almost achieved in a basic unit. But the production and equipment maintenance of workshop must obey the global arrangement of enterprise. Therefore, the maintain plan, production plan and spare part plan of the workshop should be confirmed by the head office. It can be found that the condition management to route inspection is a special part of the enterprise information management.

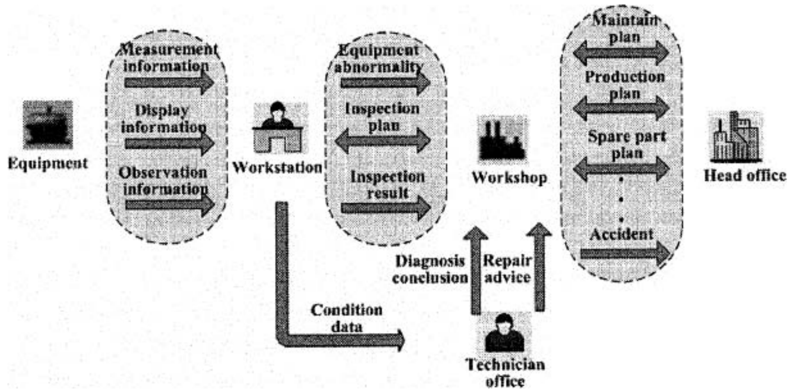

Fig. 1. The information transfer model of route inspection

4 System design

The function of route inspection system is to acquire, manage and utilize the numerous and various condition information. In this section, a route inspection system based on intranet, called MTREE, is design and some emphases are described as follows.

1) The instrument for information acquiring. The condition information is classified as measurement information, display information and observation information in the information transfer model, so the corresponding instrument is

designed to achieve their acquisition. A serial of convenient measurement instrument is developed to acquire the vibration and temperature signal. Because their function emphasizes on the frequent measurement, not the analytic capability, the cost is reduced greatly. It is favorable for route inspection on a large scale. On the other hand, the display information and observation information are acquired by the palm handheld, which replaces the paper and pen with the help of digital production. These two types of instrument, which can communicate with the PC to accept inspection plan and callback the data conveniently, are hardware basis of the system.

2) The information organized according to user role. The participants of route inspection take charge of different work and their information demand is different also. The system provides four subsystems to offer information service. The detailed inspections plan, which denotes the attribute of inspection point such as type, reference data, normal domain and location, is sent to the instrument. The data collectors can accomplish their work depending on the subsystem in instrument. The Route Workstation subsystem provides the function including creating, sending, and receiving and checking inspection plan and analyzing data to enhance the work efficiency of the plan administrator. In addition, two clients, Data Analyzer and Condition Browser, are developed to satisfy the information demand of the diagnosis technician and equipment management. The Data Analyzer provides the abundant diagnosis methods, and the Condition Browser provides the statistical information which help to make decision.

3) Connecting workstation with enterprise. To solve the conflict between the independence of workstation and the information integration of enterprise, two types of database are established. One is the workstation database, which is saved in the workstation computer and supports the Route Workstation subsystem. The other is the enterprise database. Through an automatic running program, the information in all workstation databases is gathered and uploaded to the enterprise database timely. The clients access the enterprise database to get the equipment condition information and input some new information. By this means, the workstation can work independently while the upper department can master the equipment condition.

4) Administration of data acquisition. For ensure the data to be acquired in the required location and time, the electronic button, which has a unique number for automatic identification, is fixed on the equipment. When the data collector touch the button with data acquiring instrument, the registration number is read and corresponding inspection task is displayed. By this way, data acquisition is not only high efficient, but also under the strict control.

5) Diagnoses service to technician. Due to the medium and small equipments are various, the special diagnosis method aiming at the certain equipment type can't always fit other equipments. So besides some typical methods, several kinds of comparing methods are provided, which can compare data acquired at different time or from different equipment freely. By the accumulation within a long period, the abundant historical data of normal, abnormal and fault condition is saved in the database. It is regarded as diagnosis knowledge for the future diagnosis and shared in the enterprise.

6) Information interaction mode. There are two types of information interaction mode, client/server and browser/server, based on network. The advantage of client/server is high reliability, and the disadvantage is hard to maintain due to the program's being installed in every client. On the contrary, the client/server mode utilized the browser such as IE and Netscape to interact. So the program update is achieved easily, but the reliability is degraded. According to their characteristics, the subsystems for workstation and technician office utilize the client/server mode due to their busy data exchange. The subsystem of Condition Browser, which offers information to the workshop or head office administrator, adopts the browser/server mode because the information mainly flows in a single direction.

7) Data security. The information is saved not only in the workstation database but also in the enterprise database. After new data is acquired and saved into workstation database, they are uploaded to the enterprise database in time and the uploaded records are saved in some table. If the upload cannot accomplish due to the network block, the records can be used to resume the upload process when the network is recovered. By this dual saving mode, distributed and centralized, the data security is enhanced. Even the enterprise database is breakdown, the condition data can be still gotten back from the workstation database.

5 System construction

According to the design mentioned above, an integrated information system for route inspection, called MTREE, is developed as shown in Fig. 2. Three units, workstation, server and client are integrated to achieve distributed information acquisition on a large scale and centralized information management in a well order. From three levels of acquisition, management and utilization, the management problem of route inspection information in manufacturing is resolved.

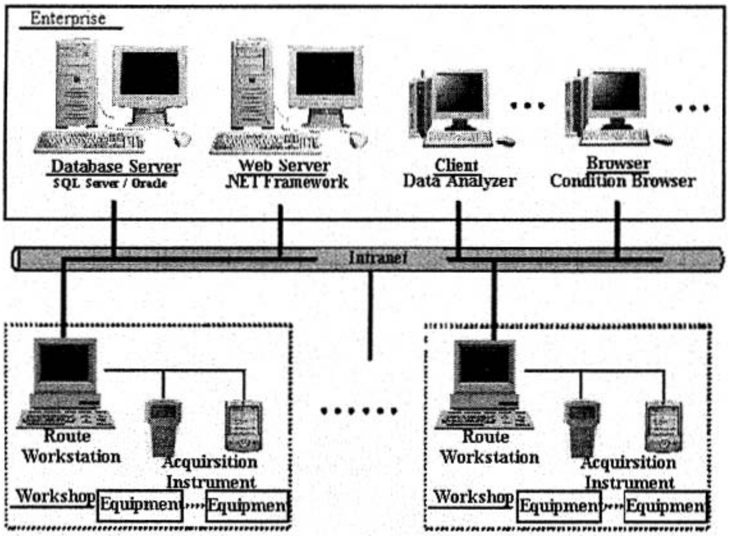

Fig. 2. Contracture of the information management system for route inspection

The Route Workstation subsystem, which works on the desktop database Access, administrates the acquiring work of condition information in workshop. Firstly, the basic information, such as workshop, equipment and inspection point, is inputted. Afterwards, the route plans, which indicate the acquisition task to certain inspection point and in certain period, are created. The plan is sent to the instrument and executed by data collector. Finally, the accomplished plan is callback to the Route Workstation. The plan administrator can deal with the data and make electronic report. In addition, a program is automatic running on the workstation computer to upload the information to the database server.

Servers, including database server and web server, are the management and server center of MTREE. The SQL Sever or Oracle is installed in the database server to save the condition information of the whole enterprise, which includes the condition data and inspection plan uploaded by workstations, diagnosis conclusion and repair advice inputted by technician and the maintenance arrangement and production plan decided by administrator. A maintenance tool is installed in the database sever to backup and restore data and configure the user right. The web server accepts the browser's requests and sends web pages back to the client's computer. Its main function is providing the information service to the administrator.

Data Analyzer and Condition Browser constitute the information utilization platform. The function of Data Analyzer includes some common methods of vibration signal processing, data trend prediction, alarm threshold setting, analysis log recording and report making, etc. In addition, the representative single data or long-range trend is saved as the case to guide the equipment condition analysis and diagnose. Condition Browser provides the abundant statistic information to the administrator, which includes equipment current condition, diagnosis conclusion, repair advice and the actual equipment photo. So the administrator can master the equipment condition and make decision expediently in his office.

6 Application

According to the location of database server, the deployment of MTREE can be classified into distributed style or centralized style as shown in Fig. 3. In distributed deployment, each workshop has independent database server, client/browser and route inspection workstation. The superior departments or other workshops can also visit the database server if authorized. In centralized deployment, there is only one database server in the enterprise and all the data are managed concentrated. In this manner, technical service and equipment management is layout in a global angel of view, while the requirement of Data security is enhanced. In spite of the difference of distributed deployment and centralized deployment, information demands of all user rules are the same. So, interfaces and functions of MTREE, which are designed according to user roles, are adapted to different deployment style.

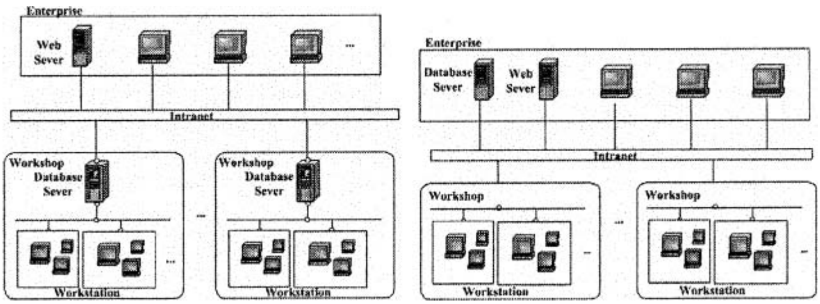

Fig. 3. The deployment of MTREE. The left is distributed and the right is centralized

The integrated information system for route inspection of equipment condition, introduced in this paper, provides a full solution for route inspection management in enterprise, and promotes the development of information management for medium and small equipments. It has been applied in several steel enterprises in P.R. China and improved the efficiency of equipment management significantly. According to the statistic of the WUHAN rolling mill factory, 13 incipient faults are discovered by MTREE in 2003, which decreases a direct loss of over 50 million RMB.

Acknowledgements

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A Data Collector for Route Inspection Based on Palm Handheld in Industry

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Abstract. Information management of equipments is a crucial component in enterprise resource plan (ERP) and data acquisition of equipment condition is the basis of information management system in enterprise. For most medium and small equipments, route inspection is the main method of condition information achievement. In this paper, condition information is divided into measurement information, display information and observation information. A data collector based on Palm handheld is developed to attain display and observation information. Acquired data is gathered to the route workstation in the spot. Then, each workstation uploads the data to the higher database server automatically, to share all the data in the range of whole enterprise. Results show that this data acquisition system enhances the efficiency of route inspection, provides support to discover the abnormity of machines and helps technicians to master the current condition of equipments timely.

1 Introduction

In process industry, condition information acquisition of equipments is crucial to realize predictive maintenance. Three methods, which are online system, portable system and route inspection, are utilized to acquire equipment condition data [1]. Compared with portable and online system, route inspection has more flexibility and lower cost. Thus, it is very propitious for the dispersive medium and small equipments.

Condition information of equipments is divided into measurement information, display information and observation information. Measurement information, such as acceleration, velocity and displacement, can be derived by handheld vibration data

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collector, whereas in many factories, display information (pressure, voltage and current which are displayed on instruments) and observation information (description of measurement points) are recorded on paper, which is low efficiency. This goes against the management and utilization of equipment data. With the development of computer science, many data collectors for display and observation data acquisition are developed based on DSP or MCU. But these traditional data collectors got no extended application because of several key defects, which are:

a) Poor storage: most data collectors for display and observation information have a poor storage of less than 2MB. It cannot meet the demand of millions of equipment data collection in large-scale enterprise.

b) Lack of input methods: only number input is supported. Chinese characters are supported restrictively. Some of them cannot display Chinese characters. Others support a Chinese character display, whereas do not hold a Chinese character input. This leads to a difficulty to record observation information, which is mainly composed of Chinese characters.

c) Portability: most data collectors for display and observation information are huge and clumsy. It is hard for workers to collect thousands of data by a jumbo.

With the development of communication science, efficient management and utilization of equipment data becomes possible. A route inspection system based on Internet called MTREE is quoted to support predictive maintenance of equipments which are numerous, various, isolated and dispersive. Technologies such as network, data communication, databases and equipment condition monitoring and fault diagnosis are used to realize the condition monitoring throughout life-span and management of mechatronic equipments. The Palm-based data collector presented in this paper is the main data achievement tool in MTREE. It accomplishes data acquisition of display information and observation information. Compared with traditional data collector for display and observation information, a Palm-based data collector has lots of advantages such as:

a) Abundant input methods: Chinese characters, English characters, numbers, symbols are supported. Users can input anything directly on the screen of the data collector by a special pen. It is as convenient as you record the information on a piece of paper. Traditional data collector for display and observation information only provides a few of buttons on it, which supports simple operations or English character input.

b) Strong memory extension ability: we develop a data acquisition system based on Zire71 Palm handheld. It has 16M RAM and a SD extension slot. Storage can be extended to 4G, which can hold trillions of data. It is unnecessary for technicians to upload data to workstation frequently anymore, just because there is no more memory to save more equipment condition data.

Multiple communication interfaces: USB, infrared and serial communication are supported. Data transfer between workstation (PC) and data collector (Palm handheld) becomes much faster than ever.

2 Data collector in MTREE

MTREE, an information management system, is constructed based on database in enterprise intranet. It is the platform for implementing information management of equipment condition in enterprise. All route inspection data of equipment condition in different departments is uploaded to the database server. Thus, all the information is shared in the entire factory. By the equipment condition data, managers can master the equipment running state and discover abnormity timely, which supports predictive maintenance and optimizes equipment management. The framework of MTREE is shown in Fig. 1.

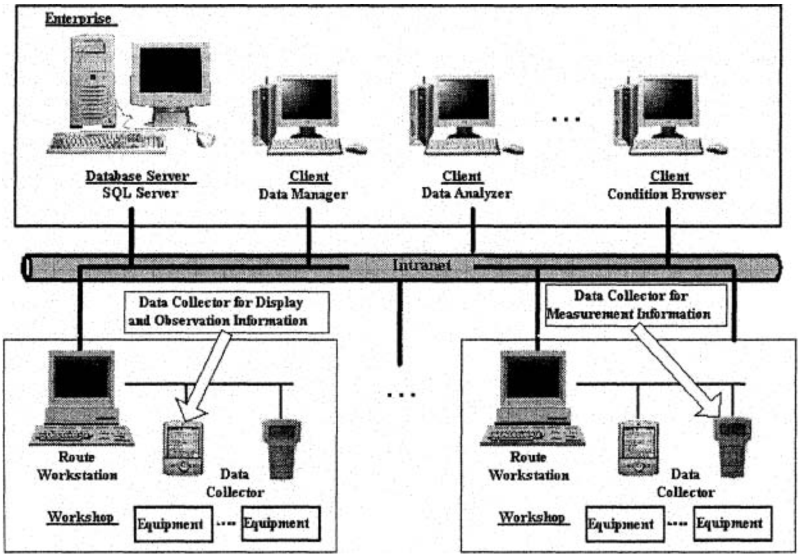


Fig. 1. Framework of MTREE

Equipment condition data is the key support of the route inspection system (MTREE). Moreover, there are a lot of display and observation information in route inspection information. So, a data collector for display and observation information is a sticking point in the route inspection system. It should: a) be convenient to data acquisition and upload; b) have good portability and a large memory. Palm handheld owns the basic hardware requirement that is portable and easy to extend memory. Data upload can be expediently achieved by its strong communication ability. Also, since users can input something directly on the screen of Palm handheld, acquisition of display and observation information becomes much easier. Thus, a data collector for display and observation information is developed based on Palm handheld in the route inspection system (MTREE). The corresponding software is designed for data acquisition, uploading on the Palm side, and data management on the workstation side.

3 Structure of data collector system for display and observation information

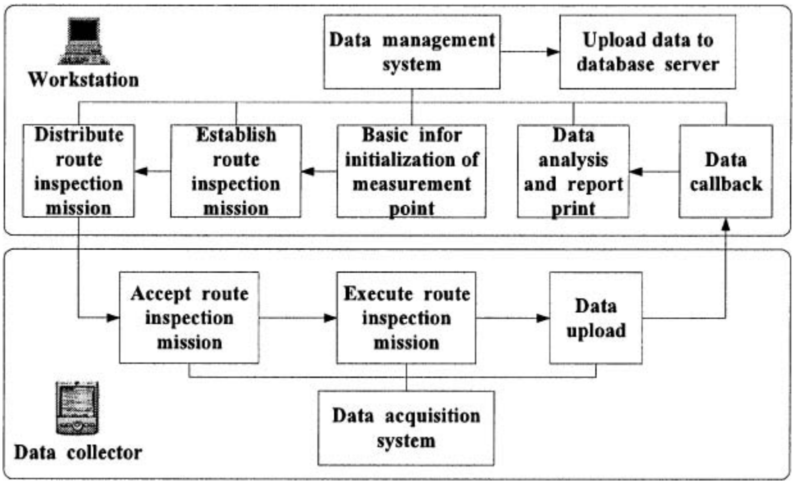


Fig. 2. Structure of data collector system for display and observation information

According to the characteristics of route inspection information for equipment condition, display and observation information are acquired dispersedly and supervised uniformly. The structure of data collector for display and observation information system is shown in Fig. 2.

The data collector system for display and observation information is constituted of data acquisition system on data collector and data management system on workstation. Data collector achieves data acquisition of equipment condition and workstation focuses on data management and utilization. USB port is used to realize data exchange between data collector and workstation. Whole system works as the following steps: First of all, by the database management tool in the data management system in workstation, route inspection manager inputs all the basic information of measurement points, such as department information, equipment number, measurement point type, to system database. Then, route inspection missions are established. After that, necessary missions are transferred to data collector, using USB communication. Inspectors take the data collector with missions to worksite and find the corresponding measurement point in the route inspection mission. For instance, measurement point A is a current of ammeter in department B with equipment number C. The inspector finds the ammeter in the stated place and record the current of the ammeter to data collector. When all the necessary missions are completed, the inspector uploads the collected data to the nearest workstation. Route inspection manager analyzes the data to decide whether the equipment is in good condition or not. Reports of equipments, measurement points and inspected data are printed if necessary. At the same time, collected data on different workstation are uploaded to the database server automatically where all the data are stored and shared by the intranet in enterprise.

Since the different characteristics of display information and observation information, different acquisition patterns are used to them. Measurement points of display information include the following contents: 1) the department name, equipment number and measurement point number that is unique to a measurement point; 2) measurement point type (such as velocity, temperature, flux, etc), unit dimension (such as mm/s, °C, M^3/h), reference value, maximum value and minimum value. Inspectors are asked to record the displayed value on the instrument (such as 1 mA on an ammeter) to the data collector. Reference value, maximum value and minimum value are used to estimate whether collected data is normal or abnormal. Measurement points of observation information include the following contents: 1) the department name, equipment number and measurement point number that is unique to a measurement point; 2) probable description of the measurement point (for a shaft, it could be "normal", "misalignment", "wear", "damaged", "in repair") are set in the description database. Inspectors decide the condition of the measurement point by a certain tool and select the appropriate description for it on data collector. If there is no appropriate description in the selection, an "unknown" description can be selected as the temporary option. After all the data are uploaded to the workstation, a new description will be added to the description database.

4 Key technologies

Data management system on workstation is developed by Visual Basic 6.0. System database is designed in Access 2000. Following functions are supported in the system: initialization of measurement point information, establishment and distribution of route inspection mission, callback of equipment condition data, inquiring and editing, data trend analysis of equipment condition data, and building correlated reports. Data acquisition system on data collector is developed by CodeWarrior 9.0, programmed in C language. Operations listed below are supported in the system: Acceptance of route inspection mission, periodical route inspection, data collection, inquiry, modification and upload, statistics on execution of route inspection mission and clue to illegal data.

4.1 Database design

The database file on route collector includes all the information of route inspection mission. It is a binary file with an extension PDB (Palm Database). A PDB file is composed of the following three parts [2]:

- Header. The first 78 bytes of PDB file is called file header, which includes the following information: database name, flags, version, create time, modified time, backup time, modified number, application information size, sort information size, type, creator ID, unique ID seed, next record list and number of records;
- Record Entry Index. Record entry index starts from 79th bytes. Each index for a record takes 8 bytes. It is like table of contents in a book. The position (offset) of a record can be found by its entry index.
- Record Data. Record data follows record entry index. All the information of measurement points is included in record data. This is the main body of the database.

A record in the database is composed of all the information of one measurement point in the route inspection mission. Data expressions of display and observation information are different. Display information is expressed in number, whereas observation information is expressed in characters. They are crisscross in the route inspection mission. In order to enhance the search speed for a record in the database, display and observation information are stored in one database with a mark "measurement point type" for differentiation. A record in the route inspection mission database includes the following contents:

Common information. Common information exists in both display and observation measurement point, which comprises route inspection mission name, department name, equipment number, measurement point number and measurement point type. A record can be uniquely indexed by its route inspection mission name, department name, equipment number and measurement point number. Measurement point type specifies the measurement point is a display or observation point.

Unique information in display measurement points. Unique information in display measurement points includes record value, maximum value, minimum value, reference value, and unit dimension. Inspectors are asked to record the displayed value on the instrument as "record value". Maximum value and minimum value indicates whether the record value is normal. Reference value gives the standard of the measurement point value. Unit dimension includes volt—unit of voltage, ampere—unit of current, etc.

Unique information in observation measurement points. Unique information in observation measurement points includes description of measurement points, which are set in the description database. Inspectors select the appropriate description for observation measurement points on data collector.

4.2 Communication module design

Communication module achieves the data exchange between workstation and data collector. A communication cradle is used to connect Palm handheld (data collector) with USB port on PC (workstation). On data collector, Palm OS serial communications stack is used to finish file transfer between Palm handheld and PC. On workstation side (PC), a DLL for USB file transfer provided by Palm is utilized.

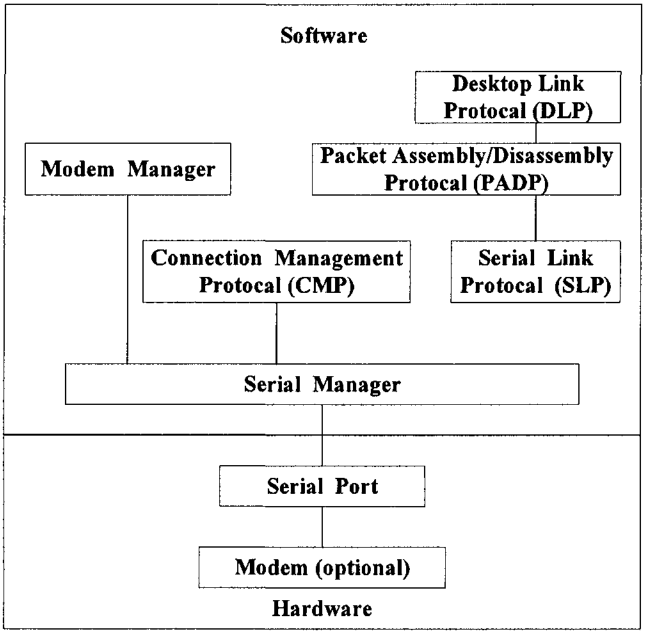


Fig. 3. Layers that make up the Palm OS serial communications stack

The Palm OS serial port supports serial communications at speeds between 300 and 115,200 bps. On the software side, the Palm OS has several layers that make up its serial communications system [3]. Each layer adds to and relies upon the capabilities of the layer beneath it. Fig. 3 shows how the different layers of the Palm OS serial communications stack relate to one another.

Serial manager. At the lowest level, the serial manager provides direct control of RS-232 signals and the hardware serial port. This layer allows for byte-level serial input and output, which makes this layer the most flexible for use in custom applications.

Modem manager. Built directly on top of the serial manager, the modem manager provides a small API for modem dialing and control, which is capable of handling a modem attached either directly to the handheld's serial port or through a Palm modem cable.

Serial Link Protocol (SLP). Also built on the serial manager, this protocol provides an efficient send-and-receive system for data packets, including CRC-16 error checking. Both the HotSync desktop program and the Palm Debugger use this protocol for communicating with a Palm OS handheld resting in its cradle.

Packet Assembly/Disassembly Protocol (PADP). Built on the Serial Link Protocol, PADP provides buffered data transmission capabilities for the Desktop Link Protocol, described below. PADP is entirely internal, and your applications do not have access to this layer.

Desktop Link Protocol (DLP). DLP is built on top of PADP and provides remote access to various Palm OS subsystems, including data storage. HotSync technology uses DLP to perform synchronization and to install and back up databases. Though you cannot directly access DLP's features through a Palm OS application, you indirectly make use of it if you write a HotSync conduit for a desktop computer.

Connection Management Protocol (CMP). CMP is built directly on the serial manager layer, and it is another protocol the system uses for negotiating baud rates and exchanging basic information with outside communication software. Only the operating system has access to CMP.

Since serial manager allows for byte-level serial input and output, it makes this layer the most flexible for use in custom applications. Therefore, serial manager is selected as the solution of communication module on data collector.

5 Realization of data collector system for display and observation information

Data collector system for display and observation information is divided into data acquisition system on data collector and data management system on workstation. The main interface of data management system on workstation is shown in Fig. 4, which includes the following modules:

1) Establishment, Distribution and callback of route inspection mission. In the establishment of route inspection mission, add, modification and deletion of route inspection missions or measurement points in route inspection mission are allowed by administrator of the system. Inspectors can download certain route inspection missions to data collector. When the mission is done, collected data is uploaded to workstation.
2) Analysis of route inspection data, Report center and equipment running log. Analysis of route inspection data makes a trend analysis of certain measurement point data on equipment. In report center, reports listed below can be printed or written in Microsoft Word documents: equipment report, measurement point report, route inspection data report, route

inspection mission report, equipment running log report, statistics report of equipment running.

3) Database maintenance tool. System administrator is allowed to create and maintain route inspection database, using database maintenance tool. The following operations are supported:
   - Create a new route inspection database;
   - Maintain existed databases;
   - Data inquiry;
   - Other tools, including database upgrade and combination, configuration of combination, database backup and clearance, editing description of observation information.

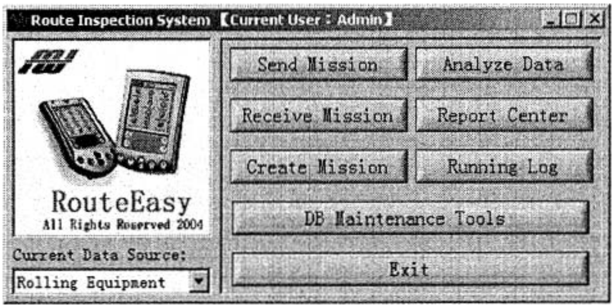
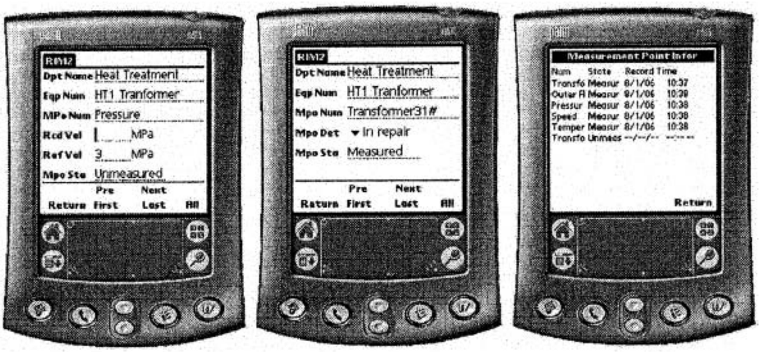


Fig. 4. Main interface of data management system on workstation

Data acquisition system on data collector includes the following functions:

1) Data acquisition: including data acquisition for display information and observation information. Typical data acquisition interfaces for display and observation information are shown in Fig. 5 (a) and (b);
2) Statistics on execution of route inspection missions: Statistics on execution of current route inspection mission, which includes measurement point state (whether the point is executed) and route inspection time (information input time), as shown in Fig. 5 (c).



(a) (b) (c)

Fig. 5. Interfaces in route inspection system for display and observation information. (a) Data acquisition interface for display information; (b) data acquisition interface for observation information; (c) Statistics on execution of route inspection missions

6 Conclusions

Route inspection system for display and observation information presented in this paper, has been used in a steel rolling factory in Wuhan, P.R. China, since 2004. Results show that all the functions in the system work steadily. Compared with the traditional data collector for display and observation information, Palm Handheld based data collector for display and observation information enhances the efficiency and precision of route inspection for display and observation information, which supports predictive maintenance of equipments.

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Study on Information Integration of Condition Monitoring and Fault Diagnosis System in Manufacturing

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Abstract. Aimed at the problems of equipment condition information share and integration in the enterprise monitoring and diagnosis systems, the XML-based model of equipment condition information was presented by analysing the structure of equipment condition information. Afterwards, with the help of the model, the idea of intranet-based software "bus" for machine monitoring and fault diagnosis system was proposed, which is a criterion that specifies the data presentation, management and communication protocol. According to the difference of work mode, the information provider is divided into pusher and puller, the information applicant passively or actively receives the information correspondingly. Then, the technique has been applied to the information integration between the portable condition monitoring system and the online condition monitoring system, Results show that it have enough flexibility and expansibility, and can be applied to large-scale information integration of equipment condition information.

1 Introduction

Machinery information integration has the potential to rationalize and improve business processes in oil refinery, metallurgy, petrifaction, and other industries. With the development of technologies, many condition monitoring and fault diagnosis systems of various corporations have been applied in industries, which leads to disordered phenomena in enterprises, such as various information sources, different

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information formats and representations. Simultaneously, with the development of remote monitoring and diagnosis technology [1-6], enterprise presses for a method to support machinery information integration.

A key challenge in any information integration task is to resolve the heterogeneity among the semantic terminologies used in the various information sources to be integrated [7]. Another key challenge is to resolve the information communication in the various condition monitoring and diagnosis systems.

Aimed at challenges above, firstly, this paper analyzes the structure of equipment condition information and presents an XML-based model of equipment condition information to resolve the problem of information represent, then, puts forward an information integration framework to realize the information communication. Section 4 describes a prototype implementation of the framework. Finally section 5 concludes the paper.

2 Machinery Condition Information Representation

Traditional representation of machinery condition information uses text file or database. Its main drawback is that representation has strong dependency on application system. Meanwhile, it is difficult to solve the integration of heterogeneous information and heterogeneous environment. For example, it is difficult to represent pictures using text file. For all, MIMOSA (Machinery Information Management Open Systems Alliance) puts forward a CRIS criterion and defines a machinery information database criterion, but almost all companies don't completely follow the database criterion in application, like Bentley Company in USA and Strongwish Company in China.

The Extensible Markup Language (XML) [8], a World Wide Web Consortium (W3C) [9] Standard, has been widely accepted for storing and exchanging structured and semi-structured documents. Many XML sublanguages have been developed to define constrained data in XML format for special application areas, often by means of a Document Type Declaration (DTD) or XML Schema [10], definition. For example, Mathematical Markup Language (MathML) [11], is defined for electronic interchange of mathematical symbols, equations and formulae or Voice Extensible Markup Language (VoiceXML) [12], is developed for voice markup and telephony call control to enable access to the Web using spoken interaction. Such markup languages are becoming increasingly popular because XML is simple, easy to understand, extensible, searchable, open standard, interoperable and there is a wide range of tool support for creation, manipulation and transformation of XML documents automatically [13]. In this section we discuss machinery condition information representation using XML based on generic machinery condition information model.

Machinery Condition Information Model

In the first step, the machinery condition information representation of individual mechanical component is modeled using UML. The classes in the UML model are encoded the machinery condition information nodes.

The second step is to identify the functionally equivalent constructs in different machinery component and generalize them at a higher level of abstraction. Fig. 1 presents a part of generic model for machinery information.

The UML diagram is a graphical representation of the model. In third step, for storage and model interchange, the UML models are encoded in XML DTD definition. This results in one DTD for each of the representations in various machinery condition monitoring and fault diagnosis system. The produced DTD and the XML representations of the machinery condition information are instances of them that will be validated against the models.

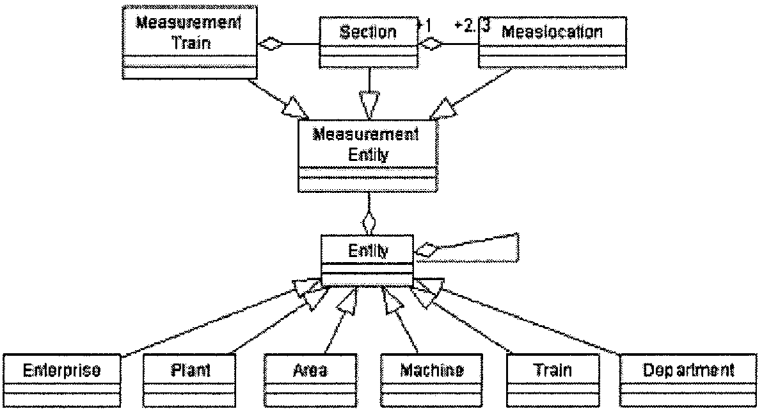

Fig. 1. Generic Machinery Information Model

3 Information Integration System Framework

In Fig. 2 we present the multilayer framework for information integration system of condition monitoring and fault diagnosis system. We also demonstrate the usage of the framework for building the information integration system. The framework is composed of three parts: Adapters for various systems, Software bus framework, Location Service. Adapter for various systems components are the representation transformers, Software bus framework is the transfer and Location Service component provides location information of various adapter components.

The aim of the framework is to let users focus on specifying what they want, rather than thinking about how to obtain the answers. As a result, it frees them from the tedious tasks of finding relevant data sources, interacting with each source in isolation using a particular interface, and combining data from multiple sources.

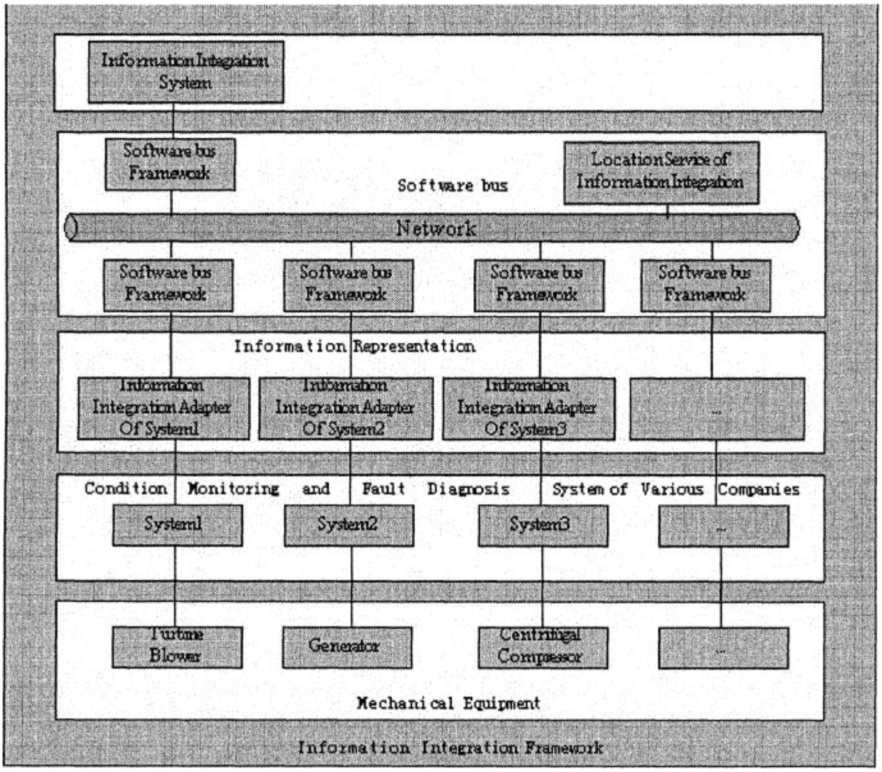

Fig. 2. System structure of Information Integration System

3.1 Adapters

A set of adapter of various systems is required to convert the representations from various systems to the machinery condition information model of XML abstraction. It takes charge of encoding the data in history database (history data) or memory database (real-time data) using XML and transferring the XML document stream to software bus framework. So, it must be developed correspondingly according to different condition monitoring and fault diagnosis systems.

3.2 Software Bus Framework

Software bus framework is required to transmit XML document stream through physical network. It is consists of application development interface and a daemon service. Fig. 3 shows the software bus framework architecture. Daemon service provides the communication function through Intranet. Application development interface called by the adapter component is required to build the associations between the adapter component and daemon service and control behaviors of daemon service.

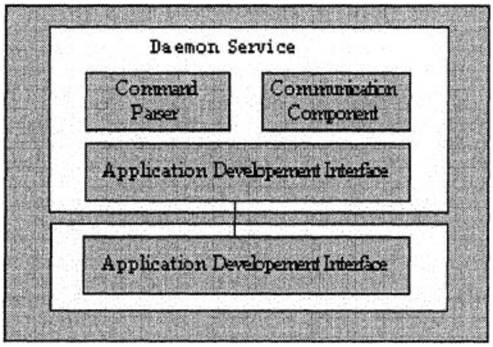

Fig. 3. Components of Software Bus Framework

Daemon Service is divided into two parts: Command Parser (CP) and Communication Component (CC). CP is required to interpret and execute the command from other daemon services. CC takes charge of sending and receiving command or data through physical network.

Daemon service as an information provider of information integration system works in three modes: push mode, pull mode and mix mode.

1) Push mode: is used to transfer real-time data of online system. When it works in this mode, information integration system must register to it. So, it could notify information integration system when new data are coming.
2) Pull mode: is used to transfer history data of condition monitoring and fault diagnosis system. When it works in this mode, information integration system submit query requirement to daemon service using address obtained through location service component.
3) Mix mode: provides functions both push mode and pull mode.

According to the difference of its work mode, the information applicant passively or actively receives the information correspondingly.

3.3 Location Service

Location service component is required to maintain and update the address of adapters. When an adapter starts, it must notify location service component and update itself address using software bus framework component. Meanwhile, location service component is required to query status of the adapter with some time interval to refresh the address list.

4 A Prototype Implementation

We have developed a prototype based on structure above. Our prototype is an information integration system that integrates information of both a portable measurement system (It installed on notebook has a portable measurement hardware.) and an online monitoring system. Figure 4 shows the structure of system. Firstly, adapter component for each of monitoring system is developed correspondingly. Then an information integration system is developed using information integration system framework. Figure 5 shows the main user interface of information integration system. In control panel of the main user interface, a machine tree is displayed using tree view control, which shows structures of both portable system and online system. The right panel shows a wave after FFT of a measure point.

The prototype was developed using the C# programming language and all the experiments were run in an Intel 4 2.40G MHz with 512 MB of RAM and running Microsoft Windows 2000 Operating System. It's about 400ms to query a history data with 1024 dot using the system. The time required to query data is quite reasonable and depends on the size of history data.

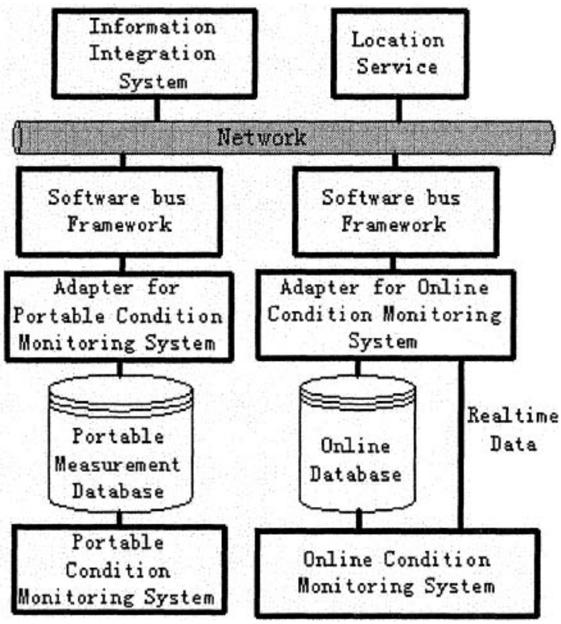

Fig. 4. System structure of the Implementation

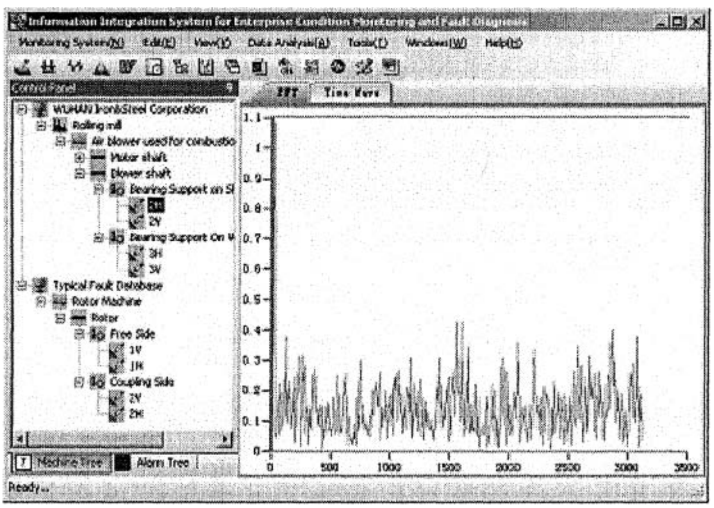

Fig. 5. Main UI of Information Integration System

5 Conclusions

In this paper we presented a framework for information integration of condition monitoring and fault diagnosis system. The framework is based on abstraction of machinery condition information using XML. With the help of the model, the idea of Intranet-based software "bus" for machine monitoring and fault diagnosis system was proposed, which is a criterion that specifies the data presentation, management and communication protocol. According to the difference of work mode, the information provider is divided into pusher and puller, the information applicant passively or actively receives the information correspondingly.

The obtained results of the prototype system show that the framework and with reasonable performance. As a conclusion, this paper provides the fundamental mechanism to build information integration system of machinery condition that will perform machinery condition analysis independently of the specifically application system. Information fusion of machinery condition based on the mechanism is the next target.

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Metadata and Semantics: A Case Study on Semantic Searching in Web System

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Abstract. Metadata is used in Web information systems to improve search results. Searching for resources based on metadata usually relies on keyword matching, i.e. user's query terms must match with metadata terms of the relevant resources. The Semantic Web framework incorporates ontology with metadata to retrieve resources. This paper describes a case study of semantically enhanced searches in a Web information system. The study combines ontologies with metadata to augment searches in a Web resource collection. Ontologies representing semantic associations between the US presidents were created and allow some semantic queries for the domain. For example, a semantic query for resources about "the US president who is the successor of Bill Clinton" can be formed instead of the query term "George W. Bush". The semantic queries were formed using description logic expressions. Evaluation of the results demonstrated good precision with moderate recall. Factors contributing to and detracting from retrieval performance were identified and addressed. The results highlight both the potential and issues in combining ontologies with metadata for enhancing search in next-generation Web information systems.

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1 Introduction

Metadata is a surrogate for a resource represented in terms of attribute name-value pairs. These attributes provide additional information about the resource such as title, author, subject, etc. Metadata allows the retrieval of resources by matching terms in user queries with terms in the specified metadata attributes. For example, in retrieving the resources authored by John Smith, the query term: *author="John Smith"* may be used. Some applications of metadata in Web information systems range from searching multimedia resources to searching product catalogs.

One of the limitations of metadata search is that the keywords used in user queries must match with the keywords used in the metadata. For example, in order to find all the resources whose subject is about the US president "George W. Bush", the query term: *subject="George W. Bush"* must be used. Metadata by itself does not allow semantic queries, i.e. queries that rely not only on keyword matching but on underlying semantics. For example, the resources found for the above query are also resources for queries about "the current US president", "the US president who is the successor of Bill Clinton" or "the US president who is a son of another president". These queries share similar meaning to the first query but cannot be used in either full-text or metadata based systems.

Semantic search is a new approach for search enabled by the Semantic Web framework [1]. Semantic search offers an enhancement to keyword-based search in that the words used in queries do not need to match the words used in describing the resources. In particular, it allows for retrieval that incorporates the underlying semantics of terms. Ontologies are used in most semantic search systems. The potential of semantic search has been demonstrated in some search systems [2-4].

This paper presents a case study on the use of semantic search in a Web information system. It demonstrates the combined use of ontology and metadata in enabling semantic search in a Web resource collection. Unlike prior work, it quantifies the retrieval effectiveness obtained based on expert analysis of the corpus and the retrieval results. Metadata were extracted from some book titles in the collection of Amazon.com. Ontologies on the subject topic of the US presidents were created and integrated to augment metadata search on the subject. The ontologies represented semantic associations between the US presidents, i.e. their chronological orders and biological relationships. A semantic search system was built over a description logic system. Nine queries for books about the US presidents' biography were formed based on the semantic associations. Evaluation of the results demonstrated the value of semantics in Web searches. Some factors that impacted the retrieval performance were identified and addressed.

2 Background

Description logic (DL) is often used for the logic layer of the Semantic Web. Specifically, the Web Ontology Language (OWL) standard contains the OWL DL sub-language providing expressiveness that supports inference by description logic [5]. Description logic consists of three basic types: *Concept*, *Role* and *Individual*. A concept can be *primitive* or *defined*. A concept is a *defined* concept, if it can be described in term of previously known concepts; otherwise it is a *primitive* concept. A role is property of concept. An individual is similar to concept but can only be used to describe at most one individual. Below is some background on DL theory summarized based on [6-8].

The semantics of DL is usually given using the notion of interpretation. The interpretation $I = (\Delta^I, {}^I)$ consists of a non-empty set (Δ^I) and an interpretation function $({}^I)$. The interpretation function could be applied to a concept, i.e. $C^I = I(C)$, which maps a concept into a subset of Δ^I. The interpretation could be applied to a role, i.e. $R^I = I(R)$, which maps a role into a subset of the cartesian product of Δ^I, i.e. $(\Delta^I \times \Delta^I)$. The interpretation function could be applied to an individual, i.e. $O^I = I(O)$, which maps an individual name into a member of Δ^I.

$\mathcal{SHIQ}$ is an expressive description logic, whose expressiveness also includes role transitivity ($\mathcal{R}+$), hierarchy of role ($\mathcal{H}$) and inverse role ($\mathcal{I}$). $\mathcal{SHIQ}$ concept expressions can be constructed using the combination of the following constructors: $\neg C$, $(C \sqcap D)$, $(C \sqcup D)$, $(\exists R.C)$, $(\forall R.C)$, $(\leq n\ R.C)$ and $(\geq n\ R.C)$, where C, D are concepts, R is a role, and n is an integer. A role is a transitive role if it satisfies the following condition: if $(x, y) \in R^I$ and $(y, z) \in R^I$, then $(x, z) \in R^I$. The syntax and semantics of $\mathcal{SHIQ}$ concepts and roles are provided in Fig. 1.

Concepts		
Syntax	**Description**	**Semantics**
A	Concept name	$A^I \subseteq \Delta^I$
$\neg C$	Negation	$\Delta^I \setminus C^I$
$C \sqcap D$	Conjunction	$C^I \cap D^I$
$C \sqcup D$	Disjunction	$C^I \cup D^I$
$\exists R.C$	Existential quantification	$\{x \mid \exists y\ (x, y) \in R^I \wedge y \in C^I\}$
$\forall R.C$	Universal quantification	$\{x \mid \forall y\ (x, y) \in R^I \Rightarrow y \in C^I\}$
$\leq n\ R.C$	Qualified number restriction	$\{x \mid \#\{y \mid (x, y) \in R^I \wedge y \in C^I\} \leq n\}$
$\geq n\ R.C$		$\{x \mid \#\{y \mid (x, y) \in R^I \wedge y \in C^I\} \geq n\}$

Roles		
Syntax	**Description**	**Semantics**
R	Role name	$R^I \subseteq \Delta^I \times \Delta^I$
R^{-1}	Inverse role	$\{(x, y) \in \Delta^I \times \Delta^I \mid (y, x) \in R^I\}$

Fig. 1. Syntax and semantics of $\mathcal{SHIQ}$ concepts and roles

TBox Statements	
Syntax	Satisfied if
$C \doteq D$	$C^I = D^I$
$C \sqsubseteq D$	$C^I \subseteq D^I$
$R \sqsubseteq S$	$R^I \subseteq S^I$

ABox Statements	
Syntax	Satisfied if
C(a)	$a^I \in C^I$
R(a, b)	$(a^I, b^I) \in R^I$

Fig. 2. Syntax and semantics of *TBox* and *ABox* statements

A $\mathcal{SHIQ}$ knowledge base ***K*** consists of two kinds of statements: *terminological* and *assertional*. The set of the first kind of statements constitutes the ***TBox***. The set of the second kind constitutes the ***ABox***. The ***TBox*** contains the statements describing concepts and roles. The ***ABox*** contains the statements describing individuals. ***TBox*** and ***ABox*** statements are in the forms shown in Fig. 2.

The first form of ***TBox*** statements ($C \doteq D$) indicates equivalence between two concepts. The second form ($C \sqsubseteq D$) indicates a subsumption relationship between two concepts. In particular, concept C is subsumed by concept D if every individual that is a member of concept C is also a member of concept D. The third form ($R \sqsubseteq S$) indicates a subsumption relationship between two roles. The first form of ***ABox*** statements (C(a)) indicates that individual *a* is a member of concept *C*. The second form (R(a, b)) indicates that two individuals: *a* and *b* are related by role *R*.

3 Implementation

3.1 System Architecture

A conceptual architecture for implementing semantic search for a Web information system is shown in Fig. 3. The four major components include Web Resource Collection, Semantics Data Source, Semantic Search System and User Queries. Web resource collection is where resources and metadata reside. Semantics data source provides ontologies. In this study, the resource collection was autonomous. The ontologies were created by the study and independent of the resource collection. Semantic search system was built over a description logic system. It acquired metadata from the resource collection and ontologies from the semantics data source. The acquired data were pre-processed, e.g. parsed and reformatted, before they were interpreted by the description logic system. The user submits a query as a description logic expression to the system. The system returns a list of resources whose metadata semantics match with query semantics. The results were not ranked.

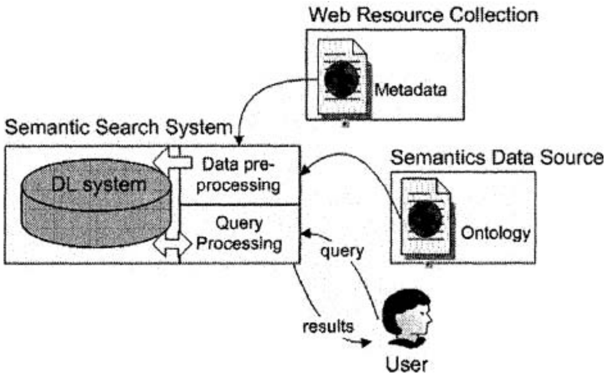

Fig. 3. Conceptual architecture of semantic search for a Web information system

3.2 Semantic Search System

The implementation of semantic search system utilizes the RACER (Renamed ABox and Concept Expression Reasoner) system [7]. The RACER system is a knowledge representation system that has a support for the description logic $\mathcal{ALCQHI}_{\mathcal{R}^+}$ or $\mathcal{SHIQ}$. All the standard inference services for ***TBox*** and ***ABox*** are supported by RACER. The implemented system utilizes the RACER system version 1.7.6 running on a computer with Windows 2000 operating system, Pentium-733MHz and 1GB RAM.

3.3 Web Resource Collection

The study used the book collection of the Amazon.com website as the Web resource collection. Only the book titles in the subject category: "*Biographies&Memoirs/ Leaders&NotablePeople/ Presidents&HeadsOfState*"[3] were used by the study. The category is the most likely category containing biography books about the US presidents, which was the subject topic for the study. Metadata for 927 book titles in the subject category was acquired via the Amazon.com Web service interface[4] on March 21, 2004. The obtained data was cached to insure the consistency of the data used across different queries.

Metadata for each book title were pre-processed and represented to the DL system in the following format:

[3] http://www.amazon.com/exec/obidos/tg/browse/-/2418
[4] http://www.amazon.com/webservices/

has_subject (i1234567890, george_washington)

Where *i1234567890* is the book's ISBN plus the 'i' prefix, *george_washington* is a keyword assigned to the metadata attribute "subject" for this book title, where every whitespace character is replaced by '_' character. Only the metadata attribute 'subject' was processed for each book tile. Other metadata attributes such as author, price, etc. were ignored. The role *has_subject* was created as a primitive role in the DL system.

3.4 Ontologies

Ontologies in the subject domain of the US presidents were created. The ontologies represented semantic associations between the US presidents. In particular, the relationships between each US president, i.e. chronological order and biological relationships, were expressed. The ontologies were represented to the DL system in the following formats.

is-next-predecessor-of (bill_clinton, george_w_bush)
C_george_w_bush (george_w_bush)
C_george_w_bush ⊑ C_us_president

In the first statement, President Bill Clinton was modeled as the predecessor of President George W. Bush. The second and third statements represent the subsumption relationship between the concept of President George W. Bush and the concept of US president. The relationships between the US presidents defined in the ontologies are shown in Fig. 4.

In order to permit inferences, roles were modeled using inverse, transitivity and role hierarchy. For example, *is-child-of* was modeled as inverse of *is-father-of*, *is-predecessor-of* was modeled as a transitive role and *is-cousin-of* was modeled as a role subsumed by *is-relative-of*, etc. The roles defined are shown in Fig. 5.

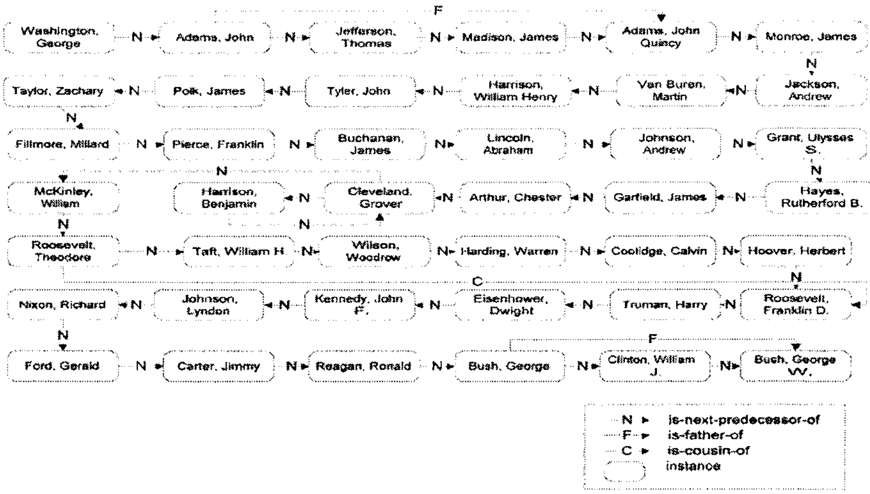

Fig. 4. Relationships between the US presidents defined in the ontologies

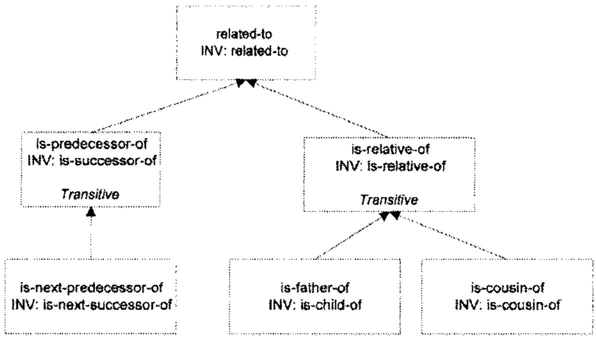

Fig. 5. Role hierarchy and properties defined in the ontologies

3.5 Queries

Nine queries in the topic area were created. The queries were expressed in terms of semantic relationships between the US presidents instead of names. Queries were defined on two aspects: chronological order and biological relationships. Four of the queries were expressed in terms of the US presidents' chronological order (Q2-Q5). Four of the queries were expressed in terms of the US presidents' biological relationships (Q6-Q9). List of the queries and their mapping into DL expressions is shown in Table 1.

Table 1. List of the queries and their mappings into DL expressions

Queries	DL expressions
Q1: Books on biography of the US presidents	∃ has_subject.C_us_president
Q2: Books on biography of the first US president	∃ has_subject.(C_us_president ⊓ ≤ 0 is-next-successor-of)
Q3: Books on biography of the US presidents after President John F. Kennedy	∃ has_subject.(C_us_president ⊓ ∃ is-successor-of.C_john_f_kennedy)
Q4: Books on biography of the US presidents between President John F. Kennedy and President Ronald Reagan	∃ has_subject.(C_us_president ⊓ ∃ is-successor-of.C_john_f_kennedy ⊓ ∃ is-predecessor-of.C_ronald_reagan)
Q5: Books on biography of the US presidents before President Thomas Jefferson	∃ has_subject.(C_us_president ⊓ ∃ is-predecessor-of.C_thomas_jefferson)
Q6: Books on biography of the US presidents who are fathers of other US presidents	∃ has_subject.(C_us_president ⊓ ∃ is-father-of.C_us_president)
Q7: Books on biography of the US presidents who are sons of other US presidents	∃ has_subject.(C_us_president ⊓ ∃ is-child-of.C_us_president)
Q8: Books on biography of the US presidents who are cousins of other US presidents	∃ has_subject.(C_us_president ⊓ ∃ is-cousin-of.C_us_president)
Q9: Books on biography of the US presidents who are relatives of other US presidents	∃ has_subject.(C_us_president ⊓ ∃ is-relative-of.C_us_president)

4 Evaluation

The retrieval performance of the semantic search system against the queries was assessed in terms of precision and recall. The relevancy of the retrieved resources to the queries was assessed by a panel of three judges. The judges were the graduates from the Master of Library and Information Science program at the University of Pittsburgh. A resource was judged as relevant to a query if at least two judges marked it as relevant. Precision of the results for each query is shown in Fig. 6. The number of relevant resources retrieved per the number of resources retrieved for each query is also displayed in the graph.

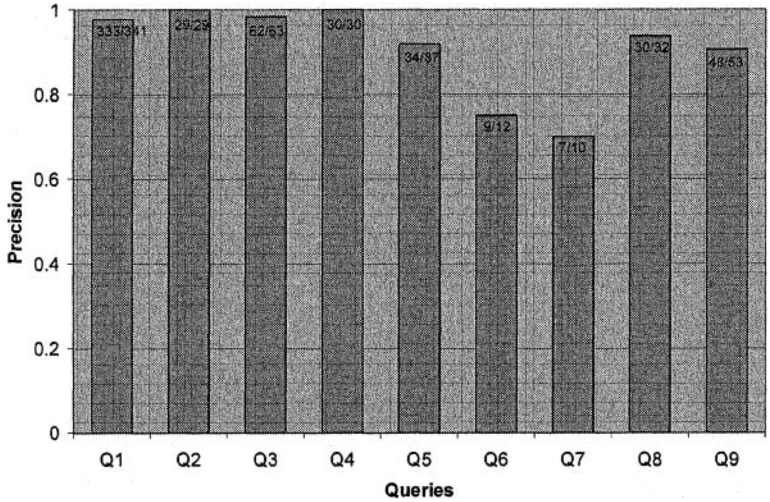

Fig. 6. Precision of the results

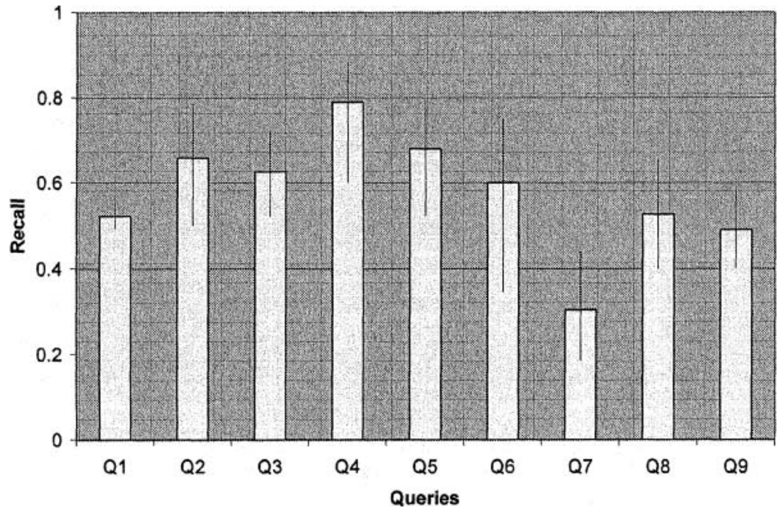

Fig. 7. Estimated recall of the results

In measuring recall, the number of relevant resources for each query must be known. However, obtaining such a number requires exhaustive examination of all the resources in the subject category for each query. In order to provide some indication of recall while maintaining manageable number of resources reviewed by the judges, the study measured estimated recall instead of actual recall. The number of relevant resources for each query was estimated based on the assessment of 500 resources sampled randomly from the resources in the subject category[5]. The formula in measuring recall is provided as:

$$\text{Recall} = \frac{\text{Total relevant resources retrieved}}{\text{Total relevant resources retrieved} + \text{Total relevant resources non - retrieved}}$$

The number of relevant resources retrieved was the same number obtained when measuring precision. The total relevant resources non-retrieved is estimated as $p_{nr}N$, where p_{nr} is the proportion of relevant resources non-retrieved found in the sample of 500 and N is total number of resources (= 927). The estimation ranges from $L_{nr}N$ to $U_{nr}N$, where L_{nr} and U_{nr} are the lower and upper limits of the 95% confidence interval for p_{nr} and are obtained using the formulas defined in [9]. The estimated recall and the estimation range for each query is shown in Fig. 7.

The results show good precision (0.7-1.0, average = 0.91). Some degradation in precision was due to some questionable classification of resources and resources with less degree of relevancy. In particular, some resources located in the subject category were questionably not biography books about the US presidents. For example, the subject category includes some books written about letters from the US presidents, which were not considered biography books about the US presidents. Other possible misclassifications include books about first ladies or other family members included in the subject category of the US presidents. The most degraded precision was found in Q6 (= 0.75) and Q7 (= 0.7). These were due to books focusing on the story of President John Adams' entire family, not only the members that were US presidents. These resources were assessed as irrelevant to the queries due to their generality.

The results show overall moderate recall (0.3-0.79, average e= 0.58). Degradation of recall was due to the use of general subject terms in resource metadata. In particular, many books in the subject category were assigned the general subject term "Presidents and Heads of State" instead of particular names of the presidents that the books are about. For example, many books about President George W. Bush were not retrieved because they were assigned only the general subject term. This resulted in the most degraded recall in Q7 (= 0.3). The lack of specific information in the subject terms was the only cause found for the degraded recall.

