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Determining Information Requirements for E-Business Systems From Activity Space to Information Space

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ABSTRACT

The study of information requirements for e-business systems reveals that the level of detail, granularity, format of presentation, and a broad range of information types are required for the applications. The provision of relevant information affects how e-business systems can efficiently support the business goals and processes. This paper presents an approach for determining information requirements for e-business systems (DIRES) which will allow the user to describe the core business processes, whose specification maps onto a business activity space. It further aids a configuration of information requirements into an information space. A case study of a logistics company in China demonstrates the use of DIRES techniques and assesses the validity of the research.

INTRODUCTION

Electronic business (e-business) is emerging as one of the most exciting research areas in our era. E-business systems are dynamic networks of interrelated IT systems that enable the conduct of business between two or more parties electronically. It offers an innovative and a promising way for companies to trade and cooperate in the ever-changing market. The value of e-business undoubtedly comes from its electronic nature, which is fast, effective and global. E-business systems provide a fast and effective way in which customers can explore all goods (or services) in a few minutes, and at the same time, to choose and order the desired ones. E-business has a wide and global adoption because it is based on the Internet infrastructure, which could easily help companies to reach potential customers and conduct business worldwide.

When designing an e-business system, it is essential to understand the business operations and to capture the information requirements for the various users of the system (Fayad *et al.* 2000; Georgakopoulos *et al.* 1999; Johnnesson and Perjons 2001). E-business systems serve buyers, suppliers and business trading partners as well as internal employees of the firm. To develop such kind of systems, there are some issues on information provision that need to be addressed, which has raised two primary concerns. Firstly, there is a need to ensure the provision of appropriate information to help customers in making purchase decisions, whilst also supporting the firm in its collaboration with suppliers and business partners. The second concern is to consider the issues at the management level, which are related to the provision of the most appropriate information to the corresponding managerial level. The provision should be set out with regard to the formulation of the business vision and missions, goals and objectives, polices and rules for the organisation, in order to maintain customer relationships and to manage supply chains. E-business systems, therefore, involve numerous stakeholders for different objectives and requirements. This becomes a real challenge for determining the right information requirements based upon which the e-business systems can be designed and developed as such to encapsulate the notion of trust.

Trust is an essential notion in e-business systems (Jones *et al.* 2000, Salam *et al.* 2005). Customers must trust that the systems would not provide the wrong information and that the actions of the systems carried out on their behalf will not be in conflict with their intentions (Chen *et al.* 2004). One must also trust that the other trading party is willing to bear any responsibilities due to the provision of the appropriate information. However, e-business systems are designed and developed without providing any guidance on how to best build this trust. This represents a large gap in knowledge, because in the sophisticated world of e-business, trust can never be guaranteed to occur to facilitate the impeccable occurrence of e-business transactions. What is more important is to provide mechanisms to build this trust between the customers, sellers and other relevant parties. There are, obviously, design issues to be tackled at the strategic level. Methods that allow the designers to understand the information requirements for all

trading parties need to be in place. This will be the first step in creating predictable e-business systems (Beynon-Davies 2004; Casati and Shan 2001; Johnnesson and Perjons 2001). To this end, the method for Determining Information Requirements for E-business Systems (DIRES) is introduced in this paper.

DIRES is based on the premise that the key element of an organisation is its members with designated roles and responsibilities who perform business activities in a coordinated manner through the use of information (Chong and Liu 2000, 2001; Sun *et al*. 2000). The essential function of information which is created and used throughout the business value-chain highlights the importance of information and communication; hence the effective utilisation of information determines an organisation's competitiveness in the marketplace (Liu 2000, 2004; Liu *et al.* 2001). The e-business system which supports the management and execution of business activities will become an integral part of all enterprises in the digital economy. This paper introduces DIRES with its set of techniques that enables users and developers to determine information requirements for the design of e-business systems from a methodological perspective. Following an explanation of the basic concepts in DIRES, a set of constituting techniques is presented. The method is applied to a case study in freight transportation to demonstrate its use, and the development of the method is critically validated. Finally discussions and conclusions are drawn.