[5] The evaluation scheme was developed as a part of a larger study involving more queries and resources. The reduction in effort was not substantial in the subset reported in this paper.

5 Conclusions

This paper presents a case study on semantic searching in a Web information system. A semantic approach in querying resources about the US presidents was demonstrated. Ontologies were combined with metadata search to allow for expressive semantic-based queries. Evaluation of the retrieval system over the defined queries showed promising retrieval performance, particularly in terms of precision. Retrieval performance was impacted by some errors and omissions in the metadata of the resource collection. Improving the metadata quality could result in improved retrieval performance by the system. In particular, misclassification of resources in the collection should be minimized to improve precision. Resource metadata should be provided as specifically as possible to improve recall.

The results highlight both the potential of semantic search in Web information system and some factors that can impact its retrieval performance. Other related issues such as user interfaces and result ranking are beyond the scope of this paper and should be further investigated.

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A DSS based on Entropy Method in EIS in Chinese Financial Sectors

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Abstract. At the time of commercial banks verifying and assessing the loan applications of enterprises, there is one important problem faced that is how to choose the qualified ones from the numerous applications, which could be named of the Decision-making Program of Loan-granting (DPL). The members of evaluating and granting loan group make up from different departments of banks and different specialized experts. How to synthesize suggestion of expert, draw and reflect expert panel's result of suggestion most, it has been a focus question of the decision theory all the time. The problems of loan's group decision were briefly introduced, and then the authors proposed an entropy-based DSS for examining and approving loan applications. The core mathematics models were emphasized which applied a combination of the multi-attribute group decision-making plural entropy model and traditional group eigenvalue method for the loan evaluation purpose. And then its function, structure modules, key technology and solution method were reviewed in detail. Finally, an example is proposed to show how the entropy method can be applied to the evaluation practice.

1 Introduction

Credit risk means refer to a kind of default possibility of debtors or borrowers fail to debt or banks' loan in full amount in time with various kinds of reason. At once a contract broken, creditor or bank will bear loss of financial affairs because of failing to get the income expected.

Facing contingent credit risk, foreign commercial banks generally adopt an expert-assess-method by giving credit mark at the time of examining and approving

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a loan application, abbreviate named of expert system model. It is an effectual credit risk analysis and management system formed among commercial banks' long-term credit activity. The greatest characteristic of this method is that, credit officers with abundant experience who trained for a long time control policy-making power of banks' credit. Therefore, in the course of credit decision, credit officer's professional knowledge and subjective judgments, other key elements and their weight are the most important decisive factors. Under the expert system, because of every commercial bank's own terms different, the content of credit analysis carrying on is also different. Although the content varies, most banks' credit analysis focuses on "5C" of loan applicants, namely Character, Capacity, Capital or Cash, Collateral, Condition.

In the essence, the credit method adopted currently by domestic commercial banks is also a kind of the 5C-based expert system models, which changes only in form, has distinct Chinese characteristics further. In China, an internal special committee holds the power of making credit policy. At first, the loan secretariat collect and verify application materials which are enterprise financial statements consist of balance sheet, profit-and-loss statement, cash flow statement, etc. After compiled complete, these materials give to the committee for credit examination and approval for vote meeting. Finally, the committee members decide whether approve the application or how much is awarded for comprehensive accrediting amount.

At the time of commercial bank verifying and assessing the loan applications of enterprises, there is one important problem faced that is how to choose the qualified ones from the numerous applications, which could be named of the Decision-making Program of Loan-granting (DPL). But these committee members come from different departments of banks, and are different specialized experts. How to synthesize suggestion of expert, draw and reflect expert panel's result of suggestion most, it has been a focus question of the decision theory all the time. The author proposed an entropy-based DSS of examining and approving loan applications, which are suitable for distinct Chinese characteristics, named of LEDAS (Loan Examination Decision Analysis System). This system contribute s to change traditional loan application for risk assesses and controls, improve banks' credit risk management level and working efficiency. This paper first proposed a logic and software structure of LEDAS. Then its function, structure modules, key technology and solution method are analyzed and designed in detail. At last, a case study is proposed to show how the DSS can be applied to evaluation practice. The results of the study show that the suggested system can improve the decision quality. Moreover, the author probes into some questions existing at present and further research directions.

2 Systematic modeling

In application materials, various kinds of financial statements of applicant are the most important factors for approval, and are also the primary standard whether granting the loan while evaluating. In addition, credit officers will consider other factors, for instance: loan motive, reputation of debtor, experience of similar project, the time finished, refund plan etc. It is the process of credit loan examination and approval. Fig. 1 describes a general course of "LEDAS of Industrial and Commercial Bank of China" in detail.

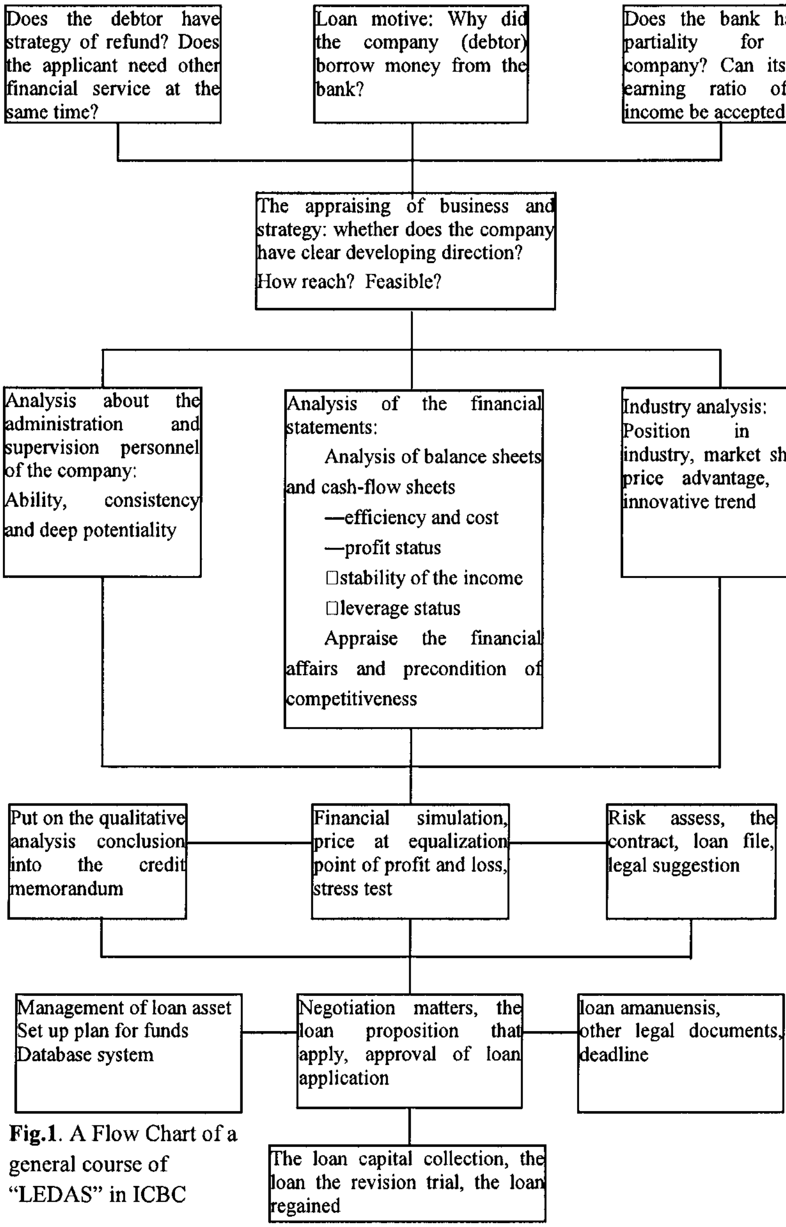

Fig.1. A Flow Chart of a general course of "LEDAS" in ICBC

Because these members of the for credit examination and approval committee are all experts coming from different fields, and their ability, level and partiality are all inconsistent, the most essential and difficult problem of LEDAS is how to synthesize suggestion of expert, draw and reflect expert panel's result of suggestion most. This paper proposed a new method for the process of Loan Examination Decision Analysis, which combines group eigenvalue method with multi-attribute group decision-making plural entropy method.

The decision-making system G composing by m experts of S_1, S_2, $\cdots$ S_m evaluate n subjects $B_1, B_2, \ldots, B_n$. No. I experts S_I evaluate subjects B_j as $x_{ij} \in [I, J]$ $(i=1,2,\ldots,m;\ j=1,2,\ldots,n)$. The larger value is the more excellent aim B_j. S_i and grade of its group G are made of n lines vector xi and m×n matrix X:

$$x_i = (x_{i1}, x_{i2}, \ldots, x_{in})^T$$

$$X = (x_{ij})_{m\times n} = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix}$$

They are the conclusion giving by the experts and groups in the decision-making processing. They represent each individual gauge to the evaluated matter.

Because of the limitations of each professional level, business scope, experience, range of knowledge, integration capability, and some other factors closely related with making policy such as state of mind, mood and partiality, in actual life the expert whose dependability is up to 1 of decision does not exist. However, we could image there is a definitely ideal one, whose decision is most exact and right. His dependability is up to 1. The best decision-making expert called ideal expert S_*, his grade vector is x_*:

$$x_* = (x_{*1}, x_{*2}, \ldots, x_{*n})^T$$

Known by reference [1], the ideal expert's grade vector x_* is got through calculating formula (1).

$$\underset{\|b\|_2=1}{Max} \sum_{i=1}^{m} (b^T x_i)^2 = \sum_{i=1}^{m} (x_*^T x_i)^2 = \rho_{\max} \qquad (1)$$

In formula (1), $\rho_{\max}$ is the greatest eigenvalue of the matrix $x^T x$; x_* is the positive eigenvector of the $\rho_{\max}$. And

$$\|x_*\|_2 = 1$$

Reference [2] defines uncertainty of decision conclusion of the expert S_i as his decision entropy H_i. For the sake of proposing the calculation formula of H_i, underneath we import some symbols from reference [2]. First we transfer x_i into identity matrix, namely

$$D_i = (d_{i1}, d_{i2}, \cdots, d_{in})^T \in E^n$$

$$D = (D_1, D_2, \cdots, D_m)^T = (d_{ij})_{m\times n}$$

In the formula, $i = *,1,2,\cdots,m$, $d_{ij} = x_{ij} \Big/ \sqrt{x_{i1}^2 + x_{i2}^2 + \cdots + x_{in}^2}$, $j = 1,2,\cdots,n$

So $0 \le d_{ij} \le 1$, and

$$D_i^T D_i = \|D_i\|_2^2 = \sum_{j=1}^{n} d_{ij}^2 = 1 \qquad i = *,1,2,\cdots,m$$

Then, according to the grade point of the expert S_i ($i = *,1,2,\cdots,m$), $N_i = (N_{i1}, N_{i2}, \cdots, N_{in})$ represents the good and bad places of appraised objects $B_1, B_2, \cdots, B_n$. The object, which the expert S_i offers the tallest grade point, is recorded as B_{j*}

$$x_{ij*} = \max_{1\le j\le n} x_{ij} \quad i = *,1,2,\cdots,m$$

So $N_{ij*} = 1$. On the contrary, for the object B_{j0} which is attained the lowest grade point, $N_{ij0} = n$.

Definition 1: The decision level vector of the expert S_i is

$$E_i = (e_{i1}, e_{i2}, \cdots, e_{in})$$

$$e_{ij} = 1 - \left|N_{*j} - N_{ij}\right| - \left|d_{*j} - d_{ij}\right|$$

In the formula, $i = 1,2,\cdots,m$; $j = 1,2,\cdots,n$

From definition 1 we can conclude, in the decision level vector $E_* = (1,1,\cdots,1)$ of the ideal expert S_*, each vectorial weight value is up to maximum 1, his decision result is the best one. More low is individual decision level of the expert S_i, more big is the gap with the ideal expert S_*, and more little is each vectorial weight value of the decision level vector E_i. Therefore, the decision level vector E_i is objective to completely reflect the conclusion's level of the expert S_i to the appraised objects $B_1, B_2, \cdots, B_n$.

Definition 2: The decision level of the expert S_i, can be measured by the uncertainty of his conclusion that is decision-entropy H_i. H_i is equal to the sum of broad sense entropy of each vectorial weight value of the decision level vector E_i.

$$H_i = \sum_{j=1}^{n} h_{ij} \quad i = *,1,2,\cdots,m \qquad (2)$$

In the formula,

$$h_{ij} = \begin{cases} -e_{ij}\ln e_{ij}, 当 1/e \le e_{ij} \le 1 时 \\ \frac{2}{e} - e_{ij}\left|\ln e_{ij}\right|, 当 e_{ij} < 1/e 时 \end{cases}$$

According to Reference [2], when the decision uncertainty of the expert S_i is lower, the reliability is higher, and the decision-entropy H_i is smaller. Each expert S_i's decision- entropy H_i can be calculated, and it reflects his decision level.

Combining the multi-attribute group decision-making plural entropy model with traditional group eigenvalue method applying for the loan evaluation purpose, there are two applied methods according to the different types of the evaluation course.

1) If the experts synthesize in many aspects attribute of the applicants, they give a mark by the overall performance of each one. Then, the mark vector x_* can be calculated through GEM. At last, the corresponding applicant of the biggest vectorial weight value could be approved.

2) If the experts give a mark one by one for various fields attribute in applicants, the weight ω_i of each expert's opinion in various fields attribute can be calculated:

$$\omega_{ij} = c_{ij} \Big/ \sum_i c_{ij}, \quad c_{ij} = 1/h_{ij}, \quad i = 1,2,\cdots,m;\ j = 1,2,\cdots,n \qquad (3)$$

In formula (3), h_{ij} is the attribute j's entropy value of the expert S_i; ω_{ij} is the attribute j's weight of the expert S_i.

So the expert panel gives a mark value for the applicant a as

$$E_a = \sum_j \sum_i x_{ij}^a \omega_{ij} \qquad (4)$$

In formula (4), x_{ij} is the expert S_i's mark value for the attribute j of the applicant a; ω_{ij} is the weight of the expert S_i when evaluating the attribute j.

3 System frame structure Design of LEADS

The goal of LEADS is to classify the customer groups in some area, seek top group of customers, measure the risk of credit products, and acquire optimal financial structure of credit products. According to former relevant indexes of loan customer and potential loan customer as criterion, the system go on and consider every possible angle in whole bank all project of support, subsidiary credit policymaker carry on loan examinational and approval decision. The LEADS can be divided into several parts (see Fig. 2): 1) Human and computer mutual system. It is mutual interface between system and end users. The system commands the user to input the necessary data (using on computer) and information (using on control), and show users to operation situation and final outcome. 2) The management subsystem of applicant enterprise's information, including enterprise's basic information, historical credit materials, operation situation, enterprise group operation information, legal representative of enterprise, enterprise surtax materials, etc. 3) The information subsystem of loan projects, including loan application form, the report of credit application, information of guarantee enterprise, loan guarantee situation, the follow-up tracing circumstance, etc. 4) The decision support subsystem of loan projects' examination and approval, including synthetically analyses module, regional index data, comprehensive inquiry system, office automated system. 5) The approval subsystem of loan projects makes up by two parts: the voting of credit approval and the management of the voting results. 6) System maintaining subsystem, including dictionary management, authority management, roles of users, control information of the report forms.

4 An Example Study

Using above giving criterion system, the case is about to appraise and analyze three enterprises' applications of loan projects nowadays. In order to raise the veracity, our subject group has done actual survey and randomly selected a lot of criterion data of three enterprises and the concrete criterion data of their loan projects situation in four years. The credit examination and approval committee is made up by six experts. The experts evaluate them respectively from two respects including debtor's financial situation and development prospect of the loan project, and then give a mark (maximum 5, minimum 1). The criterion mark values based the opinion of experts have been listed in Table 1.

Table 1. The experts' grade table for debtors and the loan projects

Economic indicators	Debtor	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
Debtor's financial situation	B1	3	1	1	1	2	1
	B2	4	4	2	2	4	3
	B3	5	5	4	3	5	4
Development prospect of the loan project	B1	5	1	2	1	3	1
	B2	4	3	4	2	4	4
	B3	1	4	5	4	5	5

By marking the result data of financial situation of debtors in Table 1, have

$$X_1 = \begin{pmatrix} 3 & 1 & 1 & 1 & 2 & 1 \\ 4 & 4 & 2 & 2 & 4 & 3 \\ 5 & 5 & 4 & 3 & 5 & 4 \end{pmatrix}, \quad F_1 = X_1^T X_1 = \begin{pmatrix} 17 & 31 & 53 \\ 31 & 65 & 86 \\ 53 & 86 & 116 \end{pmatrix}$$

By the exponential iterative calculation, have the eigenvector of the matrix F_1's corresponding biggest latent root

$$x_{*1} = (0.3159,\quad 0.5589,\quad 0.7668)^T$$

According to formula (3) and formula (4), we get the entropy values and weight values of each expert, which have been list in Table 2, through evaluating the enterprises' financial situation.

Table 2. The entropy values and weight values of each expert ($j =$ enterprises' financial situation)

S_i	$E_i = (e_{i1}, e_{i2}, e_{i3})^T$	h_{ij}	ω_{ij}
S_1	$(0.8916,\ 0.9932,\ 0.9403)^T$	0.1670	0.141
S_2	$(0.8384,\ 0.9417,\ 0.9953)^T$	0.2090	0.113
S_3	$(0.9032,\ 0.8875,\ 0.8288)^T$	0.3631	0.065
S_4	$(0.9514,\ 0.9756,\ 0.9650)^T$	0.1059	0.222
S_5	$(0.9822,\ 0.9626,\ 0.9786)^T$	0.0755	0.311
S_6	$(0.8022,\ 0.9706,\ 0.9823)^T$	0.1588	0.148

Table 2 proves that expert3's cooperating is relatively bad because of his most heavy entropy value. Herewith, according the mark values of evaluating the loan project's development prospect, we could get the entropy values and weight values of each expert which have been list in Table 3.

Table 3. The entropy values and weight values of each expert ($j =$ loan project's development prospect)

S_i	$E_i = (e_{i1}, e_{i2}, e_{i3})^T$	h_{ij}	ω_{ij}
S_1	$(-1.4116,\ 0.7467,\ -1.6056)^T$	6.1487	0.0225
S_2	$(0.7868,\ 0.7368,\ 0.6831)^T$	0.6787	0.2043
S_3	$(0.9430,\ 0.8467,\ 0.7794)^T$	0.3897	0.3548
S_4	$(0.7868,\ 0.6188,\ 0.6831)^T$	0.7461	0.1853
S_5	$(0.9008,\ -0.1533,\ -0.2206)^T$	2.8951	0.0478
S_6	$(0.7868,\ 0.8467,\ 0.7794)^T$	0.7461	0.1853

From table 3, the entropy values of expert 1 and expert 5 are very much heavy, so their cooperation is very bad. We should consider replacing them. According to the formula (4), we receive the final result like Table 4.

Table 4. Synthetically final result table

Debtor's code i	1	2	3
Mark value E_i	3.1334	6.7031	8.8634

The result is: $B_3 > B_2 > B_1$. So, the debtor B_3 is optimum.

5 Conclusions

Strengthening credit risk evaluation management to keep stability of the banking, it is significant to protect the healthy development of national economy. This paper quantitatively studies system cooperative model in the course of credit evaluation, effectively solves the problem of the many attributes of group decision, which is the credit evaluation system's key problem, prompts the banking to change the method of controlling and determining credit risk from qualitative observation while being past into quantitative analysis nowadays, improves accuracy and maneuverability of this kind of evaluation and decision. Certainly, it is very difficult to devote present theory research results into really practice use, so we should have much further research and discussion.

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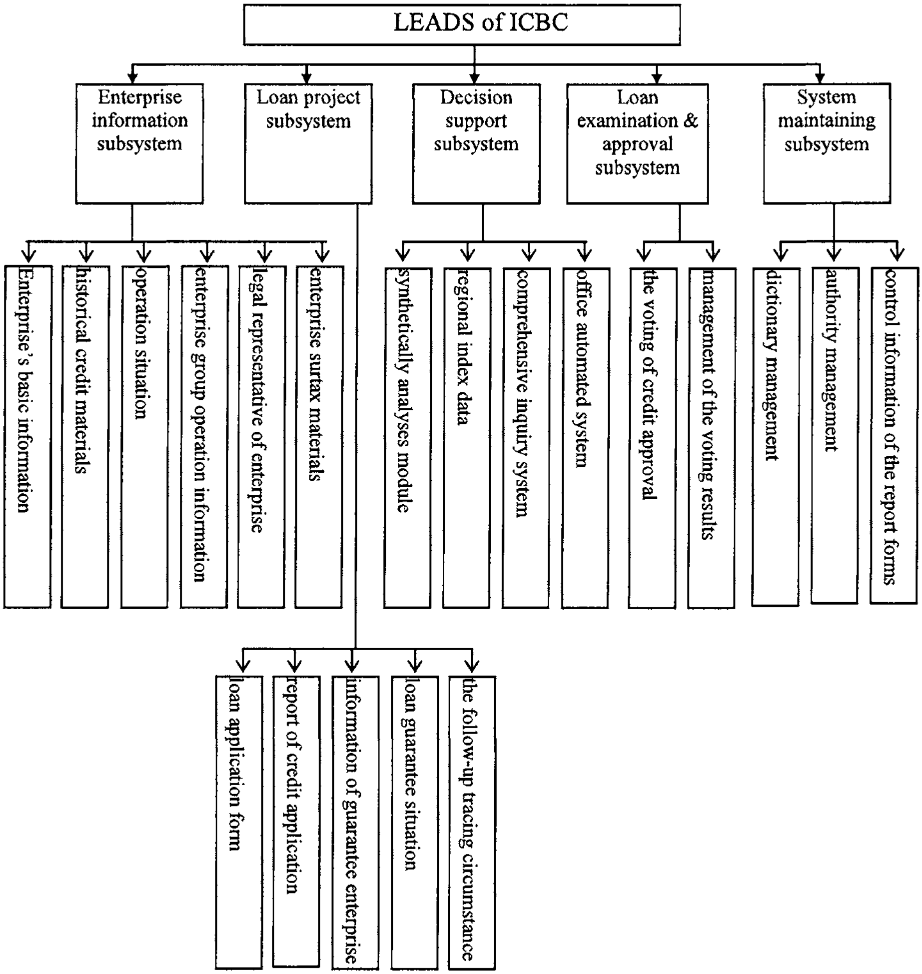

Fig. 2. The framework of LEADS

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Knowledge Portal Construction and Resources Integration for Hydropower Corporation

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Abstract. Based on the scientific and technical research project "Data Collection and Decision Support System for Hydropower Dam Construction", which is set up by the Chinese National Development and Reform Commission, this paper, which aims to solve the problems in managing the construction of large-scale hydropower project, focuses on the knowledge portal using Web Services and J2EE.

After studying China Gezhouba (Group) Corporation (CGGC), which is building the largest hydropower project of the world, Three Gorges Project, a multi-layer architecture and a supporting system for the knowledge portal is put forward. The method for integrating existing resources is also proposed. Enterprise application integration (EAI), which is platform-free and improving the interoperability of heterogeneous system, is realized by interoperability in distributed environment, software combination technology, heterogeneous system integration, and application mid-ware specification. All the resources are in the open and unified environment and are easy to share. The process of designing and developing knowledge portal for CGGC Operation Management System is further provided to illustrate the architecture proposed above.
Key word: Knowledge portal, Web Services, EAI, Hydropower Corporation.

1 Introduction

Reviewing the history of applying information technology to management, the trend of development is from data management to information management and now towards knowledge management. Since Decision Support System was firstly put forward in 1970's, computer and information technology in knowledge management and knowledge processing is more and more discussed, especially over the recent decades [1].

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Relative researches mainly focus on building Knowledge Management Systems, which is one of the hotspots of computer and Artificial Intelligence (AI) researches, and providing computer as tool to support knowledge management [1].

Technically speaking, the rapid development of computer technology in recent decades promotes the improvement of enterprise knowledge store and knowledge process. For example:

Development of network technology and distributed computing pattern, especially the development of Internet/Intranet, has profound impression on the knowledge management supported by computer. On one hand, network helps to improve the availability of information and inspire the demand of processing the information and retrieving useful knowledge, On the other hand, network provides the infrastructure for distributed knowledge share and collaborative innovation.

The development of Artificial Intelligence (AI), especially the development of Agent technology, provides favorable technical preparation for computer-aided knowledge processing [2].

Other development of information technology, such as groupware, data warehouse and data mining, further supports the knowledge management system technically [3, 4].

With the development of E-Business, integration of information system, e-business and knowledge management is more and more discussed [5].

Knowledge portal, which is one of the important components of decision support system, is developed to improve the knowledge share, knowledge application, and knowledge creation. The ability of analyzing and judging are enhanced and therefore decision-making is supported.

The organization location, operation data, experience and knowledge of Hydropower Corporation are all distributed, which is also the character of the industry. Especially in the large scale hydropower projects, layouts are dispersed; quality assurance nodes are distributed and related information is mass. Above characters make it necessary to apply network technology and information technology to the management and decision-making, especially combing the special experience and knowledge of experts from different departments and different industries.

China Gezhouba (Group) Corporation (CGGC), which is one of the largest hydropower corporations of China, has accomplished many large hydropower projects, including the largest one of the world, Three Gorges Project. CGGC owns rich experience of huge hydropower dam construction in special geography environment. At the same time, various information systems have been built after several years' information construction.

After information construction for several decades, more than twenty local area networks (LAN) have been built and PC terminals are more than 2,000. A management information system (MIS), which supports production, operation and management, has been developed, together with Beihang University. Three Gorge Dam process control system, shutoff statistical analysis system, project cost and quality management system and supervision system for concrete production, transportation, which are all domestic-advanced, have been successfully developed.

Regarding the universal characteristic of Hydropower Corporation and based on the actual conditions of CGGC, Beihang University, together with CGGC, applied for scientific and technical research project "Data Collection and Decision Support System (DSS) for Hydropower Dam Construction", which helps collecting and managing the information of operation of hydropower project. The operation is supervised real-timed, analyzed and guarded. The experience of dealing with exception of operation is collected and used in making decision and in supporting the quality and safety assurance.

Building model knowledge portal for Hydropower Corporation and studying the method of integrating various heterogynous resources are important contents of the research project, which will be further explained as follows.

2 Knowledge Portal System for Hydropower Corporation

2.1 Brief Introduction to the System

Knowledge portal for Hydropower Corporation, which is the entry to the corporation knowledge platform for users, is the centralized and unified provider of data, information and knowledge resource.

According to the characters of existing information system, unified access to information and knowledge resource is designed. A series of standards and specifications for knowledge share via net are defined and an integrated knowledge portal for the corporation is developed.

The construction of knowledge portal system consists of criterion system, portal, Mete data Directory Service, Unified Authentication and Resource Access Control (RAC), retrieval and navigation, assessment and supervision system, virtual organizational collaboration environment, application service integration environment and resource connection.

2.2 The Architecture of Portal

2.2.1 Multi-Layer Architecture

Knowledge portal for Hydropower Corporation, which uses multi-layer architecture based on the web, is composed of five layers: client layer, web layer, application service layer, application support layer and resource layer. Multi-layer architecture is used to improve the reliability, extensibility, and retractility of the system. Various requests from users are posted to application service layer and handled in the application service layer. If the request is in need of backstage service support or information and knowledge access, application service layer will revoke the interface of service support layer and resource layer.

(1) Web Layer

Portal web layer is in the demilitarized zone (DMZ), including load balancing servers and web servers, which provides the access of request and load balance. Only portal web layer is accessed when users visit the portal. Backstage service and resource are not accessible so that the security of the whole system is assured.

(2) Application Service Layer

Application service layer, which is the kernel of portal system, includes application servers and database servers. Various services of portal system, unified authentication, Resource Access Control (RAC) and interfaces of service resource are deployed in application servers. Database system includes information database, authorization database and content management database.

(3) Application Support Layer

Application support layer includes a series of application support systems, such as information and knowledge retrieve and navigation system, knowledge map, virtual organization collaboration environment, application integration environment, evaluation and supervision system, which are integrated in the portals by portlet and Web services [6].

(4) Resource Layer

Resource layer refers to all kinds of information and knowledge resources in business systems where recourses are created and services are provided, including information in operation management system, knowledge share Portlet, human resource management system and equipment management system.

Main idea of multi-layer architecture lies in separating application service logic from data resource, and subdividing the function and roles of servers. Business logic, presentation and data store are in the different layer so that the system is robust, safe, open, extensible, capable and short-cycle. Multi-layer architecture supports multi platform, distributed calculation, load balance, centralized management of information and easy operation.

2.2.2 Design Based On Views

The knowledge portal system are be extracted to four views, presentation view, application view, data view and management view. Through the views above can knowledge resource be presented uniformly, can application resources be connected uniformly, can data be integrated uniformly and can system resource be managed uniformly.

(1) Presentation View

Presentation view refers to the portal system providing a unified net desktop system for users to access the knowledge resource platform. The distribution and heterogeneity are shielded and the various recourses of the corporation can be uniformly used.

(2) Application View

Application view refers to the integration of application service via developing an application container and application service registration center. Retrieval and navigation of information and knowledge, virtual organization collaboration and other supporting services are connected uniformly to portal system.

(3) Data View

Data view means the integration of data resource by portal system. First, metadata catalog database is constructed by the metadata catalog criterion, mass information and knowledge resources are indexed. Information and knowledge resources are accessible by resource access interface and resource integration interface.

(4) Management View

Management view refers to the unified management of internal resources, including Unified Authentication, portal security assurance, assessment and supervision system and content management, which supports unified supervision and management.

2.2.3 Logical Structure of Knowledge Portal

Via portal system, which is user-oriented, resource can be located, and construction can be guided. Requirements are acquired form users and coordinated by management department, so that the integration and application are accessible.

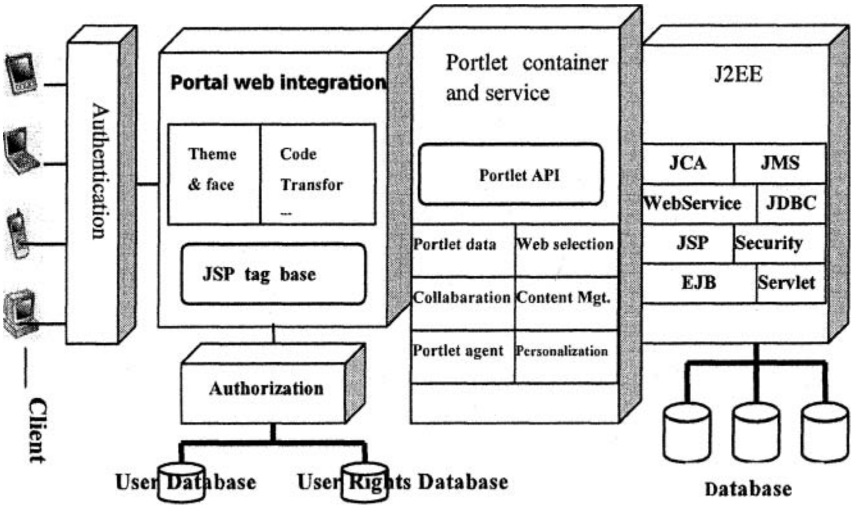

Fig. 1. Technical architecture of knowledge portal

Portal system is logically divided to four layers, resource layer, support layer, function layer and portal layer. Portal site provides unified entry to knowledge resource platform for users by using the service from service layer. Service layer provides unified presentation and access to resources available by extracting service from support layer. Support layer provides connection to the resource of bottom layer. Resource layer includes all the resources from all the subsystems.

2.3 Technical Composition of Knowledge Portal for Corporation

The technical architecture of knowledge portal as follows shows.

In the technical architecture (see Fig.1), different layers are loose coupling. Each layer uses component technology and block structure, by which can the resources and services be connected seamlessly and transited smoothly [7, 8].

2.4 Unified Authentication and Resource Access Control

Knowledge portal combine all the applications, information and workflows. Knowledge resource platform of corporation is composed of integrated knowledge nodes of distributed and heterogeneous information. By Unified Authentication technology, users can access to all the separate systems by logging into the system once. Resource access control takes the policy of Role-Based Access Control (RBAC), by which can all the resources be accessed by valid user so that all the resource are free from illegally access.

2.5 Integration Environment of Application Service and Resource Connection

Enterprise application integration (EAI), which is platform-free and improving the interoperability of heterogeneous system, is realized by message processing mechanism, interoperability of distributed environment, software combination technology, heterogeneous system integration and application mid-ware specification.

A series of criterion of application service integration are constituted and realized in this environment. So that service abstract, service deployment, service management, service registration and discovery are provided.

Service abstract extract existing application systems to service according to the criterions of integration, including business logic, deploying document and other relative files. Business Logic implements encapsulate legacy functions and communicate with legacy systems. Deploying documents, based on XML, describe all the configure information, such as access control, database configure, by predefined specification of configuration documents. Application service is easily to be loaded in this integrated environment. Other relative documents include all the required source files for service.

Service deployment refers to deploying the service to application integration environment. Whether the service conforms to the integration criterion is firstly checked. Then deploying describing document is read and current service is configured and operated.

Service management provides processing of encapsulated transactions, configuration management, multi-threads, resource connection pool and other bottom detailed service container so that application service could be quickly encapsulated and automatically deployed. Meanwhile, bottom support services are provided according to specific application service, including security, transaction, category visiting and remote access interface. Service management also provides life-cycle management and Performance Monitor.

Service discovery and registration center provides registration center which is application service oriented. When deploying service, service is firstly registered in service registration center and can be modified when service is updated. Users can discover the service by Web or standard API and integrate them by standard interfaces.

Application service integrated environment is designed based on existing architecture of application servers, Web Services container and Web servers. And a resource container is developed in accordance with engineering application. So that service abstract, service deployment, service management and service registration and discovery are provided. To share all the information and knowledge resource, application services are unified presented in the architecture.

The architecture is divided into 5 layers, which are information and knowledge resource layer, resource connection layer, service management layer, service abstract layer and service application layer.

3 Operation Subsystem

Operation management subsystem is one of the most important components of CGGC portal system, by which could the statistical data be collected in time and programming and decision be made timely. Users can access to the basic information and communicate with other related departments on line, share the knowledge and value-added service with them, by which could knowledge be innovated.

The implementation of the system will improve the integration of information and knowledge from branch companies and project departments, the study and reuse of various resources, the relationship between different projects. Detailed information of production and operation will be collected timely so that the management is improved, Various methods, such as graph, text, video and virtual reality model, are used to present the rich resources and knowledge of corporation and to improve the knowledge transmission and application.

3.1 Layered Architecture

To make the platform effective and flexible, operation management subsystem takes layered model and mid-ware technology. It is logically divided to three layers, which are data layer, application layer and connection and presentation layer.

Separating the connection layer from application handle layer makes the platform robust and powerful. By using the advanced construction technology, this platform not only performances stably and powerfully, but also well opened. Applications are loaded to the platform easily and processed by workflow engine, so that each application can be maintained conveniently and new application can be added quickly.

3.2 Resource Connection and Integration

Operation management subsystem has to integrate a widely heterogeneous data resource. The procedure is as follows:

(1) Analysis of Heterogeneous Data

Because different companies are in the different phases of the information construction, they stored their data about production and operation in different formats, so do their data management systems. From simple file to complicated net database, different storage makes the resource of heterogeneous data. The existing data satisfy the current users of separate systems, but doesn't meet the need of corporation users, who want to be aware of all the data located in different format. Thus a distributed application system, built upon the heterogeneous data, is necessary [9].

The heterogeneity of data lies in:

1) System heterogeneity means that the application systems, database systems or operation systems, where the data are stored, are heterogeneous.

2) Heterogeneous patterns, means data are stored in different formats. Storage patterns including relation patterns, object patterns, object-relation patterns and file nest patterns, in which relation pattern is most popular. There could be differences in structure even the same storage pattern is used. For example, the data types are not totally the same in different relation database, such as DB2, Oracle, Sybase, SQLServer, and Foxpro.

3) Heterogeneous source means the heterogeneity of external data and internal data.

(2) The Requirement of Data Integration

The aim of integrating heterogeneous data is to provide unified, safe, timely information for operation system application to meet the requirements of query, data mining and decision making. Therefore, integrated data has to be of integrity and security in data accessing.

1) Integrated

After the integration of separate information in different isolated operation systems, query can be uniformly executed in data warehouse which integrated various data organically and achieve associated store, without accessing each isolated system. Data are no longer stored simply and separately in each database.

2) Integrity

Integrity refers to the data integrity and restriction integrity. Data integrity refers to extract data totally, while restriction integrity means the relationship between different data, which is the only character of presenting the logic of data. Restriction integrity is the premise of data publication and exchange, and can improve the processing and the efficiency.

3) Consistency

Different information differs semantically, and causes all kinds of incomplete and wrong information. From name to structure, semantic conflicts make integration result redundant and the processing, publication and exchange of data interfered. Integrated data should be transformed following the data structure rules and codes [10].

4) Data Access Security

Different data resources belong to different companies and each database owns rights control. Therefore access and security management are not centralized. In order to keep the security of accessing the data source without intrusion and shield the original data access control, designing a unified user security management is necessary.

(3) Heterogeneous Data Integration and Integrating Pattern Realization

Aiming to meet the requirements of heterogeneous data integration, data warehouse technology and data extraction tools are used to integrate heterogeneous database and heterogeneous types of files, such as text and spreadsheet [10]. Based on the existing systems, independent data transforming code secondary development is executed to collect raw data, clean wrong data, integrate heterogeneous data, transform data structure and refresh data periodically.

Based on the theory of data warehouse, heterogeneous data is integrated to integrated database by exchanging access technology.

3.3 Resource Retrieval and Navigation

System retrieval is designed differently according to different data source.

1) Mixture of metadata and distributed data interfaces are usually used for local resources.

2) Data collection method, i.e. Web virtual interface, is used when dealing with those data with high requirements.

3) Special technology for system application.

Inter-operability of heterogeneous resources focuses on platform heterogeneity, operation system heterogeneity and database heterogeneity, among which the crucial problem is the retrieval interface. Therefore, new technology, such as Web Services and grid technology are applied, based on XML/Web services/UDDI, according to current resources [6]. The structure designed above helps to improve the inter-operability of heterogeneity resources.

4 Conclusions

Knowledge portal system, which is an important component of decision support system, is the platform for knowledge share, knowledge reuse, and knowledge creation. Developing knowledge portal for large scale Hydropower Corporation should take characters of legacy systems and future development into account.

It is necessary to study the characters of legacy information systems and existing knowledge resources when building a multi-layer architecture and a supporting system for the knowledge portal based on WEB SERVICE and J2EE. Enterprise application integration environment, which is platform-free, improves the interoperability of heterogeneous system and provides an open and unified environment, is realized by message processing mechanism, interoperability in distributed environment, software combination technology, heterogeneous system integration and application mid-ware specification. By enterprise application integration environment, data, information and knowledge from all the branch departments are integrated effectively and a platform of high performance for knowledge share and innovation is also provided.

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A Method for Enterprise Knowledge Map Construction Based on Social Classification

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Abstract. Knowledge map is an important and effective instrument of corporate knowledge management. A great number of unordered knowledge resources in the enterprises bring about difficulties to the knowledge map construction. This paper proposes an effective method based on social classification to organize the enterprise knowledge resources and to construct the knowledge map further. According to the characteristics of knowledge usage in the enterprise, the enterprise knowledge map is defined as a domain-centered system to display knowledge and their relationships. By virtue of the collaborative nature of social classification, the proposed method collects individual knowledge tagging data and selects some important topics from tags to form a domain knowledge map. Then topics in different domains are related to each other by similarity and the enterprise knowledge map is constructed. At last, a prototype knowledge map system, which is being implemented for an enterprise, is presented.

1 Introduction

With the acceleration of global economic and IT development, enterprises today endeavor to explore better approaches to improve organizational adoption, survival and competence in the new business environment characterized by dynamic, discontinuous and rapid pace of change [1]. Knowledge management is increasingly viewed as a crucial factor for organizational sustainable competitive advantages [1, 2]. It embodies organizational processes that seek synergistic combination of data and information processing capacity of IT, and the creative and innovative capacity of human beings.

Empirical studies have shown that while organizations learn and create knowledge, they also forget (i.e., do not remember or lose track of the acquired knowledge) [3, 4]. Many organizations accumulate a large amount of knowledge

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along with their business progress. Unfortunately, their employees have to spend so much time and effort on knowledge searching and selection before they can find out what they want. Therefore, it is very important to create knowledge map to specify the captured knowledge and relationships in order to facilitate knowledge navigating and searching.

Currently, the enabling technologies of knowledge map mainly are Intranet-based software solutions, which combine powerful visualization techniques with database management system [5]. Yet, while the technological implementation can lead to a useful knowledge map artifact, the process of mapping is even more challenging. Essentially, the knowledge mapping process is the process of knowledge organization and classification. Many organizations, for the convenience of storing and searching knowledge, have their own approaches and practices on knowledge classification, in which they usually design taxonomies manually to organize the key files. Manually organizing knowledge to categories requires significant time and effort, so it is difficult to design taxonomy to cover the whole domain of interest in enough detail. In recent years, automatic document classification has been widely researched and used [6]. This kind of methods has shown to be reasonably effective when dealing with huge amount of various contents on the Internet. However, it is not suitable for organizing the knowledge in a real enterprise environment. A Knowledge map for an organization has to reflect the business process and be comprehensive to knowledge workers, which can not be resolved by current automatic classification methods.

In this paper, we present an improved social classification-based method for knowledge organization and knowledge map construction. The proposed method develops enterprise knowledge map as a multi-level system including the individual level, team level and organizational level. According to the similarity of knowledge structure in a business domain, our method defines domain as the basic organizing unit of enterprise knowledge map to display knowledge and their relationships. Owing to the collaborative nature of social classification, the proposed method collects individual tagging data and selects the important topics from tags to form a domain knowledge map. Then we can relate topics in different domains by similarity and construct the enterprise knowledge map.

The rest of this paper is organized as follows. Section 2 examines related work and background concepts that we have employed. Section 3 presents the outline of the proposed method for knowledge map construction, including its architecture and basic procedure. Then in section 4, the detailed method is provided. In section 5 a prototype system for an enterprise is presented. Finally a conclusion with future research is given in section 6.

2 Related Work

In this section, we briefly present some research literatures related to knowledge map construction and social classification.

2.1 Knowledge Map Construction

A knowledge map is the display of acquired knowledge and relationships [7, 8]. The knowledge in knowledge map may involve various shared contents, such as text, graphics, videos, models and data. The relationships among them are determined by linking concepts or topics discovered from these shared contents. There are several main strategies for constructing knowledge maps, including building directories, manually drawing concept map/topic map, and automatic knowledge classification [9].

A directory is an alphabetical or classified list of names, addresses and other data. On the Internet a web directory is usually used to organize topics in groups and subgroups, such as YAHOO! and Open Directory Project. It is a simple but effective way to organize a large volume of information, especially when coupled with a search engine. Nevertheless, it is recognized that the interface of directory becomes increasingly difficult for users to navigate as the hierarchy grows larger [10, 11].

Concept Map [12] and Topic Map [13] are drawings, in which blocks represent concepts, topics or things and connecting lines represent relationships. This kind of maps can help better organize, display and understand knowledge. However, the creation process requires highly creator's cognitive skills and significant time and effort.

More recent works construct the knowledge maps for some kinds of web contents, employing machine-learning algorithms to cluster the web documents. Document representation and clustering technique are two major issues in text clustering. The vector space model (VSM) is usually adopted to represent documents, where a document is represented as a multidimensional vector, while each dimension corresponds to a unique key term extracted from the documents. A common clustering technique is Self-Organizing Map (SOM), which is an unsupervised neural networks algorithm. Chen et al. [14] categorized a portion of the Internet documents with multilayered SOM to generate a hierarchical knowledge map system. Ong [9] employed an improved interface combining a 1D alphabetical hierarchical list and a 2D SOM island display to automatically generate a hierarchical NewsMap. To some extent, the knowledge map construction method based on automatic text classification is effective. But when applied in a real organizational environment, it suffers from many problems. First, the method relies much on the linguistic usage. Clearly, in organizational knowledge repository there are many kinds of files, such as drafts, videos, which have few words and consequently are not suitable for this kind of methods. Second, the design of taxonomy may not reflect business needs [6]. To address the above problems, an effective method for mapping enterprise knowledge is highly desirable.

2.2 Social Classification

Social classification refers to the collaborative way in which information can be organized on the web. It allows users to publicly add keywords to the shared contents, as is totally different from the traditionally categorizing performed by an authority or authors. Users can not only categorize information for themselves, but also browse the information categorized by others. Keywords tagging is nothing new; the interesting thing is that when persons tagging in a public space, the collection of their keyword/value associations becomes a useful source of data in the aggregate [15]. Today, tagging is a widespread phenomenon popularized by applications such as social bookmarking (Del.icio.us) and social photo sharing (Flickr). It is discussed in some researches that tagging on the Internet has some limitations and weaknesses. For instance, ambiguity can emerge as users apply the same tag in different ways, while the lack of synonym control can lead to different tags being used for the same concept, precluding collocation [16].

We argue that social classification would be a fruitful way when it is applied in an organization. As the employees, especially those who work in the same or similar domain, share common business goals and have relatively similar business background, the problem in uncontrolled vocabulary will be solved to some extent. What's more, the social classification generated by employees will facilitate workplace democracy and the distribution of knowledge organization tasks among people actually using them, which is most helpful for an enterprise when there is nobody in the "librarian" role or there are too many unordered contents for few authorities to classify. So here we propose an improved social classification-based method to organize knowledge resources and construct enterprise knowledge map.

3 Outline of the Proposed Method

In this section, we describe knowledge map structure and the basic procedure of the proposed method for knowledge map construction.

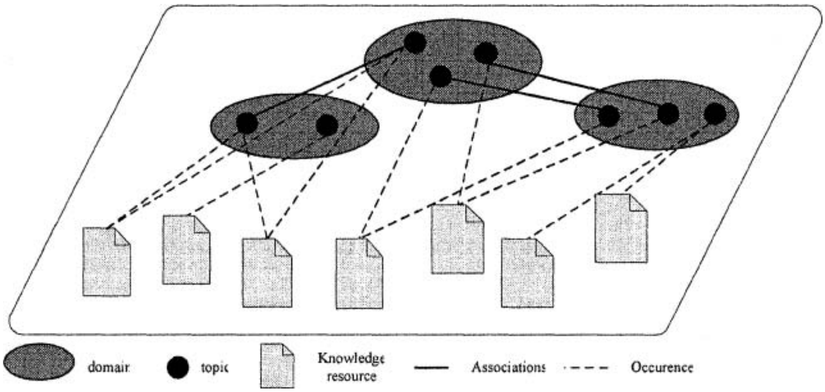

Fig. 1. Knowledge map structure

Fig. 1 shows the proposed knowledge map structure. To display knowledge and relationship, our proposed knowledge map is defined as sets of domain, topic, knowledge resource, relationships. For an enterprise-wide knowledge map, it is very difficult to map all kinds of knowledge into one picture. So here we define domain as the basic unit to organize knowledge and relationships. Domain is the context where a specific task, project or business will be carried out and also where knowledge is used, so domain-based knowledge mapping is more meaningful. Similar to topic map [13], our proposed knowledge map also consists of topics, which represent some concepts in a domain. Topics in different domains are related to each other by associations. A topic may also be related to knowledge resource by its occurrences.

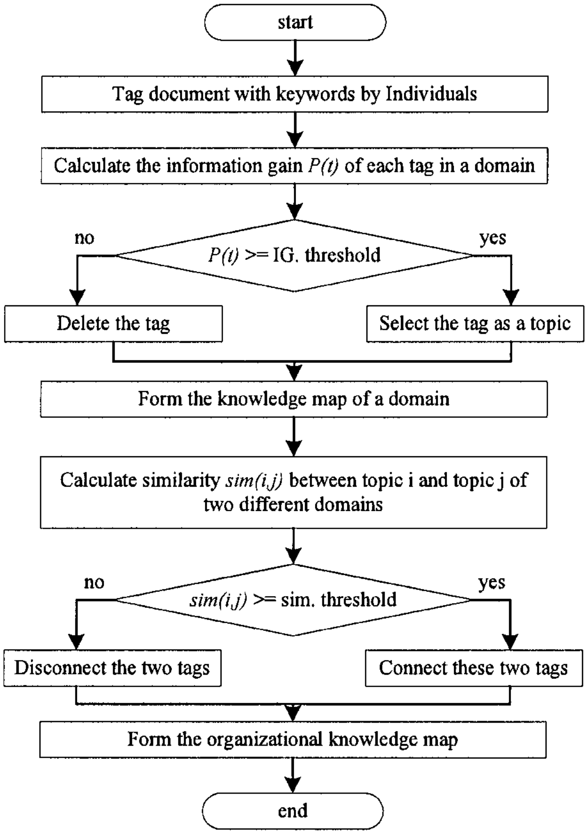

Fig. 2. The basic procedure of knowledge map construction

Fig. 2 shows the basic procedure of constructing the knowledge map. In Fig. 2, there are three major tasks associated with the knowledge map construction method: individual knowledge tagging, domain topic selection and inter-domain topic association analysis.

- Individual knowledge tagging is a process of social classification, which is the basis of the enterprise knowledge map construction. When individuals refer to some documents, which are helpful or important for his work, he will tag them. This is a process where knowledge works organize their knowledge.
- Domain topic selection is a process to construct a knowledge map for a team or department. When the members have classified the knowledge of interest, domain topics will be selected from the tags given by individual through an algorithm.
- Inter-domain topic association analysis is a process to construct the enterprise knowledge map. It carried out when two topics in different

domains are similar with each other to some extent.

Here we assume that all the classifications made by individuals are rational, i.e. they tag the documents according to their business needs. The relevant details will be discussed in section 4.

4 Knowledge Map Construction

In this section, the method to construct the enterprise knowledge map is described in detail. According to the framework mentioned in Section 3, the method is divided into three parts: individual knowledge tagging, domain topic selection and inter-domain topic association analysis. They correspond to knowledge classification on individual level, knowledge organization on team level and knowledge map construction on organizational level, respectively.

4.1 Individual Knowledge Tagging

Similar to the social classification, the method here also takes individual knowledge organization as a tagging process, in which users label some content they create or experience with one or more labels, or tags. However, tagging in a real enterprise environment is required to reflect the business needs, i.e. the tag given by a user should be comprehensive to others persons who work in the same domain.

The core idea of tagging must account for the full environment of social tagging. It is formalized as a three-place relation,

Tagging (object, tagger, tag).

Individual tagging is a process to form a personal knowledge map, which record every user's ideas about knowledge classification and his knowledge usage manners. It means more for the organization. The collection of tagging data will provide great insight into the status of allocating and applying knowledge and help to construct the enterprise knowledge map.

4.2 Domain Topic Selection

We have mentioned above that a domain provides a context where knowledge items and their relationship are displayed. When a specific task or project is carried out, a domain appears. As the project is going on, the tag space will consist of many unique terms words or phrases that is tagged on documents. It is highly desirable to reduce the tag space without sacrificing categorization accuracy.

According to Yang's study on feature selection techniques [17], information gain has relatively good performance. So here the domain topic is selected through analyzing domain members' tagging data and calculating the information gain of each tag. The tag t will be selected to be a topic when its information gain is greater than a predefined threshold α. The process can be expressed formally as follows.

Assume that the current tag is t, and the set of categories made by domain expert is $C = \{c_1, c_2, \dots c_m\}$, the information gain of tag t is defined to be:

$$P(t) = -\sum_{i=1}^{m} P(c_i)\log P(c_i) + P(t)\sum_{i=1}^{m} P(c_i/t)\log P(c_i/t) + P(\bar{t})\sum_{i=1}^{m} P(c_i/\bar{t})\log P(c_i/\bar{t})$$

If $P(t) \geq \alpha$, then the tag is selected as a topic of the domain.

4.3 Enterprise-Wide Knowledge Map Construction

In order to facilitate knowledge reuse among the organization scope, it is necessary to relate the topics of different domains by similarity, which is the process of the enterprise-wide knowledge map construction.

Topic (tag) here is represented in vectors

$$topic_x = \{w_{x,1}, w_{x,2}, \cdots w_{x,n}\}$$

Where each $w_{x,k}$ is a weight for document k for topic x. The weight of a document for a specific topic can be calculated referred to the definition of TF-IDF. We will not explain more about it here.

Similarity of two topics in different domain equals to cosine of the angle between them, i.e.

$$sim(topic_x, topic_y) = \cos(\theta) = \frac{topic_x \cdot topic_y}{|topic_x||topic_y|} = \frac{\sum_k w_{x,k} \times w_{y,k}}{\sqrt{\sum_k w_{x,k}^2}\sqrt{\sum_k w_{y,k}^2}}$$

If the similarity between topic x and topic y is greater than a predefined threshold β, then we will build a connection between these two topics. Otherwise, there is no association between them

5 Knowledge Map System Implementation

Based on the proposed method, a prototype knowledge map system is being implemented in a knowledge management project for a Chinese manufacturing enterprise. The enterprise will be referred to as Company A due to confidentiality. Company A is a large state-owned aviation industrial limited company in the northeast of China. Its main business scope covers the design and development of airplanes. Design is a knowledge-intensive activity. After more than 50 years development, Company A have accumulated a large number of unordered knowledge materials, which leads to the ineffectiveness of knowledge searching and using, so it is an urgent task for company A to organize his knowledge resources and construct his own knowledge map.

The system employs Service-Oriented Architecture. Individual tagging, work center knowledge recommendation and organizational knowledge map construction are designed to be the three fundamental functions of the system.

Individual tagging is an important function in the system. It allows users to organize knowledge of interest during his work. When a user tags a document in the repository, the tagging action will be stored as a record and the tag will be saved as an attribute, as is shown is Fig. 3. Fig. 4 show the user interfaces of individual tagging.

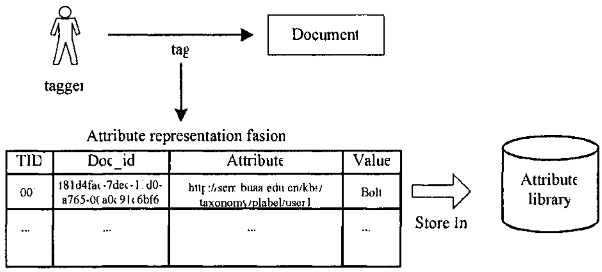

Fig. 3. Individual tagging

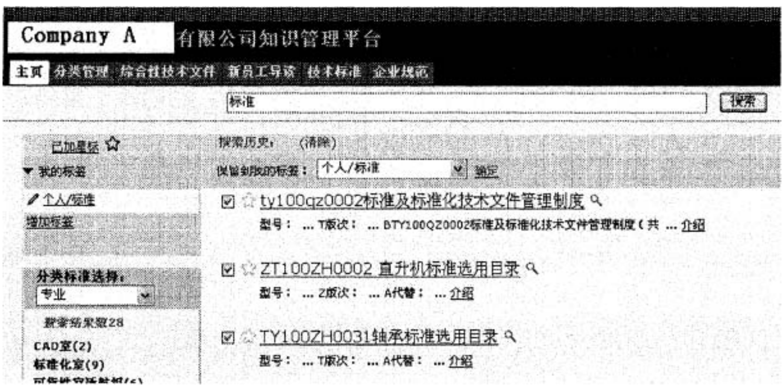

Fig. 4. The user interface

We design a virtual collaboration environment, work center, to manage the knowledge in a domain. Work center is a platform where members can share opinions about knowledge classification application. On one hand, every member's tagging data will be collected and analyzed, and a recommendation based on collaborative tagging will be given. On the other hand, an expert in this domain draws the domain knowledge map according to his expertise and experiences. The enterprise knowledge map is constructed when the topics in different domain is related to each other by similarity.

6 Conclusions

In this paper, we design a method for enterprise knowledge map construction based on social classification. Social classification is currently popular on the Internet. We argue collaborative tagging will provide some pragmatic benefits for enterprise knowledge organization. Unlike other methods for knowledge map construction, the proposed method develops the enterprise knowledge map as a multi-level system including knowledge tagging on individual level, topic selection on the team level and topic association on the organizational level. By virtue of the collaborative nature of social classification and the similarity of knowledge structure in a business domain, our method proposes that the knowledge structure in a business domain can be analyzed and integrated from individual knowledge tagging. The enterprise knowledge map then is organized based on domain to display topics, knowledge resource, and their relationships.

The project is still going on and further research is more challenging. With the implementation of the system, we can obtain more tagging data from users. It is necessary in further research to refine the algorithms in above method and validate them with the real data. Tagging and work center (domain) are both meaningful settings for knowledge organization in the enterprises. Another crucial problem is what kind of measure we can take to drive more workers to employ them.

Acknowledgements

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Critical Success Factors for ERP Life Cycle Implementation

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Abstract. ERP implementations are complex undertakings. The purpose of this study is to establish ERP implementation model in China firms based on project life cycle theory. ERP implementation is an information system project. Drawing from literature research, case research, experts- interview, questionnaire investigation, a critical success factors model is developed that posits that ERP implementation is mostly influenced by top manager support, project champion, external experts, education & training, accuracy of data, project management factors. The research, divided the project of ERP implementation into programming, executive, stabilization, ascending four phases based on project life cycle, investigates the critical success factors in ERP implementation to provide a better understanding of the key factors leading to implementation success when planning ERP implementation projects and also provides researchers with a foundation for further empirical research.

1 Introduction

Enterprise resource planning (ERP) systems represent critical organizational resources [1]. ERP provides a total, integrated software solution to manage an organization's core business and information-processing needs. It supports a process-oriented view of the business, and increases the efficiency and effectiveness of enterprise-wide business processes [2]. Most firms of any significant size are in some stage of implementing ERP systems. Although ERP systems can bring competitive advantage to organizations, the high failure rate in implementing such systems is a

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major concern [3]. Some of these problems arise from technical aspects of the system, the majority of these problems and failures result from management, social, and organizational issues.

According to the reported, approximately 50% of the Chinese firms implemented MRPII or ERP is finally failed, the other 30% to 40% has not realized the system integration, only then 10% to 20% firms succeed in implementation according to budget on time [4].

2 Literature Review

The high failure rate of ERP implementation, calls for a better understanding of its critical success factors [5], especially in china. Through an extensive literature review, Nah et al. [6] found 10 articles that provide answers to the question: "What are the key critical factors for ERP implementation success?" These 10 articles were identified through a computer search of databases of published works and conference proceedings in the information systems area. From the review, Nah et al. identified 11 factors as being critical to the successful implementation of ERP systems. These 11 factors are: appropriate business and IT legacy systems; business plan and vision; business process re-engineering (BPR); change management program and culture; communication; ERP teamwork and composition; monitoring and evaluation of performance; project champion; project management; software development, testing, and troubleshooting; and top management support. These factors were obtained after careful analysis and grouping of related sub-factors.

We used these factors identified by Nah et al. [6] and expanded the content of the literature by adding four additional research articles [7 - 10]. In this research, we use this result as a benchmark to evaluate project life cycle's perceptions of critical success factors for ERP implementation.

3 ERP Implementation Based on Project Life Cycle

ERP implementation project essentially is a management improvement project, but is not the computer system development project. Thus there is not a proper quantification-tool to measure ERP implementation result. Any an advancement management pattern cannot be pushed freely, and ERP implementation is not exceptional. ERP implementation project has four independent phases according to the project life cycle theory. Each phase's goal, main content, achievement and standard are all difference from another. Therefore it is scientific and effective to enhance the success rate to ERP implementation.

The ERP implementation step is as follows: at first seeking initial business demand, then programming plan, allocating software and implementing software, and at last reengineering business process.

Ross [11] developed a five-phase model based on 15 case studies of ERP implementation. The phases are design, implementation, stabilization, continuous improvement and transformation. The design phase is essentially a planning phase in which critical guidelines and decisions making for the implementation are determined. Stabilization occurs after cut-over and is a period of time in which system problems are fixed and organizational performance consequently improves. This is followed by a continuous period of steady improvement in which functionality is added. Finally, firms expect to reach the stage of transformation in which organizational boundaries and systems are maximally flexible. Markus and Tanis [12] developed a four-phase model of ERP implementation: chartering, project, shake-down and onwards and upwards. Lynn [13] defined as preparation phase, executive phase, adjustment phase, and ascending phase.

Several points need to be made about these three models. Firstly, Markus & Tanis [12] and Ross [11] included a planning phase that occurs prior to the actual implementation project. Secondly, these two models collapse the actual implementation project into one discrete unit. Thirdly, these two models include a post-project phase in the model of the whole ERP implementation enterprise. Finally, none of them relates CSFs to the phases of implementation.

The model on which this research is based, the project life cycle, synthesizes previous models in that it recognizes the importance of the planning and post-implementation phases. However, the focus of the model is on the implementation project and the factors that influence a successful outcome at each of the phases of the implementation. The project life cycle model of ERP implementation, shown in Fig.1, proposes an integrated model in which ERP implementation based on project life cycle is divided by four phases: programming, executive, stabilization, and ascending according to characteristic of information system project and the domestic condition of ERP implementation.

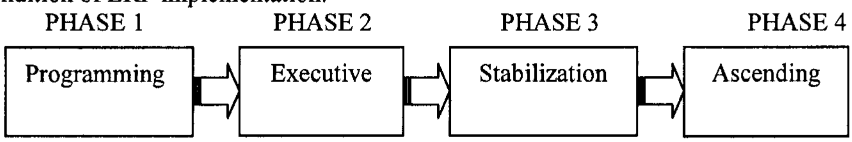

Fig. 1. The project life cycle model of ERP implementation

3.1 Programming Phase

The Programming phase is the start phase of ERP implementation project. Its task is to ready for the next phase. It includes the selection of an ERP, assembly of a steering committee, determination of high-level project scope and broad implementation approach, selection of a project team manager and resource determination.

3.2 Executive Phase

The task in executive phase mainly is to make a business process solution which can satisfy the customers potential demand, and to install system, start implementation project, train the core group, special-subject discuss, medium term and final test. Whether the ERP implementation project will success or failure directly depends on the level of project management in the phase. The phase has five sub-phases: set-up, re-engineering, design, configuration & testing and installation. Figure 1 provides a graphical representation of project life cycle.

3.3 Stabilization Phase

The old system is to be replaced by the new system in the stabilization phase. Also in this phase the data will be transformed and end-user will be trained. The stabilization phase may extend over several years and includes the phases of system repair, extension and transformation, and continued till all end-users can work with the new system proficiency.

3.4 Ascending Phase

ERP implementation effect will be compared with the goal that is proposed in the programming sub-phase in order to inspect business process degree, the facility condition and the system execution. It is necessary to detail and correct the system, such as software upgrade.

4 CSFs for ERP Implementation

The importance of CSFs differs in each phase. It is displayed that top manager support, project champion, external expert, accuracy and integrity of data, well-defined project goal, project management, educating & training, methods and tolls implementation, business process reengineering (BPR) and evaluation of performance are all accepted as the top-ten CSFs in Chinese by Ross, Lynn and Sweden IFS Corporation case empirical study [14] and on literature research and expert interview. The results are shown as Table 1.

Table 1. CSFs for ERP Implementation

Phases	Factors
Programming	Top manager support, project champion, external expert, project management, BPR, education & training, staff cognition
Executive	Project champion, project management, external expert, education & training, accuracy of data, methods and tolls, BPR, staff cognition, communications
Stabilization	Project champion, education & training, accuracy of data, methods and tolls, top manager support, communications
Ascending	Project champion, education & training, evaluation of performance, top manager support, staff cognition, top manager support

4.1 Project Champion

The project champion will play very important role in the implementation project. It consists of software supplier and representative of firms. The representative of firms is composed of all of department managers, who will undertake the strong character, and the IT department only gets up to support function, and members of software supplier must be skillful and experience in ERP implementation.

4.2 Top Manager Support

ERP implementation is relates to the firm overall management question. Top manager support is the only one CSF that can make ERP implementation successful [15] [16]. The ERP implementation is viewed as a transformation in the way the company does business by top management. Top manager support continuous will ensure enough manpower & financial & material to finish the ERP implementation project with the specify quality, quantity and time. Just like Davenport said, it is only top manager that can evaluate and review business & technique conflict appeared in the ERP implementation process.

4.3 Education and Training

Top managers and all system users must be fully educated so they understand how the ERP system should be integrated into the overall company operation. All users must be trained to take full advantage of the system's capabilities. A failure to educate and train all relevant personnel will guarantee implementation problems. Education & training is carried on grade by grade at all time [17]. Through education & training, the manager all levels are clear about ERP and the enterprise change after ERP implementation and how to work each post [18].

4.4 Project Management

The complexity of ERP implementation is very high, given the vast combination of hardware, software and organizational issues involved [19]. One approach to overcoming this kind of complexity is to stress the need for 'a great amount of methodical planning and calculated management' [20]. This approach is often taken in text books on IT project management [21]. However, as organizations and projects evolve over time, so should project management priorities. Some degree of improvisation [22] may also need to be part of the skill set of ERP project managers. Therefore, it is perfected project management strategy that can guarantee ERP implementation success. The ERP project management must have a definitive project plan and an official arrangement [15].

4.5 Accuracy of Data

Data entered into an ERP system may be used throughout the organization. Because of the integrated nature of ERP, if inaccurate data is entered into the common database, the erroneous data may have a negative domino effect throughout the enterprise. Inaccurate data can lead to errors in market planning, production planning, material procurement, capacity acquisition, and the like. If a company with inaccurate data just forges ahead under the assumption that data errors will be corrected when they are spotted, the ERP will lose credibility. This encourages people to ignore the new system to continue running the company under the old system [17] [23] [24].

4.6 External Expert

The qualified experienced ERP implementation consultant is one of important critical successful factors. Consultant is a go-between among the enterprise and the software supplier, which has the independence objective standpoint and good multidisciplinary knowledge and instruction methodology [25].

5 Research Method

Since most ERP implementation research has been done and much has focused on CSF, there is a distinct challenge to develop a research model that adopts the project life cycle from prior research. The CSFs of ERP implementation on project life cycle are shown in Table 1. We will rank these CSFs from empirical in this study.

5.1 Questionnaire Designing

To assess project life cycle' perceptions of the CSF for ERP implementation and the degree to which each factor is considered critical, we developed a survey questionnaire. The questionnaire used in this study attempted to measure its of each CSF illustrated in table 1 in different phase. Most of the items in this study were itemized using Likert-Scale, in which respondents were asked to indicate their level of importance for each of the construct items (CSF) using their response on a five-point scale.

5.2 Data Collection

A total of 178 responses were received. Each respondent company had implemented ERP system. The questionnaire was sent through internet mail to the 500 organizations and 23 usable surveys were received making the response rate to be around 31%.

5.3 Data Analysis

Table 2 presents the results of the survey. From Table 2, we find top manager support influence ERP implementation effect mostly and draw the bar chart as Fig. 2. The top-six CSFs are top manager support, project champion, external expert, education and training, accuracy of data and project management by order. Then we draw a conclusion that CSFs of ERP implementation differ in each phase in Chinese firms, finally develop CSFs model of ERP implementation shown as Fig. 3.

Table 2. Mean rankings of CSFs by degree of importance in ERP implementation

Order	CSF	Mean
1	Top manager support	6.89
2	Project champion	6.75
3	External expert	6.56
4	Education & training	6.34
5	Accuracy of data	6.18
6	Project management	6.05
7	Business process reengineering	5.84
8	Communications	5.62
9	Staff cognition	5.45
10	Methods and tolls	5.21
11	Evaluation of performance	5.03

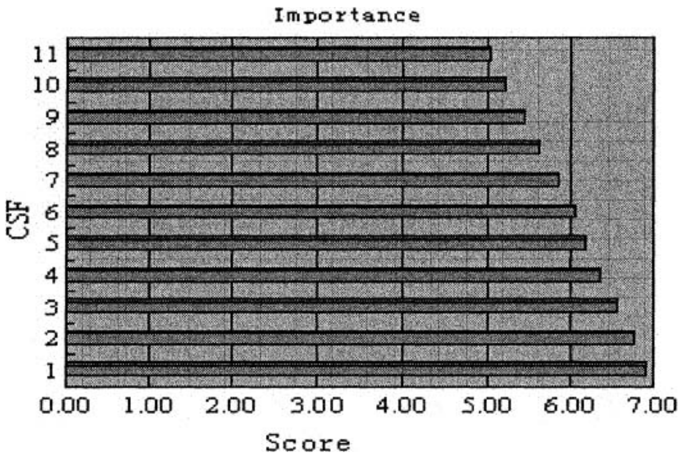

Fig. 2. Rank of CSF

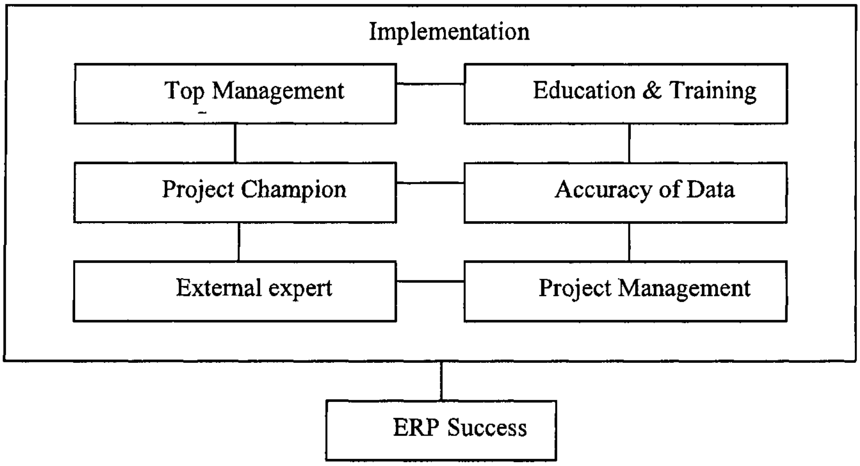

Fig. 3. Critical successful factor model of ERP implementation

6 Conclusions

ERP implementations are usually large, complex projects, involving large groups of people and other resources, working together under considerable time pressure and facing many unforeseen developments [26]. This paper has reported on the development of a project life cycle of ERP systems implementation which focuses on the implementation project itself and links it to CSFs. That model was used in internet case studies of ERP implementation. Evidence from the case studies suggests that top manager support & project champion is more important than the other 4 CSFs obviously. For researchers, it is a useful model of ERP system implementation and provides a foundation for further empirical research. For practitioners, it provides a template that suggests important CSFs to consider during particular project phases. The case study findings emphasize that practitioners need to pay even more attention to top manager support of CSFs across the phases of the implementation project.

The research presented in this article has limitations. First, the evidence was gathered only from internet. Second, this article focuses purely on the relationship between implementer and enterprise. In practice, there may be multiple implementation partners or vendors involved, providing different parts of the system or different services.

More focused research efforts will be necessary to validate and develop CSFs of ERP implementation based on project life cycle. We see the findings a starting point to gain a better understanding of how to effectively make sure ERP implementation from failure to success.

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The Study of Information Integration in EIS Based On Grid

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Abstract: This paper first illuminate the literature survey of the EIS and Grid research, and then introduces the Grid conception. Then the paper establishes a system topology Structure description. In the topology structure used the host and subsidiary node conception, based on the topology structure, the EIS information integration frame structure based on Grid is established. The paper gives a detailed description of the structure. Then the paper conceived the safety EIS access mode. At last, the paper sums up the advantages of the using grid technology into EIS information integration.

1 Introduction

1.1 The research background

With the popularization of the computer and the development of network technology, many enterprises introduced or have voluntarily developed the enterprise information system (EIS) to improve their operational activity efficiency nowadays, but during the process of application, the information integration and the data access form standard disunity makes information unable to share and collectively manage, and then formed the so-called " information isolated island ". In order to dispel this phenomenon, the application of the Grid technology with the purpose of resources integration and cooperation share to construct the enterprise information system has become inevitable trend in coordination.

Traditional information data integration management use the way like this: pick up the needed information from the subsystem or terminal equipment to center equipment for use and access. This process cause many problems. The Grid

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technology comes into being has made the problems solve more easily and also obviously reduced the cost and risk, and then the user will also obtain better services.

1.2 Influence of Grid Technology on EIS

The grid caused all kinds of information and application procedure that distribute in the world carry on the seamless fusion and the communication, thus forms the brand-new commercial opportunity for an enterprise.

Use the Grid in EIS can help us avoid the Information isolated island; realize the integration of the logistics, financing flow, information flow and the task flow.

The Grid solve the data isomerism, enable the EIS unified manage the information and make the process of information share and integration easier.

2 Grid Technology Introduction

If there existed a technology which connects large amounts of computers located at different places through net, it can make a visual super-computer by share the idle processing power, which would efficiently make up for the scarce of resources, saving the money being invested, sharing resources as well. This technology is namely Grid Technology.

Grid is an infrastructure which provides comprehensive computer resource and service with sharing as its core. It can realize the all-round sharing of computer, storage, data, information, knowledge, experts etc. The core conception of Grid is an old saying "Grid is computer".

The essence of Grid is not its size but by the sufficient use of the software and hardware existed in the net support the calculation, data, storage, information share etc. in the WAN. By using Grid, we can avoid the Information isolated island; obtain high performance by the low cost.

Grid is firstly the resources integration extending to the management domain and then the solution technology based on these resources.

The characteristic of the Grid is: 1) Low cost; 2) Resources strong distribution; 3) Isomerism; 4) No protocol standard generally accepted; and 5) Autonomy, Dynamic, and Extension Resource

The Grid tries to realize the connection of all the resource in the net, make people use the net as comfortable as use the electricity and don't need to consider where it comes from. It is called Think & Obtain.

3 EIS Information Integration Frame Structure Based On Grid

3.1 System Topology Structure Description

Many Enterprises use the data concentrates to pick up the needed information from the terminal equipment to the center equipment. This process cause many problems, such as the center equipment burden is overweight, or ask for high performance and high cost, real-time renews is difficult and so on. Here use the topology structure to set some nodes, including host nodes and subsidiary nodes, the host nodes use network structure and one host node can attach some subsidiary node. The disperser controls are used here. Fig. 1 shows the topology structure.

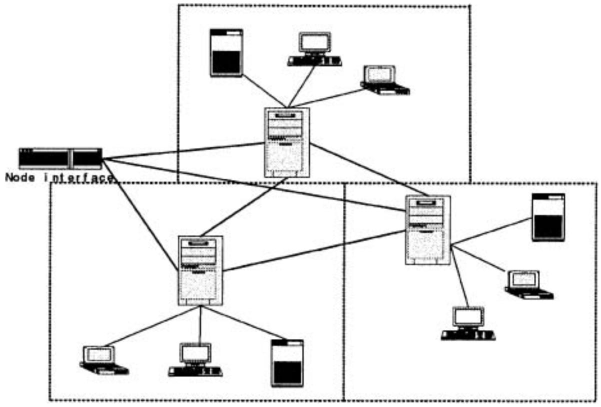

Fig. 1 System Topology Structure

Because the use of the disperser control, even the local network breakdown cannot affect the entire system. The system has very high reliability. Each node established a straight link, and the information flow is the shortest. The node construction emphasize on coordinated and mutually operation. All the nodes provide resource for sharing and monitor, optimize these resources through the host node. The system uses service interface to extend nodes.

3.2 EIS Information Integration Frame Structure Description

In EIS the information integration goal is not establish an entity database, but is integrate the data dynamic information into unification virtual view. The original data in local is still used.

The EIS system structure is divided into 3 levels. It shows the mapping that from the domain application layer to the infrastructure layer through the grid service and the grid middleware level. Consider current EIS platform information integration demand and grid technology development condition, the author provided the entire EIS information integration frame structure, based on three-level systems structures, Fig. 2 shows the main level and the function configuration.

We can see that the three main parts of the structure is: Infrastructure, Grid intermediate level, and the domain application. The infrastructure is the foundation, the Grid intermediate is the core and the domain application is the purpose.

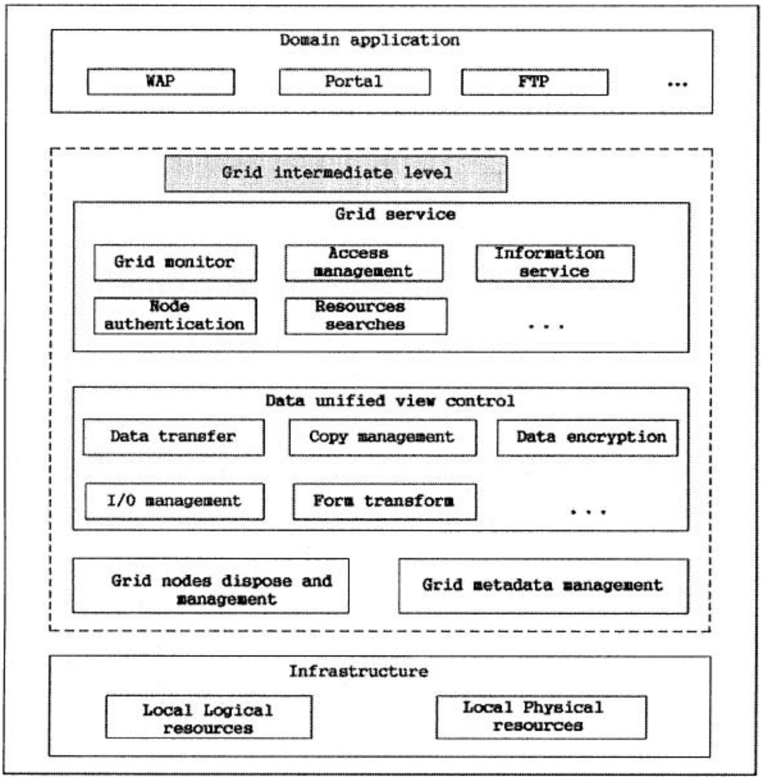

Fig. 2 EIS Information Integration Frame Structure

·Infrastructure

Provides the basic network strut environment to be qualified needs the local logic and the physical resources which shares.

·Grid intermediate level

This level is the core of the whole EIS, which transform the data form, manage the data and provide public service. This part can be divided into three parts:

(1) **Grid nodes dispose and management& Grid metadata management** Dispose the nodes, manage and monitor the nodes. Pick up the metainformation from the nodes and doing management and correlative operation.

(2) **Data unified view control** This is the main part of the Grid intermediate level. The view control provides data pick-up, form transformation, information transfers, and so on.

(3) **Grid service** Provide basic grid service, such as Grid monitor, node authentication, access management and so on.

·Domain application

For different application domain provide different application, and for different application there are different visit forms. Provide the access interface to other users.

3.3 EIS integrated Information Access Mode

The enterprise information data distributes in the different nodes, the dynamic changed data provides different service to different users. Here based on the system topology structure and information integration frame, we establish the EIS integrated information access mode, Fig. 3 shows the mode.

The EIS access mode manifests the characteristic as followed:

·Security

Local login make sure the user is legal and the node authentication make the user legally login the neighborhood nodes.

·Transparency

When login, the users face a unified data view. EIS hides the integration detail and then the user access the information data on other nodes as if use the local information data.

·Good service

The topology structure made the whole system can store more data than before, and because of the host nodes buffer, the user can obtain high handle speed.

·Openness

The system can accommodate and handle all kinds of different form data.

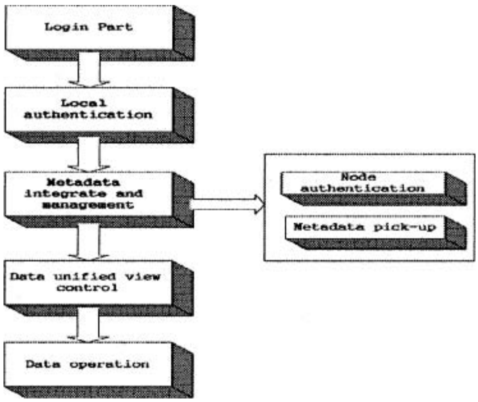

Fig. 3 EIS Integrated Information Access Mode

4 Conclusions

The enterprise data is the most important numeral resources of EIS, by establishing the EIS information integration frame structure; we realized the data sharing in EIS and simplified the system operation. The structure aimed to implement the whole system visit and seamless integration; enhance the local data control and maintenance; use the original data and resources to the great extent. The safe access mode is applied, and then reduced the information data transfer. The design shows the advantages of using grid technology into the EIS construction. Because of the time and knowledge limits, the application detail needs further research.

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Critical Success Factors in ERP Upgrade Projects

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Abstract. Enterprise information systems have proven invaluable in improving the administration of organizations. Since the turn of the Century, enterprise system upgrades have become important. This study reports interviews with the CIOs of six institutions that have undergone (or are undergoing) enterprise system upgrades. Each interview discussed the process used to upgrade. Focus was on discussion of major critical success factors. This paper reviews critical success factors reported in the literature for enterprise system installation projects, and adds to that body of knowledge by preliminary views of factors important in successful enterprise system upgrade projects.

1 Introduction

Enterprise systems have spread rapidly among organizations. According to AMR research [1], ERP market size was $47.88 Billion in 2004. Although ERP systems offer a great deal, implementation success is far from assured. Statistics show that more than 70% of ERP implementations fail to achieve their corporate goals [2] and the number of horror stories about failed or out-of-control projects is growing [3]. Previous research has shown that failure to understand the business implications of ERP systems is related to implementation failure [4, 5]. Despite great technical challenges, the biggest problems in ERP implementations are business problems [6].

Recent reviews [7] suggest that most existing ERP research focuses on selection and implementation, not on ERP's post-implementation impacts. Selection and implementation are critical areas, and numerous valuable insights have been studied by many researchers, to include Akkermans & Van Helden [8], Gefen [9], Hong and

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Kim [10] and Robey et al. [11]. These studies have cited the factors given in Table 1 as influential in ERP installation success.

According to Staehr et al. [12], the ultimate impacts of ERP on the organization – once the system has been implemented and has been "shaken down" – are not as thoroughly researched. Therefore, understanding post-implementation of ERP will help organizations succeed longer after the ERP implementation. ERP upgrade is one of the major activities in the post-implementation stage of ERP implementation [13]. Every three years, a major ERP upgrade and several small upgrades are typically needed to keep the system running smoothly. Organizations will spend a significant amount of money on each ERP upgrade project. Without comprehensive understanding of ERP upgrade concepts in the organizational environment may lead to terrible nightmares, and even result in irretrievable disaster. Therefore, the aim of this research focuses on what factors are associated with ERP upgrade success.

Table 1: Critical Success Factors Cited in ERP Installation

Relationships with consultants	Top management support	Package customization
Core team characteristics	Project champion	Project management
Business process reengineering	User involvement	Implementation approach
Change management	Package choice	Add-on module integration
User training	Module choice	A clearly stated business case

There are several reasons why this study is important. First, each ERP upgrade project costs a significant amount of money. For example, a Midwest university spent over $2 million on a recent ERP upgrade project. While first time ERP implementation happens only once, ERP upgrades will happen many times after the first ERP implementation (probably once every three years). Therefore, the cost of ERP upgrade is continuous along with the usage of the ERP system in the organization.

Second, relatively little research attention has been given to ERP software upgrade. One possible reason could be that upgrade is perceived to be a smaller project (compared to first time ERP implementation), and another reason could be that little theory has been developed regarding the topic of ERP upgrade. However, ERP upgrade is one of the important activities in the ERP software lifecycle, and an effective and efficient implementation of ERP upgrade has a tremendous impact on an organization's continuous business process improvement.

Third, little progress has been made in identifying relative importance of success factors in each ERP upgrade stage. Understanding the relative importance of success factors in each stage can help IT managers emphasize on dominant issues during the ERP upgrade projects. Especially when there are needs to make decisions about trade-offs among different upgrade activities, IT managers can focus on the most important factors other than less important factors in each upgrade stage.

2 ERP Upgrade

ERP upgrades are mainly intended to take advantage of new technologies and business strategies to ensure that the organization keeps up with the latest business development trends. Therefore, the decision to upgrade ERP is usually not driven by code deterioration or anticipated reduction in maintenance costs alone, but by different purposes. According to an AMR study [14], 55% of upgrades were voluntary business improvements triggered by the need for new functionality, expansion or consolidation of systems; 24% of upgrades were triggered by technology stack changes; 15% of upgrades were forced by de-support of the running version of software to avoid vendor support termination [15]; and 6% of upgrades were triggered by bug fixes or statutory changes.

The cost of ERP upgrades is high [16]. Swanton [14] mentioned that the cost of each upgrade includes: 50% of the original software license fee and 20% of the original implementation cost per user, which means over 6 million dollars for a 5,000-user system. Typically, each ERP upgrade requires eight to nine months of effort with a team the equivalent of one full-time employee per 35 business users. The ERP-adopting organization does not have to develop and re-write the ERP system itself but rather it replaces (or upgrades) the old version with a readily available new version from the ERP vendor. However, a lack of experience may cause the costs and length of the upgrade project to approach or even exceed those of the original ERP implementation effort. Collins [17] listed some general benefits for organizations from ERP upgrades:

- Eligibility for Help Desk Support: Most of ERP software vendors stop providing technical support 12 to 18 months after the next version becomes available. Therefore, keeping upgrade with the pace of ERP vendors will guarantee the support for the system from the vendors.
- Solutions for Outstanding "Bugs" or Design Weaknesses: It is impossible to guarantee spotless and error-free ERP systems after the implementations even though vendors will conduct many different testing processes to eliminate the happenings of errors in the system before the leasing time. "The majority of software bugs are resolved and delivered either fix-by-fix, or all-at-once as part of the next release version of the ERP package." In this case, upgrades will be beneficial to the organizations in problem solving.
- New, Expanded, or Improved Features: ERP software provides organizations the knowledge and strength (i.e. best practices) from the vendors. ERP upgrades provide organizations future enhancement from the vendors to give the organizations better opportunities to catch up the current business development, improve their processes and build more efficient business models with new functions, new features and new processing styles provided in the upgraded ERP versions.

Collins [17] described a four phase upgrade procedure. Phase one included impact analysis and initial upgrade. Impact analysis is to conduct impact analysis to evaluate the upgrade version and identify the differences between customized applications and new applications in the new version. Initial upgrade then can help merge the customized application and new application together smoothly. Phase two is solution development, in which "all modifications that were overwritten are redeveloped and retested". Acceptance /performance testing is the phase three to finally test the whole system. Finally, production conversion is conducted to run the new version in the organization. This model is useful in that it distinguishes between the 'phases' of change which the organization passes through as it implements change, and the 'processes' of change, i.e. the methods applied to get the organization to the desired state. The model progresses as follows:

2.1 Assessment Phase

For the manager, the change process begins when questions are asked about what the originators of the proposal actually want to do. It begins with a general review of the organization, and it is relevant to organizational health, which is itself to do with motivation. By examining motives, managers should find out both positive and negative reasons for introducing change by asking all kinds of questions related to the change, such as what are the desired outcomes? What are the problems? How does the project fit with the strategy of the organization? What is the likely effect on the organization? What is to be the role of the manager? Outcomes of the assessment phase include:

- Identification of what changes are required,
- Justification of changes,
- Identification of resources required.

2.2 Planning Phase

The organization should make a detailed plan regarding all aspects of the resources of the organization. This includes staffing and personnel implications, structural implications, technical features and requirements, hardware and software arrangement, training plans, communication plans, etc. Outcomes of the planning phase include:

- Clarification of goals and objectives for each milestone,
- Identification of specific activities required to undertake desired change,
- Commitment obtained from stakeholders,
- Identification of support required to enable change to occur,
- Identification of staff development needs,
- Design of feedback mechanism,

- Review of general organizational implications.

2.3 Action Phase

Changes identified are agreed upon and implemented. Actions and outcomes of the action phase can include:

- Putting the personnel in place,
- Communicating with the entire organization regarding activity results,
- Adjusting and refining changes where necessary,
- Reviewing the general organization implications,
- Putting the change into operation.

2.4 Renewal Phase

The initial activity in this phase is to place the new system into operation. That tends to be very short in duration. But the renewal phase also offers the prospect of assessing the success and impact of the change, it also helps make changes permanently effective within the organization. Activities can include:

- Monitoring and evaluating changes,
- Results and outcomes from change communicated throughout the organization,
- Continuous development of employees through training, education,
- Ongoing monitoring and evaluation.

2.5 Method

Six IT managers were interviewed with a semi-structure interview format to explore key successful factors for ERP upgrade. The purpose of this study is to gain an initial understanding of key factors in ERP upgrades. Structured interviews were conducted with six CIOs of a diverse set of organizations.

2.6 Organizations

A. Color Imaging is one of the largest independent toner manufacturers in the world. It is a middle size company with over 100 employees. They adopted an Impact 4.0 (Syspro) ERP system in 1998, and upgraded to Syspro 6.0 to obtain new functionalities and features. This upgrade project took 6 months.

B. DePaul University is a university in Chicago, Illinois, using ERP for administration. Their initial ERP system (PeopleSoft) was adopted in 1999. The upgrade project took about nine months. In 2003 they began their upgrade planning, due to the end of service support of the particular software system used, and because of the desire for greater system functionality.
C. Lincoln Electric System is an electric utility distributor in Lincoln, Nebraska. They initially adopted an SAP in 1999, upgrading to R/3 4.7 in 2004. This project took three and one-half months. The primary reason cited for the upgrade was difficulty in obtaining useful support from SAP for an older version of their software.
D. Molex is the world's second-largest manufacturer of electronic, electrical and fiber optic interconnection products and systems with 16,241 employees and 115 operations on six continents. They adopted an ERP R/3 system at Corporate World Headquarters (Singapore) in 1996, and installed it in the Lincoln branch in 1998. In 2003 they upgraded from version 3.01D to version 4.6B in a five month project. The upgrade was adopted to gain new functionality, as well as anticipation of an announcement by SAP that they would stop support in a few years if an upgrade wasn't undertaken.
E. The State of Nebraska uses ERP to join many diverse information systems in support of the administration of state government. They adopted J.D. Edwards' OneWorld 3 system in 2002. However, the service for this system was due to expire, and the newer package had added functionality enabling the State to record operations that were cumbersome in the old system. The upgrade project was underway, and was expected to take about nine months.
F. The University of Nebraska uses ERP for administration of all elements, including four distinct University programs. They adopted an SAP package in 1999. In 2004 the support contract was about to expire, and better technical support was desired (it took up to two months to get support for the old version). The upgrade project was underway, and was expected to take about 11 months.

3 Results

The assessment phase took about two months. Five months were spent in the planning phase, to include the simulation sandbox. The overall project took 11 months, and the implementation was again very short, so about four months may be inferred for the action phase. Valuable insight was provided about the need to focus training on how the system should be used to help the organization rather than focus on software.

3.1 Recapitulation of the Upgrade Process

These upgrade projects took between 2.5 months (a local system, with no customization) to 11 months (a more complex organizational structure with heavy training requirements). Customization may be needed by organizations, but will incur a cost in time (and thus money). The assessment phase was often quite short, although larger organizations took longer because of the need to obtain corporate approval. Planning and action phases were relatively consistent. We would conclude that upgrade projects involve lower levels of risk and uncertainty (and thus variance) than initial installations because the organization is very familiar with what the system should do. The renewal phase (putting the system on-line) was very short. With proper project management, overnight or a weekend was proven possible.

3.2 ERP Upgrade Critical Success Factors by Phase

Each organization was asked to select those factors that they found important by project phase. These results are given in Table 2.

The six organizations were quite consistent in their selection of critical success factors by phase. Business vision was selected by all organizations in the assessment phase. Top management support was selected by four the six organizations in this phase. One organization also selected communication.

In the planning phase, there was unanimity that project management was the most important success factor. Communication was selected as second in importance by five of the organizations. Two selected external support, which would emphasize the need to work with vendors.

In the action phase, project management continued to be selected as important (five of six organizations). One organization identified the need for a positive organizational culture. This was the multinational organization. The other organizations were smaller in geographical scope. Training was cited by five of the six organizations (the other selected the value of a project champion). Four organizations cited the need for user involvement. Customization was tabbed by one organization, the only appearance on this list, although it clearly was cited as an important factor in the reviews of the upgrade process.

The renewal phase was quite short in most of the cases. All organizations (even those currently undergoing their upgrade projects) cited the need (or expectation) that user involvement was important. Two also cited the need for external support (from vendors).

Table 2: Critical Factors by Phase

Phase	1st	2nd	3rd
Assessment	A – Top support	A- Business vision	
	B – Business vision	B – Top support	
	C – Business vision		
	D – Top support	D– Business vision	
	E – Business vision		
	F – Top support	F – Business vision	F - Communication
Planning	A – Project mgmt	A – Ext. support	
	B – Project mgmt	B– Communication	
	C – Project mgmt	C– Communication	
	D – Project mgmt	D– Communication	
	E – Project mgmt	E– Communication	E – Ext. support
	F – Project mgmt	F - Communication	
Action	A – Project mgmt	A – Training	A – User involved
	B – Project mgmt	B – Proj. champion	
	C – Project mgmt	C – Training	C – User involved
	D – Org. culture	D – Training	D – User involved
	E – Project mgmt	E – Customization	E – Training
	F – Project mgmt	F - Training	F – User involved
Renewal	A – User involvement	A – Ext. support	
	B – User involvement	B – Ext. support	
	C – User involvement		
	D – User involvement		
	E – User involvement		
	F – User involvement		

4 Conclusions

ERP upgrade projects have grown in importance, as vendors are seeking to generate revenue through improved systems. The reticence of vendors to support old systems was noted by multiple organizations in this study. (The value of improved functionality was also noted.)

Upgrade projects seem to be much more controllable than initial ERP installation projects. This should be expected due to the experience organizations gain with their original systems. All of the organizations seemed to do something that fit the theoretical model of an upgrade project that we used. Assessment, planning, and action phases were present to at least some degree. The renewal phase noted by the six organizations involved very smooth turnover. A limitation of the study is that future implications were not yet available in all cases (problems may crop up later), although all organizations credited strong planning and project management as ways to assure smooth transitions.

Of the list of eleven critical success factors provided, nine were selected for one or more phases. Top support and business vision seemed critical in assessment. Project management and communication were usually selected as critical in the planning phase. Project management, training, and user involvement were commonly selected in the action phase. User involvement and external support were cited in the renewal phase. Some factors were selected rarely (external support, project champion), indicating that they may apply in specific circumstances. Two of the eleven factors were not selected (business process reengineering, internal support). That might be because business process reengineering is less important in upgrades, because the initial ERP selection included most of that. (Selecting processes was, however, mentioned as part of the upgrade process by one organization.) Internal support might have been inferred, and probably overlaps with user involvement and top management support. One organization selected customization (which was not on our list), reflecting the importance of this feature that was noted by a number of other organizations.

ERP upgrade projects were shown to be less problematic that initial ERP installations, which in retrospect, may seem obvious. However, the six cases clearly show that some factors are more critical in different phases. And clearly careful planning is needed to attain success.

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The Influence of Knowledge Transfers on the Implementation of Enterprise Information Systems

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Abstract. Introduction The implementation of Enterprise Information Systems is difficult and challenging. It requires that many users learn to use the new system and coordinate their work. The goal of this study is to understand the relationship between the extent of user learning via social means and its impact on the implementation success.

1 Introduction

Many organizations including public universities are implementing large Enterprise Information Systems using software such as SAP, PeopleSoft, etc [1, 2]. Some of these such as Enterprise Resource Planning Systems (ERP) are implemented to streamline operational processes, improve business performance, and facilitate information delivery methods in organizations. Despite these benefits from implementing ERP systems, reports list many problems faced during the implementation of these systems, that some of these have even been labeled as failures [3-7] Some of the more high profile organizations that have faced problems with enterprise system implementation include Hewlett Packard, Boeing, and Siemens [8-10]. Some large public Universities have implemented these systems and have seen its share of difficulties [1, 2]. The costs of implementing ERP systems run into millions of dollars, and failure to properly implement the system can lead an organization into financial ruin [11-13]. Hence, researchers are interested in

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understanding the various factors that could promote the successful implementation of these enterprise information systems.

When compared to smaller information systems used by single users, the diversity and the large number of users who have to adapt and learn to use a new enterprise information system add many complexities to the implementation process. Furthermore, users' tasks tend to be interdependent in that a user cannot work solely on their task, but may have to rely on the task results of other users. Groups of users have to learn, assimilate the new system, and use it to complete their interdependent tasks. Cases studies suggest that some groups of users (business units), and organizations seem to easily adapt to the new system and quickly reengineer business processes, while others face a more difficult time. Prior findings suggest that the implementation of these large integrated systems necessitate a substantial amount of knowledge transfers to occur among users of the system, sometimes referred to as social learning. The nature and extent of these knowledge transfers are expected have a substantial impact on the successful implementation of systems [14, 15]. We therefore propose that if users in an unit are able to easily transfer knowledge and learn about the system, there is a greater likelihood that the implementation will be more successful in that unit.

Using Social Network Theory as our foundation, we test our ideas on an ERP system being implemented across many different units of our University [16, 17]. We believe that organizational units characterized by close, diverse and dense ties among its employees will have relatively rapid and efficient knowledge transfers that serve to lower knowledge barriers and facilitate user learning; hence, we can expect a more successful implementation of the system. On the other hand, in organizational units with sparse, infrequent ties, knowledge transfers will tend to be fragmented leading to a slowing of the implementation process. We have developed multidimensional measures to gauge ERP success. We intend to determine the level of knowledge transfers occurring in a unit and determine its influence on these success measures.

We are collecting data from over thousand users of the ERP system that is being implemented at our University. We plan to collect data over three time periods, before the system is implemented to serve as a baseline measure, immediately after the system is implemented, and finally, we will collect data when the system is fully operational and in routine use. In the future, spending on EIS such as ERP systems, are predicted to increase even further, it is very critical to identify factors that can facilitate the successful implementation of these systems [9, 13, and 18]. We believe our empirical study can make a contribution by identifying the role of social knowledge transfers on the successful implementation of EIS and provide information for researchers and practioners to build upon.

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Mobile Customer Demand Discrimination Modeling in Enterprise Information Systems

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Abstract. In the highly competitive environment, the real-time and dynamic customer demand analysis technology is required by the enterprise information systems in order to respond to the customer demand efficiently and automatically. Based on the background of mobile industry, this paper makes a mobile customer demand analysis model and proposes ways to capture customer demand knowledge. Firstly, a contour model of customer value layers is gotten by investigation and specific interview; secondly, the significant attributes of customer value layers are screened out; finally, a customer demand discrimination model is built while making the customer demand objective layer as the output of the model and making customer demand attribute layer as the input of the model. Well-formed model could judge the classification of customer demand objectives dynamically from their demand attributes. This model is used in analysis of mobile customer samples.

1 Introduction

In the highly competitive environment, the mobile operators must be able to adjust their service processes to respond to market shifts and various customer needs efficiently and automatically. Therefore, the real-time and dynamic customer demand analysis technology is required for the enterprise information systems. Influenced by the aim, environment and individual preference, the different customer group leads to the difference of customer demand [1] [2]. Previous studies mainly focus on these subjects: firstly, predicting customer preferences and repeat-purchase

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patterns through consume history analysis [3]; secondly, analyzing the antecedents and consequences of consume behavior and customer loyalty [4] [5]; thirdly, classifying customers by using clustering analysis [6]. It's a bit subjective with such a low intelligence level and large manual work. Woodruff, Butz and Goodstein proposed the CVD (Customer Value Determination) and built the correlative relationships among the customer demand attribute layer, the consequence layer and the objective layer [7]. However this research did not present technical tools to implement the CVD knowledge capture. Based on the background of mobile industry, this paper makes mobile customer demand analysis model and proposes ways to capture customer demand knowledge. Firstly, a contour model of customer value layer is gotten by investigation; secondly, the significant attributes of customer value layers are screened out; finally, a customer demand discrimination and analysis model is built. Well-formed model could judge the classification of customer demand objectives dynamically from their choices on demand attribute layer. We use this method to analyze the samples of 122 mobile telecommunication customers.

2 Framework for Customer Demand Discrimination

The supporting framework for the process of mobile costumer demand analysis is presented in Fig.1. The subsequent sections of this paper will explore it in detail.

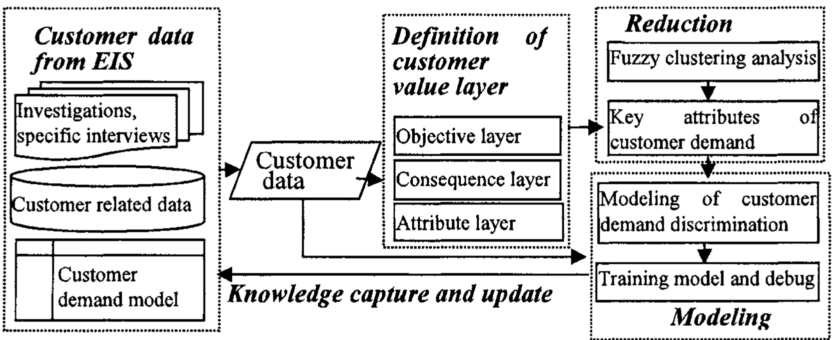

Fig. 1. Framework for customer demand discrimination

3 Mobile Customer Demand Discrimination Modeling and the Knowledge Capture

3.1 Contour Model of Mobile Customer Value Hierarchy

Woodruff advanced the CVD indicating that from the bottom of customer value hierarchy, customers firstly consider the attributes and availabilities of products. At the second layer, customers begin to make expectation according to these attributes. At the top layer, customers form expectation about the realization of their aim. In this paper, the mobile customer value hierarchy consists of three layers. The objective layer means the ultimate motivations of customers engaging in mobile telecommunication services. The Consequence layer means the customer experience of mobile services. The Attribute layer means the usage of mobile services. Based on the mobile customer interview that made in X city, this paper constructs the mobile customer value hierarchy presented in Table 1. The factors of objective layer and attribute layer are defined as the variable a_i □i=1, 2...29□□

Table 1. Mobile Customer Value Hierarchy

Objectives	Communicative Object (a26)		Business Object(a27)		Recreational Object(a28)		Informational Object(a29)	
Consequences	Convenient communication,		High quality, knight service, high standing		Fashion, pleasure, selfhood, fun		Knowledge, in time, information	
Attributes	short massage service call	a1	U-net	a6	Color ring back tone	a13	News service	a19
			Routine service	a7			Weather info	a20
	waiting call	a2	Ticket booking	a8	mobile ring	a14	Travel info	a21
	diversion	a3	Uni-colour E	a9	mobile picture	a15	Finance info	a22
	little secretary	a4	E- bank	a10	E-game	a16	Physical news	a23
	voice mail box	a5	Stock exchange	a11	chat	a17	Entertainment info	a24
			Mobile purchase	a12	mobile movie	a18	U-map	a25

3.2 Significant Attributes Analysis of Customer Value Hierarchy

The significant attributes of customer value hierarchy mean the key attribute variables of the attribute layer which distinctly correlate with the objective layer. This step is mainly to decrease the data dimension in customer demand analysis.

A. The Principles of Significant Attributes Analysis

According to the rough set theory, data of the customer value objective layer and attribute layer can be defined as $S=(U,A,V,f)$. Here, $U=\{u_1,u_2,\ldots,u_n\}$: The set of customers where m is the total number of customers. $A=\{a_1,a_2,\ldots a_m\}$: The set of variables of the objective layer and the attribute layer. $A = C \cup D$, where C is the characteristics set of the attribute layer, and D is the characteristics set of the objective layer. V is the set of the customer attribute parameters. The value of

$f(u_j, a_i)$ indicates the value of u_j about a_i. The significant attributes analysis is solved by fuzzy cluster. The process of the analysis is:

Step1. Partition customer set A into D and C. Consider the numerical character of attribute a_i in attributes set C, and represent attribute a_i as a_{ij} (j=1,2,...,k). Here k is the number of incoordinate value of attribute a_i.

Step2. Calculate the fuzzy similarity matrix R. Here:

$$r_{ij} = \sum_{k=1}^{m} (a_{ik} a_{jk})^2 \Big/ \sqrt{(\sum_{i=1}^{m} a_{ik}^2)(\sum_{k=1}^{m} a_{jk}^2)} \tag{1}$$

Step3. Calculate the fuzzy transitive closure t(R) of the fuzzy correlation matrix R. Use the cluster method to analyze t(R) with intercept λ and find out the significant attributes set.

B. The Process of Data Analysis

The investigation gave 150 pieces of questionnaire out to the mobile individual customers in X city. 122 effective sheets of questionnaire were retrieved. The rate of retrieving efficiency is 81.3%. The questionnaire contains two parts, questions about the importance of the consume objects in the objective layer and questions about whether the customers have engaged the services of the attribute layer. In order to be less costly and easily applied, 50 questionnaires are chosen as the analysis samples. From total 25 products/services, 13 products/services were found that have distinct correlation with the customer demand objective. The results are presented in Table 2.

Table 2. Significant Attributes of Attribute Layer

objective layer	λ	attributes cluster	Significant attributes
Communicative Object	0.908	{a1}{a2,a3,a4}{a5}	a1,a2,a3,a4
Business Object	0.999	{a6,a9},{a7},{a8,a10,a11,a12}	a6,a7,a9
Recreational Object	0.997	{a13,a14}{a15},{a16}{a17,a18}	a13,a14,a15,a16
Informational Object	0.95	{a19},{a20},{a21,a22,a23,a24,a25}	a19,a20

3.3 Mobile Customer Demand Discrimination Modeling

We build customer demand discrimination model while making the customer demand objective layer as the output of the model and making significant attributes of the attribute layer as the input of the model. This paper uses 61 customers as the training samples set and others as the contrastive samples set. The model is trained by adopting BP-neural network method, and the best acceptable training result is achieved. The accurate percentage of forecast is 80.517%. The weight matrix from input layer to hidden layer W is described as:

The weight matrix from input layer to hidden layer r is expressed as:

$$W = \begin{vmatrix} -0.904 & 0.673 & -0.824 & 0.258 & -0.368 & -0.334 & 0.016 & 0.138 & -0.019 & 0.352 & -0.788 & 1.263 & 0.533 \\ -0.036 & -0.734 & -1.180 & -0.937 & -0.056 & -0.261 & -0.618 & 0.858 & 0.059 & -0.447 & -0.084 & -0.415 & -0.07 \\ -0.634 & 0.324 & 0.063 & 0.676 & 0.211 & -0.35 & -0.557 & -0.428 & -0.704 & 0.265 & -0.725 & 0.164 & 0.147 \\ 0.507 & -0.224 & 0.441 & -0.201 & -0.027 & -0.205 & 0.156 & -0.579 & -0.478 & -0.792 & 0.036 & -1.022 & -1.48 \\ 0.335 & -0.724 & -1.017 & 0.847 & -0.698 & -0.255 & 0.388 & -0.152 & -0.292 & 0.587 & -0.353 & -0.190 & 0.745 \end{vmatrix}^T$$

$$T = \begin{vmatrix} 0.918 & 0.393 & 0.921 & 0.973 \\ 0.145 & -1.252 & 0.363 & -0.459 \\ 0.852 & 0.724 & -0.424 & 0.509 \\ 0.976 & -0.195 & -1.577 & -0.247 \\ 0.992 & -0.537 & -0.395 & 1.527 \end{vmatrix}$$

3.4 Customer Demand Knowledge Capture

Well-formed model could judge the classification of customer demand objectives dynamically from their demand attributes. 2 customers are randomly selected from samples and the comparison between the analytical conclusions and the actual demands is presented in Table 3. For getting obvious conclusion, we assume 3 as the dividing line. It can be indicated that the model can discriminate the customer demand with high accurate percentage. Furthermore, the model can indicate a measurable conclusion based on customer motivation that has the advantage of high stability and reliability.

Table 3. Comparison Between Analytical Conclusions and Actual Demands

customer		a26	a27	a28	a29	customer demand object
1	Actual demand	5.0	2.0	2.0	3.0	Communication object, Information object
	Analytical conclusion	4.9	3.1	2.6	3.8	Communication object, Business object Information object
2	Actual demand	5.0	3.0	2.0	4.0	Communication object, Business object, Information object
	Analytical conclusion	4.9	3.	2.9	3.8	Communication object, Business object, Information object

4 Conclusions

Based on the background of mobile industry, this paper makes mobile customer demand analysis model and proposes ways to capture customer demand knowledge. The method is used to analyze the samples of 122 mobile telecommunication customers. We make a contour model of mobile customer value layer, and screen out 13 key variables of attribute layer. The results of customer demand discrimination reflect its outcome with the correct percentile over 80%. Compared with previous methods of customer clustering analysis, it is more precise and higher in the intelligent level. Furthermore, the conclusion is much more understandable.

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Predicting Churn Probability of Fixed-line Subscriber with Limited Information: A Data Mining Paradigm for Enterprise Computing

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Abstract. The phenomenon of subscriber churn is becoming more and more serious in the fixed-line communications industry. In order to build customer loyalty and maximize profitability in the ever-increasing competitive marketplace, a churn prediction method becomes necessary for a fixed-line services provider. However, today's researches on churn prediction in the telecommunications industry mostly concentrate on mobile services field, rarely on fixed-line services field. One prime reason is the less amount of qualified information for churn prediction in the fixed-line services providers. In response to the limitation of information, especially the incompletion of call details and unreliability of subscribers'demographics in the investigated fixed-line services provider, we propose, design and experimentally evaluate several churn-prediction models applying three different data mining techniques (Decision tree, regression, neural network), with predictors (i.e. input variables) derived only from subscribers' contractual information and bill details. The predictors can be mainly categorized into four types: duration of service use, payment type, amount and structure of monthly service fees, change of the monthly service fees. The result shows that these limited but appropriately designed predictors can effectively predict subscribers' churn probabilities and decision tree outperforms regression and neural network in this study, with the optimal predictive and explanatory power. What's more, it also indicates that duration of service use is the most predictive predictor, and payment type and other variables of amount and structure of monthly service

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fees within different months especially the latest months are also effective predictors. According to the result that the predictors within the latest months are more effectual, we then build different decision tree models using historical data of different amounts of months. We find that with the reduction of early monthly data for prediction, the model performance index "churner captured proportion in top ranks" declines very slightly, which can be ignored. However, the amount of the data for processing and the runtime of prediction model decreases significantly. Hence, we suggest that using relatively fewer, latest months' data to predict subscribers' churn trends would be an effective way.

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A Case of Individualized Information Monitoring and Customizing System for a News Group

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Abstract. Information content service industry is expanding rapidly in China nowadays. The paper describes the monitoring and customizing of information content and designs one of them. The paper investigates the characters, the functions and the performances of the system. Specially, the paper compares the monitoring and customizing system with searching engine in different aspects. The system applied successfully in Dazhong News Group, which is one of the largest news groups in China and publishes eight kinds of newspapers and two periodicals at present. So the applications of the system are illustrated briefly. Finally, the paper introduces the multimedia calling center of DaZong News Group and Information Platform, which is one of the largest information service platforms in China.

1 Introduction

Information monitoring and customizing technology is a service which continuously obtains and analyzes the information change of monitoring target within the pre-set range in certain periods. In fact, the traditional press cutting service is a kind of information monitoring service which provides enterprises with information of industry and rivals, although it is much slower than information monitoring and customizing system.

Generally, information monitoring and customizing system monitors public media, including newspaper, radio, TV, publications, research report, websites of government department, enterprise recruiting advertisement, industry supervising organization and rivals, and so on. According to different intentions, information monitoring can be classified into personal interests (stars, work environment, etc.)

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monitoring, government policy consensus monitoring, enterprise competition environment monitoring, etc. At present, the most common use is enterprise competition environment monitoring, which in detail includes rivals/partners/supervisors monitoring, industry/policy environment monitoring, market/business environment monitoring, trademark monitoring, technology trends monitoring, consuming environment monitoring, etc. The paper describes a monitoring and customizing system of information content and implements it in a news group in China.

2 Main Functions of the System

It is an information content service system based on Internet with functions of real time information collection, self-definition topic classification, personalized distribution and knowledge management. By using new technologies in both Chinese and English information processing, it continuously traces thousands of websites of media, enterprise and business in tens of countries and districts, automatically filters information content, eliminates useless pages, precisely obtains target information, and matches them with user's requirement to guarantee users to get the information needed in time. At present, the amount of new information collected and monitored each day is about 30,000 pieces.

2.1 Information monitoring service

The service includes news monitoring, web pages monitoring and web station scan monitoring, etc. The frequency could be from several times a day to non-stop, according to users' requirement. With enough bandwidth, monitoring cycle could be less than 3 minutes.

2.2 Information customizing management

User customization is a personalized service interfaces, including:

- Topic object dictionary of complete self-definition

The dictionary supports the mixed coding of Chinese and English, and the topic word supports kinds of combinations of 'and, or, not', like 'A+B-C'.

- Management of topic customization

Users can set monitoring target themselves, and add, delete and modify the settings. They can also set hundreds of targets easily through 'quick customization'.

- Scanning of websites in English, simplified and traditionalized Chinese
- Customization of scanning scope

Users can change monitoring scope by key words. And they can also adjust monitoring scope by categories.

- Intelligent filter of websites
- Automatic adjust of website scanning order
- Automatic expansion of scanning scope

2.3 Monitoring result management

- Create reports of canning results automatically

This way, users can not only read, repeat use, download and save those results, but also do secondary search and develop through them.

- Edit news-re-editing monitoring results.
- Label and sort news according to importance
- Eliminate repetition automatically
- Analyze statistics of monitoring results
- "Push" information automatically

3 Comparison of the System vs. Search Engine

The system makes users describe their information demands in natural-like languages, so it will send the matched information to users regularly.

The differences between search engine and information monitoring and customizing system can be seen from Table 1.

Table 1. Comparison of information monitoring and customizing system vs. search engine

	Search Engine	Information monitoring and customizing system
Using motivation	Query old information	Tracing the latest information
Obtaining method	Users look for information	Search and analyze information and "push" the results to users.
Information timeliness	Days or weeks to get the information into database.	Obtain, process and inform the latest information in real time.
Information scope	The latest information only inside the website.	The latest information in all dynamic websites, covering thousands of medias and channels
Convenience	Users search again and again.	The system informs automatically according to users' demand.
Query target	One topic at one time.	Traces a lot of topics at one time.
Information management	Simple display of mass repeated information.	Provide function of personalized knowledge management.
Query results	Ranked by weight, but no management function. New/old, read/unread could not be distinguished.	Provide functions of repetition auto-elimination, sentence expert, and personalized knowledge management.
Results management	Lost the process and results after query finished.	Save information, create reports and monitoring knowledge base.

4 Main performance parameters of the system

- News websites coverage

At present, it covers 25 countries (districts), including English, simplified and traditionalized Chinese, more than 5,000 Chinese news channels and 4,000 English channels.

- The amount of news monitored everyday

There are more than 35,000 pieces of news monitored everyday, about 53MB news data.

- News monitoring cycle

The cycle time is less than 5 minutes, which depends on net bandwidth and server hardware. A PC server of single CPU can finish a monitoring cycle in about 600 seconds with enough bandwidth.

- Customized topic matching time

It is about 6μs (microsecond, based on Intel Celeron 400) for each user.

- Number of customized topic matched

Customized topic of each user can be the logic combination of any topics, which could be several, tens of, even hundreds of, according to requirement.

5 System application analysis

The system includes five kinds of monitoring services:

- News customizing service for news enterprises and individual customers.
- Business and policy information customizing service for enterprises
- Industry and field information customizing service for governments
- Academic customizing service for research and education institutes
- Personalized and special topic information service for individuals.

6 Integrated information platform

Dazhong News Group built the information platform, which is one of the biggest multi-media IP calling center in eastern China. It broke through the single plane media mode of news group, founded a solid information service platform composed of one platform (a media platform), two bases (multi-media information database and profession information database), three channels (network, short messages and calling center), and greatly improved integration service level and economic benefit.

Based on IP media calling center and short message center, it integrates services like information query, customer requisition, transaction acceptance and solution, logistics and distribution, intelligent office, value-added business and electronic commerce. In order to dig customers' potentiality, guarantee customer loyalty and increase media competition ability, it provides several kinds of interview and feedback methods, such as telephone, fax, Internet, E-mail, etc.; offers enterprises with information service which is "one-stop", personalized, friendly and intelligent.

On the basis of the platform, several new businesses were exploited:

- News clue collecting
- Member club
- Consultation
- Investigation
- Complain
- Electronic yellow page
- Medical treatment website
- Tickets Service
- Electronic shopping

Dazhong information center in China was built in June, 2004, when it is time for college entrance exam. The consulting meeting of college entrance exam co-hosted by Dazhong information center and *Qilu Evening Newspaper,* integrated kinds of media channels such as newspaper media, Internet, calling center, short message center, etc, centralized the recruit specialists of each college, and built a direct communication bridge between recruit specialists and the students as well as their parents. During the meeting, the consulting calls amount reached more than 5,600 each minute, and the short messages more than 6,000. As a result, the society showed a very good feedback of the meeting.

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A Study on Knowledge Management in Enterprise Information Systems

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Abstract. Knowledge is considered as an enterprise's invisible assets. Surviving in today's highly competitive and ever expanding global economy requires efficiently managing corporate knowledge. Increasing requirements for extended enterprises have stimulated the integration of knowledge management (KM) function into ERP systems for knowledge asset management. So far enterprise information systems such as ERP systems are developed and implemented for mainly managing physical assets of an enterprise since 1990s. Due to the fact that both types of assets need to be properly managed, the integration of KM and ERP becomes a strategic initiative for providing competitive advantages to enterprises. This paper discusses how to deploy KM and ERP concurrently in the framework of enterprise information systems, with a discussion of the interaction of KM and ERP systems in systems perspectives.

1 Introduction

In the era of global economy, the world-wide business environment has been dramatically changed in recent years which contributed to today's competition in many industry sectors [15]. Enterprise information systems such as ERP systems have been adopted and implemented at a speedy pace to improve competitiveness. In such a highly dynamic environment, enterprises also increasingly recognize that knowledge management is one of the most important factors contributing to business success. In general, an enterprise, especially a high-tech enterprise, has two major types of assets, physical and knowledge assets. Today's enterprises are forced to conduct their business with the help of knowledge management and their competitive edge largely depends on knowledge, expertise, know-how, patents, and innovations.

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1.1 Knowledge Management and Knowledge Management Systems

Knowledge has been defined slightly different by many authors. For example, Davenport and Prusak [8] argued that knowledge is a mix of experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. According to this, although knowledge is related to both data and information; but is neither data nor information.

As knowledge originates and transfers, it is embedded in organizational documents, routines, processes, as well as practices and norms. Knowledge management (KM) is the organizational process for acquiring, organizing, and communicating both explicit and tacit knowledge so that users may use the knowledge to be more effective and productive. KM systems are information systems designed to collect, code, integrate, disseminate, and facilitate organizational knowledge.

In the last few years, increasing attention has been paid on the KM issues in organizations. Efficient knowledge management leads to superior business performance such as organizational creativity, operational effectiveness, and quality of products and service [3, 14, and 18]. In decision making processes, decision makers require a combination of different types of data, information, and knowledge. Research shows that KM is useful in ERP [2, 3, and 11]. Currently the research emphasis in the area has been on the KM framework and approaches [5, 10, and 16].

1.2 ERP and ERP System

ERP is a system that concentrates on the realization of business integration concepts [13]. The key driving force to implement ERP systems is the need of integrating processes and systems across the global supply chain operation and improving performance and cutting costs [8, 21]. ERP originates from MRP II (Manufacturing Resource Planning), which in turn, is an extension of MRP (Material Requirement Planning). The key underlying idea of ERP is to achieve a capability of planning and integrating enterprise-wide resources.

A successfully implemented ERP can link all areas of an enterprise including customer relation, manufacturing, human resource, financial management, and distribution with customers and suppliers, and forming a highly integrated system with shared data [17]. Potential benefits include drastic declines in inventory, reduction in working capital, abundant information about what customer wants and needs, along with the ability to view and manage the extended enterprise of customers, suppliers, and alliances as an integrated whole.

1.3 Concurrently Implementing ERP and KM

Although ERP and KM systems emphasize different characteristics, the primary goal of the both systems is to improve the competitiveness of enterprises in global markets. From practical point of view, KM systems are not preferred to be implemented in isolation but concurrent with numerous subsystems such as PDM, CAD, SCM, and even ERP. A few authors have suggested that it is possible to implement ERP and KM concurrently with ambidextrous results [22]. On the other hand, KM can be employed through the entire ERP life cycle to support ERP implementation such as feasibility analysis, user requirement analysis, system design, development, maintenance, and testing.

As implementation of two different IT concepts, the key characteristics of ERP and KM are quite different in their orientation: with ERP systems focusing primarily on managing physical assets and KM systems on innovation and utilization of knowledge assets [6]. In general, ERP defines business processes as standard routines to maximize organizational efficiency. In comparison with the orientation of ERP systems, KM emphasizes on continuous learning at the individual and organizational levels as a complementary approach to improving productivity and efficiency.

This paper is intended to discuss the issues of concurrent implementation of ERP and KM in the framework of enterprise information systems. After discussing the interactions between ERP and KM systems in Section 2, issues related to implementation are discussed in Section 3. Section 4 proposes some ideas on the methods for integrating ERP and KM. Conclusion is provided in Section 5.

2 Interaction between ERP and KM Systems

The distinction between information and knowledge not only suggests their different implication and value for organizations, but also suggests that both ERP and KM system are needed in order to provide and leverage the respective values of information and knowledge.

Enterprise information systems such as ERP can provide the information platform for knowledge capturing, storing, sharing, and innovating, since KM must dependent upon integrating data and information though ERP. KM integrated with ERP can improve the business processes managed by ERP to increase firms' competitive advantages. The interaction between ERP and KM systems are synergistic and of significant importance.

2.1 Common Goals of ERP and KM Systems

Despite the different focus of ERP and KM systems, the two systems, to some extent, have common goals. Both ERP and KM aim at improving business processes to achieve better business performance, with tasks based on data, information, and knowledge.

ERP systems emphasize the efficiency of business processes in enterprises. To achieve the goals, ERP systems maintain mechanism for data/information consistency through high degrees of standardization, formalization, and specialization. KM systems devote to the knowledge processes of enterprises such as knowledge creating, storing, transferring, and sharing. In perspectives of enterprises, the ultimate goals of the two systems are helping enterprise survive in the global market by improving their performance. In summary, ERP and KM systems manage the business from the point of views of physical and knowledge assets respectively.

With a proper framework in which ERP and KM can cooperate with each other, an enterprise can benefit from the advantages of ERP and KM and be successful in global competition.

2.2 Interaction between ERP and KM Systems

In a given enterprise in which ERP and KM systems are implemented concurrently, the interaction between ERP and KM systems can be discussed from two perspectives: the effects of ERP on KM, and the benefits from KM for ERP implementation.

ERP systems can provide transaction processing capabilities that help integrate all of a firm's transaction activities. Using such transaction processing information, a firm can plan their activities such as production in which KM can be useful for a series of activities including transaction processing support [3, 12]. Some ERP products have provided software components for facilitating knowledge management. For example, SAP provides solutions for knowledge management and transfer, which is integrated into an interface to share with various other components of the system.

2.2.1 Effects of ERP on KM

ERP includes certain key models of organizational process, and provides a key tool for acquiring information about the day-to-day business activity. ERP also provides a large body of data and information in an enterprise for possible use as knowledge after appropriate processing and integration. Therefore, ERP system becomes a key channel for capturing, exploring, and sharing knowledge.

ERP also changes the way of organizational learning through enabling and facilitating organizational members to innovate. For example, innovations can be made using sophisticated analytical tools rather than simply operating within the limit of pre-defined analysis. The forms of creativity also change and it will consequently change what the organization can learn about its internal business process as well as its environment.

In addition to the changes in organizational learning, implementing ERP will also result in major changes as organizations know more about their business and business processes, which will also make related knowledge available for capturing, utilizing, and sharing. As a result, the knowledge about organizational business processes becomes more widespread as the experience with ERP grows, which eventually makes knowledge management an imperative task.

2.2.2 Effects of KM on ERP

Knowledge related to ERP implementation is facing a number of challenges. First, knowledge may be captured and processed by transient resources only; it will vanish soon after the ERP implementation is complete. Therefore knowledge-carrying objects are not considered perpetual in an organization. Second, traditional practices do not have an explicit process to ensure that the knowledge being captured will be assimilated, verified, and stored for future use. Third, the volume of knowledge being captured may prevent it from being condensed into a single deliverable at the end of implementation. KM system, which can be implemented with ERP, is able to support ERP implementation efficiently as these issues are resolved.