THE DIRES METHOD

The DIRES method aims to enable users to articulate business operations and configure information requirements in an interactive fashion. It facilitates users during a business domain analysis to specify business processes by describing the business terms, and to derive the information requirements based on business knowledge and rules captured in the system (Liu and Ong 1999, Liu et al. 2003).

There are three important concepts, ontology, activity space and information space, in the DIRES method. An ontology of the business domain is presented in a chart that delineates the business terms and the core business processes (Chong and Liu 2000, 2001). These business processes can be further decomposed into a number of business activities, which possess information elements. The principal purpose of the ontology chart is to describe common e-business processes (Jones et al. 1979). These business processes can be decomposed to form an activity space and information space, which will then determine information requirements for systems design (see Figure 1).

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Figure 1: Determining information requirements.
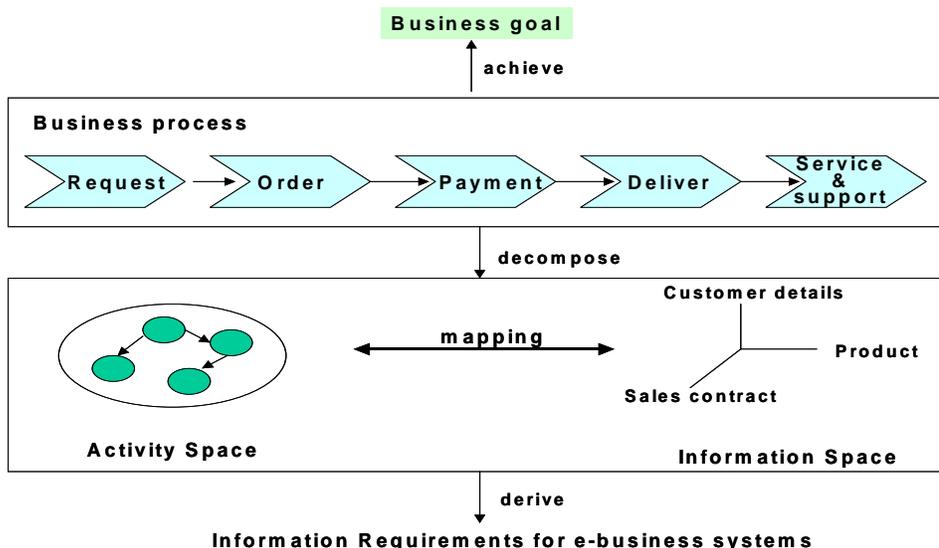
In an e-business context, managers and customers usually require information to make decisions for different purposes. For example, a manager may wish to access the performance on sales in certain locations; customers may request information on certain types of product/service for purchase; and the firm needs to plan production by getting enough supply. In order to design an efficient e-business system to serve these purposes, the business operation can be conceptualised in a sequential business process and the business operations can be represented in activity spaces, which consist of a set of dimensions equivalent to these business terms in the process. The information required by the activity space can be organised in the information space. A mapping between these two spaces will determine the information requirements for the system (Sun and Liu 2001).

DIRES ARCHITECTURE

DIRES provides a mechanism for systems developers to start an analysis from a problem statement, which may be vague, and gradually move on to acquire more concrete knowledge of the business operation by using a set of techniques. This analysis can be carried out at two major phases: *domain analysis and modelling*, and *configuring information space*.

Domain Analysis and Modelling

Domain analysis and modelling (Figure 2) involves process analysis, agency structuring, role/activity analysis and information analysis. The process analysis focuses on the business process aspects at the enterprise level. Agency structuring, conducted at the same time as the process analysis for their interdependency, identifies human actors (i.e. agents), their roles and responsibilities within the organisational structure. Role/activity analysis further identifies activities involved by each role. Finally, information analysis determines the information requirements for each role and activity.