Knowledge management will also make the knowledge transfer between consultants, IT staff, business process engineers, and management possible. Such transfer is characterized by multi-dimensionality and diversity of sources. As an example, an expert in a certain area must have the chance to learn more about other business areas. An IT expert needs more in-depth knowledge about subject areas in the business processes in order to configure ERP systems for better serving the organization's goal.

3 Systems Perspectives for Integrating ERP and KM

ERP and KM are the two philosophies for managing business enterprises. The knowledge-based view of enterprises argues that KM system is the centre of business enterprises and an enterprise's competitive advantage depends upon the effective integration and management of knowledge assets. From another angle, the information processing view considers that ERP is the centre of enterprise management; ERP enhances business performance through minimizing internal and external uncertainties by improving information flow. Although either view has its limitation, however, from systems perspective, they are complementary to each other [24].

Although ERP and KM are based on different management philosophies, ERP and KM systems complement to each other to some extent. ERP system provides a platform for capturing, creating, storing, and sharing knowledge. KM manages both tacit and explicit knowledge that may be acquired through ERP information platform. However, human factor is one of the most important factors in integrating ERP and KM systems since implementing ERP and KM will impact an enterprise's culture and employees. In fact, any ERP or KM initiative without considering human factors will fail. The success of integrating ERP and KM depends upon the active involvement of company employee throughout the organization as well as on their cooperation with the organization's broader business strategy and culture. Social systems are equally important in ERP and KM [4]. It is clear that the integration of ERP and KM should consider the fact that not only technology but also people play an important role. Meanwhile, the complexity of social processes and their importance in promoting collaboration should be considered.

4 Integrating ERP and KM

ERP and KM can be integrated on the basis of existing ERP and KM systems, or a newly developed KM system can be integrated into an existing ERP system. In the first approach, the relationship between ERP and KM is corporation. In the second approach, a KM system is integrated into an ERP system in terms of modules. The first approach is generally considered as a common approach.

4.1 Integrating Existing ERP and KM

It is usual that both ERP and KM are provided by different vendors and both are stand-alone systems. Integrating these two separate systems can provide an enterprise with better business performance. With the integration, the system can manage physical as well as knowledge assets for achieving competitive advantages than ever before.

From the enterprise's point of view, managing both types of enterprise assets is highly desirable. Although ERP and KM emphasize different types of assets respectively, the integration would satisfy the requirement of systematic management (Figure 1)

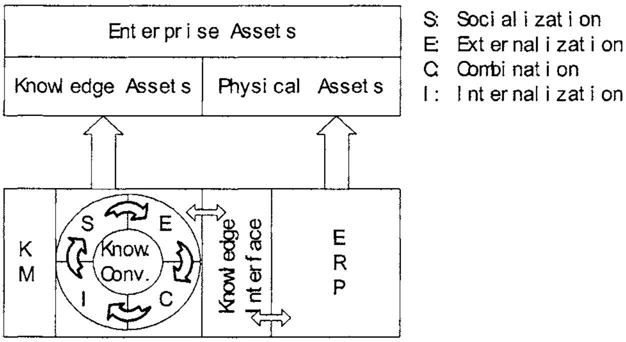

Fig. 1. General method for integrating ERP and KM

4.1.1 Knowledge interface between ERP and KM

According to the functions performed, there exist two types of knowledge interfaces between ERP and KM. Knowledge interfaces are the software brokers that transfer knowledge from ERP to KM or from KM to ERP. In other words, knowledge interfaces are the channels though which knowledge flows between ERP and KM. Therefore the knowledge interfaces play important roles in incorporating KM and ERP (Figure 2). Also there are two knowledge circles such as learning circle and innovation circle. As ERP requests knowledge for business processes, ERP employs the methods provided by the knowledge interface to obtain knowledge. As the KM requests operation knowledge, KM uses the knowledge interface to interact with ERP. In general, according to its function, knowledge interfaces can be classified into K-Discovery, K-Classifying, K-Storage, K-Identifying, and K-Indexing.

Knowledge interface from ERP to KM

K-Discovery: It has the methods to access the data from ERP. Also, it will discover knowledge from ERP process data with information context.

K-Classifying: It has the methods to categorize knowledge according to the type of knowledge and the domain context which the knowledge belongs to.

K-Storage: It has the methods to save knowledge and knowledge context to the knowledge base. It also maintains the linkage between knowledge and its context.

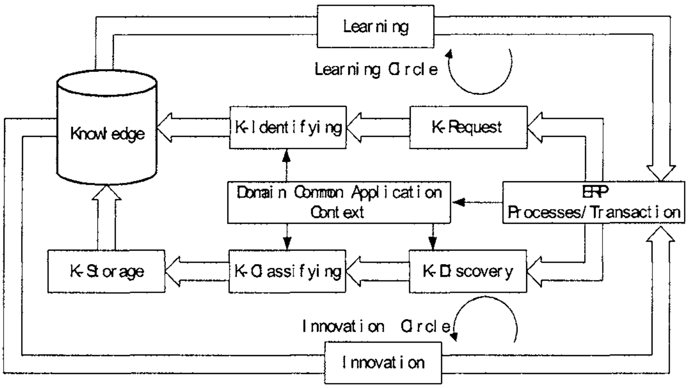

Fig. 2. Knowledge transfer process in incorporation environment of ERP and KM

Knowledge interface from KM to ERP

K-Identifying: It provides users with the methods to send knowledge request, and transfers the request with its context into query on knowledge base.

K-Indexing: It has the methods to interact with knowledge base engine based on the query commands given by K-Identifying.

In mining knowledge from ERP, two factors to be considered are the objective of knowledge mining such as finding-driven knowledge mining and validation-driven knowledge mining, and the methods of knowledge description and identification.

In general, knowledge in ERP is characterized by multi-factoring, nonlinear, and non-uniform. The following steps can be used to discover knowledge in ERP. Let F represent knowledge field, $K(F)$ represent knowledge set in knowledge field F, $D(F)$ databases in ERP with F. The elements in $K(F)$ are based on the knowledge description derived from $D(F)$.

Step 1. Eliminate redundant features using non-correlation features in rough set theory [19, 26]; obtain databases $D_R(F)$ for knowledge discovery. k-nearest neighbor method is then used. First, each sample x in $D(F)$ is considered as a group, according to the criteria of nearest neighbor method, k neighbors of x are tested. The distance between two sample x and y is defined as (if x and y are n dimensional)

$$d(x,y)=\sqrt{\sum_{i=1}^{n}(x_i-y_i)^2}$$

If d_{min} is the distance criterion, the samples, with distances less than d_{min}, belong to the same cluster.

Step 2. Determine the correlation factors between parameters using PCA (principal component analysis) [25].

Let matrix X formed by m n-dimension sample vector,

$$X_{m\times n}=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Consider m vectors from linear combination of n-dimension vector $\{x_1, x_2, \cdots, x_n\}$,

$$y_i=\sum_{i=1}^{n}a_i x_i \qquad i=1,2,\cdots,m \quad m\le \min(m,n)$$

y_i (i=1,2,...,m) can substitute matrix X to reveal the knowledge with original data.

Step 3. Estimate knowledge by k-fold cross validation method. The data set y_i (i=1,2,...,m) is divided into k subsets, and the method is repeated k times. Each time, one of the k subsets is used as the test set and the other k-1 subsets are put together to form a training set. Then the average error across all k trials is computed.

4.1.2 Integration framework

ERP systems have the capability of managing an enterprise' physical resources, while KM provides the mechanism to manage the knowledge resources. From the point of views of knowledge creation and innovation, knowledge management is emphasized in two aspects of ERP systems, i.e., business transactions and the related data that are collected and managed by ERP (see Figure 3). The incorporation of KM and ERP takes place in these two aspects.

Although ERP and KM perform their respective tasks and functions, knowledge interfaces are needed for information and knowledge sharing. With such interfaces, KM systems identify business process in ERP systems, make knowledge requests, and implement knowledge discovery, classifying, and storage based upon the information provided by ERP.

KM systems carry out K-discovery and K-identifying with the information contexts that are provided by ERP. ERP staff or those business processes within ERP systems can obtain knowledge by request with certain contexts. In this process, knowledge interface and domain common application context are considered important for linking KM system and ERP system to achieve information and knowledge sharing.

Adapting to the knowledge transfer processes in business enterprises, knowledge management has the function of transferring both explicit and tacit knowledge. KM systems are not only involved with organizational knowledge resides in the business process managed by ERP, but also individual knowledge that is partially managed by ERP. Therefore, ERP system platform is needed for implementing KM systems for knowledge management, which is one of the key components of enterprise management.

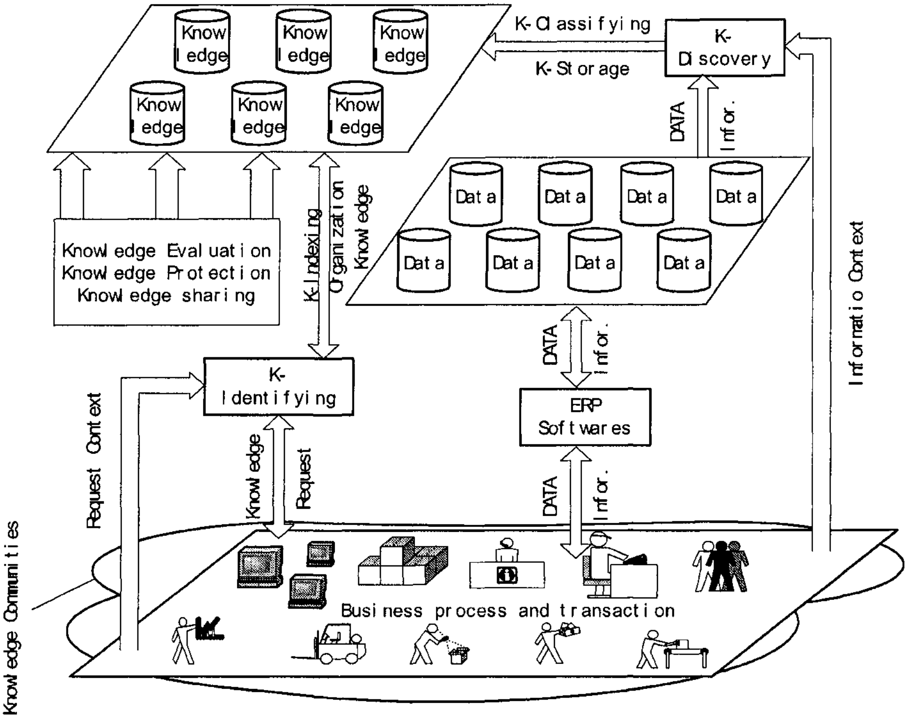

Fig. 3. A framework for integrating ERP and KM

4.2 Integrating KM into ERP

ERP system has the capability of managing physical assets within an enterprise. However, ERP do not manage the knowledge in an enterprise. Due to the differences between ERP and KM, it is not easy to take advantage of integrating KM and ERP by simply adding a KM module into an ERP system. It is obvious that KM has its own purpose compared with that of ERP; to some extent such purposes may be conflicting to each other. For example, KM emphasizes the flexibility in business routine, whereas ERP focuses on the standardization of business routines. In integrating KM into ERP, changes are needed in ERP to facilitate KM implementation. Such changes include knowledge base management, knowledge presentation, etc. As a module in an ERP system, KM in general can support ERP for better decision making function. KM can capture knowledge, transfer tacit knowledge to explicit knowledge, and help use or reuse knowledge for ERP purpose. The future generation ERP may include a KM module through achieving trade-off between their contradictions based on two managerial philosophies.

5 Conclusions

Enterprises world wide are facing increasing competition in the knowledge economy era. To be competitive and successful, it is imperative for enterprises to renovate their enterprise information systems such as ERP and integrate knowledge management function. Future generation ERP systems with knowledge management capacity will be more responsive to the changes in global business environment.

An enterprise has two types of important assets: physical and knowledge assets that are managed by ERP and KM systems respectively. As a result, implementing both ERP and KM is highly desirable. From enterprises' point of view, ERP and KM systems should be integrated for competitive advantages. Due to the fact that the objectives and characteristics of ERP and KM are different to each other, the integration involved is a complicated process. The paper discusses the issue of jointly implementing ERP and KM systems. The interaction between ERP and KM systems is also analyzed in systems perspectives.

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AN OPEN WEB SERVICE-BASED DSS

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Abstract. This paper presents a new and open Web Service-Based DSS framework under distributed service-oriented architecture. In the past, DSS always refers to a software product. But in this new framework, DSS appears as a website, we called it as decision support website. This paper explores the details of the architecture of the decision support website and describes the business mode about this website. Then we give the whole implementation process of web service. The new DSS change the features of the traditional DSS completely by adopting web service application integration technology and introducing into new business mode.

1 Introduction

Decision Support System (DSS) is an application software system, which is used to help decision maker to solve half structured or unstructured problems by using models, data and knowledge [1]. Traditional DSS is composed by user interface component, data base, model base and their management system. Model base is the primary component of DSS. With the rapid development of computer and network technology, the development of DSS application software system has experienced various different phases. Especially with the emergence of Web 2.0 concept, new DSS appears unceasingly.

A Web service is an interface that describes a collection of operations that are network accessible through standardized XML messaging [2]. It covers all the details necessary to interact with the service, including message formats (that detail the

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operations), transport protocols and location. The interface hides the implementation details of the service, allowing it to be used independently of the hardware or software platform on which it is implemented and also independently of the programming language in which it is written. This allows and encourages Web Services-based applications to be loosely coupled, component-oriented, cross-technology implementations.

In this paper, we present a new DSS architecture that is open and based on Web Service. Unlike the traditional DSS which generally refers to a software product, in this architecture, the DSS appears as a website on the Internet. We called this new DSS as decision support website. Every model and data is encapsulated as independent Web Services. DSS makes decision by calling these model and data web services. Meanwhile, we found a private UDDI registration center, by registering in this UDDI registration center, everyone in the world can add model and data into this open DSS.

2 The Architecture of Web Service-Based DSS

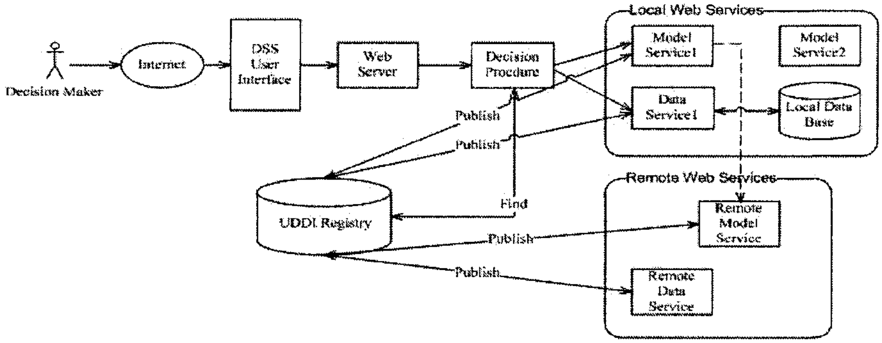

Fig. 1. The Architecture of Web Service-Based DSS

Fig. 1 illustrates a new DSS architecture that is based on web service. In the technology framework, this new DSS uses the web service technology which is a distributed calculating technology. DSS makes decisions for people by invoking a series of web service. These services may belong to the developer of DSS and other corporations as well. This DSS consists of following components: Web Server, UDDI Server, Web Services and local Database. The architecture of this DSS can be divided into three layers. From top to down, they are Web Services Layer, Web Server Layer and User Interaction Layer (Browser).

1) Web Services Layer

Web services layer includes a set of web services. In this new architecture, the model of traditional DSS is encapsulated as an independent web service. It can be used alone or with other Web Services to carry out a complex aggregation or a business transaction. There are two kinds of web services: local web service and remote service. Local web service is an application unit that developed by the DSS developer. Remote web service is developed by other corporations or individual. DSS does not know how these services implement, which programming language is used to develop these services. It only knows the function of each service. After publishing in the UDDI registry center, DSS can invoke these services by Internet. In the traditional DSS, DSS application interacts with database directly. Bu in this new technology architecture, we add a data service between DSS application and database. When DSS want to acquire data from database, it needs to invoke this data service to interact with database indirectly. By adding a data service between DSS and database, this new DSS becomes more independent and general.

2) Web Server Layer

Like the Web Server in the traditional DSS based on B/S, in this architecture, DSS application and local web services are all deployed on Web Server.

3) User Interaction Layer

The main component of user interaction layer is web browser. Users log on the DSS by browser, and interact with DSS. After a series calculation, web server sends results to the user's browser. Web browser is only a tool used to display information and results. Using browser to interact with DSS makes the DSS becoming platform-independents.

To meet all kinds of demands which may come from different industry and different people, DSS needs to have all kinds of models and data. There are hundreds and thousands of models, and they are impossible to be developed by one corporation. So this DSS is designed as an open application system. In this open DSS, other corporations and peoples can add their models into DSS with web service form. UDDI registry center just likes a bridge between DSS and other service providers. By registering on the UDDI center, DSS can invoke these remote web services on the Internet. By integrating other web services into this open DSS, it can become a comprehensive decision support system.

We also present a new business mode that is very different from traditional mode. In the past, DSS always is a software product that developed for one enterprise. In this new architecture, the DSS is not a product again, it appears as a website, and we called it as decision support website. Every people in the world can logon this website to help them to make decisions. The user of website should pay fees to website operator. To encourage other enterprises or peoples to add their model services into website, website also pays fees to service provider. In this new architecture, the main tasks of software develop corporation is operating the decision support website.

3 The Implementation of Web Service

3.1 Developing a New Web Service

The main tasks of this phase are developing and testing a web service. There are many ways to develop a web service. You can develop a new web service completely or transfer an existing application to a web service, or you can compose other web services to become a bigger web service. There are many platform that can implement web service, we use Microsoft's .NET platform to establish a new web service which can calculate the area of a circle [3].

```
<%@ WebService Language="C#" Class=" CalculateArea" %>
using System;
using System.Web.Services;
public class CalculateArea : System.Web.Services.WebService
{
  [WebMethod] public double Circle (double r)
  {
    double t = Math.PI * r * r;
    return t;
  }
}
```

Inputting the above codes into any text edit tools, saving the document under the directory of "WWW ROOT" in Web Server, renaming the document as "Area.asmx", now we have established a web service. We can test this web service by inputting "http://localhost/Area.asmx" into browser's address bar. In the above document, it defined a "CalculateArea" class that inherited from "WebService". In the "CalculateArea" class, it defined a public method named "Circle". This method has one input parameter whose type is "double" and returns the area of a circle depending on the input parameter which indicates the radius of a circle.

3.2 Producing WSDL Document

Web service description document has an important role in the web services architecture. It describes the function and location of a web service, the type of transfer protocols and the interface of operations and so on. It is through the service description that the service provider communicates all the specification for invoking the web service to the service requestor [4].

Web services architecture uses WSDL for service description. WSDL is an XML document that can be created by tools automatically or produced manually by inputting XML tag into any text edit tool. For instance, the description of above web service which calculates the area of a circle can be acquired by "http://localhost/Area.asmx?wsdl" URL.

3.3 Publishing a Web Service

The purpose of publishing a service is making service requestors can discover and invoke this service. A service description can be published using a variety of mechanisms. These various mechanisms provide different capabilities depending on how dynamic the application using the service is intended to be [2].

The simplest publishing mechanism is the direct publish. A direct publish means the service provider sends the service description directly to the service requestor. This can be accomplished using an e-mail attachment, an FTP site [2]. Direct publish can occur after two business partners have agreed on terms of doing business over the web, or after fees have been paid by the service requestor for access to the service. In the above DSS framework presented in this paper, if another corporation which has lots of model services want to add their model services to this open DSS, it can use a direct publish mechanism. In this case, decision support website can maintain a local copy of the service description for invoking. Another publishing mechanism is that service provider publishes web services on UDDI registry center. This mechanism may suit to individual who has a little web services and want to add these services into decision support website.

3.4 Web Service Discovery and Binding

How to discover a web service depends on the style of web service publishing. If a web service is published directly to service requestor. In this situation, service requestors can get WSDL document directly from service provider, then they can make use of service description to create right SOAP invoke message. If a web service is published on UDDI registry center, service requestors can search a web service by interacting with the interface supported by the UDDI node.

In the above DSS framework presented in this paper, DSS will invoke web services during two different phases of an application lifecycle-design time and runtime. At design time, DSS creates an agent class according the service descriptions. Then DSS can use this agent class to invoke the method of a web service just like local class [5]. At runtime, DSS queries service descriptions dynamically, then according to the descriptions, DSS creates right SOAP request message, and receives SOAP response from remote machine.

4 Conclusions

In this paper, we present a new DSS architecture based on web service. It is very different from traditional DSS both in technology and business mode as well. We give the whole implementation process of web service.

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The Theoretical Underpinnings of the Influence of Customer Reward Programs on Customer Retention: A Framework and Propositions for Future Research

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Abstract. This paper proposes a framework and propositions for future research on the influence of customer reward programs on customer retention by reviewing the studies on the customer reward programs by employing the SEM and discrete choice dynamic programming model. This framework will give rationale and advices theoretically on how to implement relationship marketing instrument in CRM, further, it will enrich the research methods and means of related themes to enterprise information systems.

1 Introduction

Customer reward programs, also is known as "loyalty programs" or "frequency purchasing programs" in retailing and "frequent flyer programs" in airline. Though the specifics of these programs are different from each other, the goal of these programs is to establish a higher level of customer retention in profitable segments by providing increased satisfaction and value to certain customers [1]. Most of scholars claim that the emphasis of relationship marketing is developing, fostering long-term customers and gaining profit from the relationship in the end [2-3], and reward programs is a relationship marketing instrument which can satisfied these demand [4-5].

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2 Theoretical Backgrounds

2.1 Perceived Value of Reward Programs

Some scholars proposed the influence factors of reward programs perceived value. O'Brien and Jones [6] suggested that five elements determine the value of a reward program: cash value, redemption choice, aspirational value, relevance and convenience; Dowling and Uncles [7] added psychological benefits of belonging to a program and accumulation points; Kivetz and Simonson [8] proposed that customers consider the luxury rewards are more perceived value than necessity reward; Yi and Jeon [9] claimed that the type of reward program and the time of reward program are the main factors of perceived value of reward program, and involvement moderates the effects of the factors on perceived value; Kivetz and Simonson [10] proposed the factor of "idiosyncratic fit" is an important factor.

2.2 The Influence of Perceived Value of Reward Programs on Customer Retention Behavior

The essential aim of customer retention is building and retaining customer loyalty, which can realize the repeat purchasing [11]. The research focus of customer retention behavior is the dependent variable of customer retention such as repeat purchasing, positive word-of-mouth, price tolerance, relationship retention during, and wallet share, etc. Currently, seldom research focuses on the influence of perceived value of reward programs on customer retention behavior, but Yi and Jeon's [9]. Their research results show that involvement moderates the effects of reward programs on customer loyalty.

2.3 Quantitative Analysis of the Customer Retention via Exchange Data

With the developing of enterprise information systems, it is possible to collect the customer exchange data and employing the mathematical model such as discrete choice model to analyze the customer behavior.

Verhoef Peter C. [5] investigates the differential effects of customer relationship perceptions and relationship marketing instruments on customer retention and customer share development over time. The SEM and the discrete choice model are both employed in the study. Bolton Ruth N. et al. [1] develops a process model of how customers' service experiences – including their experiences with the competition and loyalty programs – influence their repatronage behavior. Lewis [12] models customers' response to a loyalty program under the assumption that purchases represent the sequential choices of customers who are solving a dynamic optimization problem. Chunqing Li [13] presents a dynamic customer relationship management model in a dynamic environment where customers maximize utility and the firm maximizes CLV. Lewis's [12] and Chunqing Li's [13] study all utilized a research methodology know as estimable stochastic structural dynamic programming or discrete choice dynamic programming. These methods are fairly well established in economics [14], and applied in marketing in recent years [12, 13, and 15].

3 The Framework of Future Research and Research Details

3.1 Research Framework

Based on the current research, we proposed a framework of future research (Fig. 1.). The vertical line divides the framework into two parts that describe two study methodologies: the left is the customer behavior model; the right is the mathematics analysis model.

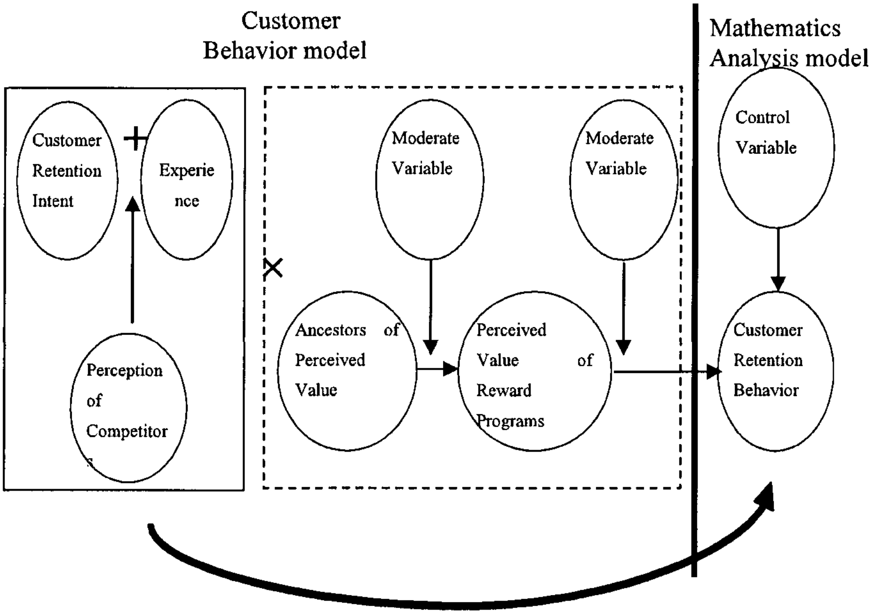

Fig. 1. The research framework of the influence of reward programs on customer retention behavior

In the left part, there are two rectangles: the real one describes the situation of considering competition, and the broken one is the contrary. The symbol "+" means customer retention intent, customer experience, and customer perception of competitors influence the customer retention behavior jointly. The symbol "×" means the influence is relative to whether customer joining the reward programs, which is a Boolean-variable in the model. If the Boolean-variable equals 0 (not joining to the reward programs), the model means exploring the effect of real rectangles on customer retention behavior, and if 1 (joining to the reward programs), means exploring the effect of both real rectangles and broken rectangles on customer retention behavior.

3.2 Research Details

According to the research framework of Fig. 1, future research can be classified according to two dimensions: research method (Customer Behavior Model or Mathematics Model) and whether considering competition.

Customer Behavior Model of not Considering Competition

In this situation, the future research would include two sub-problems (Fig. 2.):

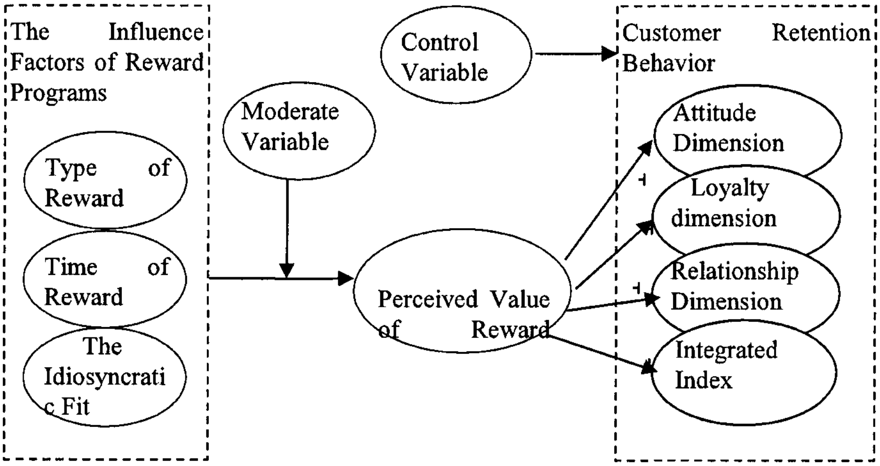

Fig. 2. Customer behavior model (Not considering competition)

Sub-problems 1: The influence of different reward programs on perceived value

In reality, the details of reward programs are different. Though the ancestors of perceived value of reward programs are not clearly defined, type of reward, time of reward and The Idiosyncratic Fit have been studied experientially. Besides of these ancestors, other factors should be explored and studied. Moreover, sometimes, the effect of moderate variables on independent variables is remarkable, so confirming moderate variables in special research environment is an important target in future.

Sub-problems 2: The influence of perceived value of reward programs on customer retention behavior

In this part, customer retention behavior can be segment to four dimensions: attitude dimension, loyalty dimension, relationship dimension and integrated index. Attitude dimension refers to relationship commitment and trust [3]. Loyalty dimension refers to customer behavior variables such as repeat purchase, cross purchase, positive word-of-mouth, price tolerance, cooperation behavior, etc. Most research claimed that reward programs would change customer behavior, enhance customer loyalty [16]. Relationship dimension refers to relationship length, relationship breadth and relationship depth [17]. Integrated index refers to customer retention rate and customer share development over time [5].

Based on which, we propose hypothesis: the perceived value of reward programs has a positive relation to attitude dimension, loyalty dimension, relationship dimension and integrated index.

In special research environment, how to confirm the variables in four dimensions and the scales of the variables is the key problem. Moreover, moderate variables and control variables could be put into the model of Fig. 2. After confirming the variables and scales, researchers can design the questionnaire, collect the data, test of hypotheses and analyze the goodness-of-fit of model. SEM and Lisrel can be considered in model design and analysis.

3.2.2 Customer Behavior Model of considering competition

In this situation, the future research model can be seen in Fig. 3:

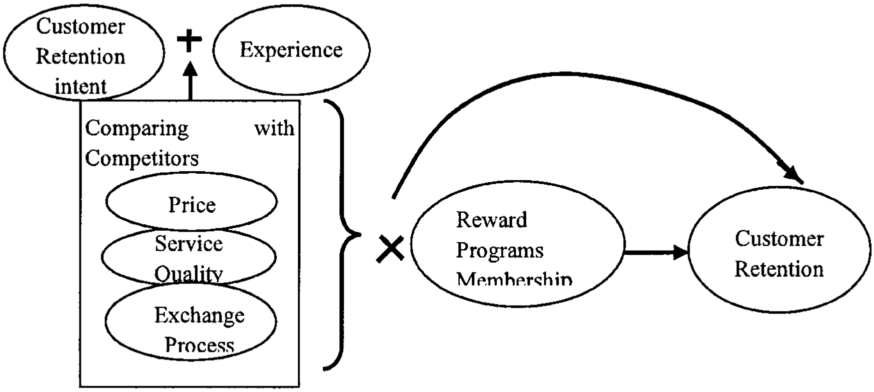

Fig. 3. Customer behavior model (considering competition)

When considering competition, the discrete choice model can be applied. Firstly, the relationship between customer and firm can be defined a state variable of 0 or 1, that is, if the customer decides to join the reward program of next period, the state variable equal to 1, otherwise, 0. So, the researchers should pay more attention to the factors that influence the decision of customers. Bolton Ruth's model [1] proposed there are three aspects that decide decision of customers. They are customer retention intent, customer experience and perception of competitors. In future research, based on Bolton Ruth's model, the perceived value could be considered a new factor.

In future research, there are three problems: confirming the scales of variables, building discrete choice model and changing the questionnaire data into discrete choice model. The cause of data change is the variables of the discrete choice model may be different from the questionnaire data, or the linear combination of the questionnaire data.

The parameters of model can be confirmed with logistic regression and the goodness-of-fit can be evaluated by likelihood and fit coefficient. The advantage of the logistic regression is forecasting customer's probability of joining the reward programs in next period.

3.2.3 Mathematics model

Mathematics model here refers to discrete choice dynamic programming that has advantage in the situation of "when customer considers both current and future benefit". Because of the reward, customers always have the character of "looking-forward" when they joined a reward program, therefore, researchers can study the reaction of customer on reward programs and customer's behavior change via discrete choice dynamic programming.

Generally speaking, there are three key points in building discrete choice model: confirming the variables of the model, defining the state variables and the evolution of variables and estimating the parameters of the model. About the first, researchers can conclude variables from the conception model we have proposed in 3.2.1; about the second, the key point is describing customer's state adequately by smaller state space as possible; and about the third, researcher need design mew algorithm according to detail model.

As same as conception model, we can also study the reward programs in the situation of considering competition or not here. But when considering the competition, the customer state should be adjusted and the complexity of the estimate algorithm is higher.

4 Conclusions

Based on reviewing the literatures about reward programs, this paper proposes a framework and propositions for future research about the influence of customer reward programs on customer retention. The framework not only explores the relation of customer perceived value on the reward programs and the outcome factors of customer retention by employing the SEM, but also develops a discrete choice dynamic programming model to forecast the customer value perception based on their exchanging data so as to reflect the dynamic process of customer retention. This framework will give rationale and advices theoretically on how to implement relationship marketing instrument in CRM, further, it will enrich the research methods and means of related themes to enterprise information systems.

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The New Cognition of Supply Chain Integration: Management Interface Integration

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Abstract. As the basic concept of the management integration, the management interface can indicate the connection ways and mechanism of the node enterprises in the supply chain. According to the analysis on the principle of the management interface integration, three patterns of supply chain management integration is put forward here, which not only provides a new way to research on the supply chain integration, but also adds new connotation for the integrative philosophy in supply chain management.

1 Preface

Serving as the new mode of the operation of the modern enterprise, supply chain has drawn the wide attention in the circle of academy and enterprise home and aboard on the aspect of its operation, especially a large amount of research achievements have been done in the information integration, further the relevant software as ERP, SCM, CRM, APS and SRM has been introduced. Presently the integration research of these systems is being done with the combination of the operation practice of the supply chain in order to constitute the integration interface of the supply chain meaningfully, so the knitted enterprises can be connected and communicated effectively through the information interface to respond the market demand quickly.

However, as an integration system, supply chain relies on the supplying and demanding. Under the circumstances of the complete competition, the motive of this relation integration is that Nash Equilibrium solution of the non-corporation does not make the income of the knitted enterprises Pareto Efficiency, but through the corporation, the overall interests of the supply chain are increased to make the income of the knitted enterprises higher than Nash equilibrium. Therefore, the integration of this supplying and demanding relationship manifests in the integration

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of logistics; integration of information and the management integration of supply chain. The broad sense of management makes many scholars combine management with logistics, management with information trend, so there exists a limitation to do the research on the integration of supply chain from one aspect.

The research on the integration of supply chain all covers the connotation of management, and the value chain after the integration mainly manifests in the form of entity value flow and virtual value flow. But the optimization of the supply chain value flow is realized through the management activities, which determine the direction of the entity value flow and virtual value flow in the supply chain, and there exists an independent management interface to the information system among the entity value activities, so the integration research on the supply chain management interface will add new connotation to the supply chain integration and the philosophical thoughts of supply chain management.

2 Supply Chain and Supply Chain Management

Supply chain is the new mode of the modern enterprise operation. First of all, the structure of supply chain should be defined clearly. Now many scholars home and aboard don't hold identical views on the connotation of supply chain. On the basis of analysis of supply chain, Mentzer and DeWitt [1] divided supply chain into three classes according to the complexity of supply chain: direct supply chain, extended supply chain and ultimate supply chain, which is demonstrated as Fig 1.

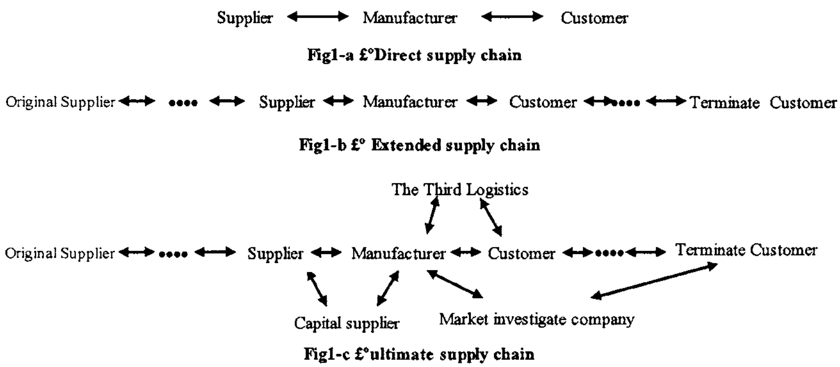

Fig. 1. Catalog of the Supply Chain Channels

Obviously this kind of division is based on the complexity degree of the relationship of supplying and demanding among the knotted enterprises. A brief description on the supply chain is given in Fig 1, which demonstrates that the direct supplying chain is ordinarily composed of one manufacturer, one suppler and one customer, and involves the stream of products, service, fund and information from the upper reaches to the lower reaches. The extended supply chain is described in Fig

1-b. On the basis of the direct supply chain, the original supplier, the supplier of the upper reaches, is added, the terminate customer, the customer of the lower reaches, is added, the general supply chain description is given. The terminate supply chain includes all the organizations of the upper and lower reaches, such as the third logistics, the third fund provider and market investigation company, so that a complete supply chain description is given.

The supply chain, no mater which level it is in, exists in the reality before the conception of the supply chain was proposed. Because of the insufficient supply in the society, larger profit still can be made through the competition among the enterprises in the supply chain, so that the corporation among the enterprises of the upper and lower reaches is neglected.

As long as the rapid development of the productive forces and the enriching supply in the society, major markets have been turned into the buyer from the seller, so that the market competition becomes more fierce, in addition, the customer' expectations, the enterprises' risks, the cost pressure, the products' quality and reliability have been increased. Meanwhile, the opportunity window of the products is reduced, the maintaining time of the product's cycle and difference, and the introduction time of the new product is shortened, etc. The operation mode dominated by the competition among the enterprises not only hinders the development of the enterprise, but also effect the level of the whole supply chain's response to the customer's demanding. Therefore the management of the supply chain becomes the important topic to make the strategies in and out of the enterprises.

The management of the supply chain is a kind of management philosophy, which views the supply chain a whole with a systematical viewpoint; the respective functions are fulfilled not in accordance with the different enterprises or sections alone [2 - 4]. In other words, the supply chain management philosophy is the conception of the extending relationship, which makes most enterprises cooperatively to manage all the logistics from the supplier to the terminate customer [2]. Therefore the supply chain management, as the management philosophy, is to seek the synchronization and integration of unity of the operation and strategic ability in the enterprises and among the enterprises. (Ross 1998).

In the management and practice of the supply chain, the enterprises are to make their operation and the supply chain management's philosophy thoughts act in unison. The enterprises can mutually share the information, mutually share the risks and rewards, corporate for the same target, concern on the same customers' service, integrate the process, construct the partners and maintain the long term partner relationship, etc to fulfill successfully the supply chain management philosophy.

3 The Proposal of the Supply Chain Management Interface

The supply chain management philosophy is a whole-viewpoint-applied systematic thought in the supply chain management. The supply chain, an artificial system, is constituted through the integration. It is known that management is a way of integration, so the supply chain management is a kind of the integration of the supply chain. It is an important aspect of the integration of the supply chain that the supply chain is managed generally from the supplier to the supplier and from the customer to the customer. Furthermore, the management of the whole supply chain is based on the integration of the management, which can be regarded as the supply chain integration.

The relationship among the enterprises in the supply chain is a direct and indirect supply and demanding relationship, the enterprises connect with each other through the logistics, the flow of information and fund, so the direct demonstration of the supply chain integration is the integration of the logistics, information flow and fund flow. Through the integration of the logistics, information flow and fund flow, the operation of the supply chain is conformed. But the logistics, information flow and fund flow in the supply chain can not be dispatched from the content of the management, even can be dominated by the management, for example. Such management activities as the storage strategy, supplying strategy, manufacture strategy, sale strategy dominate the tread, amount and process of the materials. In addition, the entity and virtual the value flow in the supply chain can be bettered through the management of the supply chain.

The specific connection among the enterprises in the supply chain can be described by the interface among the enterprises in the supply chain. The direct and object interface among the enterprises in this supply chain mainly include the materials interface (embodied through the logistics), the information interface (embodied through the information flow) and fund interface (embodied through the fund flow). But in the supply chain, the logistics, information flow and fund flow are governed by the management. It is through the management activities that the value flow of the supply chain can be bettered and the right treads of materials, information and fund. Obviously these entities or virtual interfaces contain the content of the management, that is to say, there exists the management relationships among the enterprises in the supply chain---the management interface, and the supply chain management integration is mainly embodied in the management interface integration. Therefore the management interface integration is the important content of the supply chain management integration.

4 The Principle of the Supply Chain Management Interface

The supply chain management interface can be indicated by three categories, see Fig. 2.

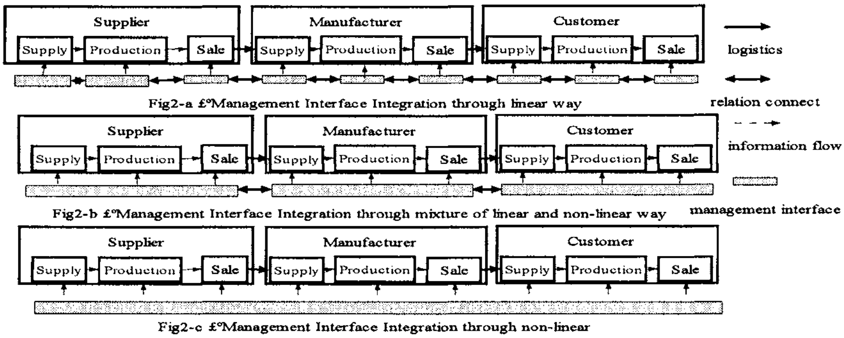

Fig. 2. The Three Categories of Management Interface Integration

Fig. 2-a indicates that the interior entities of the knotted enterprises in the supply chain are confirmed through the integration' linear connection (Here they are also called interfaces, but initial interfaces). When the information technology is not advanced, the management integration of the enterprise is ordinarily based on the initial management linear confirmation inside the enterprise, and then in this enterprise, the function can probably be doubled because of the management integration. The supply chain confirmation among the enterprises is based on the initial management interface linear confirmation. For example, the confirmation of the supplier and the producer is fulfilled through the interface confirmation (connection) between the sales department of the supplier and the supplying department of the producer, and it is similar that the confirmation of the producer and the customer is based on the linear confirmation process. Thus through the linear interface confirmation, the supply chain's function will be probably doubled. Its linear double relationship can be indicated by $E_A + E_A + E_A = kE_A, (k > 3)$, E_A is a single function, which explains that the whole function kE_A is the linear doubled after the three units with the function of E_A are linear confirmed.

Fig. 2-b indicates that the connection among the value entities in the knotted enterprise in the supply chain is no longer through the linear joint connection, but through the non-linear confirmation of the management interface among the value entities, so that the enterprise management interfaces in formed [10]. The whole operation of the value entities in the enterprise is fulfilled through the enterprise's management interface, that is to say, through the management interface of the enterprise, to realize the connection of the arbitrary value entities in the enterprise's management interface, so that the synchronous operation and the function emerging of the supply chain in the enterprise come into being. The connection among the knotted enterprises in the supply chain (among the enterprises having direct supplying and demanding relationship) is also based on the enterprises' management interfaces. Through the interface confirmation between the two enterprises, the non-linear confirmation can be realized among the enterprises. But the management connection among the enterprises having no direct supply and demanding relationship is realized through the linear way after its non-linear confirmation with

the enterprises having direct supply and demanding relationship. For example, in Fig. 2, the management relationship between the supplier and the customer, through the non-linear confirmation of the supply and demanding interface between the producer and the supplier, and after the non-linear confirmation of the supply and demanding between the producer and the customer, the producer being the medium, is confirmed further in the way of linear connection. Obviously, the integration result managed by the way of the interface integration may bring the emerging functions for the interface integration of the enterprises having direct supply and demanding relationship, but for the whole supply chain's integration, the double effect will come into being on the basis of the whole function of the enterprises.

Fig. 2-c indicates that when the information technology is highly advanced, the whole operation of each knotted enterprises in the supply chain is based on the enterprises' management interface through the non-linear confirmation of the respective management interface of the value entities in the enterprises. The entirety and corporation operation of all the knotted enterprises in the supply chain is also based on the formed supply chain management interface through the non-linear confirmation of the respective management interface. With the aid of the supply chain management integration interface, the management in coordination can be realized among the arbitrary enterprises in the supply chain (direct and indirect supplying and demanding relationship), and finally the functions of the supply chain are emerged.

The function emerging of the supply chain integration is mainly demonstrated in two aspects: one is the function emerging of the respond speed and agile degree, because the influence on the Bullwhip Effect is decreased to the lowest essentially through the interface integration so that the response rapid appears the function emerging, which can be demonstrated by $E_A + E_A + E_A = E_A$; On the other side, with the aid of the integration interface, the exchange among the arbitrary sections may bring about new functions. For example, a section with new functions will be possibly confirmed through the exchange among R&D sections, and R&D sections with the other manufacturing sections and intermediate-testing sections to be in charge of a new product's R&D and marketing, which can be demonstrated by $E_A + E_B + E_C = E_D$, showing that the new functions appear through the integration. Here the function emerging can be understood as the t contents in two aspects, the predetermined function's non-linear enormous emerging and the functions innovation.

Through the analysis on the categories of the supply chain management interface integration, it is known that the second and third management interface integration are build on the highly developed information technology, With the development of IT and Internet, information will be separated with management and becomes the important sources of the enterprise and the independent manufacturing factor. Thus the management orders through the management interface will be affected on the management objects by the means of information; information has become the medium between the management and the management object. Compared to the management interface, information interface still exists. With the strengthening of the information interface function, many functions of the management interface are complemented through the information interface. Through the information interface, the management interface acts on the management object, which is the reveal of the mechanism of the enterprises' operation management. Fig. 3 shows that inner process of the management interface acting on the management object.

5 Analysis on the supply chain integration mode based on the management interface integration

In the research of the supply chain integration, Stevens and Graham proposed 4 stages [5]. Shihua developed it to be the 5 stages based on Stevens [6]. With the aid of the principle of the management interface integration, the outer integration of the supply chain (Steven's fourth stage and Shihua's fourth and fifth stage) is divided into 3 categories, which is divided under the circumstances of the highly development of the IT. Different categories will have different operation modes.

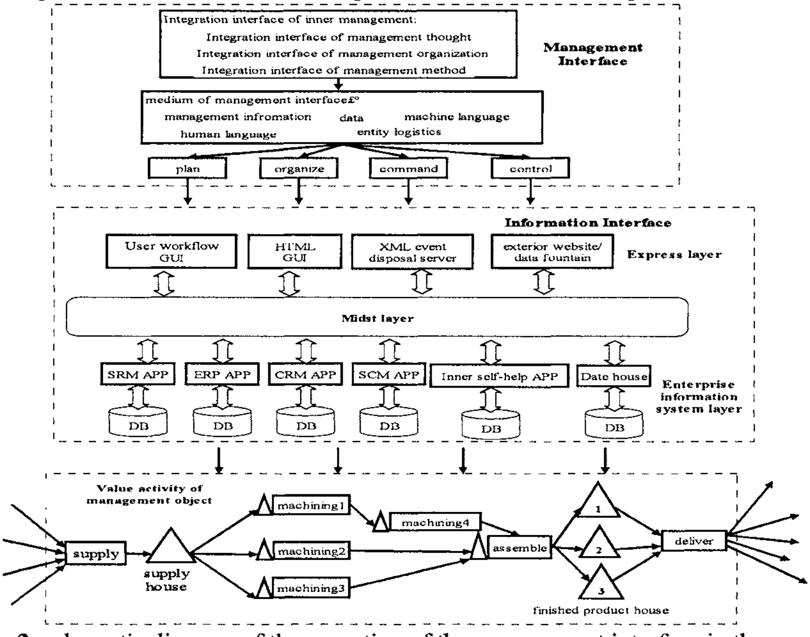

Fig. 3. schematic diagram of the operation of the management interface in the enterprise

5.1 Supply Chain Integration Mode of the Linear Confirmation of the Information Interface and Management Interface

The knotted enterprises of the supply chain all have their own information interfaces and management interfaces, it's highly effectively corporation is done through the management interface in the enterprise. But the value increasing activities of the supply chain is realized through the flow of the materials, semi-product and product among the knotted points among the enterprises. Through the connection of the information interface among the enterprises, the information exchange is realized; through the connection of the management interface, the control of the supply chain management is realized, the specific supply chain integration mode can be seen in Fig 4. The confirmation between the information interface and management interface in the supply chain is all based on the linear connection, compared to the supply chain structure based on the supply and demanding relationship of the complete competition, the functions to merge the supply chain increase. But this kind of mode exists Bullwhip Effect of the information, thus the integration effect of the supply chain will be affected.

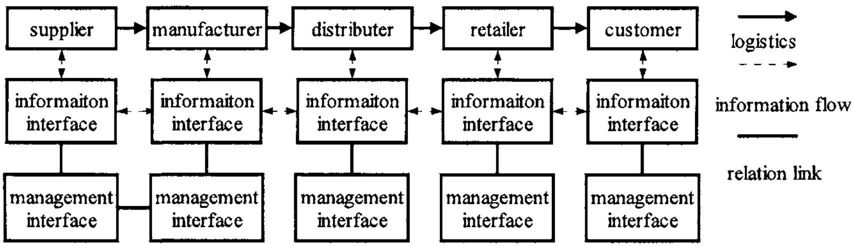

Fig. 4. Supply Chain Integration Mode of the Linear Confirmation of the Information Interface and Management Interface

5.2 Supply chain Integration Mode of the non-linear Confirmation information interface and the Linear Confirmation of the Management Interface

In the first supply chain integration mode, a large amount of energy will be consumed to eliminate the Bullwhip Effect when the information is transmitted, and to balance and handle the connection of different information systems, which will cost a lot. With the increase of the knotted points in the supply chain, the cost will increase linearly. Certainly the supply chain benefit will increase linearly with the increase of the management interface intensity.

With the development of the IT, the integration of the enterprise's information interface in the different knotted joints of the supply chain will be realized through the middle layer, so that the enterprises can be connected through the integration's information platform and get the needed information through the share of the information. But the traditional series structure mainly exists in the management interface; the management interface integration between the two supplying and demanding enterprises is undertaking independently, each management interface is integrated in the way of linear series connection after the integration of the management integration, See Fig 5. In this supply chain integration mode, the supply chain and policy response is far lower than the information-getting rapid, which shows that the information synchronization can be realized technologically in the knotted enterprises of the supply chain. But the management's failure in synchronization will affect the synchronization of the information, so that synchro-logistics and synchro-production is difficult to be realized and the goal of the agility, quickness and flexibility of the supply chain is also hard to be realized.

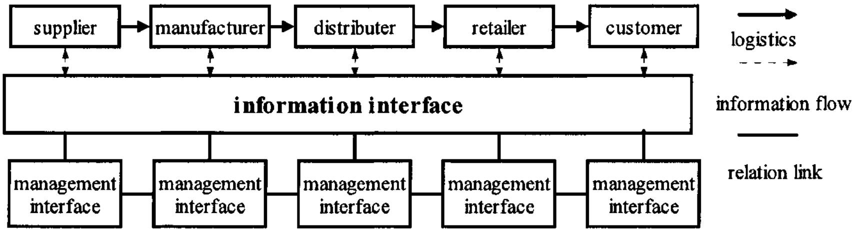

Fig. 5. The Supply Chain Integration Mode of the non-linear Confirmation of the information interface and linear Confirmation of the management interface

5.3 The Supply Chain Integration Mode of the Non-Linear Confirmation of the Information Interface and Management Interface

Supported by the IT, many functions of the management can be realized through the information system that provides the guarantee for the integration of the management interface. Through the analysis on the properties of mutual mixing and complementing and under one common goal, the management interface of the knotted enterprises in the supply chain is confirmed effectively, while the logistics and the flow of the information, work, fund and value are handled and bettered, to realize the synchronization of the information and management in the supply chain, so that the synchronic logistics and synchronic flow of information and production will be realized, and finally the function emerging of the integrated supply chain will come into being, see Fig 6. The benefit the supply chain gets is that Pareto Efficiency in the real meaning.

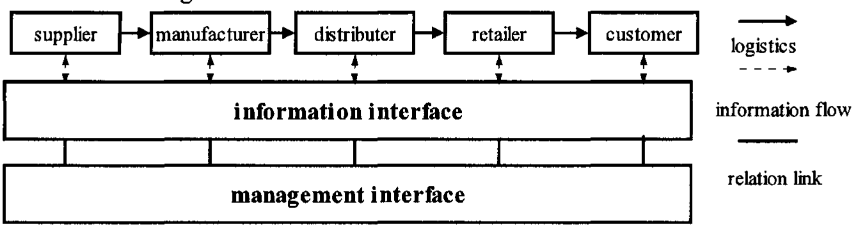

Fig. 6. The Supply Chain Integration Mode of the non-linear confirmation of the management interface and information interface

5 Conclusions

Through the analysis on the management philosophy of the supply chain management and the supply chain integration, the conception of the management interface is proposed, three categories of the supply chain interface integration are given, and the difference of the supply chain function, resulted by the management integration through the three management integration methods, is explained. Finally through the mechanic analysis on the management interface integration principle and on the basis of Steven's etc supply chain integration, the three integration modes of the supply chain based on the management interface integration are raised.

Acknowledgements

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A Hidden Markov Model of Customer Relationship Dynamics in Retailing Industry

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Abstract. There are many types of relationship encounter between customers and retailing industry such as advertisement, service encounter, targeted marketing activities, price and display promotions, these customer- retailing industry encounter may have some enduring or immediate impact on customer's buying behavior. In the sequence of customer's buying behavior and relationship encounter, the customer may be in some state latently which has different likelihood to choose and shift between them. However, the researcher can not observe the actual state directly except observes the buying behavior.

We apply Netzer [1] approach to evaluate of the effectiveness of customer-brand encounters on the dynamics of customer relationships and the subsequent buying behavior, we construct a hidden Markov model in which the Markovian states are a finite set of relation states, the number of states is determined by Bayes factor with validation log-likelihood and the log marginal density measures. The transitions between the states are determined by the history of interactions between the customers and the brand. The probability of a dichotomous choice is determined by the encounters that have an immediate effect on the customer's choice. The individual-level parameters are estimated using a Markov Chain Monte Carlo hierarchal Bayes procedure [2]. We calibrate the proposed model using demographic data, as well as using longitudinal purchasing data provided by shopping mall. We use some other data to assess the prediction ability of the HMM.

This empirical application demonstrates the value of the proposed model in understanding the dynamics of customer-company relationships and

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predicting purchase behavior. Using the proposed model, we are able to probabilistically classify the customer base into several relationship states [3], and estimate the marginal impact of customer-company interactions on moving the customer between these states. It is important to find which is the strongest marketing activity, which pushing the customer to higher state that has bigger probability to choose.

In order to balance the expenditure, marketing activities should be targeted on those whose likelihood is maximal [4]. The proposed model could be used to estimate the customer's relationship state based on its demographic data and transaction record. Compared with the customer segmentation on observed behavior, we can see latent states customer segmentation can increase the amount of purchase much more.

Acknowledgements

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Extended Enterprise Information Sharing in a Supply Chain Environment based on Symbiosis Theory

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Abstract: In modern times, the competitions between enterprises are actually the ones between supply chains. Adequate Information sharing is one of the key factors which will highly improve the efficiency of supply chain. The cooperation models of supply chain are modeled and analyzed, and a two-dimensional enterprise symbiosis model is set up to analyze the symbiosis behaviors between enterprises and the symbiosis energy functions of the model to realize that how the enterprises get their competition advantage by supply chain. According to the analysis, the importance of suitable information sharing to supply chain is obvious. Moreover, a two-dimensional enterprise information sharing model is built to express how the information sharing affects the efficiency of supply chain. To different symbiosis models, the enterprises should share different rank information to meet the demand of symbiosis. The article gives a guideline to enterprises in supply chain that how to make information sharing strategy to get a satisfactory works efficiency at a low information sharing risk rank.

1 Introduction

With the coming of the information economical times, the development of Information technology and information correspondence network introduces the enterprises into one new boundless digitized commercial times. In the sever competition times, if enterprises want to obtain long-term competition advantage, they must carry on the cooperation with the outstanding enterprises, and try to establish win-win cooperation relationships. The information sharing is the foundation of the cooperation between enterprises, and also is one main origin of the

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supply chain advantages. Evens thinks [15] that "the supply chain management conforms the supplier, the manufacturer, retails the business, the retail merchant, until the final user company into one overall model by the forward feed information flow". Cachon and Fisher's statistical analyses prove that information sharing compares traditional order information exchange will make the average cost of supply chain save 2.2%, even reach 12.1%. Chen's research also indicates that effective information sharing may alleviate "bullwhip effect" Even, enterprises in supply chain establish strategy alliance to get more competition advantages through more deeply information sharing.

Although information sharing brings so many benefits, unchecked information sharing is unaccepted. Excessive information sharing also causes information sharing risk cost. Many scholars have studied this question; the main opinions are as followed:

1. The traditional supply and demand relations cause the transformation resistance.
2. Information sharing adds the enterprise's cost.
3. The corporation's business secret might leak through the information sharing.
4. Information sharing possibly reduces the enterprise bargains ability.
5. Information sharing is difficult to monitor.
6. The supply chain dynamic alliance possibly faces disintegration.

In recent years, there are also some in-depth researches (about) the problem of the actual functions of information sharing in supply chain.

Gavirneni had taken two levels of supplies chain with limited stock capacity as the research object. He obtained that the supply chain will achieve the overall benefit maximization only under the complete information sharing condition

Lee and Vhang make a summary research report on information sharing. They give us a relatively entire and qualitative definition for the types information sharing and the application of information sharing and proposed a three-rank model of information sharing.

In brief, current research on information sharing is focus on three aspects: first, the resistance of realization, the importance and necessary of information sharing in supply chain. Second, the research of information sharing model based on in request— proxy theory; third, researching on how to carry out information sharing in supply chain, Such as the structure design of EIS.

With the view of enterprise bionics, the symbiosis theory gives us a complete new view on this problem. The relationships between enterprises in supply chain are actually different kinds of symbiosis models. So we can take use of symbiosis theory to analysis the role of information sharing in supply chain, and according to different types of symbiosis models which have different information sharing characteristics. We can get a clear theoretic explanation on why we share information, and give a guideline that sharing "what" to" who" is most properly. Further, this research could set an example for us to research other problem with biology theory.

2 The Symbiosis Theory

In the economic society, the different enterprise's relationship is similar to the one between different kinds of species in the nature. Chinese scholar Chunqing Yuan thinks [1] “Symbiosis is the relationship which come into being according to some kind of symbiosis pattern between the symbiosis units under certain symbiosis environment” and proposed a better complete symbiosis theory system.

2.1 Basic concept of symbiosis

2.1 .1 Symbiosis system

The symbiosis system is the set of symbiosis relations which symbiosis units formed under certain symbiosis model. The state of symbiosis system is decided by symbiosis organizing mode and symbiosis behavior mode.

In the symbiosis theory, there are four symbiosis modes:

They are as follows:

a. single-point symbiosis mode:

They formed symbiosis relationships, when $\forall t = t_0 , \psi = \psi_0$, if $\delta_{ij}^m > 0$

b. Not continuous symbiosis mode

some not continuous combination of (T, ψ), This is $T = t_1, t_2 \ldots\ldots t_p$; $\psi = \psi_1, \psi_2 \ldots\ldots \psi_p$.And during all the combination, $\delta_{ij}^m > 0$ is formed.

c. continuous symbiosis mode

When $T \in [t_0, t_p], t_p \neq 0; \psi \in [\psi_0, \psi_p] \psi_p \neq 0$, to every symbiosis unit $\delta_{ij}^m > 0$ is existed.

d. Integrative symbiosis mode

A complete new symbiosis model, the symbiosis units formed a particular interface, the symbiosis lost some of their unattached ability, and the symbiosis body also gains something that they never do.

2.1.2 Symbiosis Energy Function

To evaluate the effect of symbiosis units' mutual influence, the symbiosis theory introduced symbiosis energy function. The definition [1] of symbiosis energy function: In a symbiosis system with n dimensions, if the symbiosis energy of unit i is marked with $\mathrm{E_i}$ under no symbiosis, the additional symbiosis energy got from symbiosis system is $\Delta \mathrm{E}$, the symbiosis energy function of this system is:

$$\mathbf{E} = \sum_{i=1}^{n} \mathbf{E_i} + \Delta \mathbf{E} \tag{2-1}$$

$\mathrm{E_i}$ And $\Delta \mathrm{E}$ are decided by $\mathrm{Z_i}, \mathrm{M_i}, \rho_j, \theta_{ij}, \eta_j, \lambda$, and δ_{ij}. $\mathrm{Z_i}$ is the main nature parameter of symbiosis unit i. $\mathrm{M_i}$ is the symbiosis mode of unit i, θ_{ij} is symbiosis coefficient, ρ_j is symbiosis density , η_j is symbiosis dimension, δ_{ij} is symbiosis degree, λ is the eigenvalue of interface.

$$\Delta E = E_S = f(Z_a , Z_b, \theta_{ab}, \lambda, \rho_{sa}, \rho_{sb}, \eta_{sa}, \eta_{sb}) \quad (2\text{-}2)$$

3 The application of symbiosis theory to information sharing of supply chain

We can apply the symbiosis theory to analyzing the information sharing between enterprises in supply chain.

3.1 The Symbiosis Behavior Analysis of a Simple Two-Dimensional Enterprises Ecology Model in Supply Chain

Hall divides enterprise's relations into three types: "two-dimensional pattern ", " the radiation pattern " and " the network pattern ". In fact, "the network "and "the radiation pattern" is more common, but between the interior enterprise's relations is the superimposition of different "two-dimensional pattern ".

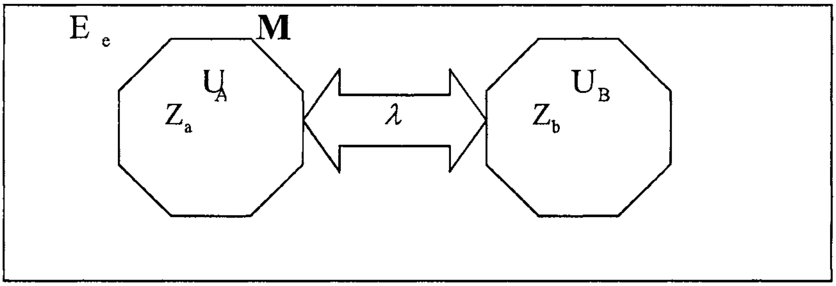

Chart 1. Two-dimensional enterprise symbiosis model

So, the enterprise's relations in supply chain can be simplified to "two-dimensional pattern". Establishing a "two-dimensional pattern" information sharing model under the hypothesis that this cooperation with other enterprise and other affect factors are regarded as enterprises' symbiosis environment.

E_e is symbiosis environment; U_A, U_B stand for the symbiosis units A and B which are enterprises in supply chain. The symbiosis relation is $S = (U_A, U_B, M, E_e)$.

Based on symbiosis theory, the energy function of this model is:

Total energy: $E=E_a+E_b+\Delta E$ (3--1)

Increment of energy:

$$\Delta E = E_S = f(Z_a , Z_b, \theta_{ab}, \lambda, \rho_{sa}, \rho_{sb}, \eta_{sa}, \eta_{sb}) \quad (3\text{--}2)$$

Further, the model only two-dimensional, so ignores the symbiosis dimension and the symbiosis density, then the type 3-2 may be simplified to:

$$\Delta E = E_S = f(Z_a , Z_b, \theta_{ab}, \lambda,) \quad (3\text{--}3)$$

Z_a, Z_b are the main nature parameters of enterprises symbiosis units. Between the enterprises in supply chain, inevitably exists relations, this is $Z_{ai} = \varphi(Z_{bj})$ .the relations are the source of foundation of increment of symbiosis energy. The associate coefficient is the parameter which measures the degree of cooperation. It increases with the improvement of symbiosis organization mode and intensity of co-evolving. λ is the eigenvalue of interface, if λ is smaller, it means that the cooperation between enterprises is closer, the interface is broader, the contact medium is better; then the resistance of exchanges is smaller, symbiosis organization is more advantageous to the new energy production. Therefore, improving the information sharing between enterprises contributes to getting more competition advantages from the cooperation of supply chain.

Symbiosis theory is applied to analyzing the role of information sharing in the two-dimensional enterprise symbiosis model. The result is shown in following chart.

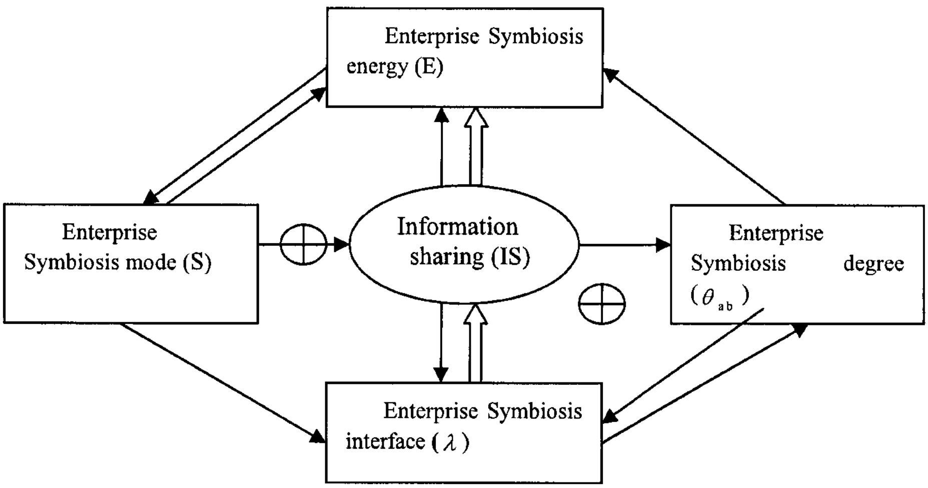

Fig.1 Information sharing function

Figure 1 clearly demonstrates the necessity of carrying on information sharing between enterprises in supply chain. Effective information sharing may bring two positive feedbacks to enhance the production of additional symbiosis energy.

(1)S--λ--IS--E--S.

According to the characteristics of cooperation, the enterprises choose their symbiosis mode, then establish symbiosis interface to exchange material and share information. The information sharing is the only way for symbiosis interface to control the symbiosis, divide the work and cooperate with other units. This is the essence of enterprise symbiosis. By the harmony function of information sharing, the symbiosis produces more and more symbiosis energy. This is also the process of supply chain getting its competition advantage. When the symbiosis energy approaches the critical point, the symbiosis state will change, therefore, more deeply cooperation relation is formed. The new symbiosis mode will demand further information sharing which will bring more quick energy accumulation.

(2)IS--θ_{ab}--λ--IS

Highly efficiency information sharing will promote the mutual influence between symbiosis enterprises and improve the parameter θ_{ab}. If the enterprise symbiosis degree is improved, the symbiosis body will require more information sharing. This is a positive feedback cycle.

In essence, Symbiosis is a process of self-organizing. The elevation of whole enterprise ecology system is the fundamental source of enterprise development.

The existence of symbiosis interface characteristic value λ, also proves that sharing information should be paid.

Therefore, the information sharing is very necessary. But the best form of information sharing is not the most extensive information sharing, but the rational, temperate information sharing.

3.2 Strategic Analysis of the Information Sharing in Supply Chain Based on Symbiosis Theory

According to the symbiosis theory, different symbiosis modes need different ranks of information sharing. Firstly, enterprises could recognize the symbiosis modes between the enterprises and his partners by the characteristics of different symbiosis modes. Secondly, we can summarize the information that maybe shared in supply chain, and divide them into four ranks depending on the risk that brings to the company if the information is shared. Lastly, the enterprise will allocate different information sharing ranks to his partners by their symbiosis mode. By this way, the enterprise will meet the need of different symbiosis modes with lower information sharing risk cost

According to the analysis above, the conclusion is as follows:

	Single-point symbiosis mode	Non-continuous symbiosis mode	Continuous symbiosis mode	Integrative symbiosis mode
Characteristics of synergy evolution	Not obvious	Relative obvious	Obvious	Very obvious
Requirement of information sharing	Unilaterally	Minority aspect	Majority aspect	Entire
Rank of information sharing	Work rank	Management rank	Strategy rank	Core rank

Table 1. Symbiosis mode and its information sharing rank

4 Conclusions

The article research the necessity of information sharing from the view of symbiosis energy, establish a two-dimensional enterprise symbiosis mode, draws the conclusions that:

1. To the different symbiosis mode in supply chain, the symbiosis system needs reasonable necessity information sharing, to satisfy the request of evolution together.
2. The existence of information risk cost.
3. For different ranks if symbiosis mode, the article authorize different ranks of in formation sharing.

The research is too superficial. First, the real relation between two enterprises in supply chain may deeply affected by other cooperation which is among other enterprises. Secondly, to different type of enterprise, the significance of same type information is various. But the research of apply symbiosis theory to information sharing will provide a new way to deal with this problem. Further, the symbiosis theory could be used to many other aspects for management research.

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Study on Purchase Probability Model in CRM Systems

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Abstract. Representative customer's purchase probability is the basis to analyze the purchase behavior of always-a-share customer's segment. Currently, analyzing the representative customer's purchase probability with the Dwyer model is quite complicated. Using uncertain reasoning, a back-tracking Dwyer model and its algorithm are presented in this paper, which solves this problem in a more effective way. The work of this paper is helpful to design analytical CRM systems.

1 Introduction

Customer relationship management (CRM) has been one of the most exciting information system fields since the 1990s [1]. CRM systems are a set of enabling IT systems supporting a business strategy to build long term, profitable relationships with specific customers. The key objective of CRM systems is to provide customer with relevant information and deliver individualized products and services. Call center, sale force automation (AFA), marketing automation solution (MAS) and customer service and support (CSS) are the four software packages of CRM systems. The architecture of CRM systems is shown in Fig. 1.

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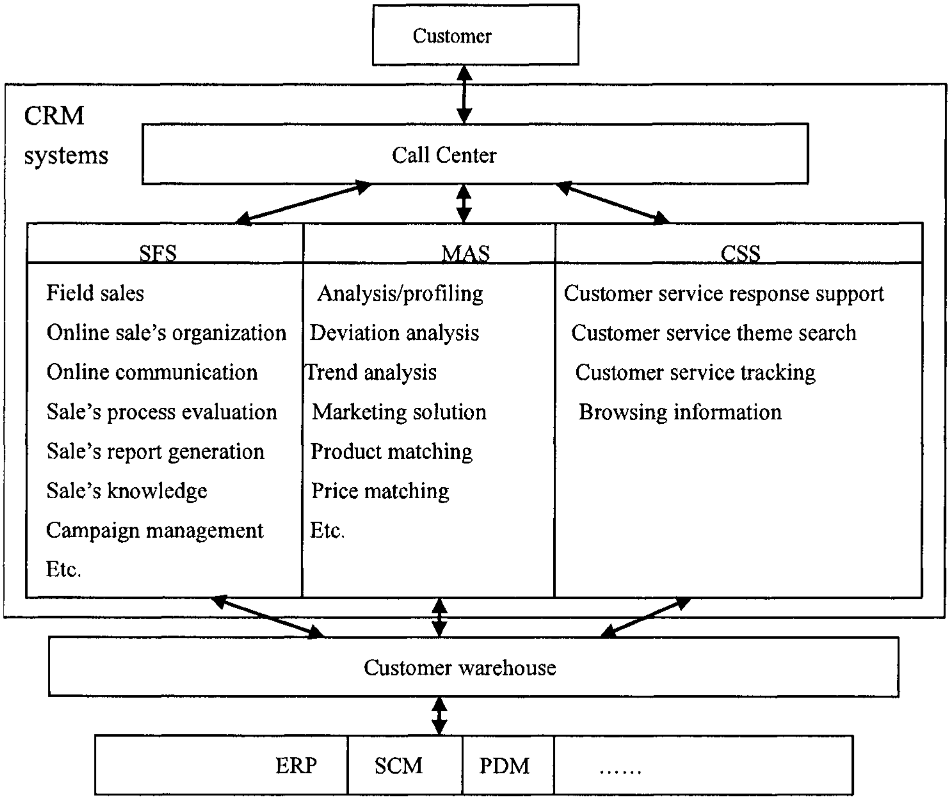

Fig. 1. CRM Architecture

Customer buying behavior analysis is one of the fundamental bases to design the functionalities of a CRM system. Customer's purchase behavior is one facet of customer profiling, the first step to analyze customers' profitability, and the base to provide marketing solution, organize sales activity and provide active customer service. Purchase probability is one of the most important variables to describe always-a-share customers' buying behavior and one of the most critical parameters [2] to calculate lifetime value of always-a-share customer [3-5]. If there is an efficient way to get purchase probability, it will improve the analytical functions of CRM systems.

Dwyer [4] obtained always-a-share customer's purchase probability through building a purchase decision-making tree. The path parameter of leaf nodes and the end condition of the tree were created through the customer's historical buying data. The possibility of next purchase depends on the late purchase of customers. Blattberg and Thomas [6] still use this method. The difference is that they use RFM (Recency, Frequency, Monetary) index to build purchase decision-making tree, while Dwyer only used "Recency" to construct the decision-making tree.

Blattberg's result is more precise; however, it is fussier to apply. Generally, the principles of Dwyer and Blattberg and Thomas are the same.

As this method was first put forward by Dwyer, we call it the Dwyer model for convenience. Through the Dwyer model, the dynamic customer quantity change can be calculated. The ratio of dynamic customer quantity and the initial quantity of the customer segment is the representative customer's purchase probability in each purchase period time. However, as the time variable t increases steadily, the Dwyer model becomes more and more complex. It is more and more difficult to get customer's quantity of the tth purchase period simply and conveniently. So, it is difficult to get the representative customer's purchase probability when t is a big.

The Dwyer model is used in most of the CLV researches to calculate representative customer's purchase probability [2, 4, and 7]. This is the reason why we design a new method. With this new method, we can get the representative customer's purchase probability much more easily and calculate always-a-share customer's CLV more efficiently. Using uncertain reasoning, a back-tracking Dwyer model and its algorithm are presented in this paper. It is proved that the new method is more effective than the Dwyer model.

2 The Back-Tracking Dwyer Model

We assume that customer's purchase behavior in the tth time period is effected by the pervious j periods' buying behavior. If during the previous j periods, a customer didn't buy anything, the purchase probability in the tth time period is zero.

For convenience, the following definitions should be made firstly:

Event A_t : a purchase behavior happens in the tth $(t = 1,2,...)$ time period; the probability of this event is $\Pr(A_t)$;

Event space Ω : Ω is the event space, with $A_t \subseteq \Omega$;

Event B_k : the last purchase behavior happened in $(t\text{-}k)$th time period, the probability of this event is $\Pr(B_k)$, where $k \prec t, k = 1,2,...$.

Under the condition of event B_k happening, the probability of event A_t happening is $\Pr(A_t \mid B_k)$. Given the fact that event B_k is a total division of event space Ω and $\bigcap_{k=1}^{j} B_k = \phi$, we can make the following equation based on the total probability formula:

$$\Pr(A_t) = \sum_{k=1}^{j} \Pr(B_k) \times \Pr(A_t \mid B_k) \qquad (1)$$

The above $\Pr(B_k)$ can also be described in the following form:

$$\begin{aligned}\Pr(B_k) &= \Pr(A_{t-k}) \times \Pr(\overline{A}_{t-k+1} \mid A_{t-k}) \times \Pr(\overline{A}_{t-k+2} \mid A_{t-k}, \overline{A}_{t-k+1}) \\ &\times \ldots \times \Pr(\overline{A}_{t-2} \mid A_{t-k}, \overline{A}_{t-k+1}, \ldots, \overline{A}_{t-3}) \times \Pr(\overline{A}_{t-1} \mid A_{t-k}, \overline{A}_{t-k+1}, \ldots, \overline{A}_{t-1})\end{aligned} \quad (2)$$

Obviously,

$$\begin{aligned}&\Pr(\overline{A}_{t-k+1} \mid A_{t-k}) = 1 - \Pr(A_{t-k+1} \mid B_1) \\ &\Pr(\overline{A}_{t-k+2} \mid A_{t-k}, \overline{A}_{t-k+1}) = 1 - \Pr(A_{t-k+2} \mid B_2) \\ &\ldots \\ &\Pr(\overline{A}_{t-2} \mid A_{t-k}, \overline{A}_{t-k+1}, \ldots, \overline{A}_{t-3}) = 1 - \Pr(A_{t-2} \mid B_{k-2}) \\ &\Pr(\overline{A}_{t-1} \mid A_{t-k}, \overline{A}_{t-k+1}, \ldots, \overline{A}_{t-2}) = 1 - \Pr(A_{t-1} \mid B_{k-1})\end{aligned} \quad (3)$$

Thereby, we can build the dynamic model of representative customer's purchase probability:

$$\left\{\begin{aligned}&\Pr(A_t) = \sum_{k=1}^{j} \Pr(B_k) \times \Pr(A_t \mid B_k) \\ &\Pr(B_k) = \Pr(A_{t-k}) \times \prod_{l}^{k-1} (1 - \Pr(A_{[t-(j-k)]} \mid B_l))\end{aligned}\right\} \quad (4)$$

The way to make out $\Pr(A_{t-k})$ is the same as $\Pr(A_t)$. $\Pr(A_t \mid B_k)$ is a constant and estimated by experience. With the assumption that customer's future purchase behavior is decided by the recent behavior, we can get customer purchase probability during any period using recursion and iterative algorithm based on the formula (4) if the initial purchase time record (the initial condition) is known.

The representative customer's purchase probability of always-a-share in any time periods is easy to get if we design the arithmetic for formula (4). When the Dwyer model is built with RFM, the analysis of back-tracking Dwyer model with RFM is as same as the process above, namely back-tracking Dwyer model with Recency only.

3 Comparison

Comparing back-tracking Dwyer model with the Dwyer model, the new method is better than the old one for time-saving and space-saving in computer operation. Table 1 shows the details:

Table 1. Comparing back-tracking Dwyer model with Dwyer model

	Arithmetic Design	Data Structure
Back-tracking Dwyer model	Recursion and Iterative Arithmetic	Only search the efficient nodes of the tree
Dwyer model	Enumerative Arithmetic	Search all the nodes of the tree, including the non-effective ones

Considering the arithmetic design, we use recursion and iterative to compute the representative customer's purchase probability. It is time-saving and space-saving, and it is more efficiency. While the Dwyer method is an enumerative arithmetic. It is slow, and hard to finish. The non-effective nodes are referred to the ones which are dead before the observed time period. Our method ignores these nodes, but the Dwyer model only stops searching when the nodes terminate.

4 Conclusions

To always-a-share customer, back-tracking Dwyer model is presented in this paper to calculate the representative customer's purchase probability of customer segment. With this method, it is more convenient to predict customer's purchase behavior, calculate CLV and support the development of CRM systems.

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A Study on the EIS Market of Chinese SMEs

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Abstract. The current Chinese EIS market is focusing on exploiting the purchase potential of the SMEs. On the basis of rare research made in this field, this paper, aiming at capturing an objective investigation, presents three aspects to illustrate the application of EIS in Chinese SMEs' market. First, several major EIS vendors are introduced, together with their reputed EIS products, and the comparison between foreign vendors and domestic ones is also made. Next, the investigation is addressed from the consumer side, portraying the profile of SMEs. Finally, this paper are put forward suggestions for the EIS vendors to develop applicable EIS for the SMEs.

1 Introduction

The great progress on application of enterprise information systems (EIS) has turned out to be a crucial impetus on economic development in China. The function of EIS market at past was mainly served on the needs of large enterprises, bank systems, etc. The recent problem is that these markets have been gradually entering the maturity stage of product life cycle, resulted in a budget shift of large enterprises from the purchase of IT software into the spending on update and maintenance. Therefore, the marketing of EIS sets emphasis into the field of small and medium-sized enterprises (SMEs). This paper objectively illustrates the situation of EIS market of Chinese SMEs from both supply and demand sides.

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2 Supply Side: Mainstream EIS Vendors

In Chinese EIS market, the total amount of software vendors achieves more than 8700, including foreign vendors and indigenous ones, but most of market share is occupied by a few influential ones[1]. Those elite incisively capture the trend of EIS market, and promote successively new products pertinently for SMEs. The leading ones are, to list a few, UFIDA, Kingdee, LangChao, Microsoft, Oracle, SAP, the former three of which are all indigenous vendors, and the latter three are the foreign ones. Their reputed products special for SMEs are listed in the Table 1.

Table 1. The Mainstream EIS Vendors and Their Products for SMEs

Companies	Products	Key Features	Prices
UFIDA	U8 Business Application Suite	Integrates modules of financial, supply chain, manufacturing, BI /decision support; Provides connectivity to PDM, bar-coding, SMS system and mobile offices.	200,000—500,000 RMB
Kingdee	Kingdee KIS	Family members: Mini Edition, Standard Edition, Professional Edition and Administration Edition; Integrates modules of purchasing, sales, salary, report, inventory, accounting, logistics, and contract.	3,000—200,000 RMB
	Kingdee K/3	Applicable to Chinese enterprises in growing phases; Solutions for financials, SCM, HR, CRM, KM, and manufacturing; Based on Windows Distributed Internet Application.	100,000—400,000 RMB
LangChao	LangChao ERP/my GS Express	Sub-series of LangChao ERP/myGS; Covering: purchasing, storage, logistics, sales, accounting, manufacturing; Smoothly updated to LangChao ERP/myGS pSeries;	30,000 RMB
Microsoft	Office Small Business Edition 2003	Including 5 programs: Word 2003, Excel 2003, PowerPoint 2003, Outlook 2003 with Business Contact Manager, Publisher 2003; Integrate with SharePoint Services, enabling file sharing and collaboration.	1701—3822 RMB
	Windows Small Business Server 2003	Standard Edition including: Server 2003, SharePoint Services, Exchange Server 2003 Technology, Outlook 2003, Shared Fax Service, Routing and Remote Access Service; Premium Edition including: ISA Server 2000 Technology, SQL Server 2000, FrontPage 2003.	5509—43,300 RMB
Oracle	Oracle E-Business Suite Special Edition	Including modules: Financials, Inventory, Purchasing, Order, Discrete Manufacturing, Sales and Service, and E-Business Intelligence; Fully integrated solution built on the Oracle Database.	438,000—658,000 RMB
SAP	SAP Business One	Covering: Financials, Sales, Service, Manufacturing, Inventory, Purchase; Easily integrate modifications into new versions.	880,000 RMB
	mySAP All-in-One	A prepackaged, industry-specific version of mySAP Business Suite, and adaptability to powerful solutions; Fully integrated business management applications; Support for e-business and collaboration.	

Sources: All of information in this Table is cited from the website of each company [2-7].

According to SIC [1], the foreign software providers occupy most shares of system software and support software, leaving small portion of software market, such as financials software and anti-virus software, to domestic vendors. Recently, when SMEs has gained considerable attention, there are opportunities for domestic EIS vendors to win out from the new round of competition. The followings compare the strength and the weakness of both domestic EIS vendors and the foreign ones.

First, the framework of EIS products is similar, but the quality is unknown. It is obviously shown in table 1 that either the domestic EIS products or the foreign ones cover similar modules. The classification of modules is easy to copy, because it is the exoteric achievement of modern management theory. However, whether a system comfortable or not relies on its usage not just its framework. Even though the products would superficially look the same, their performance may differ far away, for instance, whether the system runs speedy and stable.

Second, the price is relatively low for the domestic ones. China is world-known for its cheap labor cost, which in turn depresses the price of output. This can be seen explicitly from the price comparison in table 1. Except for the Microsoft series, the other two foreign companies' products are nearly twice priced than the two largest domestic EIS providers. The peculiarities of SMEs determine that they would allocate a small proportion of profits to EIS, but not implies that they would choose the low-priced ones at compensation of low-quality.

Finally, even though lack of experience, the domestic vendors take advantage of convenient communication with Chinese SMEs. The foreign vendors have long years' practice, while, the domestic ones are often freshman compared with their large rivals. The strength of indigenous EIS vendors lies in convenient communication with domestic SMEs, which plays a crucial role in figuring out the actual demands of SMEs, and leads to the design of suitable EIS for SMEs.

3 Demand Side: Profiles of SMEs

According to Zhang [8], the official criteria setting down for SMEs are as the followings: the work force is lower than 2000, or the total sale is less than 300 millions RMB, or the total asset value is below 400 millions RMB; meanwhile, to be a middle sized one, the work force, the total sale and the total asset value of which must reach 300, 3 millions RMB, and 4 millions RMB, respectively; and the remain accounts for the small sized enterprises.

On the basis of these criteria of SMEs, this report [8] also offers the distribution of SMEs by area and by industry: the SMEs are located centrally in the east littoral, and the number of SMEs there reaches 133932, while, that number in the middle area is 36548, and the west area covers 23758. The largest five areas are Shanghai, Shandong province, Jiangsu province, Zhejiang province, and Guangdong province, which totally account for more than a half number of the whole SMEs; Among those SMEs, the manufacturing industry takes up a large proportion achieves 179520.

Even though there is an immense potential in the EIS market serving for Chinese SMEs, the peculiarities of Chinese SMEs lay some hindrance on the development of appropriate EIS. The first barrier is the lack of approval from the manager, as mentioned by Cai and Du [9]. The small scale of SMEs indicates that the company-class decision is always made by the top manager him/herself, who are often the founder of the company, and are aware of where each dollar goes. Only if they could recognize the benefits of employing EIS, would they invest in EIS products.

Second, the SMEs are often held back by the cost and time it takes to implement EIS. To implement a system, there must be some assistant deployment. First is the basic equipment, such as computers and servers, then, the company should purchase proper software, and the last but crucial one is the possession of professionals to utilize the EIS. Only when a certain SME satisfies the three criteria could it operate the system effectively, but the problem is that each deployment appeals for money and time, which are often restricted by the scale of SMEs.

The last obstacle is how to customize for enormous SMEs. The former EIS market was concentrated on the large corporations, and the EIS providers often surveyed the actual requirements and designed the suitable systems according to the business process of the large customer. Usually, each order of large customer may reach millions of dollars, which could sufficiently compensate the customized service. However, this is not the case in the EIS market of enormous SMEs with diverse favors. The challenge comes out to be the exploration of balance between providing favorable EIS and lowering cost simultaneously.

4 Requirements for Suitable EIS

The EIS market of SMEs is still worthy to exploit, and the victory exists in consistent quality improvement together with continuous product innovation. There are three requirements on the development of EIS. First is to start from high point by adopting ICT. The main advantage supporting the progress is the movement of information communication technology (ICT). According to Piet and Petra [10], ICT is "seen as a modern catalyst for innovation," and they propose "the use of a network of SMEs, industry organizations, intermediary parties and knowledge institutes, to achieve adoption of new information and communication technologies."

Initially, the design of EIS was relied heavily on IT, and the function of EIS was merely to improve efficiency of the daily tasks limiting within the company, while the growing employment of CT enables various channels for communication in the outside transactions. Besides, spending no sunk cost on the outdated EIS, the SMEs could easily adopt the latest technology, and to win from the high starting point.

The second requirement is to focusing on each industry instead of each company by unifying industry standards. The hindrance for the EIS vendors to provide customized EIS is raised by the enormous quantity of SMEs with relatively small scale. As pointed out by Kingdee [11], "The application of EIS is not simply to transform the information electronically, but much more significantly is to promote the level of management." The tremendous quantity of SMEs prevents to develop customized EIS for each company, and the small scale ordinarily implies inadequacy in business process. Therefore, the solution is to focus on each industry instead of each company, by setting unified industry standards, aiming at to reduce the inefficiency and to improve the transaction.

The last requirement is to construct solid EIS foundation through information resource planning. The separate EIS developed before locks the information into silos, and the consequence is the repeated importing of same data, the frequent delay of information transmission, and the ceaseless updating of systems. One settlement is proposed by Gao [12], that is information resource planning (IRP), which is "A holistic information planning which covers the overall management of information, from collecting, organizing, storing, transmitting, to utilizing of information gathering from diverse channels." The core of IRP is to construct basic standards of information resource management, including the holistic data planning, and execute rigorously those standards in the development of EIS.

5 Conclusion

The field of Chinese SMEs has recently attracting the attention from EIS vendors, who successively promote pertinent products. However, the winners must be those who attach importance to consistent quality improvement and continuous product innovation.

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Study of Systems Methodology in ERP Implementation in China

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Abstract: The application and evolution of MRP II/ERP can be roughly divided into three stages: the introduction stage, the growth stage, and the maturity stage in Chinese enterprise. A successful ERP implementation requires knowledge on both ERP systems and business management. In implementing ERP, the business processes of those enterprises adopted ERP systems need to be examined. It is important to understand the ERP system itself and the business processes involved with the ERP systems and the enterprises adopted ERP systems. In order to resolve issues that may appear in the process of implementing ERP system, this paper proposes that a systematic analysis of those significant factors involved with implementing ERP systems is a necessity, especially if such analysis is conducted in the framework of systems science.

1 Introduction

With the global economy and the wide application of information technology and e-commerce, we are striding towards the era of knowledge economy from industrial economy era. In this transition, fundamental changes have been taken place in the business environment (Li, 2000a). For example, customers' demands change fast; the pace of technological innovations accelerates; products life cycle is shortening; and the market is becoming more and more competitive (Xu et al., 2005). Among those changes, there are three major factors that are influencing a modern enterprise's

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growth and survival. They are customer, competition and change. The business management good in the era of the industrial economy including the management style relying mainly on MRP II is no longer applicable in today's enterprises. In order to adapt to the external environment and taking customer, competition and change into consideration, enterprises must manage the change in business operations, reengineer business process, and adopt managerial reforms.

This paper analyzes some problems appear in implementing ERP using the data on ERP implementation in China, and discussing ERP implementation, implementation procedures, key successful factors, and the risk factors in the framework of systems theory and systems approach.

2 ERP Implementation in Chinese Enterprise

MRP/MRPII/ERP systems have been introduced into China and adopted for almost 20 years (Li, 2000b; Li et al., 2001; Chaudhry et al., 2005; Dan et al., 2005; Wang et al., 2005). In early 1980s, most Chinese enterprises have limited knowledge on MRP II and ERP. During the period of 1985 to 1990, Chinese entrepreneurs and researchers began to study western business management and practice to help improve the competitiveness of Chinese enterprises. At the same period, selected enterprises started to adopt ERP systems. From 1990 to 1999, an increasing number of enterprises have adopted ERP systems in which most of them are the leading products from major ERP vendors in the West. The introduction and application of MRP II/ERP systems in China can be roughly divided into three stages:

2.1 Introduction Stage

This stage nearly runs through the whole 1980s which is characterized by the introduction and implementation of MRP II. Such applications are mainly in traditional machine-building industry. 1980s was the period when China started the transition towards market economy. Production and operation was a serious issue needs to be handled since the productivity per worker in Chinese machine-building industry was approximately only one tenth of that developed countries. Cycle of delivering products was long, inventory was high, cash flow was not good, and the utilization rate of equipments was low. For the purpose of improving performance, some enterprises started adopting MRP II systems. Such companies include the Shenyang Air Blower Plant, and Guangzhou Peugeot Motor Corporation.

As pioneers in adopting MRP II systems in China, these companies experienced a lot of difficulties. First, the software itself had technical problems. The software introduced at the time was non-general purpose systems mostly developed for mainframes or middle-range systems. Such software needed customization that could be costly. Another problem was the lack of related technical support and service. Second, there was a shortage of the expertise of implementing MRP II. Another obstacle is that sufficient attention was not been paid by management on systems implementation. MRP II implementation was perceived as an IT project only. Despite the difficulties, some enterprises successfully implemented the systems. Such companies include Beijing First Machine Tool Plant, Shenyang Machine Tool Plant, and Shenyang Air Blower Plant.

As a result, some practitioners considered that imported MRP II software does not meet the Chinese industry needs. After analyzing the MRP II implementation results in this period, the so-called "three 1/3" rule was proposed, i.e., 1/3 of imported MRP II software can be used, 1/3 can be used only after modification, and another 1/3 simply cannot be used.

2.2 Growth Stage

This stage was roughly from 1990 to 1996 in which the so-called "three 1/3" rule was no longer popular. During this period, MRP II and ERP systems were widely adopted and implemented.

During this stage, the imported software still played a major role. However, the faster transition from the old planning economy to market economy and the changes in world market gave a serious challenge to the traditional management style in Chinese companies. Although MRP II still was the main software to be used for modernizing the manufacturing sector, its applications spread quickly to industry sectors other than machine-building that include space industry, electronics, pharmaceutical and chemical industry. Companies in this list include Chengdu Aircraft Industry Company and the First Automobile Factory of China--Volkswagen Automobile Group. In addition, companies that adopted MRP II earlier have benefited significantly from the installed systems after participating in China's 863 CIMS Program. For example, Beijing First Machine Tool Plant realized the integration between the core production management and all other functional units that can be used to adjust production planning according to the rapid change of the market. As a result, the efficiency was up for more than 30 times. The companies in this category have all financially benefited from implementing MRP II systems.

However, it cannot be ignored that, although significant achievements have been made, there are still a great deal of weaknesses. Some of which are: (1) many enterprises were lack of planning for choosing and using MRP II; (2) application scope was not wide enough. Most existing applications confined to the manufacturing sector; (3) the scope and function of management were limited to enterprises' internal operations rather than integrating all partners in the supply chain; (4) some enterprises did not thoroughly look into the function of the software and the technical support from vendors after acquiring it, which caused unnecessary waste.

2.3 Maturity Stage

It is the whole period from 1997 to the beginning of this century. The main characteristic is the introduction of ERP systems. The scope of application has been expanded from the manufacturing industry to other industry sectors. Meanwhile, the implementation result has also been improved significantly.

The rapid development of the third industry is considered a remarkable symbol of modern economic development. Financial management has already become the core of modern economy, as the information industry plays a leading role in modern economy. All of these are demanding a new type of management software. As a result, ERP becomes a major player and has expanded its application to financial sector, communication industry, high technology industry, and retail sector. For example, SAP has developed a product which can provide solutions for a variety of industry sectors including financial sector, high technology industry, transportation, telecommunications, energy, government, commerce and retail business, international trading, publishing, consulting service, even health care and hotel industry.

Existing problems include many enterprises fail to pursue business process reengineering along with the implementation of ERP which have caused the functions of ERP difficult to work well, domestic ERP market is not mature yet, regulations are needed for vendors, etc.

3 Implementing ERP Systems in Systems Perspectives

3.1 Define ERP systems

3.1.1 Characteristics

A successful implementation of ERP system requires both the knowledge on software and business processes. ERP is an enterprise information system that is consisted of business process management and information technologies, with the purpose of integrating and optimizing enterprise operations (Li and Li, 2000). It has the following characteristics (Xu, 2000; Deng, 2003):

System characteristics: ERP is a system with characteristics of a system such as wholeness, holistic properties, structure, boundary, and functions. Its most important characteristic is holistic properties (Jackson 2003; Warfield 1989; Xu 1991; Xu 1995).

Business process management: The core of ERP is managerial thinking and business process management including supply chain management, total quality control, flexible manufacturing systems, and activity business cost method, etc.

Information technology: ERP will not exist without information technology. It can be seen clearly that it is the technological advances in information technology that makes ERP possible. On the other hand, information technology is also benefited from the development of ERP systems. ERP can be considered as a system that integrates all functional units in an enterprise including marketing, production, material management, financial accounting, and human resource with the help of information technology.

3.1.2 ERP system architecture

In June 2003, the Ministry of Information Industry of China released the national industry standard entitled "Enterprise Informationization Technological Regulation: Part 1: ERP Regulation "which was put into practice in October 2003 (Chinese Ministry of Information Industry, 2003). In this document, the section on "ERP products functional requirements" provides the requirements for ERP architecture , which include: Function Classifications, Environment and User Interface, System Integration, System Management, Basic Information, Inventory, Purchasing, Marketing, BOM, Work in Progress, Techniques, MRP, Cost, Human Resource, Quality Management, Managerial Decision, General Ledger, Automatic Entries, Receivable, Payable, Fixed Assets.

These facto show the required functions of ERP including the requirement for the entire system, management function, basic information management function, production management function, supply management function, marketing management function, human resource management function, financial management function, material management function, technology management function, quality management function, and management decision function. Each of them relates to a corresponding subsystem of ERP. An enterprise determines the functions needed and defines its own ERP scope, subsystems, and boundary.

3.2 Systems management thinking embedded in ERP systems

For a successful implementation of ERP systems, it is important to have an adequate understanding of the systems management thinking embedded in ERP systems which can be summarized as follows:

Systems view. ERP systems are characterized by the concept of systems planning (Warfield, 1989; 1990) that includes planning from macro level down to micro level, from strategic level down to tactical level, and from general to specific. However, such planning is consistently focusing on an enterprise's strategic target. "One system plan" is the spirit of ERP.

Systems management. ERP is an example of systems engineering; it integrates every division in an enterprise into a whole. Each division needs to try its best to fulfill its own responsibility in the framework of the system as a whole, and every employee should be clear about his/her role. Only under the "One system plan", ERP can become and function as a system. The situation of functional separation needs to be replaced by the team spirit with systems perspectives.

System-wide data sharing. ERP is an enterprise information system in which each division of the enterprise practicing management using the same data. Any changes in data can be accessed by all divisions to realize true data sharing. Managing and making decisions based upon a central database can eliminate the problems such as insufficient information, and decisions made on unclear fuzzy data. Therefore, adequate attention should be paid to data quality.

Dynamic systems reaction to changes. ERP systems integrate customers' demands and the manufacturing activity inside the enterprise with suppliers, realizing the idea of complete service to customers. Meanwhile, ERP can trace, monitor, and reflect the operation status of the enterprise to make it more adaptable to the market and customers' demands. It is extremely important that management can quickly react to the changing data and make decisions. Therefore, enterprise information consciousness should be emphasized.

Systems forecasting. ERP systems not only reflect the status of enterprise management, but also can help solve "what-if" problems. It can be used to predict the problem that may appear in the future so as to take measures in advance instead of wasting time and energy in handling them after they have already occurred.

Systematic integration of material flow and money flow. ERP itself has the function of cost management and financial accounting. It can produce financial reports directly from the activity in production. To convert material flow into money flow directly may guarantee the consistency of production and the financial data. Financial department can obtain the money flow information which reflects the material flow and the condition of production on time, and be able to analyze the financial performance of the enterprise and participate in decision making at any time.

3.3 The concept of level in ERP implementation

To understand the levels involved with ERP in terms of systems theory is the key to put ERP into practice successfully. The levels of ERP can be mainly decomposed into the level of system architecture and the level of system integration.

3.3.1 Levels in systems architecture

The structure of ERP is composed of four levels: (1) Network level. It is the infrastructure of the system which makes the information flow both internal and external enterprise flows smoothly through the network; (2) Resources level. It includes hardware, software, and data needed by ERP system; (3) Application level. It contains different subsystems used by the personnel in different sections in an enterprise. Through these subsystems, management provides ERP with the data resource or obtains the required information; (4) Decision support level. Employing models and methods, management processes data or information for decision making.

3.3.2 Levels involved with system implementation and integration

Based on the integration nature of ERP, there are three levels involved. They are the levels of management thinking, software, and management system (see Fig.1).

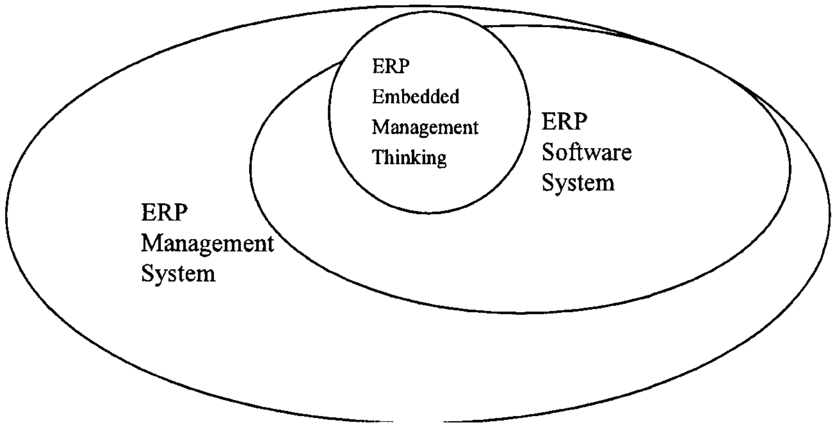

Fig. 1. Levels in ERP Integration

The substance of managerial thinking embedded in ERP is based upon MRP II and supply chain management ideas. The software level covers client server system, database, object-oriented technology, graphical interface, and network architectures, etc., and serving the purpose of supply chain management. The management system level makes ERP possible to be a truly enterprise information system that integrates enterprise management principles, business process, enterprise business data, resources, and computer systems into a single system. Through the three levels mentioned above, enterprises will be directly benefited from the management system that is also the system actually make the other two levels realized. A failure in any links in the interaction process of these three levels is a risk factor that may lower the benefits which the management system could bring to the enterprise. Therefore, the main issue to be paid attention when an ERP system is evaluated is the quality of the software and the effect of implementation which actually covers all three levels mentioned above.

3.4 ERP implementation techniques

3.4.1 Conversion methods

The methods of conversion can be roughly classified as follows. (1) Complete conversion method: With this method, the entire ERP system is implemented in full scale at once; all modules of the system are put into operation at the same time; (2) Progressive conversion method: subsystems or modules are implemented one at a time. Implementation schedule may go by units within an enterprise; (3) Wave-type conversion method: the course of ERP system implementation is advanced by wave-type of movement. Each such wave provides appropriate system functions to different units within the enterprise. Although each wave is an independent entity, they are also related to each other to some extent. It is managed by the project team to ensure the success of the entire implementation; (4) Special type progressive conversion method. This method recommends a temporary linkage between the new system and the existing system. With this method, more than one module may be implemented at the same time; (5) Parallel conversion method. The new and existing systems may be operated at the same time for a certain period of time. The purpose is to guarantee that new ERP system will reach expected performance.

3.4.2. Relationship between implementation method and enterprise characteristics

Selecting an appropriate ERP implementation method is mainly depend upon the internal characteristics within an enterprise. The factors to be considered include:

(1) Organization scale and complexity

Generally, it is suitable for a small and less complex organization to take the method of complete conversion. A relatively complex organization may adopt the progressive conversion method. With the increase of scale and complexity, an enterprise may incline to adopt the progressive conversion method (see Fig. 2).

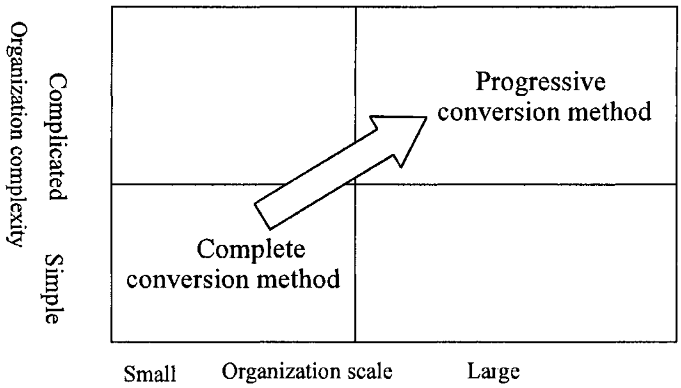

Fig. 2. Relationship between the scale and complexity of organization and the methods of system implementation (Peng, 2001; Yuan 2002)

(2) Levels of organization and degree of control

Factors such as levels of the organization and the degree of control should also be considered in selecting an implementation method. A single-level enterprise with loose control management style may adopt the complete conversion method. A multi-level organization with tight control management style may take progressive conversion method (see Fig. 3).

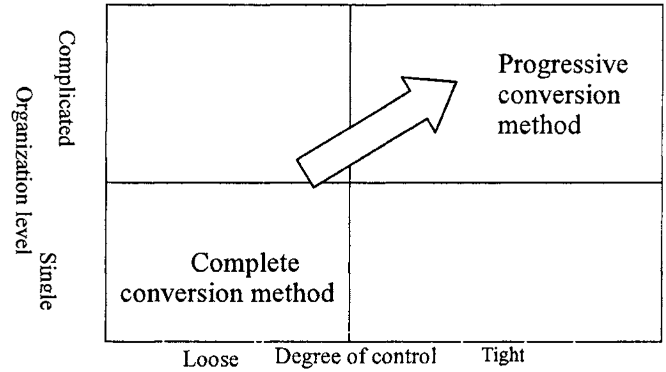

Fig. 3. Relationship between the levels of the organization and the degree of control and the methods of system implementation

(3) Scope of implementation

The scope of implementation also influences the choice of implementation method. The scope is generally defined by the quantity of modules and the extent of customization which is shown in Fig. 4 (Guan 2002).

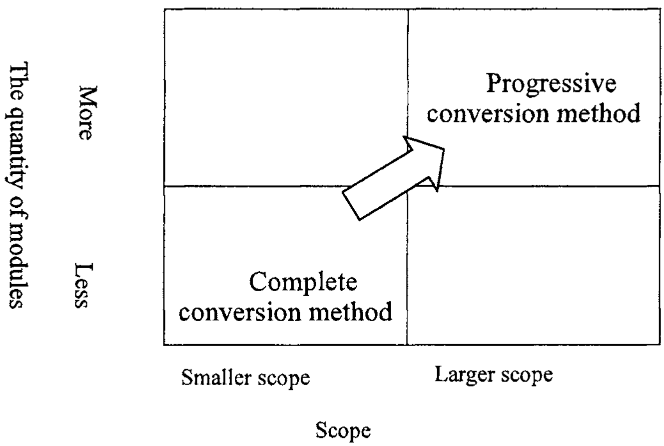

Fig. 4. Relationship between the system modules and the methods of system implementation

3.5 Key successful factors of ERP implementation for Chinese Enterprises

Based on the empirical studies of ERP implementation in Chinese enterprises, the key successful factors of implementing ERP system are as follows:

(1) Senior level management support: positive commitment, enthusiastic about the project and strong support; (2) project implementation team: Teams' organization and project implementation, for example, qualified management and team members. Team members must have background and are capable. For example, they must have experiences and be able to communicate in a cross-departmental environment; (3) external consultants: knowledge and expertise on ERP project; (4) setting goals and project scope: goals and project scope for each stage must be determined; (5) education and training: basic education of ERP and ERP system operation training; (6) project management: according to the project goal, determining project plan, allocating resources, and controlling cost and budget; (7) data: data accuracy and integrity; (8) change management: BPR; (9) methods of implementation; (10) evaluation: ERP project evaluation and assessing the contribution made by ERP to enterprise performance.

4 Conclusions

Implementing ERP systems is a deep revolution in management. In order to achieve the goal, issues in the implementation process must be systematically considered. This study attempts to propose a systems approach to ERP implementation through a systematic analysis of the factors involve in the implementation process, thus to provide solutions to a variety of problems arise in the course of implementing ERP and reduce risks.

The study proposes the definition of ERP in systems point of views. ERP is an integrated enterprise information system composed of managerial thinking and information technology. Its main purpose is to integrate and optimize an enterprise's resources. The managerial consideration of ERP includes: (1) feasibility and consistency of the plan; (2) systems characteristics of management; (3) data sharing: ERP makes it possible for different sections/divisions of an enterprise to operate using the same database. Any changes in data can be reflected on a real-time basis; (4) dynamic reaction to changes; (5) what-if-analysis; (6) the integration of material flow and money flow; and (7) the comprehensiveness of the management scope.

The study also proposes the concept of levels in ERP system. Due to the integration nature of ERP systems, three main levels can be defined. They are the levels of management thinking, software, and management system. Based upon the analysis of ERP implementation, it is proposed that only in the direction of systems approach or scientific approach can the ERP project be successfully carried out. A typical ERP implementation process mainly includes pre-preparation stage, implementation preparation stage, test operation and customization stage, and new system operation stage. There are control points at each stage which include those key control points which are critical to the success of the implementation. In addition, the paper also discusses the risk factors and how to avoid them.

ERP implementation itself is a project of system engineering or practice of systems science. A through analysis of the systems characteristics and factors is considered a necessity as basis for the successful implementation of ERP systems.

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Issues on Evaluating Free/Open Source ERP Systems

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Abstract. Free/Open Source ERP Systems represent an area which is increasingly gaining acceptance due to many reasons. However, there is still a lack of specific evaluation methods for adoption and very little academic research is reported in this area. Therefore, this paper aims to discuss important issues on Free/Open Source ERP Systems evaluation and, as of consequence, to propose an evaluation method that takes into account not only aspects related to the software itself, but also to the possibility of joining the software development effort.

1 Introduction

Free/Open Source ERP Systems (FOS-ERP) are increasingly gaining acceptance for many reasons. One reason is direct cost, since they impose no licensing costs in general. Other reason is the perception of the fact that if customization is inevitable, why not adopt a solution that exposes its code to the client company that can freely adapt the system to its needs. Adapting is a crucial point to ERPs, given that, according to [1], despite being called *software*, enterprise systems in general "have nothing to do with 'shrink-wrapped', 'off-the-shelf' items that can be used instantaneously". This remark reinforces the freedom of manipulating the code by itself in FOS-ERP: if the vendor changes its contract terms, the client company is not locked in to a particular solution supplier [2]. Additionally, can two competing companies derive a strategic differential using the same ERP? Although this problem can also happen with FOS-ERP, it seems to be bigger for P-ERP, since, due to limited (or even none) access to source code, adaptations are also very limited, restricting real differentiation.

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If, for both kinds of ERP, the fact that integration among processes can by itself be a source of competitive advantage - even if only to strengthen the generic competitive position defined by the company by overcoming some specific localized trade-offs [3], this can be extrapolated to the possibility of changing source code to drive an even better advantage.

In summary, two basic advantages attract companies to FOS-ERP: lower costs and access to application code. But this is not enough to satisfy a company's needs. There are strategic questions that must be evaluated to decide which FOS-ERP to adopt or even if a P-ERP is more suitable to the specific case of the company. This paper is going to focus on the case in which a company wants to compare different FOS-ERP for adoption, not addressing any specific issue related to comparison between P-ERP and FOS-ERP.

1.1 Motivation

Evaluating FOS-ERP is harder than P-ERP. Besides the usual functionality, technology, and financial aspects, there are also aspects related specifically to Free/Open Source Systems (FOSS) that are vital for FOS-ERP.

Evaluating FOSS projects is a well-commented matter in industry. A search conducted at Google.com for "evaluating open source" brings about 21,000 hits as for January 2006; many of them are related to evaluation methods. Narrowing the search down to "evaluating open source erp", the result goes down to only 6 distinct hits. Of those six results, one has nothing to do with the subject, one was a dead link and the other four pointed to a site that offers a tool for evaluating ERPs, open source or not. Doing the same search in IEEE and ACM digital libraries returns only approximated results, none of them dealing with this specific issue.

Although search engines aren't guarantee to find the desired information, only one keyword combination was used, and the method utilized was not scientific, the discrepancy in results and the difficulty to directly find out information about evaluating FOS-ERP show how this subject is poorly analyzed, by both the industry and the academics. In the academic arena, this seems to be another situation where technology has outstripped the conceptual hawsers: according to Kim and Boldyreff [4], by September 2005, only one paper about Open Source ERP [5] "has been published in the whole of ACM and IEEE Computer Society journals and proceedings, whereas more numerous articles have been published in non-academic industrial trade magazines."

Additionally, in the realm of P-ERP, there are methods, tools and sites for evaluation and comparison purposes. In spite of some portals like TechnologyEvaluation.com include some FOS-ERP on their evaluation database; there isn't a specialized structure for FOS-ERP evaluation in any case. One can find industry papers that offer some punctual evaluations but nothing like a specific method or tool.

Instead of a punctual evaluation of this highly dynamic kind of EIS, this paper aims to propose a basic framework for FOS-ERP evaluation, without the intension of embracing all the matters related to this matter, but with the declared intention of bringing more attention to FOS-ERP aspects and evaluation.

2 Related Work

Among the various methods proposed for evaluating FOSS, three of them were selected to be briefly described here, because they are generic enough and have as a premise the fact that normally organizations have their own way of evaluating software, influenced by their technical expertise, organizational culture, specific needs, and experience of the decision makers. Although other methods found also present these characteristics, the three here summarized seems to be more suitable to be adapted for FOS-ERP evaluation.

De Carvalho, Costa, and Xu [6] present a method based on risk to evaluate FOSS, which focuses specifically on particularities of FOSS that are consequences of the fact of their code is open. This method does not concentrates itself on evaluating functional and non-functional requirements, instead takes into account two core factors related to the FOSS development: the strategic positioning of the adopter, and the chances of the FOSS "survive" in the future. The first factor will determine if the adopter will simply use the FOSS, collaborate somehow in its development or make profit from selling it [7]:

- Consumer: a passive role where the adopter will just use the software as it is, with no intention or capability of modifying or distributing the codes.
- Prosumer: an active role where the adopter will report bugs, submit feature requests, post messages to lists. A more capable Prosumer will also provide bug fixes, patches, and new features.
- Profitor: a passive role where the adopter will not participate in the development process but simply will use the software as a source of profits.
- Partner: an active role where the adopter will actively participate in the whole open source development process for the purpose of earning profits.

The second factor is measured through development conditions, survivability, and support level. This method gives a special attention to community engagement as an indicator of the chances of the project evolves in the long range.

Wheeler [8] describes a generic method for evaluating FOSS based on four steps, joined under the IRCA acronym: identify, review, compare, and analyze. *Identify* means to find out candidate systems for evaluation, possibly by the use of Generally Recognize as Mature/Safe (GRAM/GRAS) lists of programs. *Review* is based on obtaining existing evaluations of the candidate systems, which can be comprised by consulting portals like Freshmeat.net for instance. *Compare* is maybe the hardest part of the process, since it aims to compare functionality, Total Cost of Ownership (TCO), market share, support, maintenance/longevity, reliability, performance, scalability, usability, security, flexibility, interoperability, and legal issues. *Analyze* finally implements an in-depth analysis of the remaining contenders, concentrating in functionality and security.

Golden [9] has introduced the Open Source Maturity Model (OSMM), which is a three-phase process for selecting and assessing open source software. OSMM assesses the maturity level of a FOSS through key product elements: the software itself, support, documentation, training, product integration, and professional services. In Phase 1 the adopter organization evaluates each product element in four steps: define requirements, locate resources, assess element maturity, and assign a score to the element. In Phase 2 weightings are applied to each product element, according to its perceived criticality for the adopter. Finally, in Phase 3 an overall product maturity score is calculated. OSMM supplies a set of minimum scores to determine if the FOSS is suitable to the adopter's needs.

3 ERP Evaluation and Strategic Issues

Evaluating P-ERP in general involves comparing alternatives under the light of functionality, TCO, and technology criteria; for FOS-ERP the same criteria plus the ones related specifically to FOSS must be taken into account. However, it is not a question of simply aggregating all criteria into one evaluation method, because ERP systems are not ordinary software, like web servers or content management systems. According to Caulliraux and colleagues [3], "their high implementation costs can in itself establish the option for an ERP as strategic – it is a major commitment of money, and thus with long range implications even if only from a financial point of view." Caulliraux also states "ERPs are also important not only as a tangible asset – high-value hardware and software, but also as a catalyst through their implementation in the formation of intangible assets and the company's self-knowledge." At this point, it is clear that even if a FOS-ERP implementation assumes a smaller financial importance than a P-ERP one, in terms of a company's self-knowledge it can assume a much greater importance, since it holds not only a inventory of records and procedures, but also how those records and procedures are realized in a technological fashion – through source code.

In other words, a FOS-ERP can have a smaller financial impact but a much bigger knowledge and innovation impact. Although P-ERP are also adaptable through Application Program Interfaces (API) or even dedicated programming languages, the access to the whole source code in FOS-ERP, not only an API, will drive much better exploration of the ERP's capabilities, thus allowing a better implementation of differentiated solutions.

From this standpoint, the strategic positioning of an adopter in relation to an FOS-ERP seems to be of greatest importance, driving the necessity of a differentiated evaluation process, given the possibility of deriving innovation and competitive advantage from the source code. Although innovation and advantage could be obtained if the adopter (i) develops a whole solution by itself, or (ii) simply acquire a

P-ERP, it would go back to (i) the high costs of this kind of solution, or (ii) the shortcomings related to P-ERP stated before.

3.1 Strategic Positioning

For the specific case of an FOS-ERP adopter, the Profitor and Partner roles mentioned before are not applicable to the focus of this paper, and the other roles can be reinterpreted as follows; assuming that always will have adaptations to be done to the system:

- Consumer: a passive role where the adopter will simply buy the adapting service from a software house, without any direct collaboration to the development process.
- Prosumer: an active role where the adopter will assume the adapting process, reporting bugs, submitting feature requests, and posting messages to lists. Depending on the inclination to share information, a more capable Prosumer can also provide bug fixes, patches, and new features or even modules.

Clearly, the adopter strategic positioning has a great impact on the way it sees the FOS-ERP. Different kinds of adopters may assess an identical project feature quite differently. Insightfully, some weaknesses (such as lack of documentation) revealed in the evaluation may encourage the adopter to become a Prosumer and contribute to the project, impelling it, and consequently turning into a positive return in the form of new features created by other prosumers or partners of the project.

It is important to know if the organization wants to shift from a user point of view to a developer role. Also it is necessary to evaluate if the adopter's development team has the correct skills to develop new features. So, it is necessary to verify first the software's technical features or functionalities that the adopter needs. If the software has the necessary features, and they are fully compliant to the adopter needs, there is no problem and development conditions don't need to be checked. On the other hand, if there are missing features or the existing ones are partially compliant, the adopter must choose one of the following actions: reject the OSS, check if there are plans to develop the missing features (and if the plans fit to adopter's time constraints), or join the development effort.

If the adopter decides to become a developer, project management issues, like time and costs, must be addressed. Although having other community members involved in the project is good – lowering costs, this can mean managing a project where many variables lay outside the adopter organization, thus the level of managerial control is substantially lower. In general, FOSS communities carry highly informal relationships among its members. Also, it is necessary to follow a development cycle that is influenced by many members of the community, which sometimes requires a massive coordination effort [10], depending on the complexity of the task.

In some cases the adopter can assume a dual strategic positioning. As an example, there is the case of ERP5 user Coramy [11], a leading European apparel industry. Coramy acts both as a consumer, using the services of Nexedi, ERP5's creator for customization purposes in general, and as a Prosumer, collaborating with the community with testing, discussion, and patching.

4 PIRCS: A Method for FOS-ERP Evaluation

The proposed method mixes ideas from the previously summarized methods: from [6] it uses the concept of strategic positioning, from [8] it uses some of its steps, and finally from [9], it uses the central idea of explicitly scoring each candidate. It can be understood as a *meta-method*, given that the method is composed by a series of steps or procedures that should be adapted for specific purposes, according to the adopter's software evaluation culture and specific needs.

The method is divided into five steps, identified by the acronym PIRCS: prepare (the evaluation), identify (alternatives), rate (alternatives' attributes), compare (alternatives), and select (the best alternative). The following topics detail each of these steps.

4.1 Prepare

This step is responsible for initiating the evaluation process, through the definition of a series of parameters that will have influence in the whole process. It is comprised by:

- Requirements definition: is related to functional and non-functional requirements for the ERP. This task defines a set of attributes that must be rated.
- Strategic positioning: will define if the adopter is firmly decided to be only a consumer or if it's willing to become a Prosumer in these cases where development costs and lead-time are acceptable and FOS-ERP technology is known enough to the development task. A dual positioning can be assumed, in cases where the adopter decides for developing by itself some features and contracting a third part for developing other features, because it skills are somehow limited or time and cost constraints drive this kind of positioning.
- Definition of extra attributes, used to identify the survivability level of the FOS-ERP: the adopter must analyze figures like number of posts on lists, of feature requests, of bugs and others, to identify the size and level of community involvement. In [6] a series of attributes for measuring community activity levels are listed and explained.
- Limits set up: will define lower and/or upper bounds for each attribute in the decision process. Outside these bounds, the candidate reaches a cut level, meaning that it won't be considered any more for evaluation. For attributes related to performance for instance, lower bounds are determined; for others, related to cost and time for example, upper bounds are used.
- Measurement method definition: since the method is based on scoring attributes, a measurement method must be defined. This method has to take into account

qualitative and quantitative value scales. For instance, robustness is normally qualitative, whereas cost and time are quantitative.

4.2 Identify

The identification step identifies the candidate FOS-ERP, or, in other words, the decision alternatives. To accomplish this, the process described by [8] can be used. At this point, GRAM/GRAS lists, web searches, and visiting portals specialized on ERP can be used.

4.3 Rate

Rating means measuring the utility of each attribute for each alternative. In other words, associating grades for each of the attributes defined at Prepare step. Rating will be divided in two parts:

- Rating the requirements for the system, meaning to evaluate each functional and non-functional requirement according to an established scale. For the functional requirements, it is interesting to note that the granularity of the analysis must be defined, for example, in some cases the adopter may want to analyze a module as a whole - like Payroll module, or specific functionalities of a given business process – as, for instance, automatic alerts of low inventory levels in a Inventory Control Module. If the granularity is high, the adopter must define a method to aggregate rates for specific functionalities towards a final grade for a macro-functionality or module.
- Rating the attributes that define the survivability level of the system. This kind of evaluation is also important since an active community around a FOS-ERP (or a FOSS in general) can mean fewer expenses on support and bigger probabilities of the project follow up in the future. It is also important to note that technological and methodological aspects of the FOS-ERP can define its survivability independent of the community. For instance, the use of obsolete technologies can determine a problem in the future for the system. On the opposite side, too innovative technologies can expose the project to a series of risks, including discontinuity, non-fulfillment of requirements, and fewer people working on the project.

Additional techniques can be used to accomplish rating. Weiss [12] focus on measuring the success of a FOSS using web search engines. This very intuitive technique can be used to infer how much a FOS-ERP is known – and as a consequence, used - thus giving an indirect measure of its survivability. In [6] is presented a method focused on risk level evaluation in accordance to community engagement and helpfulness, maturity, level of acceptance, technology, project hosting support, documentation, commercial support levels, release frequency, and lists activity. Both techniques can be used since the prepare level, to define an extra set of requirements for the FOS-ERP.

At the end of this step, a final rate for each attribute of each candidate (alternative) is created.

4.4 Compare

This step will take all the rates from all the candidates and establish a ranking or a pair to pair comparison, depending on the technique used to compare alternatives. To accomplish this, simple techniques like weighted averages - used in OSMM, or more sophisticated ones, like Multi Criteria Decision Making (MCDM) methods, can be used.

4.5 Select

Selection is split up from comparison when the method used to compare alternatives does establish a final ranking from where the best candidate is obtained. This situation occurs, for instance when pair to pair comparisons are used, or when the adopter decided not to mix in the same scale qualitative and quantitative attributes.

In these situations, the adopter must define a specific logic for selecting the best alternative. At this point, it is important to note that the combination of upper and lower bounds (interpreted as cut levels) and performance of an FOS-ERP can determine the adopter's strategic positioning or even the elimination of the alternative from the evaluation process. For instance, let's say that for the Production Planning and Control module the adopter defined a lower and an upper bound, respectively X and Y, where:

- Bellow X the candidate is eliminated from the process.
- Between X and Y and considering acceptable costs, the adopter will improve the module functionality. If the costs are prohibitive, the candidate is eliminated.
- Above Y the candidate will be accepted as is (for this attribute).

5 Conclusions

The aim of this paper is twofold: discuss some important issues on evaluating FOS-ERP, and also propose a basic method that can be improved for specific purposes and needs, or even generalized for evaluation of FOSS in general.

An important conclusion is that, given the strategic nature of ERPs, evaluating a FOS-ERP must include the strategic positioning of the adopter towards the development process of the candidate systems: in some cases joining the development effort means extra strategic differential for the adopter.

Additionally, the information available on the Internet about FOS-ERP, is not only inexpensive, but also is generally non-biased, given the fact that the system's source code is totally exposed for analysis, allowing a deeper evaluation of its functionalities, security, technology, and flexibility.

An interesting outcome of this discussion and possible future work is the creation of a MCDM model that would cover Rate, Compare and Select steps of the proposed method, and the application of this model in a real situation.

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Modeling Architecture and Reference Models for the ERP5 Project

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Abstract. The adoption of ERPs systems by small and middle-sized companies may not be possible due to their cost. At the same time, when adapting ERP to the company's particular needs, the user keeps depending on the system's sellers due to the lack of access and knowledge of the respective code. Free and open-source software may promote advantages to the enterprises, however, for its adoption it is necessary the development of techniques and tools in order to facilitate its deployment and code maintenance. This article emphasizes the importance of defining modeling architectures and reference models for the development and maintenance of open-source ERPs, in special the ERP5 project.