Figure 2: Domain analysis and modelling.
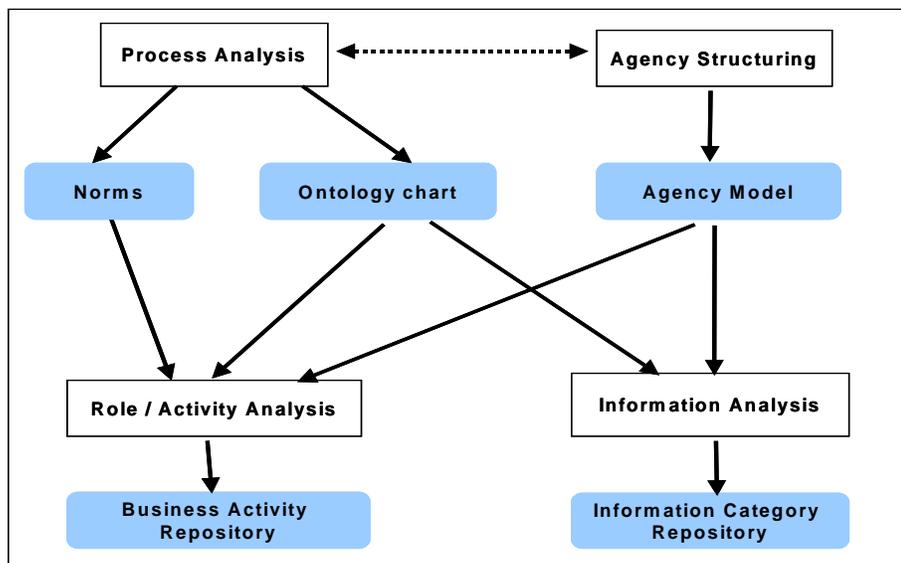

This phase produces the following deliverables:

- **Ontology chart** is produced from the process analysis. The ontology chart represents the business domain by capturing the business processes, business terms and jargons and their meanings. In addition, the chart identifies the many useful concepts such as the responsible agents, their roles and their ontological dependency relationships.

- **Business norms** are examined and captured from the process analysis. They represent a more thorough understanding of the business processes identified in the ontology chart, based on which the decomposition of the business processes can be carried out.

- **Agency models** are created based on the process analysis and analysis of agent structure (i.e. agency structuring). This conceptual model is a refinement of the ontology chart that identifies agents, their roles and relationships.

- **Business Activity repository** is a collection of business activities related to the e-business processes. This repository is the result of the role/activity analysis, which examines agents in each role and their involvement in the activities. This repository contains all the possible activities across the different processes. It will be used to facilitate an articulation procedure in the second phase.

- **Information category repository** resulting from the information analysis that takes input from the agency models. This repository defines the categories (i.e. types) of information (rather than information content itself). Each category can later on form an information dimension in an information space.

CONFIGURING INFORMATION SPACE

The phase of configuring the information space (Figure 3) carries out two analyses: *articulation of the activity space* and *configuration of the information space*. The articulation of the activity space takes input from the agency model and the business activity repository. The user will have opportunities to interact during this procedure and to customise the selected activities and specify the granularity of the activities for constituting the dimensions of the activity space. The activity space is composed of several dimensions, each of which is represented by a business term. For example, an order process consists of a number of activities, such as make a *sales contract* (including quote, tax, customer details, product and quantity), *delivery* address and date, *inventory status, amend order*, and *cancel order*. These activities normally follow the norms governing the behaviour and their sequence. In order to execute these activities, certain kinds of information are required, e.g. customer details, product, quote, delivery details, inventory status and payment terms.