1 Introduction

Nowadays, the market is more and more competitive, thus the companies must react in order to follow customers demands. For the companies to organize their resources and obtain better planning to their production processes, one of the options is the deployment of ERP (Enterprise Resource Planning) systems [1, 2]. However, the price of these systems may be an obstacle for small and medium-sized enterprises (SME) willing to obtain such systems.

The adaptation of ERP modules according to the characteristics of each company may also become important to its competitiveness, but the closed systems make the

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companies depend on the payment of such services to the system owner-developers. Open source and free software might be an alternative to the SME in order to cut down expenses. Another advantage is the possibility of the software adaptation, allowing for the users to adjust system processes or modules to the reality of their company by means of altering the source code, without being dependent on the owner-developers of proprietary codes. However, it is somewhat difficult to adapt these ERPs, regarding the modification of these codes and the deployment of the systems in an enterprise.

The analysis and documentation of the business and software requirements by means of models are essential for the open source ERPs development, making necessary the use of proper techniques and tools. In this sense, a modeling architecture that properly contemplates the modeling of all aspects of the business processes, including the other aspects related to the software development, can facilitate the reuse, better functionality, better performance, and the better system understanding, avoiding waste of efforts and resources [3, 4]. In the case of free/open source ERP systems the advantage of free code modification can be jeopardized by the lack of references from where specializations of this code can be derived.

This matter is being dealt on the ERP5 project [1]. One of the proposals is the utilization of modeling architecture and reference models, since the documentation and good understanding of business processes and information flow, are essential to facilitate the definition of the enterprise's particular requirements and for the maintenance of the associated codes [5-7].

This paper aims to highlight the need for the definition of a modeling architecture and reference models in order to facilitate the code generation and maintenance of open-source ERPs. Thus, after this introduction, the ERP5 project is briefly presented, and then some comments are made on modeling architectures and reference models

2 ERP5

The ERP5 project [4] is a free-code ERP project which aims at offering a high technology solution at low cost for SMEs. This system uses the open source Zope platform and it is object, workflow and Web based.

The ERP5 architecture incorporates advanced concepts since its inception, such an object database, a content management system, and data synchronization among different sites. It also contains a clear method for process modeling, and consequently, for source code generation. The ERP5 defines an abstract model to business management based on five categories [4]:

- Resource: describes an abstract resource in a given business process (such as individual skills, products, machines etc). Material lists, as well as prototypes are defined by the relationship between the nodes.

- Node: receive and send resources. They can be related to physical entities (such as industrial facilities) or abstract (such as a bank account). Metanodes are nodes containing other nodes, such as companies.

- Movement: describes a movement of resources among nodes, in a given moment and for a given period of time. For example, such movement can be the shipping of raw material from the warehouse to the factory.

- Path: describes how a node accesses needful resources. Paths are abstract and used for planning. Movements are realizations of paths.

- Item: a physical instance of a resource.

ERP5 is based on a model that can connect anything to a category. Some examples include a resource category (such as services, raw material, skills or money) or a company category (such as a group of companies, a group of people or retail chain stores).

3 Modeling Architecture and Reference Models

Vernadat [6] defines the word "model" as an abstraction of the reality expressed by some formalism defined by a modeling method based on the user's objective. Enterprise modeling is related to the following matters: what (it refers to the operations and objects processed by the company), how (it refers to the manner how things are made), when (it provides a notion of time and is connected to the events representing changes in the state of the enterprise), how much (for example, the economic aspects), who (it refers to the human or machine resources or agents) and where (logistic aspects, for example).

Enterprise modeling [8,9] allows not only a better understanding of the company's requirements which will interfere in the systems, but also the identification of alternatives for the several enterprise processes, reducing efforts during information systems development and allowing a better integration between the system development processes [10,11]. For Scheer [5, 6], reference models can be developed in real or theoretical situations, and they document the know-how of a process that can be used by other people. For Keller and Teufell [2] the reference models can be applied to accumulate experience in some type of business or for business process solutions implemented and performed by a management information system, for example.

In the CIMOSA (Computer Integrated Manufacturing Open System Architecture) modeling framework two parts are considered [3, 12]: (i) a particular architecture and (ii) a reference architecture. Particular architecture is a set of models documenting the business environment. Reference architecture is used to help the business users in the construction process of their own particular architecture as a set of models describing the several aspects of the enterprise in different levels of modeling (model instantiation principle). The reference architecture is separated in two layers: a generic layer providing generic construction blocks (related to the modeling language) and a layer of partial models consisting of a library of classified and reusable partial models for some industrial sector, that is, models that can be adapted to company's specific needs.

In addition to the models Instantiation Principle, the CIMOSA modeling framework has the Derivation and Generation principles.

The Derivation principle models the enterprise according to three successive modeling levels (iterations among these levels are, of course, allowed):

a) requirements definition, in order to express the business needs as realized by the users;

b) specification design, in order to build a formal, conceptual and executable model of the enterprise system (time is considered);

c) description implementation, in order to document implantation details, installed resources, exception management mechanisms and to consider non-deterministic systems.

The Generation principle, which recommends the modeling of the enterprise according to the four basic and complementary viewpoints (other views can be defined):

a) the view of function, which represents the functionality and the enterprise behavior (that is, events, activities and processes) including time aspects and exception management;

b) the view of information, which represents enterprise objects and its information elements;

c) the view of resources, which represents the enterprise means, capacities and management;

d) the view of enterprise, which represents organizational levels, authorities and responsibilities.

As described, modeling architecture and reference models aim to facilitate the work of modeling and to provide a common understanding about the company's systems. A modeling language for the description of the models is needed.

Actually in the ERP5 project, reference models to a Production Planning and Control module are being currently developed using the Unified Modeling Language (UML) [24]. The UML (Unified Modeling Language) is a graphical language for specification, design, visualization and documentation of a software system [11, 13]. The UML 2.0 defines thirteen types of diagrams, divided into three categories, representing different aspects of interactions. The main objective of the UML is to define a visual and expressive modeling language, providing easy visualization, that is, the full understanding of the functions of a system from diagrams representing it. In the communication, the development team's communication is unified and facilitated through the diagrams. From the UML reference models it will be possible to generate code to create a generic system module with generic characteristics. These reference models will be utilized to the system documentation. Then, users will customize the reference models to define the particular models considering the requirements of enterprises. This facilitates the development of particular codes.

4 Final Considerations

An ERP system can help companies in the search for competitiveness, but it is difficult to be adopted by some companies because of the high purchasing cost and the dependence of the developers for possible system adaptations, due to the lack of knowledge and lack of access to its code documentation and models.

Free and open-source ERP systems can be a good alternative. To be adopted, it is necessary to develop and use techniques and tools which facilitate the development and maintenance of such software. Modeling architecture and reference models are essential to make possible the development, implementation and maintenance of the open-source ERPs. To define a modeling architecture for the ERP5 project, the use of the CIMOSA modeling framework concepts and the architecture proposed by Eriksson and Penker [11] is being studied.

The reference models for the ERP5 system modules shall be created to document the possible generic processes and related information, which may be used as base for adaptations (or particularizations) by means of new codes. In the ERP5 Project the UML language was adopted because are worldwide accepted and used, becoming a *de facto* standard language, facilitating the diffusion of models and codes.

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Open Source Software Migration in Integrated Information Systems in Public Sector

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Abstract. This paper reports about a study on the introduction of Open Source Software (OSS) in a Public Administration located in Europe. The Public Administration examined has introduced OSS as a means to save on the license costs and to have a larger space for customisation purposes. The adoption of new software may have an impact on the employees' productivity that need to be addressed. In this article, we compare the usage of OpenOffice.org and Microsoft Office. Data about the usual office activities performed by the users participating to the experimentation have been collected by means of an automated non-invasive data collection tool. The result of this study reports a similar usage pattern of both suites in terms of workload, but a different approach in using functionalities provided by each software. A further analysis on the life cycles of documents elaborated with the office suites seems to validate the similarities among the software solutions examined.

1 Introduction

The introduction of Open Source Software (OSS) in substitution or in parallel with Closed Source Software (CSS) is an argument that acquired recently great relevance. The proposed savings in terms of license costs and the broader opportunities for software customisation are arguments that interest particularly private and public companies. There are many studies and market researches on the convenience of the migration that privilege one of the two solutions, depending mainly of the factor of cost considered [1]. A complete migration is not an easy step, especially in working environments where the interdependencies and the vertical integration is a key issue

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[2]. Supporters of OSS also stress the importance to avoid the realisation of phenomena of lock-ins, situations in which a company commits itself to a single supplier or single data format [2, 3]. There are cases of successful migrations, like the city of Calgary in Canada [4] or the region of Extremadura in Spain [5]. But there are also cases of unsuccessful deployment, like the city of Nürnmberg [6] or delays and over expenditures like the case of the city of Munich [7], both cases in Germany. The case study discussed in this paper concerns a European Public Administration. For two months a successful migration to OSS on the desktop side has been monitored. The analysis reported has focused on the software for office automation. The contribution to the field of this study is an evaluation of the similarities and differences in usage patterns of OpenOffice.org and Microsoft Office. This can shed some light on the effect of a transition on the routine of the office work in a PA.

2 The Study

2.1 Study description

The study has been based on the data collected from a Public Administration in Europe during a migration to the OpenOffice.org suite. This office automation suite offers similar functionalities as the ones offered by Microsoft Office. It is composed by a word-processor, spreadsheet software, presentation software and a drawing tool. The Public Administration (PA) examined has been adopting OSS for some time; the analysis we report refers to a situation, where the proprietary and open solution coexisted in the working environment. To monitor the time spent on different solutions, data have been collected with the aid of the PROM software [8]. With a non-invasive impact, the software gives the opportunity to register for every document the time spent, the name of the document and the functions used. This last feature is at the moment still limited, but can give useful insights of the different patterns of usage between the two solutions. The monitoring of users as we report in this paper has been performed during 2 months with both solutions installed in parallel. 100 users have been involved in the experimentation.

2.2 Dataset distribution

To have an idea of the evolving situation during the first two months of the experimentation, we can see in Figure 1 the comparison between Microsoft Office and OpenOffice.org usage. The figure refers to the average number of documents worked by all users on a specific day. As these numbers seem to report the daily averages are very similar (σOOo=1,6 ; avgOOo=4,42; minOOo=1, maxOOo=6,82; σMSO=1,6 ; avgMSO=4,2 minMSO=1,5, maxMSO=8,5).

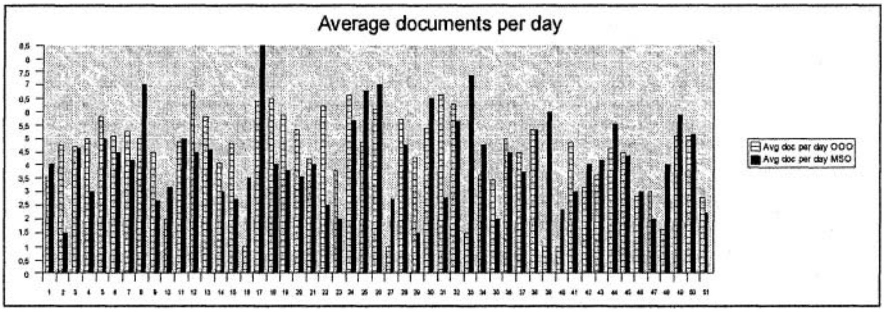

Fig. 1. Average number of OpenOffice.org documents per day (outlined) and MS Office documents per day (in black).

In Figure 2 the total daily number of documents per solution is reported. This is the global sum of all the documents handled daily by all users participating to the experimentation.

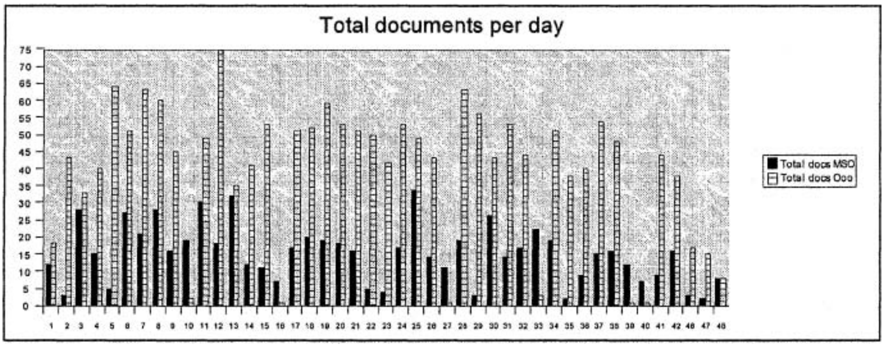

Fig. 2. Total OpenOffice.org documents per day (outlined) and MS Office documents per day (in black).

From this table can be derived that more users are in fact adopting the open solution. At the end of the period considered, the documents handled with OpenOffice.org have been 4.032 against 1.206 opened with Microsoft Office. This to justify that the migration examined is already in a mature state, in which the new technology introduced is taking over the old one.

The purpose of these figures is to give an idea of the existing situation in the PA that is the focus of our study.

2.3 Functions used

In this section we report the functionalities used on the different suites, divided per software. At the moment, the version of the software used for the data collection does not allow a more fine-grained analysis. In Table 1 the total numbers of functions adopted during the study. These were selected being the most representative one.

Table 1. Total functions used according to application type

	Microsoft Office	OpenOffice.org
Open	145	1038
Save As	205	1321
Print	170	1109
Spelling	178	578
Insert table	2	43
Find and replace	7	39

In Table 2, the same functions are reported, this time normalised with the number of documents handled per solution.

Table 2. Total functions weighted per document handled

	Microsoft Office	OpenOffice.org
Open	0.15	0.24
Save As	0.21	0.31
Print	0.18	0.26
Spelling	0.18	0.13
Insert table	0.00	0.01
Find and replace	0.01	0.01

The impact of activities like inserting tables and finding and replacing words seem very low in both solutions. We could not trace keyboard shortcuts, so the analysis in this sense is limited. In general the usage pattern of OpenOffice.org seems different, with more actions performed, like opening documents, saving and printing. Spelling instead had a higher impact in Microsoft Office than in OpenOffice.org.

2.4 Documents life cycle

To deepen the analysis of the differences between the two solutions, we derived a concept similar to the one of Product Life Cycle (PLC), in our case applied to documents. The concept of Product Life Cycle was first introduced by Theodore Levitt in 1965 [9]. Typical stages in a product life cycle are: Introduction, Growth, Maturity and Decline. There are many different variations of the Product Life Cycle model that differ mainly in the names used to describe the different stages and the purpose of the underlying analysis. A similar model has been used to study the diffusion of new technology [10]. In Figure 3 a typical product life cycle is depicted, together with the different phases of maturity.

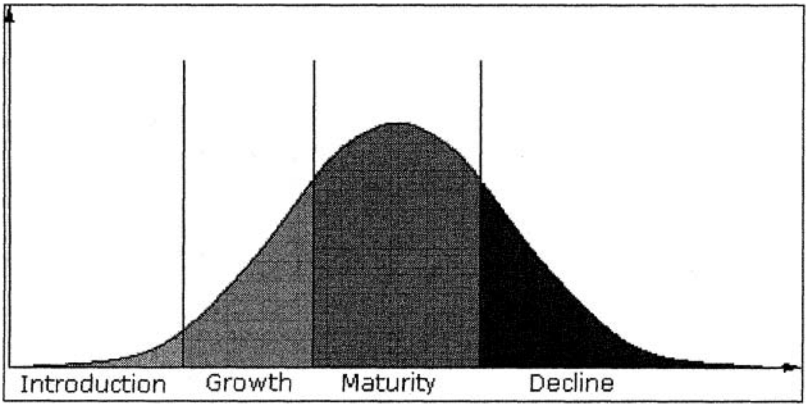

Fig. 3. A typical product life cycle, with four phases of maturity (Introduction, Growth, Maturity, Decline).

- The Introduction phase is where the product is introduced on the market; in this phase marketing has the strongest importance than in other phases.
- The Growth phase is where the increase in sales supported by marketing becomes considerable.
- In the Maturity phase the sales are stabilised and the speed of increase of sales is slowly reduced until it begins to become negative.
- In the Decline phase, the product is no more attractive to possible customers that may prefer a more technological concurrent product.

In the Product Life Cycle, the duration of each phase may be different between different products, as the adoption curve may have a different aspect.

We decided to model the DLC as a measure of software usage to further discover existing analogies between CSS and OSS. Following an analogy with PLC, we considered the life of a single document, as composed from different phases: its creation phase that starts with the generation of the underlying file, the growth phase where the document usage increases, the maturity where the usage reaches maximum levels and the decline phase, when the document's usage begins to decrement to the complete halt. To perform this task we analysed all 5.238 documents and divided them in two groups, the ones handled with OpenOffice.org and the ones handled with Microsoft Office. Subsequently, we reported the life of each document into the PLC model framework. The last step was to analyse the distribution of the derived

DLCs. In Table 3 we report the results obtained. The average length of the documents is very similar in a comparison between both solutions.

Table 3. Comparison of DLC of all documents, the scale is in days. Averages marked with a * have been obtained by excluding documents with a life cycle of one day

Application	Avg DLC length	St. Dev.	Avg DLC length*	Max DLC length
Microsoft Office	1.83	3.45	4.64	51
OpenOffice.org	1.78	3.74	4.06	46
All documents	1.82	3.47	4.11	51

As we should expect, the results of the DLC analysis are comparable, the difference between the two software solutions are minimal. As a side note, we discovered that only 25% of all documents have a life cycle greater than one day.

3 Conclusions

While the study is still limited, we are getting a clearer picture on the interactions of users with their desktop software. The study reported refers to a Public Administration where OSS has already been adopted in parallel with the closed solution for some time. In this sense we are in a more mature moment during the technology adoption, not the early phases of a complete migration. The next step would be the complete adoption of OSS for office automation, if the feasibility study performed show favourable. The results of our analysis show that proprietary and open solution can coexist on the working environment on the desktop side. Also the average number of documents per day seems comparable. Focusing on the functions used, some activities seem to be more adopted by users with the open solution than the closed one. During our study, some function we thought at first important were rarely used. A more fine-grained analysis will be possible with more accurate software for data collection, collecting more measures necessary to evaluate fully all the functions used. The analysis and evolution of the documents' life cycle, a concept borrowed from economics, seem also to justify the strong similarities between the two solutions offered.

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Analysis of M-Commerce in China

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Extended Abstract: With the development of mobile service, more and more M-commerce applications have been adopted in China. The government also encourages this trend, as presented in its policies. In this paper, four major business model of M-commerce will be introduced to analyze the applications in China. These four models are B-B-E (Employee), B-B-M (Machine), B-B-P (Promotion), B-B-C (Consumer). Examples of each model will be presented after the definition of each model.

The first model is B-B-E. The first B refers to mobile operator, the second B refers to enterprise or government, the E means employees of the enterprise or government. In this model, a wireless connection is an obvious prerequisite for employees to gain access to their enterprise applications. Wireless connectivity can be enabled through a wide range of technologies, such as smart-phone and PDA using standard mobile data networks (currently China Mobile's GPRS and China Unicom's CDMA1X), PC data cards etc. Once connected, enterprise employees can access the internet, the company intranet or take advantage of mobile data solutions that may be integrated with their enterprise systems. For B-B-E model, the most famous application in China is in the government sector, originally from Beijing East District Government. With the B-B-E solution, government staffs with mobile device support were sent to the street to report problem and interact with citizens, which significantly improve the efficiency. The solution is based on two management centers, connecting with nearly 400 municipal asset management staffs. With GIS system, the district area will be divided into 100m*100 m square grid with specified numbered municipal assets. The municipal asset management staffs will use the mobile device (also has GPS function) to go around the grids to report, interact with citizens, and solve the asset problems.

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The second model is B-B-M. The first B refers to mobile operator, the second B refers to enterprise or government, the M means machine of the enterprise or government. This model is an example of remote asset monitoring often used in some industries such as vehicle and retail. In this model, a combination of wireless connection and information collection technologies is built into the machines, which allow the enterprise or government to know the real time status information of their widespread machines. In the future, with the development of RFID technologies, the model can be extended to product monitoring market. In recent years, electronic usage in China, especially in eastern area such as Guangdong province are increasing rapidly, but the supply capacity can not meet these increase easily. So in 2005, Guangdong Electronic Utility Management Bureau introduced one B-B-M solution to collect customer electronic real time usage information, which can be used to balance the gap between requirement and capacity. When the total electronic utility reaches some specified level, the Bureau will sent SMS (Short Message) to the customers which has use more electronic than specified or electronic un-sensitive enterprises to reduce their usage as soon as possible, so the total utility will return to normal level.

The third model is B-B-C. The first B refers to mobile operator, the second B refers to enterprise or government, the C means the customers of the second B, which can be consumer and enterprises. The major difference between this model and the former model is that the wireless connection has extended outside the enterprise. In this model, the enterprise which has public information such as Meteorological Agency will allow their customers to get their information through wireless connections provided by mobile operators. The customers must pay to mobile operator to get the information, the mobile will payback some of this information income to the enterprises which own the information. Now, the most popular B-B-C model application is in the meteorological area. Because the meteorological information is useful for all customers, the customers are willing to pay some money to get the information through mobile network easily.

The last model is B-B-P. The first B refers to mobile operator, the second B refers to enterprise or government, the P means promotion. In this model, the enterprise will use the wireless connections to extend their current CRM (Customer Relationship Management) and SCM (Supply Chain Management) system, allowing their customers or supplies to access their CRM and SCM system through wireless connections provided by mobile operators. In this model, the customers and supplies are free of charge to get the information provided by the enterprise or government. This model is different from B-B-C model in the payment mechanism. For example, in recent months, there are more and more finance fraud cases (use mobile short message) in China. But only one bank named China Merchants Bank don not report one case, just because it has used one B-B-P solution to completely avoid the fraud.

The most promising model is B-B-C, because of its huge customer base and potential income. So the mobile operators must first figure out which enterprise or government customer has the unique information, and build the cooperation model as soon as possible. The B-B-P model is more difficult because the free charge mechanism.

The B-B-M model is also the next trend. With the upcoming of 3G and IP V6 technologies, this model will extend to every good, such as products and animals.

The B-B-E model is the traditional one, which is focusing on in-house application. The future of this model is the extension of current IT system to mobile technologies.

In conclusion, the M-commerce has the potential to become an important source of high-margin revenues for China operators. To achieve these growth opportunities, the operators should have well-defined strategy, the right partnerships and the internal capabilities required for success in this emerging but rapidly growing market segment.

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Free/Open Source ERP and Translation Processes: Four Empirical Cases

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Abstract. Can ERP be studied from the point of view of Science and Technology Studies? What kind of insights this approach can bring to the comprehension of the phenomenon? These are the questions we are trying to answer with this paper. In the Information Systems field, ERP have been studied according to three main approaches: ethnomethodology, phenomenology, and deconstructivism. We show how these accounts are not able to describe ERP as complex artifacts.

We suggest that an actor – network theory approach, without making a priori assumptions about the role that technology, society, politics and economics can enact, is a powerful theoretical instrument in the study of ERP. Drawing from a comparative analysis of four systems (Compiere, Erp5, GNUe and Open for Business), we show how the choice of a free/open source license was made according to different goals, and entered in the translation processes taking place in the ERP development; shaping communities, customers and developers.

In conclusion, we believe that our approach can be fruitfully applied to the study of other topics connected to ERP, such as accountability, thanks to its ability to show how the different aspects are relationally shaped.

1 Introduction

ERP systems are complex artifacts with technological, social, political, and economical aspects. Our aim with this paper is to suggest how a research based on

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the Science and Technology Study (STS, [1]) approach can bring to new insights about Free/Open Source ERP. Our work is based on a comparative case study.

In the first part of this paper we will discuss the theoretical approaches generally adopted in the analysis of ERP. We argue that the ethnomethodological approach, the phenomenological one and the deconstructivist one, are not able to give descriptions of the phenomenon useful in order to understand the relationships between the technical, social, political and economical aspects. We suggest that the sociology of translation [2], lately known as actor – network theory [3, 4], is a powerful theoretical instrument, capable of tracing the relationships taking place when studying ERP. This theoretical approach is based on a symmetrical point of view, not assuming *a priori* distinction in the construction of technology between the human and non – human elements.

In the second part, we will approach the study of four cases: Compiere*, Erp5+, GnuEnterprise (GNUe)/ and Open for Business (OfBiz)-. In this analysis, we will focus on the websites of these projects, showing how the common element, the choice of a software license, is relationally connected with every aspect of an ERP. The analysis will be done in accordance to the translation process described by Callon [2] We will stress the relational interdefinition taking place when the aim of the developers of the ERPs studied brings to the adoption of Free/Open Source licenses. In addiction we also discuss the capability of these artifacts to act in translating communities, potential customers, business partners and source code, in other words their *agency*. To this end, before the case descriptions, we discuss the views of the world inscribed in the licenses adopted.

In the last part of the paper, we will compare the results of the case analyses, drawing a first picture of the potential of STS descriptions in the study of Free/Open Source ERP.

2 The Limits of Previous Approaches

Among Information System scholars, we can identify three perspectives on studying ERP: ethnomethodology, phenomenology, and deconstructivism. Even though we are limited by space constraints in the discussion of these rich research traditions, we will try to briefly highlight what are, in our view, their limitations in capturing the complexity of the phenomena connected to Free/Open Source ERP.

The ethnomethodological approach has its foundation in the work of Garfinkel [5] and was brought to the field of Computer Science and Information Systems by Suchman [6]. The central node in this approach is the link between representations of action contained in a culture - and interpreted by the traditional sociology as a guide

* http://www.compiere.org

\+ http://www.erp5.org

/ http://www.gnuenterprise.org

\- http://www.ofbiz.org

for human action - and the methods by which members construct locally the reality. The cultural tendency to isolate human membership from non-humans membership (e.g. the tools in use in a situation), brings to the consequence that ethnomethodology cannot recognize the ordering capabilities of tools.

To understand how the phenomenological approach has been brought to the Information System field, we have to refer to Schutz writings [7]. In particular, when he concentrates on the relationship between daily life and the world of scientific contemplation. To clarify this relation he coins the term "finite provinces of meaning". Each province of meaning is characterized by a specific cognitive style. All the experiences inside a province of meaning are per se coherent with the cognitive style and compatible to each other. But what it is more important is the concept of 'finity' of any sub-world that clarifies its relation with the others. Each province is finite because there isn't the possibility to refer one province to another via transformation formulae but only with a leap, due to a trauma. Within this approach it is also hard to grasp the interaction between social, technical, economical, and political aspects of ERP.

For deconstructivist perspective we mean a research approach addressed to unveil concepts, assumptions, and implications inscribed in artifacts and representations by their designers or engineers. Such perspective was initiated by the philosopher Langdon Winner [8] that in his essay entitled "Do artifacts have politics?" underlines how technologies aren't neutral, but might irreversibly embody forms of oppression. Winner's argument is that tangible artifacts (including architectural space and other material and spatial devices) embody social relations (that is forms of power). Deconstructionism has been drawn into the Information Systems field by Star [9]. In this perspective the situated mediations of inscriptions are underestimated, it seems that technology is bad in itself. If we maintain that a technology is value-laden in itself, it is hard to study how the social factors interact with it, not to speak of the economical and political issues.

On the other end, a description in terms of translation processes seems able to overcome the limits of the above discussed approaches, not taking a priori assumptions about the mutual shaping of human and non – human elements [10]. The process of translation is both the movement of an entity in space and time, as well as its displacement from one context to another, with the necessary transformations of meanings that this always implies. Translations don't take place in one point in time, but are recursively generated and reproduced thanks to maneuvers and strategies of human and non – human actors. Michel Callon [2] identifies a recurrent pattern, consisting of typical phases, problematization, interessement, enrolment and mobilization. This pattern shapes our methodology for empirical research. Our theoretical discussion is valuable for both proprietary ERPs and Free/Open Source ones. A distinctive characteristic of the Free/Open Source software is the different conception of copyright, inscribed in the legal artifact connected to that: the license. For that reason, we will now present a brief analysis of the GNU GPL license, to which the licenses associated with our cases will be connected.

3 A (short) Actor – Network Theory of the GNU GPL 2.0[#]

In an actor-network perspective licenses should be considered as actor/actant inside the process of software's construction. Furthermore, according to Lanzara and Morner [11] licenses results from the inscription and translation in legal form of some programmers habitus [12], such as the practice of share information and software programs. We need then to briefly outline what is inscribed in the ERP licenses and what is translated by them.

Along this line of reasoning in different licenses we can find inscribed some different “weltanschaung”/view of the world, coming from different practices of sharing computer programs. Both in Free Software and in Open Source licenses seems to be inscribed the programmers' habitus of sharing programs, but differences among licenses describe and reflect different ways in which this habitus give shape to what software and users are. In this paragraph we will shortly describe the GNU GPL 2.0 license.

In our view when applied to software, this license would act as a separator between what are considered “good” and “dangerous” actors from the Free Software Foundation (FSF) point of view. The GPL preamble considers dangerous actors: (a) most part of software licenses; (b) software patents and (c) people which deny the Free Software rights. For the FSF, all the dangerous entities/actors would define the software as proprietary (not Free) and the users as not free to change and share the software. Also most of the Open Source Licenses should be considered as “dangerous” in this sense: they allow for example to release modified software under proprietary licenses. The GPL will cut then the link between software and users (good actors) from one side and the various dangerous entities from the other.

In actor – network theory terms this act of separation is the *interessement* and the artifacts used for achieve the separation are called *devices of interessement.* Thorough the interessement a stronger inter-definition of the good entities (users and software) is achieved. The well known copyleft term (2b) well explain the interessement: "You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License" [13]. By means of term (2b), the GPL ensures that licenses which clashes with the Free Software rights (the so called “Most part of Software licenses”) are detached from Free Software. The following scheme summarizes how the GPL acts in general as a *device of interessement.*

[#] For a complete analysis, see De Paoli [14].

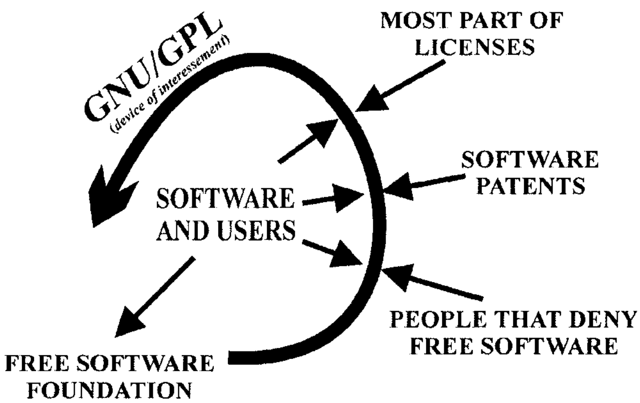

Fig. 1. The GNU/GPL applied to a generic software act as a device of interessement [14].

4 Methodology

As anticipated, our study draws from a preliminary analysis of four Free/Open Source ERPs: Compiere, Erp5, GnuEnterprise and OfBiz. They are the result of a reasoned sampling, with the aim to describe successful projects, with different goals and organizations behind them.

In order to be faithful to the ethnographic principle to "listen carefully to the natives" [15] we based our descriptions on what is publicly expressed in the projects websites, trying to give a "thick description" [16] of the translation process taking place, from the point of view of the organizations behind the projects, in a "natural documents" analysis [17]. This methodological choice is justified by the fact that our study is a preliminary one.

5 Four Empirical Cases

5.1 Compiere: choosing Open Source to gain the market leadership

The first case we present is that of Compiere, a mature project, started in 2000, with a declared goal: "we don't want to be just another ERP/CRM system for some niche industry. We want to become a primary horizontal ERP and CRM solution for small – medium enterprises". In a translation description, the declared aim of the protagonist is relevant in order to give an interpretation of what happens. In this case the protagonist is Compiere, Inc., a profit – oriented company founded by Jorg Janke, the beginner of the project (with the help of Goodyear Germany). The choice of an open source license, the Compiere Public License, based on the Mozilla Public License 1.1*, is motivated by the necessity to create a space in a saturated market, with the combination of two factors: reduced total cost of ownership and the development guidance by customers and partners.

If we try to discuss the Compiere case with the concept of translation, we can say some words about the different phases. In the problematization, defined as the phase of the interdefinition of the actors and the definition of an obligatory passage point (OPP), we can see how the involvement of Goodyear Germany act in the definition of Jorg Janke as a skilled programmer, how the use of the term open source recall the open source movement (and not the free software one, [18]), how the customers are searching money savings and quality product and how the partners are considered technical skilled entrepreneurs.

During the interdefinition of actors, Compiere Inc. tries also to define the interests of the potential customers, partners and developers, showing how it will be an obligatory passage point in the gain of the expected result, mainly through the use of the license as a device of interessement. In this case it is interesting to note how the incompatibility between the MPL and the GPL is overcome with a provision (section 13) that allows a program (or parts of it) to offer a choice of another license as well. On the Compiere licenses' web pages this point is specified in relation to the GPL: "if you use any product with a GPL license with Compiere [...] the Compiere (Mozilla) license terms do not apply [...] you need to comply with GPL terms". In this way it becomes possible to use Compiere with GPL software: the CPL does not apply at all and the users have to comply with the GPL. So, the license chosen act in the reshaping of the community directly involved in the project: the free software movement is not excluded, as well as proprietary developers (because of some restrictions on the appliance of the copyleft in the MPL). The open source choice is connected to: economical characteristics, as well as the absence of licenses costs and the fall down of the total cost of ownership; technical characteristics, the code is considered of high quality and with low cost of maintenance; political characteristics, as the opportunity to see the code and to trust Compiere ("no lies no surprises") and social characteristics, like the existence of a community surrounding the project.

The presence of a device of interessement doesn't warrant for the stabilization of Compiere like a recognized leader in the ERP industry. The enrolment, the definition and coordination of roles, is the successful completion of the interessement: the customers accept the role of Compiere, as well as the partner and the open source community. When the enrolment has taken place, the seduction of potential new actors in the actor – network of Compiere can take place (and the website is one of the instrument).

The success of a translation process is achieved when the mobilization takes place. During the mobilization, entities which were static become mobile, dispersed elements become enrolled ones. In this case, the website is an example: the listed partners, successful customers, the open source community, the websites and

* http://www.mozilla.org/MPL

magazines talking about Compiere, are mobilized by the company, speaking for them in front of the potential new actors in the network. If they will refuse their consensus to Compiere in the future, the entire project will be in peril.

As shown, the choice of an open source license, justified with the aim of entering successfully a saturated market, shapes the actors involved, their interests, and their role, in a relational way involving the open source high quality image, cost – saving aspects and political transparency.

5.2 Erp5: choosing Libre Software to create a common knowledge

In 2002 one of the French apparel leaders, Coramy, decided to abandon its in-house developed ERP solution to embrace the Free Software development model, with the aim "to reduce software maintenance costs and to allow Coramy to retain complete control over its custom developments, something that would have been impossible with standard proprietary ERP solutions." In order to do this, it chose to start a partnership with Nexedi, a Zope based solutions provider: the result was the birth of the Erp5 project. The license chosen is the GNU GPL, and the protagonist we are following is mainly Nexedi. The declared goal of the project is "developing Free ERP Software and creating a common knowledge base on ERP technologies and methodologies."

Reading the Erp5 case with an actor – network perspective leads us to reconsideration both of the project and of the Libre Software development characteristics. During the problematization, the actors defined are Coramy, the products, the others ERP solutions, potential customers and partners. The definition of Nexedi like a technical qualified actor, connected to the strategic reasons of companies interested in becoming customers, is similar to that of Compiere. The very interesting thing in this phase is that others Free/Open Source ERP solutions are considered, for example Compiere, and the contribution to a reshaping of the characteristics of a Free/Open Source ERP, not only as a technical object, but also as a documentation needed, in order to allow a clear distinction between Free/Open Source software and proprietary one: "Without any documentation on the Compiere model, there was no way for us to evaluate this risk. [...] Free ERP software requires extensive and free documentation on all the aspects of ERP: technical, juridical and theoretical." In this case, the device of interessement is not only the license, but also the project website, with a great amount of documentation and underlining the role of Nexedi, the obligatory passage point for whom want to have not only an installation of Erp5, but also simplified access to knowledge related to the product.

In this process of translation, the role of Nexedi is that of the mediator between different needs and roles, that of Coramy, interested in being recognized as the main customer of the project, that of the others potential customers, interested both in a quality product and in access to a knowledge base, that of the others Free/Open Source ERP solutions, missing documentation. The role of Nexedi as spokesperson for that actor – network can be put in discussion by these actors, but now it seems successful.

5.3 GNU Enterprise: bringing freedom to enterprises

In 1999, the maintainers of the Obelisk project and GNU G/L, a Free Software Foundation project, merged the projects, giving birth to GNU Enterprise (GNUe). In 2000 the merge with the Sanity project gave birth to the current incarnation of GNUe, GPLed software, based on volunteer contributions, with the declared goal "to develop enterprise-class data-aware applications as Free Software". It is a set of tools, at a stable level, and packages, at a planning level.

In the interdefinition of actors, the very interesting thing is the absence of the terms customers and clients. The actors involved are: the GNU project, the code, enterprises and the community. The first one is recognized as the entire work of which GNUe is part, the second is characterized by its being Free and of high quality, enterprises want to be vendor independent, the community of developers is high skilled and it wants to contribute to the GNU project.

The license act as a device of interessement with its warranty of accomplishment of the interests of the actors. In this case we want to underline that the GNU GPL is the witness, as well as the website, of the involvement of GNUe in the GNU project, so the concepts expressed before about the license can be connected to GNUe. The same thing can be said looking at the project like one enrolled in the actor – network of the Free Software Foundation. The success of the project can not be evaluated, mainly because of the planning status of a large portion of the work.

5.4 Open for Business: choosing Open Source to develop high quality software

Open for Business (OfBiz) is a suite of business applications and a framework for developing such applications founded by Jones and Zeneski, born with the aim "to develop high quality open source enterprise software", in a "community oriented" way. The license chosen is the MIT license. This is a simple non-copyleft license and is considered compatible with the GPL [13] and it allows the covered code to be used in proprietary software and do not require the distribution of Open Source version of the code.

The original developers are defined as skilled software engineers and architects, but for reaching the project goal, other competences are required, like accounting, sales and marketing. So the idea that other participants to the community life will bring these expertise, are they end user, services organizations or people who simply want to contribute. The community is defined in the characteristics of its members, the original developers are defined as leaders, the potential customers interests appears like a mix between in-house build or off-the-shelf buy, other companies can build their business on that, the code is based on adequate data models, the license is characterized as being "more open" than the GPL, as well as the development methodology started from a research of public standards disposable, the open source movement is changing irreversibly the way in which software is developed. Open for Business collects these interests and facilitate their satisfaction.

The use of the license act as a device of interessement, because it is considered able to allow the actors to reach their interests: customizations, low costs, transparency about the data model used, as well as the contribution of the project to the changes carried on by the open source community are elements protected by the license. The terms of the license, briefly discussed above, don't exclude GPLed software or proprietary one, making the involvement of other organizations more unstable. Another device of interessement is needed, for fixing the role of other companies: this is the creation of lists of Certified Affiliates, which lock customers, pulled to choose one of these companies for buying services, and the affiliates themselves, who recognize the leadership of the OfBiz project in strategic fields of their business. So the enrolment has taken place, and the mobilization is going on through the Open for Business website.

6 Conclusions: Different Translation Processes, Free/Open Source Licenses and Accountability

In this paper we focused on the translation processes enacted by four different Free/Open Source ERP projects, mainly to show how the choice of the license is connected to different goals, actors and strategies. The Free/Open Source ERP analysed appear to be part of networks of interconnected interests, like these of the developers, the customers, the partners, the Free Software community and the Open Source community. The choice of one particular license is a tool to interest and enroll actors, as well as it is a carrier of different views of the world, but its choice depends on the different interests of the individuals or organizations who launched the project. In our theoretical framework, the licenses appear able to enter these relational networks, contribute to the actor's definition and mobilizations, shaping the different meanings community, customers or partners have. The relevance of these networks of interconnected interests is shown, for example, by the research on accountability, studied in an historical period characterized by the transition from a "state manager" to a "regulatory state" [19].

Accountability is one of the main topic in ERP studies, and its conception is changing from a community related one, to a located one [20] involving responsibility in front of a public wider than the single community, that is in front of the society. The study of the relation between different accounts of ERP, as well as of different processes taking place contemporary to their development, shaping different actors, shows how the contribution by Free/Open Source ERP to the "accountability in a computerized society" [21] cannot be considered only in a technical way. This study can also bring to a reshaping of the concept of accountability, for example in the direction of understanding "how can this error be used to improve similar systems in order to improve the welfare of society?" [22].

We believe that more research following (and shaping) this theoretical framework can help to gain a deeper comprehension of the economical, political, technological, and social aspects of Free/Open Source ERP, the success of their translation processes and their consequences.

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The Implication of Dissipative Structure Theory to Enterprise Information System

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Abstract: This paper uses the dissipative structure theory to generate fresh insights that may help enterprises better understand and manage the EIS, Because the EIS fundamental structure embodies many characteristics of dissipative system which balance 'chaos' with 'order', the paper analyzes EIS under the non-equilibrium management entropy model and points out the importance of introducing negative entropy into the EIS for the first time. Two suggestion of building extended EIS and component-based system was made for the future developments of EIS.

1 Introduction

Enterprise Information System is fundamentally a software system responsible for the organizational and technological integration of a firm (Al-Mashari [1]; Davenport [3]; Loonam and McDonagh [10]). They are also referred to as ERP, EWIS and ES. Davenport [3] believes that an EIS should be defined by its ability to "seamlessly" integrate business processes and information flows up and down. Most research works and commercial products, however, are lack of the architectural integrity and functional applicability to meet these sophisticated needs of enterprises (Choi, [9]).According research conducted by the Standish Group International shows that 40 percent of all EIS installations achieved only partial implementation; nearly 28 percent were scrapped as total failures; and only 25 percent were completed on time and within budget. None of the studies so far offer a systematic description of the core concepts that result in flexible and innovative systems. Furthermore, no broader analysis has so far been presented in the literature of the fundamental principles that lie behind EIS, as we have described them. This paper will draw upon the theory of dissipative structure and principles of entropy to identify the basic principles that define the underlying structure of EIS. This analysis will show that successful system is poised at a delicate balance between chaotic and order.

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2 Conceptual Background

2.1 The Dissipative Structure Theory and the Entropy Theory

Nobel laureate Ilya Prigogine have described in detail how complex and self-organizing dynamic system is, which they designate 'dissipative structures' are generated from the behavior of 'chaotic' processes. Although Prigogine's model is based on chemical reactions, it generates profound insights into the 'new thermodynamics of open systems' that have broad applicability. It has been used to analysis the social and economic systems, issue like enterprise structure, corporation management etc. Certain conditions for a system to grow into a dissipative system are Open system, Far from equilibrium, nonlinear dynamic system.

Entropy, in general, refers to a measure of the amount of disorder in a system; high entropy means high disorder, while low entropy represents orderly status; thus, the higher entropy the more chaotic the system. Attaran and Zwick [6] define entropy as a 'measure ' of disorder, uncertainty, or homogeneity for analyzing many different phenomena. McClean [12] measured the continuous time entropy of labor stability in measuring the stability of a firm. Buchen and Kelly [7] applied the entropy concept to asset modeling under information theory. As can be seen in these cases, "a different definition is appropriate for different uses".

2.2 The Enterprise Information System and its Character

An effective EIS must be driven by organizational goals that can sustain the change of technologies over time. For an EIS, it is important to control the chaotic data in and out of the system. We can put the characteristic of EIS in the dissipative structure' way:

1) It is an open system: An open system has been defined (DOD/DISA) as a system that implements sufficient specifications for interfaces, and services to enable engineered applications software: to interoperate with other applications on local and remote systems; and to interact with users in a style that facilitates portability.

2) It is a system far from equilibrium: an EIS has many non-equilibrium factors, like the mismanagement of data; lack of safe protection; the lack of analysis on information and data; As Kauffman argues the future development can be obtained with clear level, sub-system and improved function

3) It is a nonlinear system: the information and data of EIS are from and for various different aspects and its operation is complicated and non-linear; some for facing the customer / supplier/inner sector, also there usually will be inner structure's revolution within the EIS to fit the need of the enterprise.

3 The Non-Equilibrium Management Entropy Model of EIS

Basically there are many factors affect the EIS as the function of entropy to the system, the entropy in an EIS can be categorized into three kinds: the structure entropy, the operation entropy and the environment entropy.

Assume the total entropy for an EIS far from equilibrium is S, its structure entropy is S_1, operation entropy is S_2 and environment entropy is S_3. For Mathematic analyze, S is the function of S_1, S_2 and S_3, as $S = f(S_1, S_2, S_3)$. Entropy is an extensive quantity, the entropy S for an EIS far from equilibrium is the sum of the entropy S_i for each part in the system, to wit $S = \int dS_i$. Use boolean algebra to depict the relationship between S and S_i, then $S = S_1 + S_2 + S_3$.

At the mean time, the three kinds of entropy S_1, S_2 and S_3, can be subdivided into more specific factors, S_1 can be subdivided into EIS framework entropy H_1 and strategy entropy H_2; S_2 can be subdivided into management entropy H_3, manipulation entropy H_4, data analysis entropy, H_5, project entropy H_6; S_3 can be divided into customer entropy H_7 and supplier entropy H_8, thus,

$$S_1 = H_1 + H_2, S_2 = \sum_{i=3}^{6} H_i, S_3 = H_7 + H_8$$

$$H_j = -P_1 \ln P_1 - P_2 \ln P_2 -, \ldots - P_n \ln P_n = -\sum_{i=1}^{n} P_i \ln P_i \qquad (j = 1,2,\ldots,7,8)$$

Assume the evaluation variable of the entropy is W, we could set functionality W_1 as an evaluation variable of S_1, set usability W_2, flexibility W_3 as evaluation variables of S_2, set market reactivity W_4 as evaluation variable of S_3. W can be weighed by degree of disorder R, then R_1 represents degree of function disorder, R_2 represents degree of usable disorder, R_3 represents degree of flexible disorder, R_4 represents degree of market reactive disorder. Let H_m be the highest entropy for each kind of entropy, then $W = \sum_{i=1}^{4} W_i = -R$, $R = \sum_{i=1}^{4} R_i = 1 - \sum_{i=1}^{8} \frac{H_i}{H_{im}}$

For the far from equilibrium system, the entropy change within time dt is $dS = d_eS + d_iS$. d_eS is the entropy produced by exchanging with the environment, d_iS is the entropy produced by internal consumption.

If in an EIS far from equilibrium, $d_eS < 0$, $d_iS > 0$ and $|d_eS| > d_iS$, we can make $dS = d_eS + d_iS < 0$. Entropy is decreasing, dissipative system can be formed.

We can have the following conclusions: 1) For the EIS, the two kinds of key environment's input are: customer's data and supplier's data; 2) The internal activities in EIS make the entropy increase, and affect its order; 3) The environment's input help the system to survive and develop negative entropy.

4 The Implications to EIS: Actively Introduce Negative Entropy

4.1 Extended the Scope of EIS System: Extended Enterprise

To make EIS adapt quickly to external changes depends upon the degree to which it exhibits a clear external focus. Indicate by the model, the environment entropy customer entropy S_3 (H_7 and H_8) is the key entropy to the EIS. So the scope of EIS should be extended and make the system borderless. the customer entropy and supplier entropy act as the negative entropy to balance the chaos in the system. See Fig. 1.

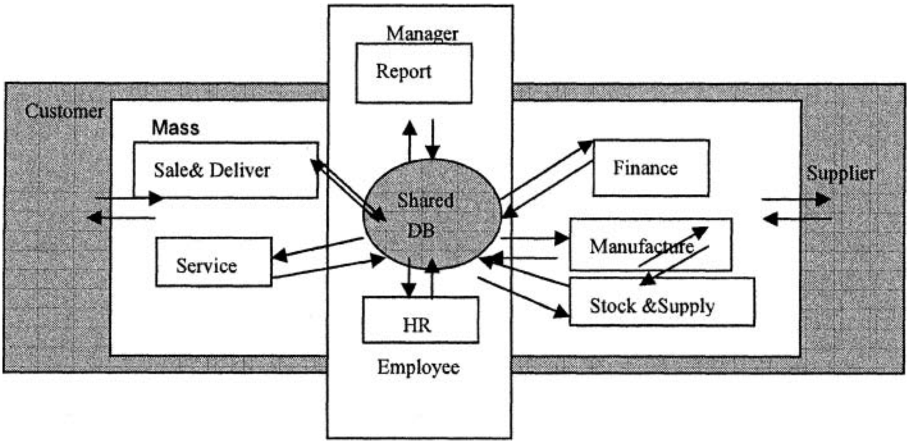

Fig. 1. Extended Enterpridse Information System

4.2 Use the complication of the system: component-based system

In an EIS, Two or more data are linked; their activities are so coordinated that when one data changes its state, the functions or activities of the other are affected. The EIS must be organized into flexible basic units that permit new structures to be identified, promote efficient exchanges of information. Let's see a case of changing in Bank EIS structure from traditional to component-based, which allows data of the innovative process to generate new 'orders.

5 Conclusions and Future Research

Ideas from the analysis of chaotic dynamic systems have been increasingly employed in economic analysis to describe non-linear, complex and creative organizational processes. This paper draws upon the dissipative structure theory lens to examine EIS for the first time. By using non-equilibrium management entropy model, the entropy statement of EIS is examined and the condition for an EIS to develop into dissipative system is found. EIS should be an extended system to actively introduce customer entropy and supplier entropy; component-based system can make use of the complication inside the system to balance 'chaos' with 'order'. The paper should be useful in contributing towards meeting enterprise mission in an efficient manner.

This EIS system consists of independent units tightly linked together and to external supplier. Since external suppliers in many cases provide inputs to other firms, and because they also have suppliers, this web of inter-industry effects will cause all markets to become increasingly chaotic. In the future research, this issue could be paid attention to.

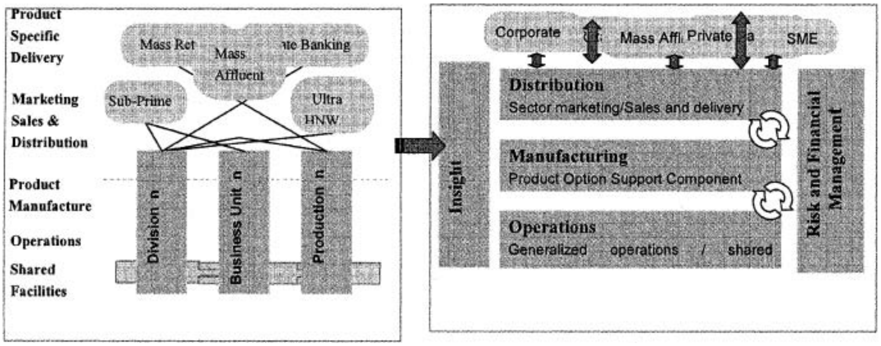

Fig. 2. Traditional 'monolithic' model and Component-based model

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Feasibility Identification for Networks with Generalized Precedence Relations (GPRs)

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Abstract. Network with Generalized Precedence Relations (GPRs) is a very important model in network planning technology which is the core technology of project management software. The most important problem should be solved first is to identify the network feasibility under GPRs in project planning phase, which determines whether its successive works can be processed successfully or not. This paper puts forward the definition of parallel subnetwork and studies the methods of its identification and feasibility discrimination. And then, we propose distinguishing methods for network feasibility in an acyclic network with GPRs, study the identifying methods for subprojects and GPRs arcs which need to be adjusted when the network is infeasible. The analysis of time complexity and computational example manifests that the proposed algorithm is feasible and effective in practice.

1 Introduction

Network planning technology is the core technology of project management software which is the most important part in large project information systems. With the help of network models, we can establish close relations among subprojects, between resources needed by each subproject and cost, which is an important basis for optimizing project scheduling, investment management, resources allocation etc by computer. Most network planning software used at present such as Primavera Project Planner (P3), Microsoft Project for Windows and so on are based on classical CPM [1] or PERT [2] model.

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As we known, the classical CPM [1] or PERT [2] model reflects the strict partial ordering [3] that exists among subprojects of a project, i.e. a successor subproject only can be started when its all predecessor subprojects have already been finished. However, there are other precedence relations called generalized precedence relations (GPRs) [3] between subprojects of a project besides the strict precedence relation in project planning in practice. Therefore, GPRs network model is more suitable to large project management than the classical CPM [1] or PERT [2].

Elmaghraby and Kamburowski [3] constructed the structure of GPRs network model based on the works of Roy [4] , Kerbosh and Schell [5]. Other related studies include De Reyck and Herroelon [6], Sakellaropoulos and Chassiakos [7], etc.

There are very complex relationships of time lags between different nodes in GPRs networks. Therefore, it is difficult to consider all constraint conditions carefully and completely in project planning phase. As a result, there may be contradictable time lag constraints which will lead to network infeasible. However, this phase determines whether its successive works such as identifying critical paths and critical subnetworks can be processed successfully or not. Therefore, the most important problem should be solved first is to identify network feasibility under GPRs.

Elmaghraby and Kamburowski [3] and Cesta et al [8] gave the definition of network feasibility in relation to this problem. In this paper, we study identifying methods for the feasibility of acyclic networks with fixed subproject durations under GPRs based on their works.

The remainder of this paper is organized as follows. Section 1 introduces the notation and terminology used in this paper. Section 2 gives some important definitions about networks with GPRs. Section 3 is problem statement. Section 4 puts forward identifying methods for network feasibility and analyzes the time complexity about the proposed algorithm. Section 5 gives a computational example. Section 6 is reserved for our overall conclusion.

2 Notation, Terminology, and Basic Definitions

We mainly use notation and terminology in line with Elmaghraby and Kamburowski [3] and modify some of them if it is necessary.

$G = (N, \mathcal{A}, \mathcal{P}, d, g)$: a network under GPRs, where N is the set of nodes, A is the set of arcs, $\mathcal{A}$ is the set of subprojects arcs, $\mathcal{P}$ is the set of GPRs arcs and $A = \mathcal{A} \cup \mathcal{P}$.

π (or π_{ij}, π_k, π_{h,PS_k}): path(or a path between node i and j, a path numbered k, path h on parallel subnetwork PS_k).

d_k (or $d, d_k^l, d_k^u, d_{ij}, d_\pi, d_{PS_k}^l, d_{PS_k}^u$): the duration of a subproject k (or a subproject (i,j), path π , PS_k). The superscript l (or u) indicates the lower (or upper) bound of the subproject's (or path's, PS_k's) duration.

g_{ij}(or $g, g^l_{ij}, g^u_{ij}, g_\pi, g^{l,up}_{ij}, g^{u,up}_{ij}$) : the length of a GPRs arc between node i and j. The superscript l (or u) and up denote the lower (or upper) bound and updated value of the length respectively, and the subscript π denotes the total length of GPRs arcs on path π.

g^l_{pub} (or g^u_{pub}): the minimal (or maximal) accumulative total time lag of several common arcs.

g^l_{pub,PS_k} (or g^u_{pub,PS_k}): The minimal (or maximal) accumulative total time lag of several common arcs can be taken in parallel subnetwork k.

$g^{l,up}_{pub,\mathrm{PS}}$ (or $g^{u,up}_{pub,\mathrm{PS}}$, $g^{l,up}_{ij,\mathrm{PS}}$, $g^{u,up}_{ij,\mathrm{PS}}$): The updated minimal (or maximal) accumulative total time lag of several common arcs (or common arc (i,j)) can be taken in the set of parallel subnetworks.

g^l_{priv} (or g^u_{priv}): The minimal (or maximal) accumulative total time lag of several GPRs arcs only passed by one parallel subnetwork.

t_j : the realization time of node j. s_h: the start-time of subproject h.

f_h: the finish-time of subproject h. PS: the set of parallel subnetworks.

$PS_{i_0 j_0}$: a parallel subnetwork with begin-node i_0 and end-node j_0.

P_{ij} (or $\mathrm{P}_{PS_{i_0 j_0}}$): the set of paths between node i and j (or the set of paths on $PS_{i_0 j_0}$).

$\mathrm{PS}^{CA(i,j)}$ ($PS^{CA(i,j)}_{i_0 j_0} \in \mathrm{PS}^{CA(i,j)}$): the set of parallel subnetworks which pass common arc (i,j), where $PS^{CA(i,j)}_{i_0 j_0}$ is a parallel subnetwork passing (i,j).

$deg^-_{\mathrm{G}}(i)$ (or $deg^+_{\mathrm{G}}(i)$): in-degree (or out-degree) of node i.

$CA(i,j)$: common arc (i,j). ML_{ij}: a minimal loop between node i and j.

Subnetwork (SN): A subnetwork is composed by all paths between node i and j.
Parallel Subnetwork (PS): The meaning is the same as completely parallel network in Dodin [9], i.e. a parallel subnetwork is composed by at least two parallel paths with identical direction between two nodes. For example, path (1→2→6) and (1→5→6) compose PS_{16} in Fig. 1.
Network Feasibility (NF): We incorporate the definition of network feasibility given by Elmaghraby and Kamburowski [3] and Cesta et al [8] to define it as follows:

A network $G = (N, \mathcal{A}, \mathcal{P}, d, g)$ is called feasible if there are project schedules which satisfy conditions: (1). $t_j - t_i = d_{ij}$, $\forall (i,j) \in \mathcal{A}$; (2). $g^l_{ij} \le t_j - t_i \le g^u_{ij}$, $\forall (i,j) \in \mathcal{P}$; (3) . $t_0 = 0$; (4). t_j , $t_i \ge 0$.

The same definition of network feasibility is used to define the feasibility of a parallel subnetwork. d, g)

Parallel Subnetwork Feasibility: A parallel subnetwork PS=$(N, \mathcal{A}_{PS}, \mathcal{P}_{PS}, d, g)$ is called feasible if there are project schedules which satisfy conditions: (5). $t_j - t_i = d_{ij}$, $\forall (i,j) \in \mathcal{A}_{PS}$; (6). $g^l_{ij} \le t_j - t_i \le g^u_{ij}$, $\forall (i,j) \in \mathcal{P}_{PS}$; (7). t_j , $t_i \ge 0$, where $\mathcal{A}_{PS}$ and $\mathcal{P}_{PS}$ are the set of subprojects and GPRs arcs in the PS respectively.

Minimal Loop (ML): A loop which does not contain any other loops is called a minimal loop. For example, path (0→1→2) and (0→3→4→13) compose $ML_{0,13}$ in Fig. 1.

Common Arc (CA): A GPRs arc passed by several parallel subnetworks is called a common arc. For example, $CA(6,10)$ is passed by $PS_{5,10}$ and $PS_{6,16}$ in Fig. 1.

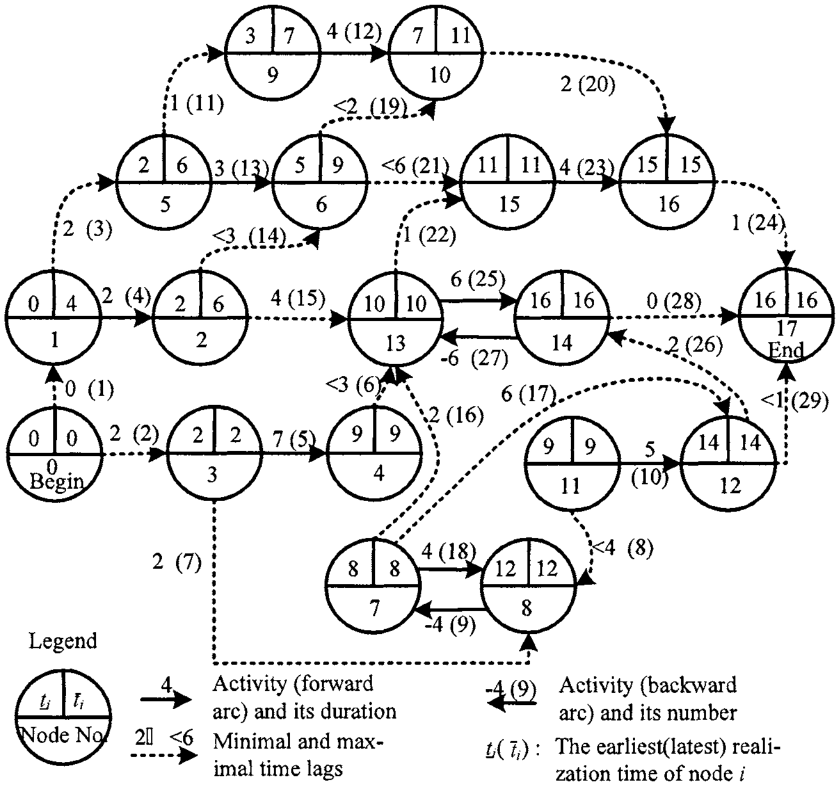

Fig. 1. An improved example of Elmaghraby and Kamburowski [3]

3 Problem Statement

A project is composed by many subprojects. According to technological conditions and resource constraints, we can get the datum of GPRs between different subprojects. However, we can not judge whether there are contradictions with these datum by our experiences or intuitions due to complex GPRs, so we can not determine whether the network schedule is feasible or infeasible.

Our problem is: How can we identify whether there is at least one feasible project schedule in a given set of subprojects durations $d_{ij}(\forall(i,j)\in\mathcal{A})$ and GPRs length interval $[g_{ij}^{l}, g_{ij}^{u}](\forall(i,j)\in\mathcal{P})$ in an acyclic network under GPRs? And should we adjust which subprojects' durations or/and the length of GPRs if there is no feasible project schedule?

The first problem can be solved by identifying the solution of the linear program (1)-(4). Simplex method and ellipsoid method can be used to identify the network feasibility. The former performs very well in practice but needs exponential time in the worst conditions. The later is a polynomial time algorithm but has little value in practice [10].

For the second problem, Bartusch [11] and Zhan [12] used cycle structure to identify some contradict GPRs if subprojects have fixed durations. However, the cycle structure does not conform to the reality of a project because there is no work to be done over again in the project under GPRs.

Furthermore, these methods or models are helpless for our problems if the durations of subprojects are stochastic.

We base our models and algorithms on an acyclic network structure with GPRs and aim at to extend them to stochastic durations of subprojects. The later will be discussed in another paper.

4 Feasibility Identification and Complexity Analysis

4.1. Feasibility Identification for Parallel Subnetworks

Parallel subnetwork feasibility can be identified by theorem 1.

Theorem 1: A parallel subnetwork is feasible if and only if its intersection of the duration intervals of all parallel paths is not empty.

Proof: Necessity: Suppose that parallel subnetwork $PS_{i_0j_0}$ is composed by m paths named $\pi_1, \pi_2, \cdots, \pi_m$ respectively.

If $PS_{i_0j_0}$ is feasible $\Rightarrow t_{j_0}$ certainly exists. $\Rightarrow t_{j_0}\in\bigcap_{k=1}^{m}[d_{\pi_k}^{l}, d_{\pi_k}^{u}]\neq\Phi$, where $[d_{\pi_k}^{l}, d_{\pi_k}^{u}](k=1,2,\cdots,m)$ is the duration interval of path k.

Sufficiency: $\bigcap_{k=1}^{m}[d_{\pi_k}^{l}, d_{\pi_k}^{u}]\neq\Phi\Rightarrow t_{j_0}$ certainly exists. $\Rightarrow PS_{i_0j_0}$ is feasible.

Corollary 1: For parallel subnetwork $PS_{i_0j_0}$, If $\forall\pi_k(k=1,\ldots,m),\exists[g_{ij}^{l}, g_{ij}^{u}]=[g_{ij}^{l}, +\infty]$ then $PS_{i_0j_0}$ is feasible, where $P_{PS_{i_0j_0}}=\{\pi_1, \pi_2, \cdots, \pi_m\}$.

Theorem 2: The necessary condition for GPRs network feasibility is that all parallel subnetworks in network G are feasible.

Proof: The conclusion is obvious.

4.2. An Identifying Method for Network Feasibility (Algorithm 1)

Suppose that there are only one network begin- and end-nodes.

4.2.1. Basic Ideas of Algorithm 1

①. Searching all minimal loops in network G under GPRs, then combining minimal loops which have the same start- and finish-nodes, and so getting all parallel subnetworks (including some parallel subnetworks generated by eliminating some arcs of subnetworks).

②. The feasibility of parallel subnetworks is the necessary condition of the network feasibility and it can be identified easily. Therefore, we check the feasibility of all parallel subnetworks firstly.

③. Searching the set $\mathrm{PS}^{CA(i,j)}$ which passes $CA(i,j)$, then computing the maximal interval value of $CA(i,j)$ in each parallel subnetwork $PS_{i_0 j_0}^{CA(i,j)} \in \mathrm{PS}^{CA(i,j)}$ and the intersection of these maximal intervals which is used as the new interval value of $CA(i,j)$ (called $CA(i,j)$ updated).

④. Checking the feasibility of all parallel subnetworks with updated value of the $CA(i,j)$, if all of them are feasible then the network G is feasible, otherwise, the network G is infeasible.

4.2.2. Steps of Algorithm 1

Step 1. Searching all minimal loops in network G under GPRs: ①.Numbering arcs in regularity: We can modify the method of numbering nodes in regularity or ternary tab method for an optimal tree. ②.Algorithm of searching minimal loops: We can modify ROOTP or ROOT algorithm to search all minimal loops in a network.

Step 2. Searching the set of parallel subnetworks: Searching minimal loops which have identical start-node i and finish-node i_{end}, then incorporating them as parallel subnetwork $PS_{i,i_{end}}$ ($i \in \{0,\cdots,n-1\}$, $i_{end} \in \{1,\cdots,n\}$ and $i_{end} > i$), and regarding other minimal loops as parallel subnetworks. All parallel subnetworks belong to the set of parallel subnetworks.

Step 3. Searching parallel subnetworks which pass $CA(i,j) \in \mathcal{P}$ and incorporating them into the set of $\mathrm{PS}^{CA(i,j)}$.

Step 4. Computing the duration interval of $PS_{i_0 j_0}^{CA(i,j)} \in \mathrm{PS}^{CA(i,j)}$. If the interval is empty then $PS_{i_0 j_0}^{CA(i,j)}$ is infeasible. Adjusting the durations of subprojects or/and the length of GPRs arcs which belong to $PS_{i_0 j_0}^{CA(i,j)}$, making $PS_{i_0 j_0}^{CA(i,j)}$ feasible.

Step 5. Computing the maximal interval of $CA(i,j)$ in $PS_{i_0 j_0}^{CA(i,j)} \in \mathrm{PS}^{CA(i,j)}$ in the condition of guaranteeing parallel subnetworks $PS_{i_0 j_0}^{CA(i,j)}$ feasible: ①.Let the duration of parallel subnetwork k be $[d_{PS_k}^{l}, d_{PS_k}^{u}]$, computing the maximal interval of common arc g_{pub}. ②. The maximal interval of common arc g_{pub} in parallel subnetwork PS_k can be computed by formula (8).

$$[g^{l}_{pub,PS_k}, g^{u}_{pub,PS_k}] = [\max\{d^{l}_{PS_k} - \sum_{(i,j)\in\pi_{h,PS_k}} d_{ij} - \sum_{\pi_{h,PS_k}} g^{u}_{priv}, \sum_{\pi_{h,PS_k}} g^{l}_{pub}\}, \\ \min\{(d^{u}_{PS_k} - \sum_{(i,j)\in\pi_{h,PS_k}} d_{ij} - \sum_{\pi_{h,PS_k}} g^{l}_{priv}), \sum_{\pi_{h,PS_k}} g^{u}_{pub}\}] \quad (8)$$

③.The maximal accumulative total interval of several common arcs in the set of parallel subnetworks can be determined by formula (9).

$$[g^{l,up}_{pub,\mathrm{PS}}, g^{u,up}_{pub,\mathrm{PS}}] = \bigcap_{k=1}^{n} [g^{l}_{pub,PS_k}, g^{u}_{pub,PS_k}] \quad (9)$$

④. The maximal interval of $CA(i,j)$ which belongs to g_{pub} in the set of parallel subnetworks can be determined by formula (10).

$$[g^{l,up}_{ij,\mathrm{PS}}, g^{u,up}_{ij,\mathrm{PS}}] = \bigcap_{k=1}^{n} [\max\{(g^{l,up}_{pub,PS_k} - \sum_{(i',j')\in g_{pub,PS_k},(i',j')\neq(i,j)} g^{u}_{i'j'}), g^{l}_{ij}\}, \\ \min\{(g^{u,up}_{pub,PS_k} - \sum_{(i',j')\in g_{pub,PS_k}\,(i',j')\neq(i,j)} g^{l}_{i'j'}), g^{u}_{ij}\}], (i,j)\in g_{pub} \quad (10)$$

Step 6. Computing the intersection of maximal intervals of the $CA(i,j)$ in $PS^{CA(i,j)}_{i_0 j_0} \in \mathrm{PS}^{CA(i,j)}$. If the intersection is empty then the network is infeasible, so adjusting the durations of subprojects or/and the length of GPRs arcs which belong to $PS^{CA(i,j)}_{i_0 j_0}$, making $PS^{CA(i,j)}_{i_0 j_0}$ feasible.

Step 7. Checking the feasibility of each parallel subnetwork according to the updated value of the $CA(i,j)$. If all of them are feasible then the network is feasible, otherwise, the network is infeasible.

4.3. The Time Complexity Analysis of Algorithm 1

Table 1 is the time complexity analysis of each step of algorithm 1. As a result, the time complexity degree [13] of algorithm 1 is $O(|N|^2\times|A|+|\mathcal{P}|\times|A|^2)$. Therefore, algorithm 1 is effective in practice.

Table 1. The Time Complexity Analysis of Algorithm 1

Steps of algorithm 1	Computing times	Complexity degree
Step 1	$\|N\|^2\times\|A\|+\|A\|^2$	$O(\|N\|^2\times\|A\|+\|A\|^2)$
Step 2	$(\|A\|-3)\times(\|A\|-2)/2$	$O(\|A\|^2)$
Step 3	$\|\mathcal{P}\|\times\|A\|\times(\|A\|-2)$	$O(\|\mathcal{P}\|\times\|A\|^2)$
Step 4	$[2(\|A\|-2)+\|A\|-1]\times(\|A\|-2)\times\|\mathcal{P}\|$	$O(\|A\|^2\times\|\mathcal{P}\|)$
Step 5	$2(\|A\|-2)^2\times\|\mathcal{P}\|$	$O(\|A\|^2\times\|\mathcal{P}\|)$
Step 6	$2(\|A\|-2)\times\|\mathcal{P}\|$	$O(\|A\|\times\|\mathcal{P}\|)$
Step 7	$[2(\|A\|-2)+\|A\|-1]\times(\|A\|-2)$	$O(\|A\|^2)$
Algorithm 1		$O(\|N\|^2\times\|A\|+\|\mathcal{P}\|\times\|A\|^2)$

4.4. A Theorem

Theorem 3: Algorithm 1 does not identify a network infeasible if it is feasible in reality, or vice versa.

Proof: The precondition of maximizing intervals of common arcs is to guarantee each parallel subnetwork to be feasible, which ensures that the intersection of these arcs intervals in different parallel subnetwork is maximal. Therefore, updating GRPs arcs according to the intersection does not decrease the solution space of feasible schedules of the network.

According to theorem 2, algorithm 1 checks the feasibility of parallel subnetworks two times, which is the necessity condition to guarantee network feasibility. Therefore, algorithm 1 does not identify a network infeasible if it is feasible in reality.

Algorithm 1 does not identify a network feasible if it is infeasible in reality: If this happens then at least one of the four conditions (1)-(4) in line with network feasible is not satisfied. However, according to algorithm 1, A feasible network satisfies $t_j - t_i = d_{ij}, \forall (i,j) \in \mathcal{A}; t_j - t_i \in [g_{ij}^{l,up}, g_{ij}^{u,up}] \subseteq [g_{ij}^{l}, g_{ij}^{u}], \forall (i,j) \in \mathcal{P}$; and t_0=0. This contradicts the assumption. □

5 An Example for Algorithm 1

We use algorithm 1 to identify the feasibility of figure 1 and all results are shown in Table 2 and 3.

Table 2. Searching Minimal Loops

Iterative order	ML_{ij}	Deleted arcs	Iterative order	ML_{ij}	Deleted arcs
①	$ML_{0,13}=\{$0-1-2-13, 0-3-4-13$\}$	$\{$0-1, 0-3$\}$	③	$ML_{2,15}=\{$2-6-15, 2-13-15$\}$	$\{$2-6, 2-13$\}$
②	$ML_{1,6}=\{$1-5-6, 1-2-6$\}$	$\{$1-5, 1-2$\}$		$ML_{7,14}=\{$7-13-14, 2-12-14$\}$	$\{$7-13, 7-12$\}$
	$ML_{3,13}=\{$3-4-13, 3-8-7-13$\}$	$\{$3-4-13, 3-8$\}$	④	$ML_{6,16}=\{$6-10-16, 6-15-16$\}$	$\{$6-10-16, 6-15$\}$
	$ML_{11,12}=\{$11-8-7-12, 11-12$\}$	$\{$11-8-7, 11-12$\}$		$ML_{13,17}=\{$13-15-16-17, 13-14-17$\}$	$\{$13-15-16-17, 13-14$\}$
③	$ML_{5,10}=\{$5-9-10, 5-6-10$\}$	$\{$5-9, 5-6$\}$		$ML_{12,17}=\{$12-14-17, 12-17$\}$	$\{$12-14-17, 12-17$\}$

Table 3. Searching Parallel Subnetworks

CA	Step 3	Feasibility of PS_{ij}	Step 5	Step 6	Feasibility of PS_{ij} with updated GPRs
(2,6)	$\{PS_{1,6};PS_{2,15}\}$	√②	{3}; [-1,3]	{3}	√
(2,13)	$\{PS_{2,15};PS_{0,13}\}$	√	[4,8]; [4,∞]	[4,8]	√
(4,13)	$\{PS_{0,13};PS_{3,13}\}$	√	[-∞,3]; [-7,3]	[-7,3]	√
(7,13)	$\{PS_{3,13};PS_{7,14}\}$	√	[2,12]; [2,∞]	[2,12]	√
(7,12)	$\{PS_{7,14};PS_{11,12}\}$	√	[6,∞]; [6,∞]	[6,∞]	√
(6,10)	$\{PS_{5,10};PS_{6,16}\}$	√	{2};{2}	{2}	√
(6,15)	$\{PS_{6,16};PS_{2,15}\}$	√	{0}; [2,6]	{0}	√
(13,15)	$\{PS_{2,15};PS_{13,17}\}$	√	[1,5]; [1,∞]	[1,5]	√
(12,14)	$\{PS_{7,14};PS_{12,17}\}$	$PS_{12,17}$×	[2,∞]; Φ	Φ	√
(14,17)	$\{PS_{13,17};PS_{12,17}\}$	$PS_{12,17}$×	[0,∞]; Φ	Φ	√
(12,14)①	$\{PS_{7,14};PS_{12,17}\}$	√	[2,∞];{2}	{2}③	√
(14,17)①	$\{PS_{13,17};PS_{12,17}\}$	√	[0,∞]; {2}	{2}	√

Note: ① The computing results are obtained with updated GPRs. ② symbol "√" and "×" represent feasible and infeasible respectively in table 3. ③ $PS_{12,17}$ is infeasible, so we have to adjust the durations of subprojects or/and the length of GPRs arcs of $PS_{12,17}$ and make it feasible. Here, we adjust the maximal lag of arc (12,17) to 2, then re-compute the maximal intervals of $CA(12,14)$ (and $CA(14,17)$) in $PS_{12,17}$ and $PS_{7,14}$ respectively and the intersection of these maximal intervals.

The computational results manifest that algorithm 1 is effective in identifying the feasibility of a network. At the same time, all infeasible parallel subnetworks can be found. So, we can adjust the durations of subprojects or/and the length of GPRs arcs to make a feasible project schedule.

6 Conclusions

This paper puts forward the definition of parallel subnetwork and studies the methods of its identification and feasibility discrimination. And then, according to the definitions of network feasibility defined by Elmaghraby and Kamburowski [3] and Cesta et al [8], we propose distinguishing methods for network feasibility with fixed subproject durations under GPRs; study the identifying methods for subprojects and GPRs arcs which need to be adjusted when the network is infeasible. The analysis of time complexity and computational example manifests that the proposed algorithm is feasible and effective in practice.

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Polychromatic Sets Theory and its Application in Enterprise Information Systems

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Abstract. Firstly, the basic conception of polychromatic sets, polychromatic graph and operation of the polychromatic sets and polychromatic graph is proposed. Secondly, the our main research status of polychromatic sets in enterprises are detailed, which includes the application of the polychromatic sets in the conceptual design, the application of the polychromatic sets in the product assembly modeling, the application of the polychromatic sets in the work flow modeling, the application of the polychromatic sets in tolerance modeling. Finally, the research conclusion and foreground is introduced.

1 Introduction

Enterprise information technology is the important weapon to improve and keep an enterprises' competitiveness in ever-changing business environment. It is a systematic methodology that is mostly required as a supporting tool achieving complicated activities connected with introduction of enterprise information systems. The enterprise information systems embodied to be impertinent can be wasting enterprise resources and weakening enterprise's competitiveness. Therefore, many consulting corporations have developed and applied various commercial methodologies in order to offer systematic guide on a construction of enterprise information systems. Methodology integrates each kinds of theory and tools scattered and must support that all of the users may utilize it easily. Thus, related methodology research must connect each kind of theory and tools in synthetic

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viewpoint to satisfy efficient construction efficiency and effectiveness of information systems. Also, previous researches show that enterprises that have systematic methodology construct more effectively information systems. More research works and commercial products, however, are lack of the architectural integrity and functional applicability to meet these sophisticated needs of enterprises. Lack of the architectural integrity is caused by two factors: absence of customizable architecture regarding inner environment and natural culture of enterprises, and non-integrated framework to manage engineering tools and output data used and generated during development and implementation of information systems. Lack of the functional applicability is caused by three factors: broken bridge linking business strategy with information strategy in rational manner, absence of economic justification and management systems, and unreliable mechanism for analysis and evaluation about level of enterprise information systems [1].

In Russia in the last century, professor V.V. Pavlov, who is the famous expert of aeronautical technology design of Russia, suggested the conception of polychromatic graph in 1988[2], presented the concept of polychromatic sets in 1995[3] and proposed the polychromatic sets theory in 2002[4], through accumulation, generalization and abstraction. Now the theory has become the major direction in Russia, and the systematic theory and technique has been widely used in enterprises of Russia, especially in the aerospace and aviation enterprises. The new methodology introduced in this paper can assure architectural integrity and functional applicability for successful development and implementation of information systems.

1.1 The basic conception of polychromatic sets

The composition of a conventional set A is as follows:

$$A = (a_1, a_2, \cdots, a_n)$$

For the elements of $a_i, a_j \in A$, the difference resides in their names even though these elements could be different. It is impossible to represent all other characteristics in the conventional set. In polychromatic sets, not only its elements, but also its entirety can be pigmented with different colors to represent the research object as well as the properties of its elements. The elements of conventional sets are also elements of the polychromatic sets. The color set $F(a_i)$ corresponds to every element $a_i \in A$ and the color set F(A) corresponds to the entirety of A,

$$F(A) = (F_1(A), F_2(A), \cdots, F_n(A))$$

$$F(a_i) = (F_1(a_i), F_2(a_i), \cdots, F_{m_i}(a_i))$$

The color constituents of polychromatic set $F(A)$ and the color constituents of its elements $F(a_i)$ are called pigmentation□they are included in a unified color set,

$$F \supseteq F(A);\ F(a_i), i=1,2,\ldots,n$$

$$F(a) = \bigcup_{i=1}^{n} F(a_i)$$

$F(A) \neq F(a)$, obviously, the characteristics of the sets is not the total of the characteristics of the element. If an object is represented in terms of polychromatic sets, its color $F_j(A)$ and $F_j(a_i)$, the color of the element a_i, correspond to jth characteristics of the object or the element.

In the polychromatic sets theory, the relationship between element and unified color can be represented using the following Boolean matrix [A×F(A)].

$$\left\| c_{i(j)} \right\|_{A,F(a)} = [A \times F(A)] = \begin{array}{c} \begin{array}{ccccc} F_1 & \cdots & F_j & \cdots & F_m \end{array} \\ \begin{bmatrix} c_{1(1)} & \cdots & c_{1(j)} & \cdots & c_{1(m)} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ c_{i(1)} & \cdots & c_{i(j)} & \cdots & c_{i(m)} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ c_{k(1)} & \cdots & c_{k(j)} & \cdots & c_{k(m)} \end{bmatrix} \end{array} \begin{array}{c} \\ a_1 \\ \cdots \\ a_i \\ \cdots \\ a_k \end{array}$$

In which $c_{i(j)} = 1$, if F_j□$F(a_i)$, and $F(a) = \bigvee_{i=1}^{n} F(a_i)$

The relationship between individual color and unified color can be represented using the following Boolean matrix [F(a)×F(A)].

$$\left\| c_{i(j)} \right\|_{F(a).F(A)} = [F(a) \times F(A)] = \begin{array}{c} \begin{array}{ccccc} F_1 & \cdots & F_j & \cdots & F_m \end{array} \\ \begin{bmatrix} c_{1(1)} & \cdots & c_{1(j)} & \cdots & c_{1(m)} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ c_{i(1)} & \cdots & c_{i(j)} & \cdots & c_{i(m)} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ c_{k(1)} & \cdots & c_{k(j)} & \cdots & c_{k(m)} \end{bmatrix} \end{array} \begin{array}{c} \\ f_1 \\ \cdots \\ f_i \\ \cdots \\ f_k \end{array}$$

In which $c_{i(j)} = 1$, assuming individual color f_i affects the existence of unified color F_j.

1.2 The basic conception of polychromatic graph

The composition of polychromatic graph is $PG=(F(G), PS_A, PS_C)$.

$$PS_A = (A, F(a), F(A), [A \times F(a)], [A \times F(A)], [A \times A(F)]$$

represents the nodes of the polychromatic graph. A represents the nodes; $F(a)$ represents the individual color of the element; $F(A)$ represents the unified color; $A \times F(a)$ represents the relationship between the elements and individual color; $A \times F(A)$ represents the relationship between the elements and unified color; $A \times A(F)$ represents the entity of unified color.

$$PS_C = (C, F(c), F(C), [C \times F(c)], [C \times F(C)], [C \times C(F)]$$

represents the polychromatic sets of the borders, in which $F(G)$ represents the unified color. The Disjunction polychromatic sets and the Conjunction polychromatic sets are built based on the disjunction algorithms and conjunction algorithms of polychromatic sets. If the borders of polychromatic graph has no colors, $F(G) = F(A) \cup F(C) = F(A)$; if both the borders and nodes are no colors, this polychromatic graph is the normal graph.

If each node is the pigmentation of one color, only one element in the ith row of the Boolean matrix $[F(a) \times F(A)]$ is $1(c_{i(j)} = 1)$. If the Boolean matrixes of borders have the same character, and the nodes and borders of this polychromatic graph have only color, this polychromatic graph is called unicolor graph.

If the nodes of the polychromatic graph can be pigmentized several colors (if the nodes of the polychromatic graph are the pigmentation of several colors), several elements are in the ith row of the Boolean matrix $[F(a) \times F(A)]$ is $1(c_{i(j1)} = c_{i(j2)} = \cdots = c_{i(jn)} = 1)$, and this nodes are polychrome, the borders of the graph possible have the same character, so this graph is called polychromatic graph.

1.3 The operation of the polychromatic sets and polychromatic graph

In the polychromatic graph, consider the restrict condition of the nodes and borders; build the map relation between the colors and elements of the object. In the polychromatic sets, a set of nodes (borders) is called nodes set (borders set), $S_i = (a_{i_1}, a_{i_2}, \cdots, a_{i_n})$, in which $S_i \subseteq A, a_{ik} \in A$. In the polychromatic sets, the pigmented functions of nodes set is $F(S_i)_A = R(F(a_{i_1}), F(a_{i_2}), \cdots, F(a_{i_n}))$, the pigmented functions of borders set is $F(S_i)_C = R(F(c_{i_1}), F(c_{i_2}), \cdots, F(c_{i_n}))$, so $F(S_i) = R(F(S_i)_A, F(S_i)_C)$. The operation of the polychromatic graph is different from the normal graph. In the polychromatic graph, the algorithms of the pigmented functions are as follows:

(1) Conjunction and Disjunction

The relationships between the colors include conjunction and disjunction. Firstly the vector space $F = (F_1, F_2, \cdots, F_n)$ is introduced in which $(F(A), F(C) \subseteq F)$; the logical relation is $F(S_i)_A = \vee_{k=1}^{n} F(a_{i_k}), F(S_i)_C = \vee_{k=1}^{n-1} F(c_{i_k(i_{k+1})}), F(S_i) = F(S_i)_A \vee F(S_i)_C$.colors matrix is called conjunction In the operations of polychromatic sets, the conjunction relation between colors is $F(S_i)_A = \wedge_{k=1}^{n} F(a_{i_k}), F(S_i)_C = \wedge_{k=1}^{n-1} F(c_{i_k(i_{k+1})}), F(S_i) = F(S_i)_A \wedge F(S_i)_C$.

(2) The entity operation of the polychromatic sets

If the element $a_i \in S$ and the $F_j(S)$ are exist, the entity of the unified colors F_j is $S_k(F_j) = (a_{i1}, a_{i2}, \cdots, a_{in})$ which the Boolean matrix represents $\left\|c_{i(j)}\right\|_{A,A(F)} = [S \times S(F)]$. The all entity elements of the all unified colors comprise $S \times S(F)$, in which the $S(F)$ is the combination of the all entities of the all unified colors; the individual entity relate to not only the individual unified colors, but also the achieved colors group. According to the definition of polychromatic sets, each the each entity group can achieve entity colors. For the polychromatic sets, each entity has one or several members. in the whole Boolean space of the polychromatic sets, the result sets which satisfying its polychromatic sets can be gained by operating the members according to the conjunction and disjunction of polychromatic sets.

(3) Descartes product

Suppose A and B are two random sets, the elements in the A are the first elements and the elements in B are the second elements, so the ordinal combinations are built. All ordinal combinations are called the Descartes product of the A, B, recorded as A×B [5, 6].

2 The research status of polychromatic sets

2.1 Application of the polychromatic sets in the conceptual design

Conceptual design is the process of achieving plans by studying out the function structure, seeking the proper function principle and choosing the basic approach through abstraction after deciding the assignment and the search algorithm can be built by using fuzzy mathematical model [7]. The key technology of Computer Aided Conceptual design comprises product information modeling and the technology of seeking schemes and so on [8]

Currently product information modeling of Conceptual design, such as the function method tree, function tree and function structure graph, must use geometrical graph, so it is difficult to be recognized with computers, furthermore not express the knowledge completely. Our team proposes the method of using the layered Hierarchy-Tree-Model of polychromatic sets to formalize the product information model express each layer function of the product as the unified colors and the individual colors and build the reason matrix and restriction matrix of the unified colors and the individual colors to provide the facility for the expression and operation of the computer [9-16]. Search the reason matrix and restriction matrix layer by layer to exclude the illegitimate scheme, and achieve the process of searching the reason matrix and restriction matrix from the whole function to the feasible scheme, so it offers facility for Computer Aided Conceptual design [17].

2.2 Application of the polychromatic sets in the product assembly modeling

The automatic generation of assembly sequence is the key link of computer aided assembles process planning (CAAPP). In the process of automatic generation of assembly sequence, the primary question is the representation of the assembly information and the building of the assembly relation model. At present, the expanded AND/OR graph, directed graph and Petri nets are widely used to build the assembly relation model, but there are many disadvantages: (1) the structures are complicated. (2) exist "combinatorial explosion ". (3) difficult to simulate the large-scale and complex systems, and (4) not facilitated to realize the system [18].

By using polychromatic sets, the combinations of each two parts of the assembly body are looked upon as the elements of polychromatic sets, the locating relationships between the two parts are considered as the holistic contours of polychromatic sets, the locating datum model can be built; the combinations of each two parts of the assembly body are looked upon as the elements of polychromatic sets, the blocking relationships between the two parts are considered as the holistic contours of polychromatic sets, the possible displacement model is built. The locating datum model and the possible displacement model constitute the assembly relation model of polychromatic sets. The locating datum equation and possible displacement can be gained from the locating datum model and the possible displacement model according to the algorithms, so all questions in the assembling process only on the conceptions of logic and set [19, 20]. The method has been used in car assembly [21, 22].

2.3 Application of the polychromatic sets in the work flow modeling

Directional graph and Petri net are the two-workflow Modeling technique used generally. The process activity and state are represented using nodes of directional graph; the mutual relationships of the nodes are represented with the directional arc of directional graph. The directional graph is difficult for the complicated business process modeling. Petri net is a kind of graphical and formal modeling tool and is suitable for describing system with concurrency and asynchrony. However, it has some weaknesses for modeling business process: (1) The business process defined by Petri net is difficult to be understood by a non-specialist; (2) Petri net is inconvenient to represent data flow. We study the work flow modeling by using polychromatic sets, firstly the process nodes of the work flow are represented, and then model the work flow by using polychromatic sets on the foundation of the conjunction graph of the work flow nodes, the algorithms of work flow function path is proposed finally [23 - 25].

2.4 Application of the polychromatic sets in tolerance modeling

The tolerance plays important role on the selection of manufacturing processes and assembly strategies. The current CAD system is only an entity constructor which provides limited support for tolerance capabilities reflecting as the limitation of contacting the tolerance with the corresponding geometric entities: the size tolerance with dimension, form tolerances with form and locating tolerances with orientation. In order to add the tolerance function into the current CAD system, the tolerance representation model should be built firstly, in which all types of tolerance can be organized and represented in the independent way. The tolerance representation model not only represents the semanteme difference for different types tolerances, but also represents the rock-frame as the carrier for the tolerance: geometric entities and metric relations. A kind of hierarchical tolerance representation model based on feature is proposed by Professor Yusheng in Zhejiang University. We represented the hierarchical rock-bottom frame of this model by using polychromatic sets, and the reason of the CP layer is achieved which provided the foundation for the programming for the tolerance model [26]

3 Conclusion

Our team supervised by professor Zongbin Li has apply polychromatic sets into enterprises, including the product Conceptual design modeling, product assembly planning modeling, workflow modeling and Tolerance Information modeling. In the polychromatic sets all enterprise information are considered into the Boolean matrix, so it has excellences, such as high formalization, facilitated to programme and complexity simpleness etc, comparing with the traditional modeling tools. In the actual application use the polychromatic sets to organize the information of hierarchy model, so the polychromatic set have wide application foreground in the modeling and analyzing the complicated system and networks.

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The Moving Competitive Advantage of Enterprises: Situation Advantage

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Abstract: In this paper, the situation advantage is defined from the angle of management innovation, which is another one of the competitive advantage of companies in incomplete information. The essential characteristics of the situation advantage are analyzed in detail, and three factors are proposed, such as the excellent boss, competitive information and added value, which bring about the situation advantage.

1 Statement of the Problem

Many academicians have dealt with the situation advantage from different viewpoints in their studies of the competitive advantage of MNC (Multinational Corporation). For example, Hymer [1] emphasizes the monopoly advantage of MNC, and Casson [2] stresses the advantage of interior. There are also some other academicians who stress the local advantage, as well as the compromise theory which is bases on all these theories. Danning [3] thinks that the MSC must possess three kinds of predominance when they intend to invest abroad: the ownership advantage, the interior advantage and the local advantage. The keystone of Danning's [3] research is not the competition of the MNC for he investigates the problem from the angle of the international production of enterprise. The local advantage, the interior advantage and the ownership advantage he summarizes mainly explain the MNC's motivation for investment and the predominance of local enterprise.

In addition, Baud [4] has put forward such an idea that the competition stratagem made by an enterprise needs create three competitive advantages: the cost advantage, the advantage of indiscrimination of product and the advantage which fasten on the market subdivision. With the predominance as above, the enterprise would possess the competitive advantage and could achieve rich and generous returns. In addition, the competition stratagem of an enterprise is related not only to its overseas benefit, but also to the subsistence and development of the enterprise. Vernon [4] probes into the source of the

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advantage and points out that the competitive advantage comes from the innovation of the products and meanwhile, the business chance is one of the advantages.

The scholars mentioned above have discussed how an enterprise acquires the competitive advantage from the point of the inherent predominance an enterprise possesses while others do not have. This sort of predominance could be considered as a composition of the hard wares of the enterprise. Vernon's last viewpoint [4] is that it is vital for an enterprise to make good use of chance and create the competitive advantage. Chance is one of the qualifications which encourage the enterprise to gain a sort of unexpected competitive advantage that other enterprise can not duplicate. Especially in such an information age, the speedy development of technology render the significant transformation of the organization structure and the prosecution idea, the innovation of management is an important object the enterprises pursue and the enterprises' management must adapt to the demand of the modern corporation's technology and the development of the times,

In the game among the enterprises, the alteration of the game element could affect the result of conflict. So we bring forward another competitive advantage from the angle of management innovation, the situation advantage. An enterprise must have an insight into business chance and recognize, grasp and make use of every opportunity, and especially have a capability for creating a situation advantage, which helps the enterprise develop itself and strengthen the competitive capacity. This competitive advantage can be regarded as a composition of the soft wares of an enterprise, and it is a kind of 'soft advantage' created by the innovative management of an outstanding entrepreneur, a kind of wisdom-witted competitive advantage, and the sapient fruit of the entrepreneur.

2 The Concept of Situation Advantage

Chance originally means the landing way of a thing in ancient French and is comprehended as opportunity in a broad sense, namely, good chance and favored condition, or good circumstances. It is the harmony of individual endeavor and the social condition, and a common phenomenon in society. In fact, chance is a summation of conditions and phenomenon of the development of temporary or long standing objective things. Hence it is widely used for folk, for a nation or for mankind, and also for an individual, for a family and for an enterprise. Different people have different opinions of 'chance' and because of different cognitive abilities and their own characteristics. Most people believe that chance is luck, and cover this word with mysterious color. There seems an invisible power that controls people's fate, and the result depends on the luck entirely, which makes the success of life to the good chance which is god-given. We accept that there is some inherent link between the chance and success, but one will submit to the fate if he considers blindly that the chance is unpredictable and purely imaginary.

Some others consider that chance is taken by accident; in fact, it is the show of someone's ability of investigation, controlling a situation and evaluation. Chance can make business go smoothly and make a breakthrough, and consequently lead to the success of one's undertaking.

Some enterprises could find chance, grasp chance, utilize chance and create chance, and then make a great progress. Such a chance that benefits the development of an enterprise is named the situation advantage. The situation advantage is a common phenomenon in the development of an enterprise. Grasping, utilizing and creating chance have been popularly studied in the field of enterprises and management. In the face of the complicated and varied competition among enterprises, it is a trial for an enterprise to grasp and create the situation advantages, and a trial for the individual ability of an entrepreneur and the synthesis ability of an enterprise, at the same time, and meanwhile, it is the key to the subsistence and development of the enterprise. Now, the formal definition of the situation advantage will be given as follows:

Definition 1. Decision-maker D_i, $i \in N = \{1.2....m\}$ has different values in m conflict variables $x_1, x_2, \cdots, x_m$ and S is the feasible set of the conflict variable X = $(x_1, x_2, \cdots, x_m)$, then the CS = $(D_i, X \in S)$is defined as conflict situation.

In the competition of the same industry, the decision-maker D_i is the actor who can really participate in the conflict and has the power to influence the eventual result. So decision-makers are limited in number. Conflict vector X is the tactic vector which the decision-maker can choose in x_i ($i \in N$), and not every decision-maker will choose all the conflict variables, but only the variable that influences the utility of the decision-maker is the conflict variable. This variable is restricted by the power of the decision-maker, while S is the scope of the enterprise game.

Definition 2. Suppose D_i and D_j are decision-makers, $i, j \in N$, X^i and X^j is the conflict vector of D_i and D_j, and the utility function of D_i and D_j are $U_i(X^i)$,$U_j(X^j)$ separately. The tactic choices of conflict of these two decision-makers in different conflict situations, have the same effect in conflict situations if and only if $U_i(X^i)= U_j(X^j)$.

Definition 3. Assuming D_i is the actor in the enterprise game, $F(U_1(X^1), U_2(X^2)......U_m(X^m))$ be his ally value function. The actor D_i would prefer strategy X^1 to strategy X^2 in F if $X^1 =(x_1^1 x_2^1...x_m^1)$, $X^2 =(x_1^2 x_2^2 ...x_m^2)$, satisfy $F(U_1(X^1),U_2(X^2),...U_m(X^m)) \geq F(U_1(X^1)...U_m(X^m))$,we define that the conflict situation, CS_1 is preferred to CS_2 in value function F.

Definition 4.$F(U_1(X^1), U_2(X^2)......U_m(X^m))$is ally value function, let the value of the decision-maker, D_i $i \in N=\{1.2....m\}$, be $X^i = (x^i_1, x^i_2, ... x^i_m)$, S be the feasible set of the conflict variable. We define that D_i has the situation advantage relative to D_k, $k \in N$, if the conflict situation, CS^i is preferred to CS^j in ally value function F for any tactic choice X^j, $X^j \in S$, in any D_j, $j \in N$.

3 The Characters of Situation Advantage

a. Transitivity: If CS_1 is superior to CS_2 on F, CS_2 to CS_3 on F, and then CS_1 is superior to CS_3 on F.

b. Relativity: The situation advantage is relative to other business enterprises which take participate in the industry competition, As a result the relativity is obvious.

c. Chanciness: The emergence of situation advantage does not have the fixed regulation, which usually does not follow the normal regulation. So the situation advantage has more chancinesses.

d. Transitoriness: The situation advantage always appears in a particular period and disappears when the time goes.
e. Development: The situation advantage is a process of formation and development. With the changes of the interior and exterior market condition and the rival's strategy, the advantage will change. Today's advantage may be changed into a disadvantage in the future. And the current disadvantage also may be changed into the future advantage.
f. Combination of subjective and objective: Situation advantage exists in every business enterprise, which the entrepreneurs need create and discover by themselves. Only the excellent boss has the talent to identify and discover the situation advantage which arises in the game process.
g. Practicality and potentiality: Not all the situation advantages of enterprises can be changed into the profits. If the situation advantage of a business enterprise is in the competition environment of a beneficial market, at the same time it can also capture the preference of customers, then the situation advantage will change into the real profits. Otherwise, it can produce little profit or nothing or produce profit only when the preference of customers is changed.

The situation advantage emphasizes that making and utilizing a transform can create the competitive advantages. On the one hand, with the fast development of science and technology and a variety of the customers' demands, the environment of enterprise is getting more and more unstable. It is not sufficient only to enhance the foresight in the dynamic situation. On the other hand, the process in which the enterprise adapts to the environment contains the content of competition with rivals. Because the conditions and targets are different, the countermeasures of different enterprises to the dynamic situation are different, too. It is impossible for a business enterprise to know its rival well. The game theory emphasizes on the rules of taking action by the feasible choices and the ability of adjusting and selecting the combinations of these rules and the formation of the ability of the new rules. The determinant factors of the situation advantage are made up of competitive information about the rivals, excellent entrepreneur and self value of the enterprise .

4 The Determinant Factors of the Situation Advantage Formation

4.1 Competitive Information

In the information society, each business enterprise who wants to survive and develop in the market competition must make an effort to obtain the political, economic and technical information related to the competition among business enterprises, especially, the competitive information related to the success or failure of the decision-making of the enterprise .It is not only the basis on which the enterprise can make out the competition strategy ,but also a basic prior condition to create a situation advantage.

With the fast development of information technology, the competitive information has brought to more attention and has become the key factor with which the enterprise's competitive ability can be measured. In the information age, collecting and disposing information is the start point and a prerequisite in a decision-making activity. Each rival constantly changes its competition strategy. The enterprise that can control and make a good use of the competition information without delay will become stronger in the competition, and may create a kind of competition advantage: situation advantage which can benefit the enterprise's survival.

4.2 The Characteristics of an Entrepreneur

a. Political character. An entrepreneur can not only closely follow the market, but also the government in management. Only closely following the market is just like walking on one leg, therefore, closely following the market as well as the government is just like walking on two legs.
b. Ability character. A successful entrepreneur must have the profound knowledge, the sharp-witted observational ability, the resolute decision ability, the organizational capability and the ability of creativity.
c. Consciousness character. An entrepreneur must not only grasp the present but also seize the future in the furious competition of the market economy. He insists on setting up the superior consciousness, information consciousness and competition consciousness, and then the enterprise will remain invincible for ever.

5 Conclusions

In his paper, the situation advantage is defined from the angle of management innovation, which is another one of the competitive advantage of companies on the basis of the analysis of enterprise competitive advantage in the international trade. The essential characteristics of the situation advantage is discussed in detail, too, and three factors are put forward: the excellent boss, competitive information and added value,

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Study on the Game of Payment Distribution Mode about AVEs

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Abstract: In this paper, the fixed-payment distribution mode of Agile Virtual Enterprises (AVEs) is studied based on game theory, and the result is compared with that of the share income mode. Finally, the paper proposes that the goal function of the game is changed thus promotes the Nash equilibrium effort level approaches or equals to the Pareto equilibrium effort level.

1 Problem Description

Fixed-payment distribution mode refers to the fixed payment by a member (usually the alliance leader) to other members based on the tasks shouldered by other members and according to the distribution amount previously agreed on (the payment can be done lump-sum or stage-by-stage) whereas the alliance leader obtain the total surplus and shoulder the total risk.

Let's assume that the agile virtual enterprise consists of two members, A and B, who are in line with the rational hypothesis and that the two members have different attitudes towards risk. Member A serves as the alliance leader and favors risk, who is willing to shoulder all the risk of the agile virtual enterprise and who thus obtain the total surplus. Member B, on the other hand, loathes risk and tries to avoid risk, who therefore is willing to obtain the fixed payment. Member A pays member B the fixed payment T (This can be the lump-sum payment or stage-by-stage payment). Further more, let's assume that a and b stand for the level of devotedness of A and B respectively, and thatαandβstand for the contribution co-efficiency of A and B whose quantity depends on the specialty and relative importance of the core ability of this enterprise. R(αa, βb)stand for the total income of the agile virtual enterprise, A(γa) and B(δb) stands for the cost of A and that of B respectively (here γ and δ refer to the cost co-efficiency of A and that of B). P and Q stand for the net income of A and B respectively. Here, a, b, α, β, γ, and δ are all bigger than 0.

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A further hypothesis includes R (αa , βb) =0.5(αa+βb)^2+(αa+βb) , A (γa) =0.5(γa) ^{2}, B (δb) =0.5(δb) ^{2}, here $\alpha < \gamma$, $\beta < \delta$ so as to guarantee the convergence of the met return G, that is $\frac{\partial^2 G}{\partial a} < 0$, $\frac{\partial^2 G}{\partial b} < 0$.

Therefore, under the fixed payment distribution mode, the met return of the agile virtual enterprise and that of its members are respectively:

$G = R(\alpha a, \beta b) - A(\gamma a) - B(\delta b)$, $P = R(\alpha a, \beta b) - T - A(\gamma a)$, $Q = T - B(\delta b)$

Substitute the return function and the cost function with the above values, we have:

$$G = 0.5(\alpha a + \beta b)^2 + (\alpha a + \beta b) - 0.5(\gamma a)^2 - 0.5(\delta b)^2 \quad (1)$$

$$P = 0.5(\alpha a + \beta b)^2 + (\alpha a + \beta b) - T - 0.5(\gamma a)^2 \quad (2)$$

$$Q = T - 0.5(\delta b)^2 \quad (3)$$

Then, the questions are: what is the value domain of the fixed payment T and what is the devotedness of each member?

2 Determination of the Fixed Payment Value Domain

To guarantee the win-win of the members, the following conditions must be met: P>0, Q>0

Place the above two conditions in equations (2) and (3), we can obtain a value domain of the fixed payment T:

$$B(\delta b) < T < R(\alpha a, \beta b) - A(\gamma a)$$

Based on the above equation, we can draw the following conclusion:

Conclusion 1: Under the fixed payment mode, to guarantee the “win-win”, the fixed payment to member B must be bigger than his cost while smaller than the difference between the total return of the agile virtual enterprise and the cost of member A (the alliance leader).

3 The Devotedness Level under the Fixed Payment Mode

First of all, let’s analyses the Nash equilibrium of the agile virtual enterprise. At present, each member maximizes his return, thus:

$$\frac{\partial P}{\partial a} = 0 \text{ , } \frac{\partial Q}{\partial b} = 0$$

Place the above conditions in equation (2) and (3) and the Nash equilibrium devotedness level under the fixed payment mode a_g^0 and b_g^0 are

$$a_g^0 = \frac{\alpha}{\gamma^2 - \alpha^2} \qquad (4)$$

$$b_g^0 = 0 \qquad (5)$$

Therefore, we can draw the following conclusion:

Conclusion 2: Under the fixed payment mode, the Nash equilibrium devotedness level of the member B (who obtains the fixed payment) is zero.

This conclusion indicates that under the condition where the fixed payment can be guaranteed, the member who obtains the fixed payment does not have the incentive to devotion during his working process, which can definitely influence his completion of the sub-task shouldered. Furthermore, the devotedness level is difficult to observe and measure. In order to solve this problem, the alliance leader of the agile virtual enterprise can set a precise standard concerning the work amount, quality and completion time for this member and can use this as the condition for fixed payment. That is to say, control and stimulus should be based upon the completion of work rather than the completion process. However, with regard to knowledge alliance, due to the facts that the resources input (experimental instrument, device and so on) and the imitativeness of knowledge-initiative work are not clear and that the responsibilities are not clear and that the results of each member are difficult to measure, the fixed payment distribution mode is suitable not for the knowledge-alliance agile virtual enterprise but for the product-alliance agile virtual enterprise.

If we compare the Nash equilibrium level under the fixed payment mode (see equation 4 and 5) with the Nash equilibrium level under the output-share mode(see equation 6 and 7 of literature [1]), we can draw the following conclusion:

Conclusion 3: without the restriction of the outside factors, the fixed payment mode stimulates the alliance leader more than the members whereas the output-share mode stimulates the members more than the alliance leader.

If the a_g^0 and b_g^0 of equation (4) and (5) are placed in equation (1), the Nash equilibrium total return of the agile virtual enterprise under the fixed payment mode is:

$$G_g^0 = \frac{\alpha^2}{2(\gamma^2 - \alpha^2)} \qquad (6)$$

In the following part, we shall set the maximization of the total benefit of the agile virtual enterprise as the target and analyses the best devotedness level and the total return of the members of the agile virtual enterprise under the Pareto equilibrium. (Here, we hypothesize that every member meets the condition of collective rationality).

For this, we need use equation (1) to obtain the partial derivatives for a and b set them zero, thus:

$$\frac{\partial G}{\partial a} = \alpha(\alpha a + \beta b) + \alpha - \gamma^2 a = 0$$

$$\frac{\partial G}{\partial b} = \beta(\alpha a + \beta b) + \beta - \delta^2 b = 0$$

When we solve the above two equations, we obtain the best devotedness level of member A and B under the fixed payment mode:

$$a_{gP}^0 = \frac{\alpha\delta^2}{\delta^2\gamma^2 - \alpha^2\delta^2 - \beta^2\gamma^2} \tag{7}$$

$$b_{gP}^0 = \frac{\beta\gamma^2}{\delta^2\gamma^2 - \alpha^2\delta^2 - \beta^2\gamma^2} \tag{8}$$

$$G_{gP}^0 = \frac{\alpha^2\delta^2 + \beta^2\gamma^2}{2(\delta^2\gamma^2 - \alpha^2\delta^2 - \beta^2\gamma^2)} \tag{9}$$

If we compare (7), (8), and (9) with (4), (5), and (6), we can see that under the fixed payment mode, the Pareto equilibrium devotedness level of each member is bigger than the Nash equilibrium devotedness level (the same as the output-share payment mode). Therefore, under the fixed payment distribution mode, the mechanism design that drives the Nash equilibrium devotedness level to the Pareto equilibrium devotedness level still exists.

If we compare the equations (7), (8), and (9) with the equations (2), (3), and (4), we can draw the conclusion:

Conclusion 4: Under the condition of Pareto maximization, the total net return of the agile virtual enterprise and the devotedness level of every member are not related to the distribution mode.

This conclusion shows that the total target of the agile virtual enterprise can always be met despite the interest distribution mode if the thought and action of each member is activated to transform from the individual rationality to collective rationality and if each member regards the total target and benefit as the guidance. This further shows the importance of the cooperation mechanism design concerning the members of the agile virtual enterprise.

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System Dynamics Report of Telecom Industry in China

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Abstract: This article analyzes mobile carriers' competition strategies by using balanced scorecard and system dynamics. We use four indexes to evaluate the situations of 2 main Chinese telecom carriers like Internal Business Index, Financial index, Market & Customer Index, as well as Innovation and Learning index. According to these four indexes and system methodology, a system dynamics model is provided, which has 4 subsystems and 80 variables. Taking the government influences into consideration as well as companies' strategies and the corresponding system simulations, we try to use system dynamics as a new enterprise computing analyzing method and give competition suggestions to the two mobile carriers.

1 Introduction

At present, Chinese telecom enterprises are facing the biggest challenges. 3G (the third generation of mobile communication technology) time is coming. Information technology is changing our world everyday. People concern how to combine internet with mobile technology. As the two mobile carriers in China, A is the dominant carrier while B is the challenger. How could B operate well in the next step? What are the results if A reacts? What should the government do next?

System dynamics is a traditional simulation tool. It's broadly used in analyzing environment, social problems and so on [1, 5]. Balanced scorecard was proposed by Kaplan and Norton and further developed by Berkman [3, 4, 6] based on managerial

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experiences of many superior companies. Developed in the early 1990s, this valuation methodology converts an organization's value drivers—such as customer service, innovation, operational efficiency, compensation [2] and financial performance—into a series of defined metrics.

Different from previous work, we resolve the problems by combining system dynamics with balanced scorecard and econometrics [7]. Searching the Securities and Derivatives Markets Quarterly Report of these 2 carriers of Hong Kong Exchanges Cooperate every half year, we extract data from 1999 to the first half of 2005 [8] and use a special software Vensim-PLE5.4c to establish a system dynamic model to simulate the operation situation of 2 carriers in China.

2 System Dynamic Model for One Mobile Carrier

This model (**Fig.1**) contains 4 subsystems according to the balanced scorecard. Considering the policy environment as surroundings, we evaluate indexes referring to EFE and IFE method [10]. The global telecommunication market environment is not considered.

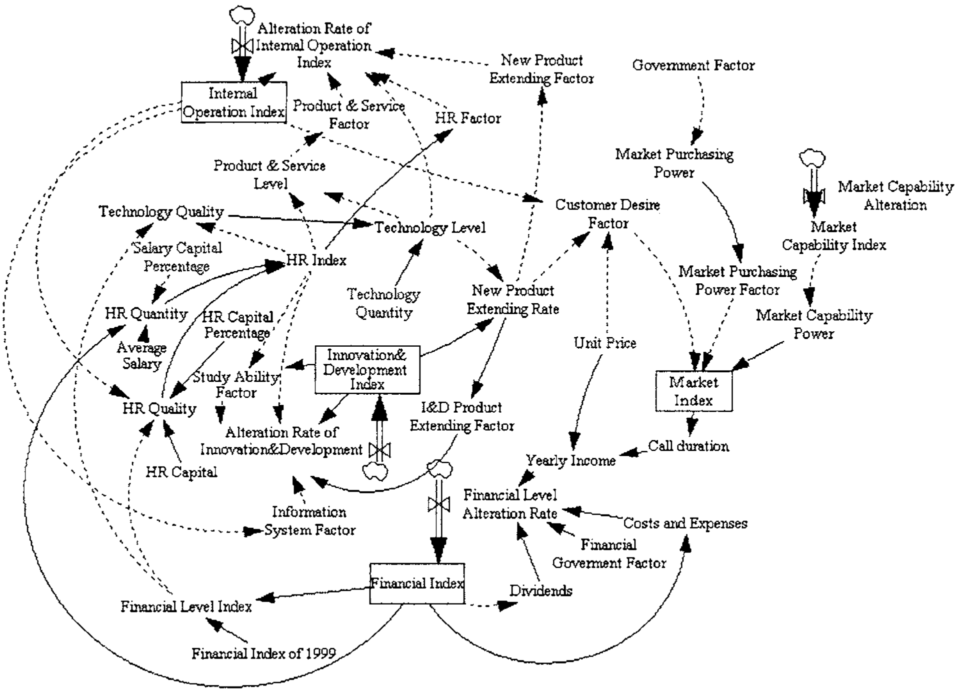


Fig. 1. Flows and stocks diagram of one operator [9, 11, and 14]

Internal sub-system [Internal Operation Index (level variable), Alteration Rate of Internal Operation Index (rate variable)]. Human resource influences the core technology, and the stronger enterprise's competing ability is the higher core tech level will be. To simplify the problems and diagram, we use 2 rates to show the output of these 2 enterprises. Human Resource Level is affected by HR Efficiency Level and HR Quantity Level. Core Technology Level is affected by Core Technology Efficiency Level. Staff Efficiency is determined by Financial Level, Standard HR Investment Ratio and HR Investment Ratio.

Financial sub-system [Financial Index (level variable), Financial Alteration Rate (rate variable)]. Financial Alteration Rate is the synthesized function of 'Income', 'Expense and Cost ', 'Revenue', 'Dividend', and 'Government Factor'. Income is the product of unit price (income per minute for the telecom companies) and the call duration. Call duration is the conditional function of the Market Level. Here Government Factor is the auxiliary variable.

Market sub-system [Market & Customer Index (level variable), Alteration Rate of Market & Customer (rate variable)]: Alteration Rate of Market & Customer is the synthesized function of 3 factors about Purchasing Power, Market Capability and Purchasing Desire.

Innovation and Development sub-system [Innovation and Development Index (level variable), Alteration Rate of Market & Customer (rate variable)]. Innovation and development ability indicates an enterprise's ability and potential.

3 Integrated System Dynamic Model for Two Mobile Carriers

This model is for the competition situation simulation of the 2 companies (**Fig. 2.**).

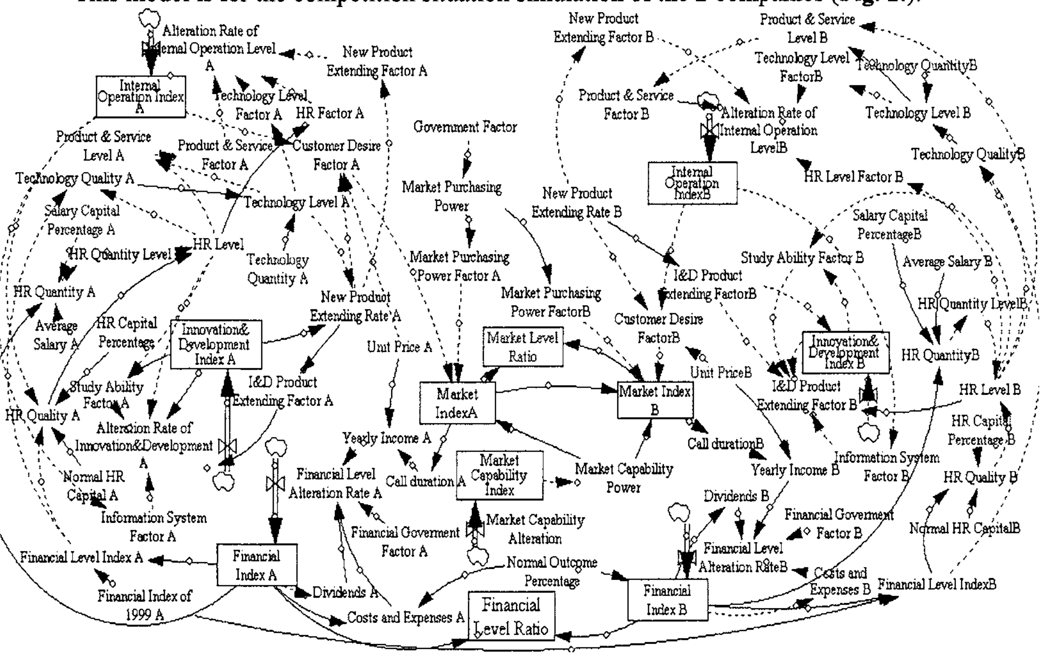


Fig. 2. The integrated system dynamic model

4 Equations for Stocks and Flows of The Integrated System Dynamic Model

Here we get the equations for the system simulation containing these 2 companies:

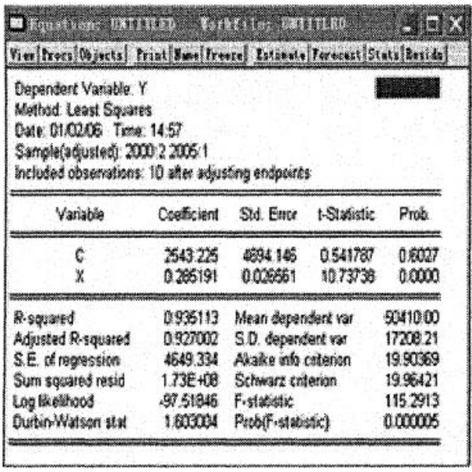
1. d(Internal Operation Level)/dt=Internal Operation Alteration Rate= f1(Core Technology Factor, Human Resource Factor, Product & Service Factor, New 2.Product Extending Factor) ; Internal Operation Level$|_{t=1999}$=4.3;
3. d(Financial Level)/dt=Financial Level Alteration Rate=f2(Income, Expense and Cost, Revenue, Dividend, Government Factor);
4. Financial Level$|_{t=1999}$=65,733;
5. d(Market&Customer Level)/dt=Alteration Rate of Market&Customer =f3 (Purchasing Power Factor, Market Capability Factor, Purchasing Desire Factor);
6. Market&Customer Level$|_{t=1999}$=5.5
7. d(Innovation&Development Level)/dt=Innovation&Development Alteration Rate = f4(Study Ability Factor * New Product Extending Factor* Information System Factor) +1)* Innovative&Develop Level;
8. Innovation & Development Level$|_{t=1999}$=1;
9. Financial Ratio= Financial Index A/ Financial Index B;
10. Market Index Ratio= Market Index A/ Market Index B;

As to the similarities between the systems of A and B we do not list the equations for B here.
The data sample is shown in Table1 in appendix.

OLS [12] parameter estimation;

$CRY=u+\beta_1*FY;$ (1)

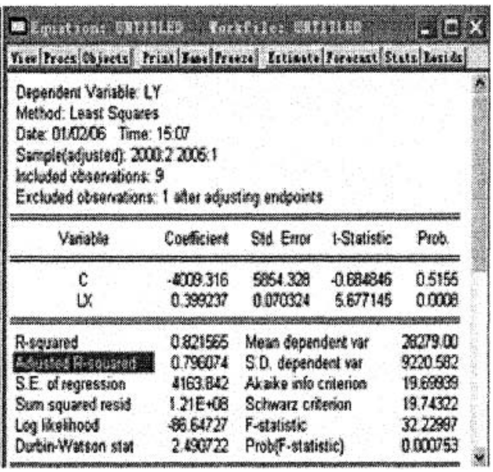
$CRL=u+\beta_1*FL;$ (2)



Dependent Variable: Y
Method: Least Squares
Date: 01/02/06 Time: 14:57
Sample(adjusted): 2000:2 2006:1
Included observations: 10 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2543.225	4694.146	0.541787	0.6027
X	0.285191	0.026561	10.73738	0.0000

R-squared	0.936113	Mean dependent var	50410.00
Adjusted R-squared	0.927002	S.D. dependent var	17208.21
S.E. of regression	4649.334	Akaike info criterion	19.90369
Sum squared resid	1.73E+08	Schwarz criterion	19.96421
Log likelihood	-97.51846	F-statistic	115.2913
Durbin-Watson stat	1.603004	Prob(F-statistic)	0.000005



Dependent Variable: LY
Method: Least Squares
Date: 01/02/06 Time: 15:07
Sample(adjusted): 2000:2 2006:1
Included observations: 9
Excluded observations: 1 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4009.316	5854.328	-0.684846	0.5155
LX	0.399237	0.070324	5.677145	0.0008

R-squared	0.821565	Mean dependent var	28279.00
Adjusted R-squared	0.796074	S.D. dependent var	9220.582
S.E. of regression	4163.842	Akaike info criterion	19.69839
Sum squared resid	1.21E+08	Schwarz criterion	19.74322
Log likelihood	-86.64727	F-statistic	32.22987
Durbin-Watson stat	2.490722	Prob(F-statistic)	0.000753

Fig. 3. Eviews output of the costs analyses

To process the data reliably and accurately, we use software Eviews. Take the conditional function of Net Assets, Expenses & Costs for example: CRY=2543.225+0.285FY. F=115.2913, DW=1.518, r^2=0.935, interpret that only 6.5% could not be explained by sampling regression linearity with 93% of the total sum of squares of deviations qualifies. The sample regression line explains the sample point with a high goodness of fit (**Fig. 3**). It means the modeling may be in a fit format. Similarly, the correlation between Expenses& Costs level and net assets of Firm B: CRL=-4009.3+0.399FL. (Low goodness of fit indicates the superior firm has more choices and is much more dependent)

Equations: LS = -2826.122 + 0.994*LFI; YS = -13872.408 + 0.633*YFI

5 Simulation Results

5.1 Carrier B:

Because financial circumstance is the most important index for the operator and market is carriers' final goal, we pick graphs concentrating on these 2 sides. **Fig. 4** illustrates the financial ratio and **Fig. 5** describes the customer index's development in the next 5 years. (After B adopts the new strategy, keeping the total investment ratio at 1.2 and it improves the salary ratio and HR investment ratio to 1.25.)

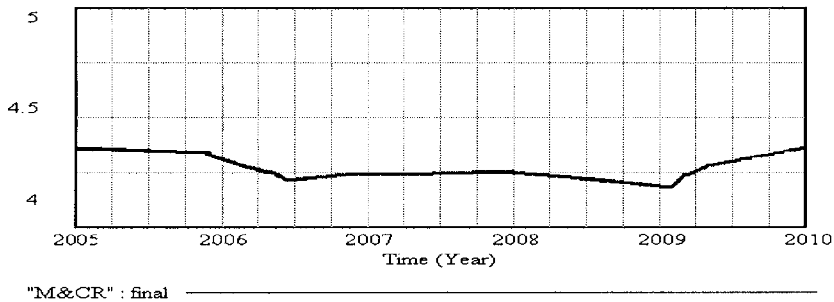


Fig. 4. Financial situation of carrier B in 2005~2010(FR- Financial Index Ratio)

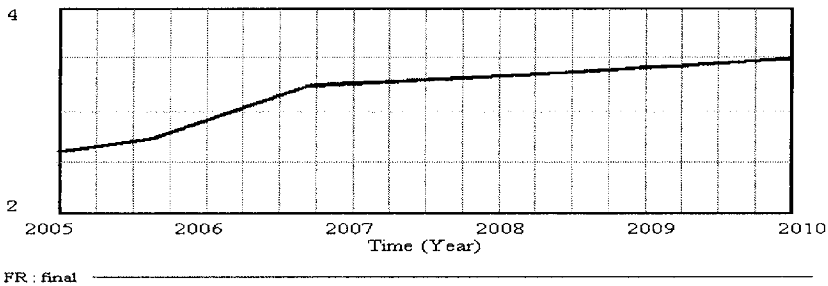
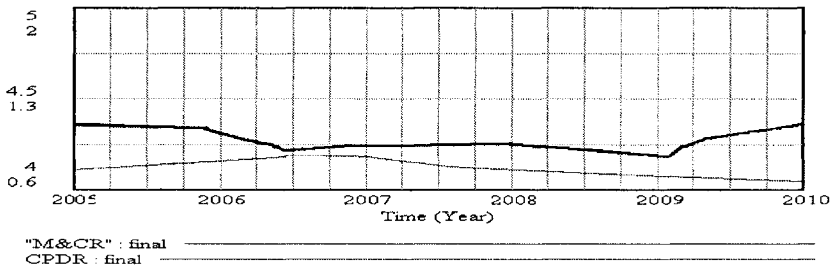


Fig. 5. If carrier B takes the new strategic plan into application 2005~2010 (M&CR-Market and Customer Ratio)

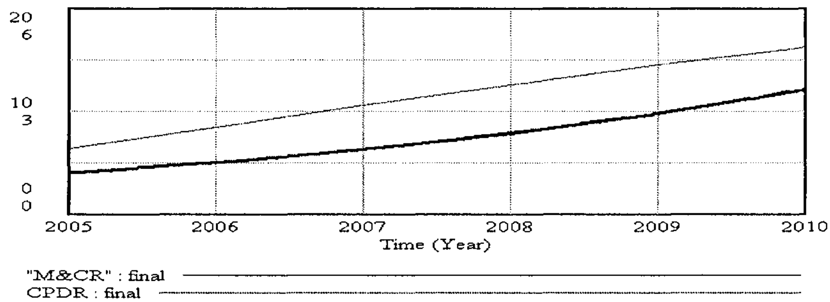
From the graphs, we could see the slopes are positive, which means the distance between A and B is always growing and the speed is slowing down, with financial index increasing to 3.5 and M & CR to 4.35 at the end of 2010, (compare with FR 7.9 and M&CR 9.2 in 2010 if B do not adopt new strategic plans and the negative deposits lead to a negative circle). Originally A's net profit was 18 times of B's in 2005 and if B adopts the strategic amendment that would be delayed to 2010 or later. In the next 5 years it would experience several fluctuations; nevertheless the overall slope is going down but still larger than 1, indicating that B is still at the disadvantageous position. Here we could see the net asset ratio is much lower than that of net profit 2.26 in 2004. And that benefits B.