Figure 3: Configuring Information Space.
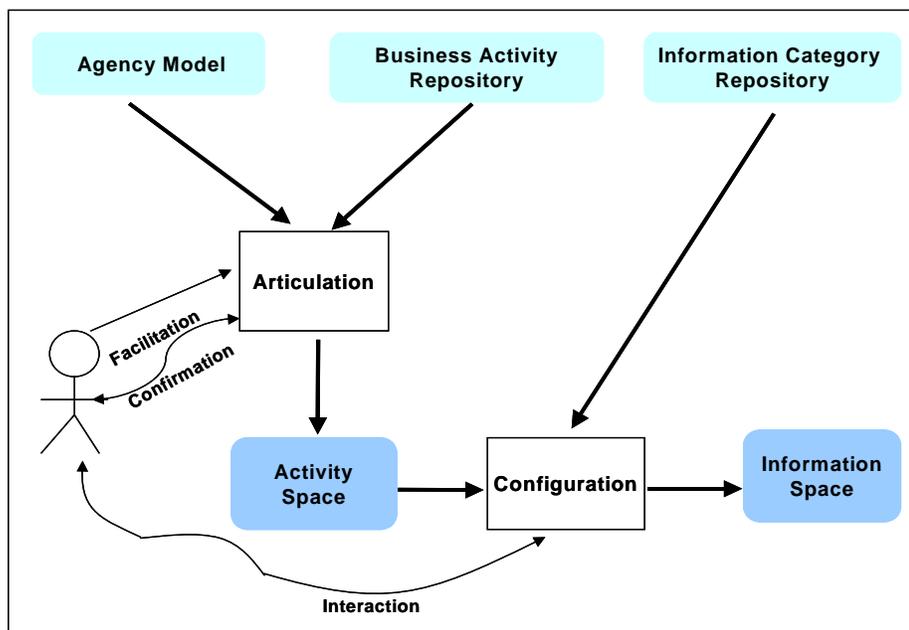
The configuration of the information space maps an activity space, with the input from the information category repository, onto an information space. The information space is formed by a number of information dimensions, with each dimension corresponding to a category of information. For example, the category of information on a purchase contract can be one dimension, which can be tuned at any level of granularity: normal

contract or special contract. The procedure of a configuring information space is complex, because there is normally a number of choices of granularity available in each dimension which may all be relevant to the business process, but to varying extents. In such cases, the user can interact during the procedure to determine, e.g. temporal and spatial granularity, any additional dimensions, and chronicle coverage.

APPLYING DIRES IN FREIGHT TRANSPORT

To illustrate the techniques in DIRES, an e-business case study is adopted from P&G Logistics Group, Ltd., a large Chinese logistics company (P&G Logistics 2005). P&G Logistics was founded in 1994 and registered as the first "Logistics" company in China in 1999. At first, it was mainly responsible for P&G's freight transportation business, as its name suggested. However, its current customers include more than 40 of the world top 500 companies and many SMEs. Except for the headquarters in Guangzhou, P&G Logistics has 7 branches located in Beijing, Shanghai, Guangzhou, Chengdu, Wuhan, Hefei and Shenyang and 48 offices around China. This network also extends to other countries and areas, such as the USA, Australia, Thailand and Hong Kong. Their logistic information management platform facilitates communication and coordination among different parties. Although the network operates on a multiple mode of transportation by air, rail, and highway, the paper shall examine mainly the over-the-road operation between cities, and local pickup and delivery. In road transport, satellite terminals are spread around major cities where there are breakbulks. The satellite terminals collect goods from customers and bring them to the breakbulks. The goods are then sorted and consolidated at the breakbulks for both the longhaul transportation to another city and shorthaul within the same city.

The Freight Operations

An entire business system of the company is composed of several major business areas. The areas where decisions often have strategic impact are identified within the business system:

- **Stocks and shares**. The company has a very elaborate stocks and shares system that is linked with staff performance and loyalty.
- **Operations planning**. All the freight activities involved at the docks, breakbulks and satellite terminals, and the coordination of transit are planned based on the information stored in various information systems.
- **Safety planning**. Safety is managed and planned regarding to longhaul, local P&D, and dock movements and garage procedures.
- **Products and services**. This area is the key, primary business operation of the company. Further analysis will be carried out in this area later in this section.
- **Tonnage and mileage management**. Tonnage and mileage are the immediate outcomes that reflect the business performance.
- **Garage and vehicle repairs**. The garage operation provides necessary support to the company's core business.
- **Damage claims**. Information from claims can be used to identify potential problems in the performance of transit, consequently to improve the quality of the services.

Analysing the Business Processes

Within the operation of Products and Services, the freight transportation is the key process, around which all other business functions are built. Therefore understanding and capturing this process is essential in modelling the core business domain. In this section, four aspects in the domain analysis and modelling as described in Figure 2 will be investigated: Process Analysis, Agency Structuring, Role/Activity Analysis, and Information Analysis.

Process Analysis

Based on the above analysis of the entire business domain, the area of Products and Services is analysed and represented in an ontology chart in Figure 4. The details of the various steps in constructing the ontology chart are excluded from this paper (for details see, Barjis and Chong 2001; Chong and Liu 2000; Liu 2000). The agents

are grouped according to their ontological dependency relationships and the types of responsibility. The ontology chart is interpreted as follows. The chart is read from the left to the right, entities that are on the right are dependent on the existence of the entities to which they are connected on their left to exist. Any entity whose existence is dependent on the existence of other entities is known as the dependant (e.g. pays), while the parent entity of the dependant is known as the antecedent (e.g. sender).

In this chart, the entities in circles are usually the companies or agents that are responsible for performing some activities. The roles of the agents at different point in time can be identified from the semi-circles. Nodes that represent verbs reflect the potential activities that the agents can perform. The activity "request" leads to the existence of the activity "generates" if the action "request" is completed. Therefore, a dotted line with a "@" sign is used to indicate that the completion of the activity "request" activates the action "generates".

Figure 4: Ontology chart of P&G Logistics.
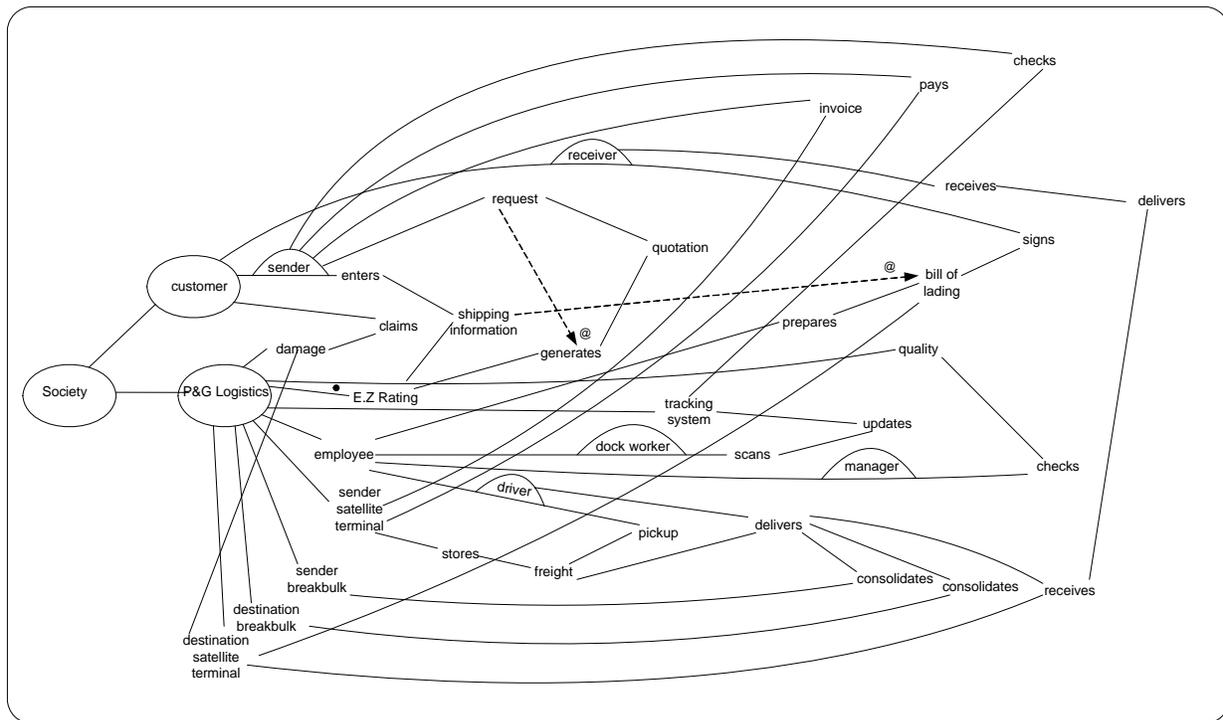
Some features of the ontology chart are worth noting. Firstly, one contribution of the ontology chart is that it provides an understanding of which agents are responsible for the activity. This is important in an e-business deal, since it is important for the company to fulfil any obligations that are incurred on them after being involved in some activity. Customers will definitely take their business elsewhere if obligations or promises are not kept. Secondly, one has to realise that the existence of an activity must be within the existence of its antecedent. Once its antecedent ceases to exist, the lifetime of the activity will also come to an end. For example, no activity 'pays' should take place when there are no customers. This understanding can be translated into implementation to ensure the integrity of the system. Thirdly, the ontological dependency relationship between different entities maps to the concept of inheritance in object oriented terms. For example, sender and receiver are two instances of customer and they inherit the characteristics of the customer.