5.2 Carrier A

For carrier A, we compare carrier A's 2 situations whether A reacts after B changes its strategies or not. Market is the corporations' aim and also the factor we very concern.



(a)



(b)

Fig. 6. Simulation for the next 5 years--A does noting (**Fig. 6** (a)), and A reacts immediately after B (**Fig. 6** (b)) when B works as in **Fig. 5** (M&CR is Market and Customer Ratio, CPDR is Customer Purchasing Desire Ratio)

We could see the financial ratio would keep on increasing from 4.35 to 12 in the next 5 years if A reacts immediately after B and the government does not interrupt with any anti-monopolization regulations. Among the top 500 companies, A ranks low in income but much higher in profit, which implies that the price of A is not very reasonable. So the structure of the price should be optimized and keep track with international level.

6 Conclusions and Limitations

Firstly carrier B could increase the investments and management efficiencies by improving human resource level and keep other level ratios to a certain degree simultaneously; To Concentrate investments in key areas including bonuses [16] and HR funds to maximize profits secondly; And to allege that they are aiming at becoming the second largest mobile carrier in China's Mobile Industry to distract competitions threats step by step [15].

Carrier A could firstly segment the market and emphasize differences. Second, it should develop products of lower price level and consider showing competition threats, improving the innovation and customer service investment, and finally individuating products to make them more different and remarkable so as to improve customers' desires.

For the government, encouraging efficient competitions, maximizing the competition capability and rationalizing resource distribution are rational suggestions. TD-SCDMA needs to be paid special attention to, with its own advantages in frequencies and standards [13].

We haven't made corresponding simulations on government side this time. Modify and making more specific simulations of enterprises' operation behaviors is part of the further work basing on the model.

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Appendix

Table1. Simulation data

Unit (million)	*Carrier A*						
Year	Income	Expenses and costs	Taxes& Interests	Net Profits	Dividends	Assets	Net Assets
First Half of 1999	16,940			4,004			
Second half of 1999	21,683			793			
1999	38,623			4,797			65,733
First Half of 2000	28,897	16,092	4,081	8,724			74,457
Second half of 2000	36,087	40,526	4,285	9,303			83,760
2000	64,984	56,618	8,366	18,027			83,760
First Half of 2001	48,864	28,146	6,909	13,809	2	13,811	97,571
Second half of 2001	51,467	30,467	6,794	14,206	2	14,208	111,779
2001	100,331	58,613	13,703	28,015	4	28,019	111,779
First Half of 2002	55,146	32,131	7,800	15,215	5,969	21,184	132,963
Second half of 2002	73,415	47,454	8,575	17,386	22,916	40,302	173,265
2002	128,561	79,585	16,375	32,601	28,885	61,486	173,265
First Half of 2003	76,675	49,858	9,355	17,462	-6,672	10,790	184,055
Second half of 2003	81,929	55,778	8,057	18,094	-3,346	14,748	198,803
2003	158,604	105,636	17,412	35,556	-10,018	25,538	198,803
First Half of 2004	86,420	58,232	9,359	18,829	-4,167	14,662	213,465
Second half of 2004	105,961	72,965	9,821	23,175	-3,236	19,939	233,404
2004	192,381	131,197	19,180	42,004	-7,403	34,601	233,404

Unit (million)	*Carrier B*						
Year	Income						
First Half of 1999	8,074						
Second half of 1999	9,376						
1999	17,450	Expenses and costs	Taxes& Interests	Net Profits	Dividends	Assets	Net Assets
First Half of 2000	10,505		360	270			
Second half of 2000	13,187			569			8,538
2000	23,692			839			8,538
First Half of 2001	13,619	10,223	111	171			
Second half of 2001	15,774	9,130	994	3,063			57,224
2001	29,393	19,353	1,105	3,234	45,452	48,686	57,224
First Half of 2002	17,991	10,576	851	2,192			
Second half of 2002	22,586	13,319	190	2,265			61,681
2002	40,577	23,895	1,041	4,457	0	4,457	61,681
First Half of 2003	31,967	15,125	729	2,137	115	2,252	63,933
Second half of 2003	35,669	19,134	991	2,461	259	2,720	66,653
2003	67,636	34,259	1,720	4,598	374	4,972	66,653
First Half of 2004	39,372	28,616	966	2,385	-1,256	1,129	67,782
Second half of 2004	39,960	35,669	922	1,822	36,327	38,149	105,931
2004	79,332	73,415	1,888	4,207	35,071	39,278	105,931
First Half of 2005	43,244	35,220	1,262	2,890	-6,628	-3,738	102,193

An Empirical Research on SMC in an Extended Enterprise Environment

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Abstract. There are few empirical researches and applications of SMC models for shortage of customer data and their complexity. Choosing IT distribution market industry as background, an empirical research is done in this paper. The conclusion is that SMC models do work in IT distribution market industry. They have relatively high prediction accuracy. Also, the revise advice for SMC is put forward to meet different types of customer behaviors.

1 Introduction

SMC models are a group of models to forecast customer's buying behaviors and were provided in 1987 by D.C. Schmittlein, D.G. Morrison and R. Colombo [1]. There are few empirical researches and applications of SMC models for shortage of customer data and their complexity [2, 3]. If SMC models are proved to be true, they are very valuable in designing analytical CRM (Customer Relationship Management) systems.

Choosing IT distribution market industry as background, an empirical research is done in this paper. Digital China is the biggest company in China's IT distribution market. Through random sample, we obtained 1324 customers' consumption records

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to determine the parameters of SMC models. Then, we selected 331 customers to test SMC models. The conclusion is that SMC models do work in IT distribution market industry. They have relatively high prediction accuracy. The application of SMC models in CRM is discussed in details. Also, the modification advice for SMC is put forward to meet different types of customer behaviors.

2 Hypotheses Development

SMC models have four models to calculate the following variables in customer behavior prediction:

1) The description on current customer's active degree; the customer's active degree is a variable describing the probability of customers' purchase; the higher the value is, the larger the customer' possibility will be.
2) Purchase frequency within the next trading period "T1";
3) The probability for customers to purchase K times within the next period "T2"
4) Expected dollar volume in each purchase.

For the limitation of the paper, the exact models are not presented in the paper; anyone who has interesting can find them in Schmittlein et al., [1, 2].

We consider that SMC models are suitable for the forecasting of customer's buying behavior in IT distribution market industry, that is:

Hypothesis 1: The customer's active degree model of SMC models comes into existence in IT distribution market.

Hypothesis 2: The expected purchases number model of SMC models comes into existence in IT distribution market.

Hypothesis 3: The probability of purchasing appointed number times during a period of time in the future model of SMC models comes into existence in IT distribution market industry.

The defect lies in that the expected future dollar volume model is not verified in this paper due to data resources.

3 Research methodology

3.1 Data collection

Digital China is a first class IT distribution enterprise in China. Our research selected its customer in the Beijing area as a sample to check out SMC models' applicability in the IT distribution field. To validate the efficiency of SMC models in IT distribution market industry, we divide the customers sample pool into two parts: customer sample I and II. The first one's final observation time is October in 2001 and the other one's final observation time is November in 2001. In other words, customers sample I traces from the initial time to October, 2001, while Customers sample II trace from the initial time to November, 2001. In order to judge the applicability of the SMC models, we analyze customer sample I using SMC models to forecast whether the customer will make purchase in November and how many times the purchases happen, then we compared the results with the actual situation in Customers sample II. The total sample is 331 customers.

3.2 SMC models validation analysis

Using Schmittlein and Peterson's 2-step parameter definition method [2] to analyze the data getting from the customer sample I, we obtain the result that $r = 1.66$, $\alpha = 3.58$, $s = 0.33$, $\beta = 0.5$, then using the corresponding model in SMC, we get the concrete value of each customer's active degree, expected purchase number and the probability to purchase certain times in November, 2001. Through the comparison of the forecasting value and actual value, we testified the applicability of SMC model in IT distribution market industry. In other words, the former three assumptions are validated.

Customer's active degree model can be used to forecast the customer's buying behavior in IT distribution market

Compared the 311 customers' forecasting active degree in November, 2001 with their true buying record in sample II , it is found that when the forecasting active degree is below 0.600, the actual purchase hardly happens. With the increase of the customer's active degree, the possibility of happening 1 or 2 times purchase increases greatly. When the customer's active degree equals to 1, the possibility of purchase once is the biggest, and so does the possibility of purchase twice. These analytical results can be seen in Table 1:

Table 1. The effect of customer's active degree model in forecasting customer's buying behavior

The Forecasting value of customer's active degree in Nov. 2001	Sample Volume	Customer's actual purchase number in November, 2001					
		0		1		2	
		Sample Volume	Ratio (%)	Sample Volume	Ratio (%)	Sample Volume	Ratio (%)
[0, 0.600]	152	151	99.34	1	0.66	0	0
(0.600, 1.000)	75	61	81.33	13	17.33	1	1.33
1.000	104	55	53.40	43	40.78	6	5.83
Total	331	267	80.91	57	16.97	7	2.12

It can be confirmed that 0.600 is the critical value between the active customers and the inactive customers. Below this value, the customers are inactive which means there is little chance left for the enterprise to trade with these customers, it is safe to say that this group of customers is already lost. And above this value, the customers are active, the higher the active degree of the customers is, the greater the possibilities and times of the purchase are. Thus, the critical value of the customer's active degree is a very important way to forecast customer's buying behavior. If the enterprise prepares to trade with some customers, the managers must be sure that these customers' active degree are higher than the critical value. So, customer's active degree is a necessary condition for enterprise to choose aim customer in the future.

Therefore, the active degree model in SMC models can be applied at the customer's buying behavior forecasting in the IT distribution industry, so hypothesis 1 is demonstrated.

The expected purchase number model can be used to forecast the customer's buying behavior in IT distribution market

Through the comparison of the forecasting value of customer's expected purchase number based on customer sample I and the actual purchase number in customer sample II, we validate the validity of forecasting the customer's future buying behavior using the SMC's expected purchase number model. The prediction details are shown in Table 2:

Table 2. The effect of customer's expected purchase number model in forecasting customer's buying behavior

The forecast of customer's expected purchase number in November, 2001	Sample Volume	The actual customer's purchase number in November, 2001					
		0		1		2	
		Sample Volume	Ratio (%)	Sample Volume	Ratio (%)	Sample Volume	Ratio (%)
[0.000,0.300)	169	167	98.82	2	1.18	0	0
[0.300,0.500)	52	41	78.85	11	21.15	0	0
[0.500,0.800)	85	65	76.47	18	21.18	2	2.35
[0.800,1.000)	35	13	37.14	22	63.86	0	0
[1.000,1.700]	13	5	38.46	3	23.08	5	38.46
Total	330	267	80.91	56	16.97	7	2.12

From Table 2, we can see that the possibility of none purchase becomes less when customers' expected purchase number increase, in other words, the purchase probability becomes larger. When the forecasting value comes to a certain value, customers incline to make more purchase. What's more, for any customer sample, we can find a critical value of customer's expected purchase number. Under this critical value, a customer's real purchase chance in future is very little. Thus, for most customers, if there is a purchase, the forecasting value of customer's expected purchase number must be higher than the critical value. Just like the critical value of customer's active degree, this condition can be recognized as another necessary condition to forecast customer's buying behavior.

Therefore, the expected purchase number model in SMC models can be applied at the customer's buying behavior forecasting in IT distribution industry, so hypothesis 2 is demonstrated.

The probability of purchasing appointed number times during a period of time model is validated in IT distribution market industry

We can get the probability $P[x^* \mid r,\alpha,s,\beta,x,t_1,t_2,t^*]$ of any customers in customer sample I with x^* times trading happened at the time period t^* (t^* represents any time period after t_2). The results show that the probability of purchasing 3 times is zero, and the chance of buying twice is small also. With the increase of x^*, this value decreases. This is corresponding to the actual situation. Take the time period of November 2001 as an example. In this month, the trading frequency of customers are all below 3, in other words, the probability of purchasing 3 times is zero, there are only 7 customers whose purchase frequency is equal to 2, which takes up 2.12% of the customer sample, there are 56 customers whose trading frequency is equal to 1, accounted for the 16.97% of the customer sample and customers without trading take up the largest portion at 80.81%. With the extending of the time t^*, this value becomes greater, this is an obvious result. This illustrates that this model is suitable for the IT distribution market. From the expression of formula (9), we can clearly see that $P[x^* \mid r,\alpha,s,\beta,x,t_1,t_2,t^*]$ is the product of two numbers which both between the value of 0 and 1. Thus, it is a comparatively small positive number. Through the one by one analysis of the customers' data sample I, we tested this point. The model based on the Digital China's customers' data is consistent with the theoretical model, hence we validate the fact that this model can be applied into IT distribution market, in other words, hypothesis 3 comes into existence.

Because this forecasting value is relatively small in most cases, it is not suitable for enterprise to use. So we advise to use customer's active degree and the customer's expected purchase number as the two important indexes to forecast customer's buying behavior.

4 Conclusions

Through empirical research, this paper proves the applicability of SMC models in IT distribution market, but these models cannot necessarily be applied to all industries. A key factor that whether SMC models could be applied is that whether Poisson distribution could be used to describe the customer buying behavior in that industry. In fact, customer's buying behavior is close to time nonhomogeneous Poisson distribution, and this case is more usual in fact. For SMC models' wide applicability, it is surely a research trend to use time nonhomogeneous Poisson distribution to substitute time homogenous Poisson distribution, which could greatly expand the range of applicability.

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Modeling the Product Development Process as a Dynamic System with Feedback

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Abstract. Effective product development process modeling can help manage the overall process efficiently and organize multi-functional team to develop product concurrently and cooperatively. In this paper, the development process is viewed as a dynamic system with feedback on the basis of feedback control theory. The dynamic model and its design structure matrix are developed. The model and its design structure matrix can be divided farther to reflect the interaction and feedback of design information. The mode and direction of the development process can be selected to satisfy constraints of process data flow and process control. A fuzzy evaluation method is presented to evaluate the performance of the dynamic development process; this allows the development process to be optimized based on re-organizing design constraints, re-organizing design processes and re-organizing designer's preferences. An application shows that modeling the product development process as a dynamic system with feedback is a very effective method for realizing life cycle design, optimizing the whole development process, improving the degree of concurrent, speeding information flow and reducing modification frequency.

1 Introduction

The demand for higher quality and lower cost products with shorter development lead-time to meet the dynamic global market's needs has made the performance of

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product development projects an increasingly important area of competitive advantage. In response to these challenges many industries have shifted from a sequential, functional development paradigm to a concurrent, team based paradigm. Increasing concurrence and cross functional development also dramatically increases the dynamic complexity of product development [1-3].

Effective modeling of product development can optimize the development process and the accumulation of design information, and it also can improve the degree of concurrent, optimize the design structure, improve product quality, and cut development cost and time. However, in practice the development process has dynamic uncertainty, time overlapping and constraint coupling, which coupled with the imperfection and fuzziness of design information leads to fluctuations in resource allocation and the accumulation of information that hampers process [3].

Moreover, product development itself is a complex, dynamic and uncertain system with feedback, and rather resembles a network (process net), where processes are highly interconnected, including feedback-loops and interactions on different hierarchical levels [4]. Because the feedback control system and product development process share the common feature of information feedback, feedback-control theory can be viewed as a very effective method for modeling the product development process.

This paper aims to analyze the dynamic characteristics of the product development process, model the product development process as a dynamic system with feedback, and present a suitable method to evaluate the performance of product development process. Section 2 gives a dynamic model with feedback and a design structure matrix for the product development process. Section 3 provides process evaluation and Section 4 illustrates a case of applying the model to Gear Transmission System Development. The research results are discussed in Section 5. Finally, conclusions are provided in Section 6.

2 A Dynamic Model of the Product Development Process with Feedback

2.1 Feedback Control Theory

Feedback control theory arose from the need to analyze the stability and performance of technological systems by means of information interaction and feedback. It, then, can be used as a very effective tool to model the dynamic product development process.

There are two methods for improving the feedback process. One is to simplify the process and delete the redundant processes that have no value to system output. The other is to strengthen the information feedback and process control.

In order to change a system output as expected by designers, all states in the system should be well controlled. There are two necessary and sufficient conditions that should be satisfied.

(i) The system output can affect all the states in the system.

(ii) All information in the system should be obtained.

In order to eliminate the adverse influence of process feedback, information interactive feedback should be strengthened to optimize the development process. In the development process, both the positive feedback and negative feedback processes should be strengthened to make the balance point of the development process either be transferred or be perfected in the initial point. In this way the design resources and process programming can be optimized.

2.2 Dynamic Characteristics of the Product Development Process

Many uncertain factors bring disturbance to the development system to some extent, and make the system unstable, which can stop or suspend the development process. The instability of a development process will be resulted in poor quality, delay in development time and high development cost.

In order to reduce the instability, the product development should be viewed as a dynamic system with feedback. A dynamic system has dynamic characteristics in each development process where the process has three different states: *proceeding* state, *stop* state *and feedback* state (see Figure 1).

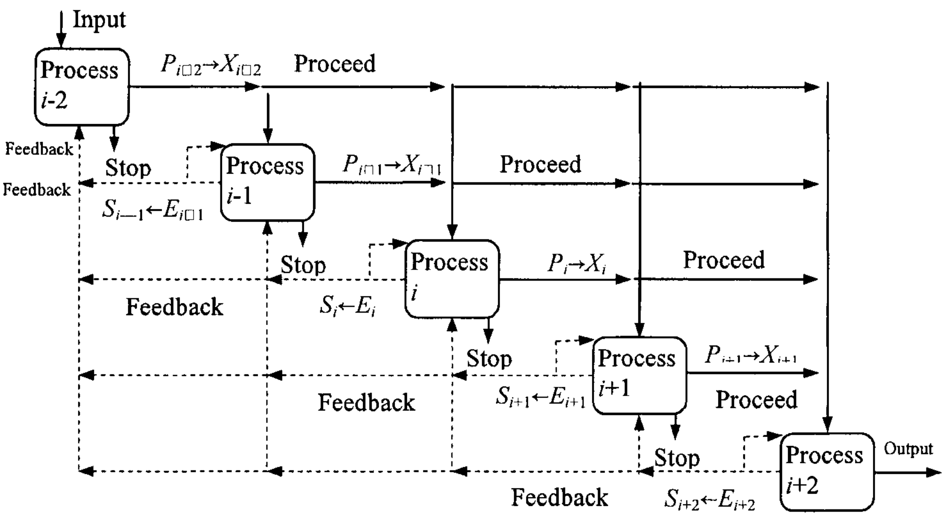


Fig. 1. Dynamic model of development process

In Figure 1, the model can be seen as two parts by the diagonal. The upper right part describes the proceeding state and the lower left part describes the feedback state. The black points in the figure express constraint evaluation points. For instance, the satisfaction of a constraint evaluation point determines the proceeding modes of development process (i.e. serial mode and parallel mode) and process flow. However, it should be pointed out that the satisfaction of the constraint evaluation point is only the necessary condition to decide process flow, not the sufficient condition. Based on the satisfaction degree and satisfaction number to constraint evaluation points, many process flows could be selected.

Due to the time characteristic of product development, there exist several time relations between processes on the basis of the satisfaction degree, satisfaction number and satisfaction sequence to constraint evaluation points.

However, meeting the constraint evaluation points is only the necessary condition, not the sufficient condition to decide time series of a process. If the relations above want to be followed strictly, the preconditions and transform conditions of a process, i.e. process control flow, must be satisfied. The feedback state of a process can be depicted by lower left part of Figure 1. Let $X = (X_{i-2}, X_{i-1}, X_i, X_{i+1}, X_{i+2})$ be the state vector of the dynamic system. The state vector not only could be the state that the designer masters the customer's requirements or the customers understand and express their requirements, or the state that the designer masters the design technology related to the product in the design process, but also could be the manufacturing state in the development process, or the state that the product satisfies the customer's requirements after it was checked and tried out. The state vector has a time characteristic, and its dimension depends on the complexity of the system. Moreover, the state vector is a fuzzy concept. The ideal state can be expressed as 1, and the most ambiguous state can be expressed as 0.

Let $P = (P_{i-2}, P_{i-1}, P_i, P_{i+1}, P_{i+2})$ be the set of state vectors of the dynamic system.

$$P_k: \quad X_{k-1} \times \prod_{n=k}^{i+2} S_n \to X_k, \; k = i-2, i-1, i, i+1, i+2 \tag{1}$$

Let $E = (E_{i-2}, E_{i-1}, E_i, E_{i+1}, E_{i+2})$ be the feedback state after the process is evaluated.

$$E_k: \quad X_k \to S_k, \; k = i-2, i-1, i, i+1, i+2 \tag{2}$$

State feedback is the precondition that makes the development process be carried out successfully. When the process proceeds, the process information should be fed back to all the upstream processes. From the viewpoint of control theory, this is a full-feedback model. Information feedback can make the constraints be adjusted in advance and make design information self-supplement, which can eliminate the influence of system perturbation and make the development process collaborative and optimal.

Theoretically speaking, full-feedback of information not only benefits the process collaboration and information interaction, but also makes the design information be fed back completely and embodies the dynamic characteristic adequately. However, under the full-feedback state, the more feedback loops there are, and the more the difficult the operation is. Moreover, it can result in redundant feedback of design information. Redundant feedback is a main reason that can make system unstable and result in the bad convergence of system optimization. Therefore, in order to increase the maneuverability of process programming, and to adapt the requirements of multi-function team and a multi-disciplinary working mode [5], not only should the number of feedback loops be reduced, but also the correct design information should be fed back to the correct location in the right time, and the redundant feedback of design information should be reduced. Therefore, the dynamic model proposed above should be modified to reduce intermediate feedback loops and make all the design information be fed back to the initial design stage. Through the revised dynamic model, the designers can analyze the problems together, and find where the problems occur. The model can be described as shown in Figure 2.

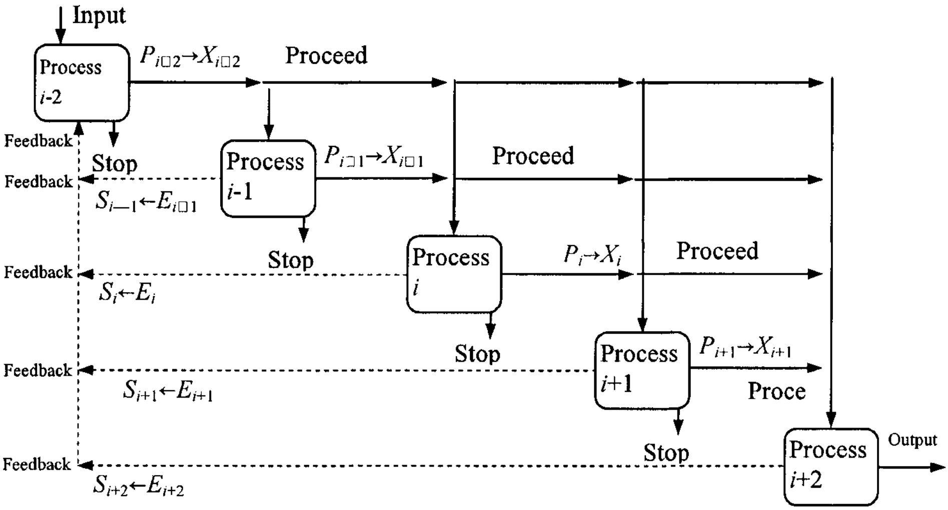


Fig. 2. Dynamic model of revised development process

After the process model is revised, the state mapping of system can be denoted by

$$P_{k-2}: \quad X_{k-1} \times \prod_{n=k}^{i+2} S_n \to X_k, \; k = i-2 \tag{3}$$

$$P_k: \quad X_{k-1} \to X_k, \; k = i-1, i, i+1, i+2 \tag{4}$$

The state feedback of the system can be expressed as

$$E_k: \quad X_k \to S_k, \; k = i-2, i-1, i, i+1, i+2 \tag{5}$$

Design Structure Metrics (DSM) provides a compact and clear representation of a complex system and a capture method for the interactions/interdependencies/interfaces between system elements (i.e. sub-systems and modules) [6-9]. The DSM method assumes that each design task can be modeled as an information processing task, using and creating information. The output information from one task becomes the input information to another task. The input/output relationships may include cycles, which indicate the need for iteration. Tasks in the matrix may be re-sequenced [1].

In this paper, a new design structure matrix is defined and used to describe the dynamic development process with feedback. The design structure matrix can be divided into two parts by the diagonal. The one part describes the interdependence relations among processes, i.e. the correlative information among different processes. The information can be the number of parameters of a process output or the communication quantity among processes. The other part describes the feedback relations among different processes, and the feedback information can be the number of feedback loops or the number of feedback parameters.

3 Process Evaluation

Process evaluation is based on factors such as quality, cost and development time. Let $\{u_1, u_2, \cdots, u_n\}$ be vector set of evaluation factors, with the range of value representing the degree of membership of the corresponding factor's satisfaction degree. Let $\mu_i(v_i)$ be the degree of membership, and v_i be the corresponding value of u_i. The weight vector of evaluation factors can be given by experts and expressed as $\{w_1, w_2, \cdots, w_n\}$.

The evaluation method can be carried out step by step as follows.

(i) If $v_i \notin \mu_i(v_i)$, then the feedback information is

- The corresponding indices of structure matrix.
- The difference between the index and its lowest value.

(ii) If $v_i \in \mu_i(v_i)$, giving the threshold of satisfaction degree and denoted by S_m.

Let $\mu_i(v_i)$ be the degree of membership of the evaluation factor. Such that

$$S = \sum_{n} w_i \mu_i(v_i) \tag{7}$$

- If $S \geq S_m$, the process is satisfied.
- If $S < S_m$, it has to carry out the process optimization and information feedback. The optimization model is as follows:

$$\text{Min} \left\| A - A' \right\|_{,\text{P}}^{1} ; \text{ S.t} \sum_{n} w_i \mu_i(v_i) \geq S_m ; \ \mu_v^{\min} \leq \mu_i(v_i) \leq 1 \tag{8}$$

where $A = w\mu(v)$. $A' = w\mu_{i=1}^{\max}$. $\mu^{\max}$ is the biggest vector of degree of membership. $\mu_v^{\min}$ is the least vector of degree of membership. $\left\| A - A' \right\|_{\text{P}}^{1}$ is the norm that $\text{P} > 1$.

The feedback information Δ is:

(a) If $v_{i\,\text{lower limit}} > v_i$, then $\Delta_i = \left| v_{i\,\text{lower limit}} - v_i \right|$

If $v_{i\,\text{lower limit}} < v_i < v_{i\,\text{upper limit}}$, then $\Delta_i = \left| v_{i\,\text{upper limit}} - v_i \right|$

If $v_{i\,\text{upper limit}} < v_i$, then $\Delta_i = \left| v_i - v_{i\,\text{upper limit}} \right|$

(b) The corresponding indices of structure matrix.

After the feedback information is fed back to the initial design stage, the multi-function design team can carry out three re-organization activities as follows based on the practical development environment to optimize the development process: (1) re-organize constraints, (2) re-organize the process, and (3) re-organize the structure of the designer's preference.

4 Application to Gear Transmission System Development

The development of a gear transmission system for the ZL50G loader is an example analysis of the dynamic characteristics of product development. In order to develop a high quality product in short time, the dynamic characteristics of the development process should be analyzed to establish an effectual process model. At the same time, because the development of a new loader inherits the features of ZL50, the interdependence and feedback relationships are more complicated.

There are seven sub-processes: (1) Prepare product specifications, (2) Preliminary design, (3) Evaluate development cost, (4) Mechanical analysis, (5) Design process features, (6) Analyze the product data of identical series products, and (7) Finalize design details.

From the analysis we identified the following:

(i) Through the dynamic analysis of the development process, the uncertain factors and some rules that can be followed can be found. Therefore, the development process activities can be organized and managed more effectively.

(ii) The development process can be optimized by the optimization of the interdependence and feedback relationships among processes. The number of feedback loops and the complexity of development process are reduced. The number of feedback loops is

$$b = \sum \sum M_b(i,j) = 6$$

(iii) From the analysis of structure matrix we can see that the feedback loops exist mainly in processes 2, 4, 5 and 6. That is to say the feedback loops exist mainly in the detailed design stage. By substituting the big feedback cycle with micro-cycles, the development efficiency can be improved and the redundant feedback can be reduced.

(iv) By improving and optimizing the relations among processes, the degree of concurrent can be improved and the development time can be reduced. Most process can be carried out in parallel or partly in parallel.

We select cost, weight and quality of transmission as evaluation factors; they can be denoted by an evaluation vector, U = (u1, u2, u3) = (cost, weight, transmission quality). The weights of evaluation factors can be given by experts and expressed as a weight vector $W = (w_1, w_2, w_3) = (0.3, 0.3, 0.4)$. For a certain process, the value of range and the degree of membership of the corresponding range's satisfaction degree can be given in advance, and the threshold of satisfaction degree S_m can also be given in advance. $S_m = 0.90$. Based on the evaluation results, we can change or adjust the helical angle, material, tooth number, modulus, tooth length, and so on, and this information is fed back to the frontward processes to modify the design processes and design constraints. The final evaluation result is that $S = 0.947$. The implementation of dynamic analysis brings great benefits to our development. The development time is shortened more than 30 percent, and the development cost is cut down more than 40 percent.

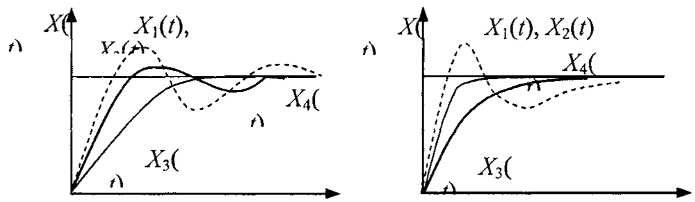
5 Discussion

There exists over-amplitude in product development process, i.e. an iterative process. The number of feedback loops, time of feedback and location of feedback has a very important influence on information interaction and product development. In order to make the development process continue successfully, the correct design information must be fed back to the correct location at the right time, so that the redundant feedback processes can de reduced. Take the state variables in the development process of gear transmission system of ZL50G loader as example, let X_1 be the state vector that the designer masters the customer's requirements or the customers understand and express their requirements. Let X_2 be the state vector that the designer masters the design technology related to the product in the design process. Let X_3 be the state vector that the manufacturing state in the development. Let X_4 be the state vector that the product satisfies the customer's requirements after it was checked and tried out. As shown in Figure 3, 3(a) denotes that manufacturing process successes after many repetitions, and 3(b) denotes that manufacturing process successes with no repetitions.

The reasonable analysis of dynamic characteristics can bring many additive benefits, such as shortening development time, cutting development cost, improving product quality, and so on. Failure to complete such a reasonable analysis leads to additive losses in the process. The evaluation precision, feedback information and re-organization activities significantly influence the convergence speed of process optimization.

From Figure 3 we can see that the customer's requirements and the instability of design technology are the main contributors to the instability of the development system. Because of increasing new requirements and the emergence of new technology, these two state variables should be emphasized to reduce the over-amplitude of the product development process.

Enhancing the evaluation precision and using the intelligent tools (such as a neural network) to real-time evaluate development process can make the best of the design information and reduce the redundant interactive process.



(a) Manufacturing process successes after many repetitions

(b) Manufacturing process successes with no repetitions

Fig. 3. The variation of process state variables

6 Conclusions

Product development process modeling is the heart of product development activities that determine the engineering productivity and industrial competitiveness. The rapid changing information technology and the competitive nature of global market make the research and application efforts in development process modeling a fast moving target. Modeling the product development process as a dynamic system with feedback is a very effective method for realizing life cycle design, optimizing the whole development process, improving the degree of concurrent, capturing designer's preferences, speeding information flow and reducing modification frequency.

However, due to the complexity of the product development, there are several problems should be taken into account in the future research.

(i) Because some processes are carried out partly in parallel, there exist limitations in the design structure matrix that is expressed as 0 and 1.

(ii) In order to speed up the convergence of process optimization, the re-organization activities of process, constraints and preference's structure should be implemented in parallel based on the feedback information.

(iii) The insufficiency of process dynamic analysis and the impropriety of process evaluation and information feedback can increase the instability of system to a great extent.

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A Disassembly Model based on Polychromatic Sets Theory for Manufacturing Systems

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Abstract: Existing disassembly models are inefficient in generation of disassembly sequence and the number of disassembly schemes tends to be explosive in combination. In addition, few models have focused on three-dimension disassembly. This paper defines the concept of connectivity of part unit, proposes the generation algorithms of connective part units, and then develops a new disassembly model based on polychromatic sets theory. Adopting possible displacement model in polychromatic sets theory as disassembling model, all connective part units are sieved by possible displacement function groups to eliminate illogical ones. Hierarchical graph is employed to describe disassembly process and disassembly sequence. Present disassembly model based on polychromatic sets is convenient for expressing restriction relation between each two parts in disassembly process. It also has advantages of higher formation level, avoiding "combination explosion" and tending to program.

1 Introduction

Disassembly is a very important and difficult process in green remanufacturing engineering. The premise of recycling and reusing of worn-out products is that the

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parts of products that have arrived at their lifecycle and need recycling can be easily taken down. So before disassembling of products, disassembly process should be programmed properly and be optimized with the aims such as economics of disassembling, coordinating of environment and feasibility of technique. Finally optimal disassembly sequences can be obtained [1, 2].

In the literature there are many papers proposing various methods for studying disassembly and recycling. Moore (1998) proposed an algorithm which automatically generates a disassembly Petri Net (DDN) [3]. From a geometrically based precedence matrix, Gungor (1998) addressed the uncertainty related difficulties in disassembly sequence planning [4]. Then Lambert (2002) studied disassembly sequence generation for electric equipments [5]. Kongar (2002) presented a genetic algorithm for disassembly process planning [6]. Park (2003) proposed that a methodology generates an optimal disassembly sequence by determining disassembly methods, employing PLM (profit-loss margin) curve to determine disassembly depth, and using MRFD (modified reverse fishbone diagram) to generate optimal disassembly sequence [7]. Gupta (2004) studied disassembly problem based on a case of cell phone [8]. Gonzalez (2004) presented a scatter search (SS), in which metaheuristic is presented aiming to deal with the optimum disassembly sequence problem for the case of complex products with sequence-dependent disassembly costs [9]. Chung (2004) presented an integrated approach to selective-disassembly sequence planning [10]. Villalba (2004) employed a recyclability index of material to determine economic of disassembly [11].

However, although many approaches to generate disassembly sequence have been developed in above literature, they have some common disadvantages as follows. They can not sieve illogical disassembly sequence, the number of disassembly schemes tends to be explosive in combination, it is difficult for them to differentiate different relations and to generate disassembly sequence, and few researches have focus on three-dimension disassembly [12].

2 Connectivity of Part Units

Connective part units are the really existent units in disassembly process which are composed of less than two parts. Their importance lies in their real existence in disassembly process. Connectivity of part units is based on the adjacent relation of parts which means that if two parts of the product have interface, they are adjacent [13]. To get generation algorithms of connective part units, firstly several definitions are made as follows.

Defination 1: If there are n parts in a product, then k-rank sub-graph of adjacent graph of the product can be formalized as Boolean vector $X^k = \left(X_i\right)$, where if part i belongs to the sub-graph, then $X_i = 1$. Or $X_i = 0$. Call X^k k-rank Boolean vector of adjacent graph and it is denoted as $\left\|X^k\right\| = k$. All k-rank Boolean vectors of adjacent graph compose k-rank Boolean vector set which is noted as $X^{(k)}$. $X^{(k)} = \left\{ X^k \left\| X^k \right\| = k \right\}$.

Defination 2: With X_1 and X_2 as base, defining binary relation as follows:

$R = \left\{ \langle x_1, x_2 \rangle \left\| x_1 \oplus x_2 \right\|_1 = k, x_1 \in X_1, x_2 \in X_2 \right\}$, so there exist that Y ($Y \in Y^k$), $Y = \left\{ x_1 \oplus x_2 \left| \langle x_1, x_2 \rangle \in R \right. \right\}$ and call Y k-rank combinatorial Boolean vector of X_1 and X_2. Y is denoted as $Y = \left(x_1, x_2 \right) \Big|_{\oplus}^{k}$.

Reasoning 1: provided that It has been known that there are n parts in some product, its adjacent matrix is $A_p = \left(a_{ij} \right)$. If $a_{ij} = 1 \left(1 \le i < j \le n \right)$, then $S^2 = \left(S_t \right)$ can be constructed, Where there is only $S_i = S_j = 1$. $S^{(2)}$ may be constructed using S^2 as elements.

Reasoning 2: If $S^{(k-1)}$ is known, then $S^{(k)} = \left(S^{(k-1)}, S^{(k-1)} \right) \Big|_{\oplus}^{k}$.

On the foundation of above definitions and reasoning, the generation algorithm of connective part units is listed as follows:

Generation flow of connective part units is showed in Figure 1.

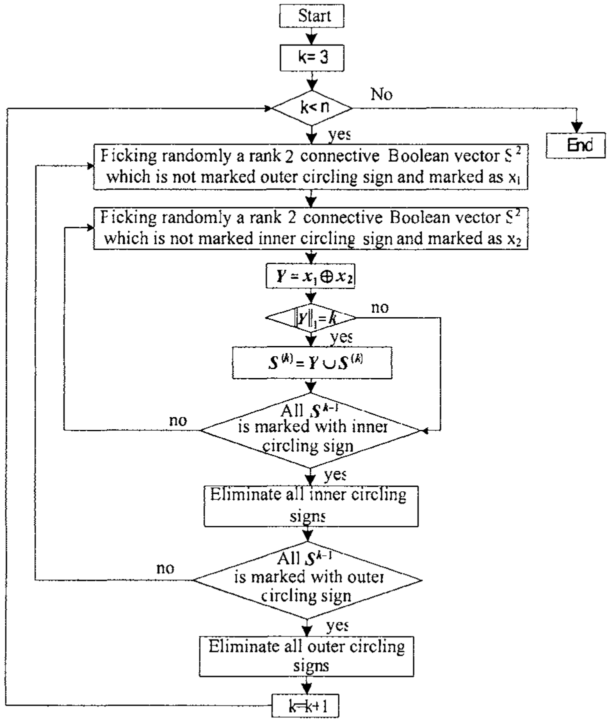


Fig. 1. Generation flow chart of connective part units

Step1: Let k=3.

Step2: To pick randomly a 2-rank connective Boolean vector S^2 which is not marked outer circling sign, and mark it as x_1.

Step3: To pick randomly a 2-rank connective Boolean vector S^2 which is not marked inner circling sign, and mark it as x_2.

Step4: To calculate Boolean sum of x_1 and x_2, that is $x_1 \oplus x_2$. And let it equal Y.

Step5: To determine whether Y is 3-rank Boolean vector or not. If yes, then $S^k = S^k \cup Y$. Or turn to step6.

Step6: To determine whether there are still 2-rank Boolean vectors which are not marked with inner circling signs. If yes, turn to step3. Or cancel all 2-rank Boolean inner signs and turn to step7.

Step7: To determine whether there are still 2-rank Boolean vectors which are not marked with outer circling signs. If yes, turn to step2. Or to eliminate all outer circling signs of 2-rank Boolean vectors, then turn to step8.

Step8: To determine whether k+1 is smaller than n. If yes, let k=k+1. Or turn to end.

3 Disassembling Model

For a connective part unit, the process of determining whether it can generate part units on next lower level by taking down one part from it is called disassembling determining. This paper advances a kind of possible displacement model of part and uses possible displacement equation groups as disassembling sieve to eliminate illogical part units from connective part units set.

3.1 Disassembling model

Generally, the premise of disassembly of a part is that there should be no any blockage on its disassembly channel. That is to be sure that disassembly channel exits. Possible displacement model describes blockage relation in disassembly in the direction ±X, ±Y, ±Z. Logical equation which is constituted with a group of parts that block the disassembly channel of some part is called possible displacement equation of the part [14]. Possible displacement equation expresses channel blockage relation in disassembly. For example, for part $a_{k,}$ if its disassembly channel is blocked, then $W(a_k)$=1. On the contrary, $W(a_k)$=0. For the part a_j which is a element constituting possible displacement equation of a_k, if it is disassembled before a_k, then its logical value in equation $W(a_k)$ is a_j=0. On the contrary, a_j=1. Logic relation between each two parts in possible displacement equation is AND/OR. Possible displacement equations of all parts constitute possible displacement model of product.

Table 1 below shows possible displacement model where $(a_{i,}, a_k)$ denotes logical relation of a_k to a_j, F_1-F_6 denotes blockage relation in the direction ±X, ±Y, ±Z and • denotes blockage of channel.

Table 1. Possible displacement model

	F1	F2	F3	F4	F5	F6
(a_1,a_2)	•					•
...						
(a_3,a_4)		•				•
...			•			
(a_5,a_7)				•		•
...	•					
...						
(a_{n-1},a_n)	•					•

3.2 Obtaining algorithms of possible displacement equation groups

To obtain possible displacement equation groups from possible displacement model, below definitions are given:

(1)F_1-F_6 shows blockage relation of movement in the direction ±X, ±Y, ±Z.

(2) $F_i(a_k, a_j)$ show the blockage relation of a_j *to* a_k, where $1 \leq i \leq 6, 1 \leq k, j \leq n$, and $j \neq k$ (n is the total number of parts).

(3) Possible displacement relation of a_j to a_k is different from a_k to a_j. That is $F_i(a_k,a_j) \neq F_i(a_j,a_k)$. Obviously, $F_1(a_k,a_j)=F_2(a_j,a_k)$, $F_3(a_k,a_j)= F_4(a_j,a_k)$ and $F_5(a_k,a_j)= F_6(a_j,a_k)$.

Algorithm of obtaining possible displacement groups is as follows:

(1) To extract possible displacement information from possible displacement model in table 1.

(2) Obtaining steps:

Step1: To determine whether part a_k is interfered.

$W(a_k) = \bigvee_{j=1}^{n}\left[\bigvee_{i=1}^{6} F_i\left(a_k, a_j\right)\right]$, if $W(a_k)$=0, then it means that part a_k is not interfered. Or if $W(a_k)$=1, then part a_k is interfered.

Step2: To obtain combination of parts that interfere a_k.

If $\bigvee_{i=1}^{6}[F_i(a_k, a_j) \vee F_i(a_k, a_m)] = 1$, then $W(a_k)= a_j \wedge a_m$.

Step3: Combinatorial law of polychromatic sets: if $W(a_k)= a_j \wedge a_m$, $W(a_k)= a_j \wedge a_l$. Then $W(a_k)= a_j \wedge (a_m \vee a_l)$.

3.3 Generation algorithm of disassembly part unit

Determining disassembling of all connective part units by using possible displacement equation groups, those part units that are determined as disassembling ones are called sub-part units, generation algorithm of which is as follows:

Figure 2 shows generation flow of part unit.

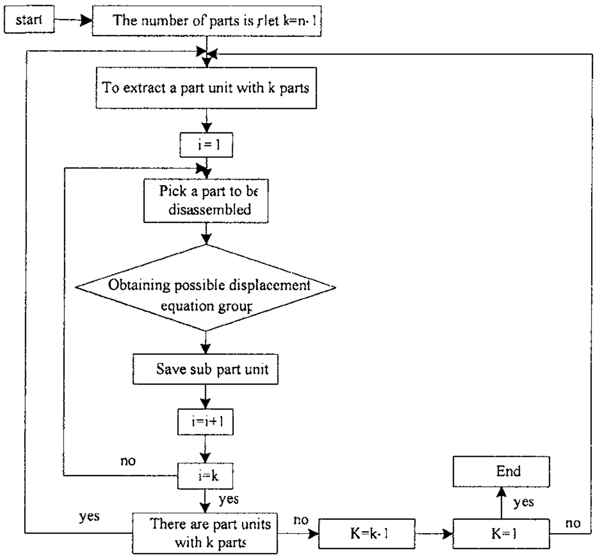


Fig. 2. Flow chart of generation of disassembly unit

Step1: To extract all part combinations with n-1 parts and pick out those combinations that meet possible displacement groups, they are sub-part units with n-1 parts and save them to unit database.

Step2: To pick a part unit composed of k parts.

Step3: To pick a part from k parts of the part unit of step2 as the disassembled one.

Step4: To determine whether every part to be disassembled meets its possible displacement equation groups. If yes, then the disassembly is proper and save the part unit with k-1 parts to sub-part unit database.

Step5: To determine whether every part has been selected as disassembled one. If yes, then turn to step6. Or turn to step3.

Step6: To determine whether there are part units with k parts. If yes, then turn to step2. Or let k=k-1.

Step7: To determine whether k is smaller than 1. If yes, then stop. Or turn to step2.

4 Generation Method of Disassembly Sequence

On the basis of obtaining possible displacement model, generation method of disassembly sequence is detailed as follows. Computer reads in possible displacement model and saves it in matrix, then searches every line of the matrix and calculates cumulative constrains of each part. Disassembly sequence can be generated according to the principle that part which has less cumulative constrains be disassembled firstly.

5 Disassembly Hierarchical Graph

After obtaining sub-part unit, we employ hierarchical graph of polychromatic sets to express level relation in disassembly [15], where set of vertexes is:

$$A = (A^{I}, A_1^{II}, A_2^{II}, \cdots, A_k^{II}, A_l^{III}, \cdots, A_m^{N}, a_1, a_2, \cdots a_n).$$

Border $e_{i,j} \in$ connects node A_i^J and node A_j^{J+1} on the next lower level. Borders in graph $G = (A, E)$ are composed as follows:

$$E \ni e_{i(j)} = \begin{cases} 1, \text{ if } A_i^J \ni A_j^{J+1} \\ 0, \text{ on the contrary} \end{cases}$$

Steps of building hierarchical graph are as follows:

Step1: Root node of the hierarchical graph is the set of all parts of product.

Step2: Beginning from root node, nodes on every level can be decompounded into one disassembly unit on next lower level and a single part. The disassembly unit can be decompounded once again. For example, node of disassembly unit in rank J can be decompounded into the elements of rank $(J+1)$ including the disassembly unit of $A_{J+1}$and the part of a_k. A_{J+1} and a_k meet the condition of $A_{J+1} \cup a_k = A_J$,k<n, and A_{J+1} can be divided once again.

Step3: Similarly, the hierarchical graph has been built when every disassembly unit has been decompounded into one single part, and then the disassembly sequence of product can be obtained from the hierarchy graph expediently.

6 Case Analyzing

Take PC box as an example to show application of present disassembly model in three-dimension disassembly. In Figure 3 each number denotes separately as follows. 1-box, 2-graphical card, 3-audio card, 4-motherboard, 5-speaker, 6-harddisk, 7-soft driver, 8-shelf, 9-power.

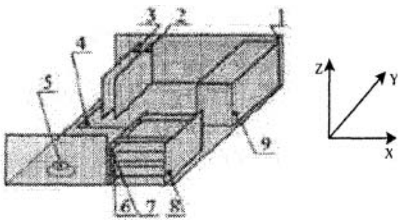


Fig. 3. Sketch map of PC box

(1) Connective part units

Total number of part units with n parts is ($2^n - n - 2$). For this example, n is 9, so total number of part units is 501. Number of connective part units is calculated as 164 .

(2) Possible displacement model

Possible displacement model of PC box is showed in Table 2. And possible displacement equation groups are as follows:

$$W(a_1) = a_4 \vee a_5 \vee a_8, W(a_2) = 0, W(a_3) = 0\ W(a_4) = a_2 \vee a_3 \vee a_7,$$
$$W(a_5) = 0, W(a_6) = a_7, W(a_7) = 0, W(a_8) = a_6 \vee a_7, W(a_9) = 0.$$

Table 2. Possible displacement model of PC box

	F1	F2	F3	F4	F5	F6
(a_1,a_2)				•	•	
(a_1,a_3)				•	•	
(a_1,a_4)				•	•	
(a_1,a_5)					•	•
(a_1,a_6)					•	
(a_1,a_7)					•	
(a_1,a_8)			•		•	
(a_1,a_9)				•	•	
(a_2,a_4)	•	•	•	•		•
(a_3,a_4)	•	•	•	•		•
(a_4,a_9)					•	
(a_6,a_7)					•	
(a_1,a_2)	•	•	•		•	•
(a_7,a_8)	•	•	•		•	•

(3) Obtaining of sub disassembly unit

By using generation algorithms of disassembly unit, number of part units on every level is calculated as following:

$\left|A^{(8)}\right| = 5$, $\left|A^{(7)}\right| = 11$, $\left|A^{(6)}\right| = 14$, $\left|A^{(5)}\right| = 13$, $\left|A^{(4)}\right| = 13$, $\left|A^{(3)}\right| = 7$, $\left|A^{(2)}\right| = 3$.

(4) Disassembly sequence

Combining possible displacement model above and method in section 3, constrain number of every part is calculated as:

$R(a_1) = 13, R(a_2) = 6, R(a_3) = 6, R(a_4) = 8, R(a_5) = 2, R(a_6) = 7,$ $R(a_7) = 7, R(a_8) = 12, R(a_9) = 3.$

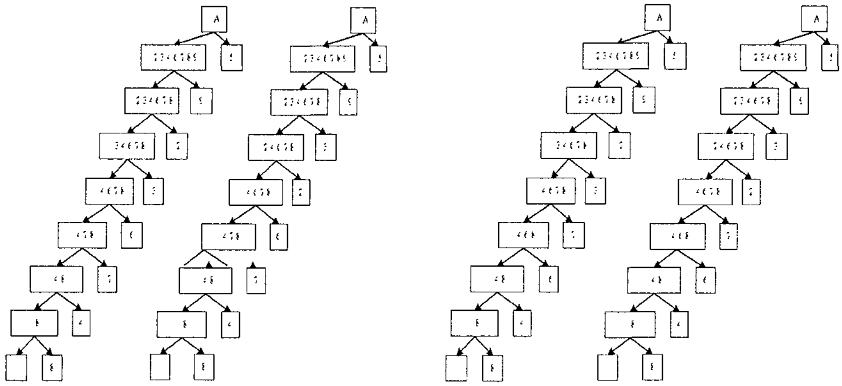
According to order of constrain number above, we can get the disassembly sequences as following:

$$(a_5 \to a_9 \to a_2 \to a_3 \to a_6 \to a_7 \to a_4 \to a_8 \to a_1)$$
$$(a_5 \to a_9 \to a_3 \to a_2 \to a_6 \to a_7 \to a_4 \to a_8 \to a_1)$$

$$(a_5 \to a_9 \to a_2 \to a_3 \to a_7 \to a_6 \to a_4 \to a_8 \to a_1)$$
$$(a_5 \to a_9 \to a_3 \to a_2 \to a_7 \to a_6 \to a_4 \to a_8 \to a_1)$$

(5) Hierarchical graph

Hierarchical graph is built on the foundation of four disassembly sequences above. They are illustrated as follows (a), (b), (c) and (d) in Figure 4.



(a) (b) (c) (d)

Fig. 4. Hierarchical graph

7 Conclusions

This paper presents concept of connectivity of part units and their generation algorithms. Connective part units are generated directly by using the generation algorithms of connective part units in order to avoid disturbing of many disconnection part units. Connective part units are sieved by possible displacement equation groups which are based on possible displacement model to eliminate illogical part units. It is effective to defend combinatorial explosion of disassembly schemes. Based on case, disassembly sequences are programmed according to the principle that part which has less cumulative constrains should be disassembled firstly, and the disassembly sequences which are consistent with real process of disassembly are obtained. Finally the process of disassembly is expressed by building hierarchical graph of polychromatic sets. This expression is concise and intuitionistic. Polychromatic sets theory adopts logical Boolean operation. It has following advantages: complexity of algorithms is less, easy to program and facilitate to extend to complex system.

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Multicriteria Model for Selection of Automated System Tests

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Abstract. Software Test Automation is a renowned way to enhance the test process, but it is not always the best approach for the project, despite that a crucial matter when applying software tests is to decide the viability of automating them. This decision is not always easy to take, because it involves persons exposing their point of view, which can bring a conflict with others opinion. In this context, this work aims to implement a decision aid model based on multicriteria to help test analysts and stakeholders in the selection of use cases for automation, according to organizational and projects' realities.

1 Introduction

Automated Software Testing is an activity that seems to have obvious benefits: tests can be executed quicker, are consistent and can be repeated various times without adding costs, however is not a trivial activity and requires good planning. It is necessary to keep in mind that automation requires good planning for the entire testing process, so that problems can be avoided. For this reason, the decision about which use cases (UCs) to have their tests automated is of great importance for a project's success.

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Tests execution may also be hybrid. The choice depends on a detailed analysis of the tests' complexity. This decision is complicated to be taken, because of the diversity of questions to be analysed and their impact on the project; however are more efficient considering time [1].

Therefore, this paper has the objective of showing a case study of the application of a multicriteria methodology to assist with the selection of use cases to be automated, with the intention of improving efforts spent. The methodologies of Multicriteria Decision Aiding (MCDA) have as strongest presupposition the fact of recognizing the importance of subjectivity from a decision-maker, person with power and responsibility of assuming consequences [4].

2 Multicriteria Model for Selection of Automated Tests

Every project is unique, with its own characteristics and specific requirements, involving a certain degree of uncertainty related to the decision of use cases to have their system tests automated. To know the project's life cycle, the people involved with tests, organizational influences, use cases' stability and types of tests necessary are all strategic factors to minimize those uncertainties.

Practical experience has shown that only an average of 60% of the project should be automated [2]. Therefore, it is extremely important to choose the correct use cases to automate and to facilitate the decision making of use cases to be automated; a multicriteria model was formulated, optimizing the process based on objective and subjective criteria to apply on diverse organizational projects. This model has a sequence of generic steps, distributed in phases of the multicriteria methodology that must be executed to make the decision.

2.1 Structure Phase

This phase aims the construction of a formal model, capable of being accepted by all the actors as a structure of representation and organization of the entire group of evaluation criteria, consisting of a specific system's analysis and making potential alternatives of decision explicit.

A criterion (c) is a tool to evaluate tests susceptible to automation in terms of a certain *point of view* (PV) or concern of the actors responsible for the analysis. In the phase where the project tests are planned, an identification of those responsible for extracting criteria that have influence in test automation is needed. The quantity of criteria (n) may vary in each project.

In accordance with [2, 3, and 6], the organization's main criteria are chosen and organized in a table, with reasons for each criterion and the question that should be answered to analyse the criterion.

The actors must be selected from stakeholders related directly or indirectly by the decision process, revealing their point of view (*PV*). Possible actors are project's manager, coordinator, test analyst, requirements analyst, developer and tester. The quantity of actors selected may change in accordance to the project's characteristics.

Actors have to answer questions related to criteria for each UC, informing if they attend ($PV(c) = 1$) or not ($PV(c) = 0$) to every criterion. If actors are not in condition of answering to a question, the question is considered as non-applicable ($PV(c) = null$), therefore:

$$PV_x(a,c) \in \{null, 0, 1\}, \quad \text{where } x = \text{UC}$$

A questionnaire is elaborated to obtain weights of actors (*weight of actor – WA*), embracing actor's experience in activities related to tests; roles performed; participation in projects; training and participation in test conferences. Each item has a value. With the measurement of all items, the actor's weight is obtained, which is normalized by a discrete variable between *zero* and *six* (considering MACBETH classification). The value varies for actors and criteria, but is equal for UCs.

$$WA(a,c) \in \{0,1,2,3,\ldots 6\}$$

Every *criterion* (c) receives a *priority* (classification), in accordance to the degree of relevance among the previously established criteria, in a decreasing order of importance. Every actor (a) must classify the criteria taking into consideration their relevance for the project's test process, and not for a specific UC.

$Priority\ (a, c_i) \in \{1, \ldots, i, \ldots, n\} \mid \forall\ c_i, c_j \mid i \neq j \Rightarrow Priority\ (a, c_i) \neq Priority\ (a, c_j)$ where $n = |\text{criteria}|$; $i, j > 0$; $Priority\ (a, c)$ = priority of criterion c for actor a

The following formula is obtained for every UC x, every actor a and criterion c:

$$WA(a,c) \in \{0,1,2,3,\ldots,6\} \text{ and } PV_x(a,c) \in \{0,1\}$$

$$\Pr iority(a,c_i) \in \{1,\ldots,i,\ldots n\} \mid \forall c_i, c_j \mid i \neq j \Rightarrow \Pr iority(a,c_i) \neq \Pr iotiry(a,c_j)$$

The three sets of values must be equalized (on the same base – base 1) after they are informed so that a correct evaluation is possible without favoring a value to the detriment of another. Therefore:

$$[WA(a,c)]_1 \in \{0, 0.17, 0.33, 0{,}50, 0.67, 0.83, 1\} \text{ and } [PV_x(a,c)]_1 \in \{\text{null}, 0, 1\}$$

$$[\Pr iority(a,c)]_1 \in \{1/n, 2/\text{n}, \ldots, n/n\}$$

Afterwards, for each actor, the three variables per criterion are multiplied, obtaining a specific punctuation, the score S.

$$S_x(a,c) = \{[WA(a,c)]_1 \text{ x } [PV_x(a,c)]_1 \text{ x } [\Pr iority(a,c)]_1\}$$

A score S for every criterion of every UC is given to each actor, and ordered under the form $S_{x,j}\ (a, c)$ where $S_{x,j}$ represents the j^{th} score of the criterion for UC x and actor a ordered with component $j = 1, \ldots, m$, where m represents the number of actors. Then, the medium (Me) of the scores is calculated, as follows:

$$Me\ (x_i, c) = \begin{cases} [S_{x,\ j/2} + S_{x,\ (j/2+1)}]/2, & \text{if } m \text{ is even,} \\ [S_{x,\ (j+1)/2}], & \text{otherwise} \end{cases}$$

The values of $S = null$ are not considered to calculate the medium. The medium's value for the UC represents the final score of each criterion per UC, considering all actors involved in the decision process. These mediums are the base of classification of UCs to automate.

2.2 Evaluation Phase

This phase constructs matrixes of judgments and acquires scales of cardinal value for every criterion. The tasks are implemented with the MACBETH methodology [5].

To use the model, equivalence was made with results and the MACBETH classification. The equalization of *point of view*, *weight of actor* and priority (shown in previous section) results in values of the general score between *0* and *1*. Medium's values are divided into six intervals related to MACBETH's classification. With the obtained categories, the MACBETH's modeling is made showing the attraction difference among UCs.

2.3 Recommendation Phase

This phase consists on the analysis of results generated by MACBETH from scales of values generated in the matrixes of judgments, which is composed of various actions that must be analysed according to the decision-maker evaluation.

The results obtained during the evaluation phase generate reports with graphics, and analysis of UCs classified in a ranking so that they may be given priorities for automation. Given this classification, the stakeholders will establish, according to specific capacities of the project and obtained results, the UCs to be automated, respecting order obtained with evaluation.

3 An Application of the Multicriteria Model: A Case Study

In the Structure Phase (step "*Identify Criteria*"), the test analyst and the coordinator made an analysis of which criteria to analyse to select UCs for automation.

Afterwards the following actors were chosen: project's tester; and representative of the test group. Afterwards they answered questionnaires for all criteria and the decision-maker obtained the weights for each actor according to the questionnaires. Each actor classified the selected criteria depending on their own perception of their priorities when on step "*Attribute Priorities to Criteria*".

A partial evaluation of the score (*S*) is made for every criterion, multiplying *point of view* of each actor for each UC, *weight of actor* and criterion's *priority*. The values given by the actor were equalized to guarantee an equal evaluation. In step "*Calculate General Scores*" the medium is calculated to obtain the final score of the UC for each criterion, obtaining the partial evaluation of each actor.

In the Evaluation Phase, a matrix of judgment was made for every criterion using MACBETH, informing attraction differences between UCs. Then scales of cardinal value were obtained and a quantitative analysis of criteria values could be made. The one with highest weight would be "*Criticity*" and the lowest "*Availability of Time/Resources*".

In the Recommendation Phase, a classification for automation was obtained for every criterion. See Figure 1 to visualize the general classification obtained. The highest priority automation UC would be "*Adjust Schedule*" (UC14) and the lowest "*Download File*" (UC18). Given the obtained results, the actors arranged a meeting and selected the four most recommended (UC14, UC08, UC20 and UC19).

This analysis provided a proper planning of UCs to automate, in accordance to the project's structure available. Besides, the resultant values, after applying the model, provides a visibility of the criteria's level related to each UC, making it possible to prevent problems.

Actions scores

Actions	Overal	CRITIC	STABIL	REPEAT	PERFOR	USABIL	TIME
[all high]	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UC14	86.65	94.74	95.65	76.92	73.33	93.75	95.00
UC8	74.36	89.47	60.87	92.31	46.67	87.50	90.00
UC20	73.13	84.21	47.83	69.23	93.33	62.50	85.00
UC19	66.69	68.42	86.96	38.46	86.67	37.50	70.00
UC7	53.19	52.63	73.91	84.62	20.00	31.25	55.00
UC18	5.97	5.26	4.35	7.69	6.67	6.25	5.00
[all low]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scaling constants:		0.24	0.21	0.19	0.22	0.13	0.02

Fig. 1. Use Cases'general score

4 Conclusions

A multicriteria model used for software system tests was presented to select **UC**s for automation. The application of this model has shown satisfactory, since the selection is not random anymore, depending on diverse subjective opinions and frequently costly. Furthermore, some problems, such as inadequate use of available resources and unnecessary automation, have been minimized, showing efficiency when using the model. Therefore, any software company working, or willing to work, with test automation, can use this model.

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