The ontology chart describes the responsible agents for each business process and their ontological relationships. However, each of the business processes involves a set of highly complex norm-governed activities. In order to capture these details, the business norms of P&G Logistics are examined and expressed in Table 1. For the reason of brevity, the business norms shown in Table 1 are not exhaustive. Due to the scope of this paper, the specification of business norms have been limited to natural language (English) though they can also be specified

using a formal language known as LEGOL (Jones *et al.* 1979; Stamper 1980), a language for specifying business norms.

Based on the ontology chart and the understanding of the business norms, an interaction model, which captures the detailed business processes of the freight transportation, can be derived as shown in Figure 5. The interaction model presents the sequence of the procedures from an enquiry from a sender consignee, to the transit of the freight, and to the delivery of the goods to a receiving consignee with all messages flow among them.

**Table 1: Business norms of R&G.**

request
BN1 **If** sender is requesting a quotation
    Then sender
     is *obliged*
     to state one of the delivery methods that is required (Guaranteed day,
      Eepress transportation services, Managed returns, International services,
      Time-critical, Precision delivery or Freezables program).

enters
BN2 **If** sender wishes to enter the pick up details
    Then sender
     is *obliged*
     to state their contact information, pickup location, shipment destination and
shipment information.
BN3 **If** sender has entered pick up details
    Then sender
     is *permitted*
     to check the cost of a freight move, shipment's location, proof of delivery or
other shipment related information.

pays
BN4 **If** sender has sent freight
    Then sender
     is *obliged*
     to make payment to P&G Logistics.
BN5 **If** sender is making payment to P&G Logistics
    Then sender
     is *obliged*
     to settle the payment with sender satellite terminal.

generates
BN6 **If** E.Z Rating is responding to customer's request
    Then E.Z. Rating
     is *obliged*
     to generate a quote of charge to the customer.

checks
BN7 **If** sender is using the tracking system
    Then sender
     is *permitted*
     to check the PRO-Number request, bill of lading request, P.O. request and
booking number request.

claims
BN8 **If** the delivered good is lost or damaged,
    Then the sender, receiver, or a third party
     is *permitted*
     to submit a claim form.
BN9 **If** a claim form is submitted
    Then claimant
     is *obliged*
     to present a statement describing the goods lost or damaged and how the
      amount of the claim was determined, a copy of the bill of lading or P&G
      Logistics Freight bill, a copy of an inspection report if one was performed,
      and a copy of the vendor's original invoice or other document to establish
      the value of the goods.
BN10 **If** the good is received for more than nine months,
    Then the claimant
     is *forbidden*
     to submit a claim form.
BN11 **If** claimant wishes to view the status of a claim,
    Then the sender, receiver, or a third party
     is *obliged*
     to submit a PRO-number or claim number.

Agency Structuring

The targeted user group, which the DIRES method is intended to help includes customers, suppliers, the employees (i.e. drivers and staff at satellite terminals and distribution breakbulks), and the operation managers, because they are the most likely to require information to perform business functions. Therefore identification of the roles and responsibilities of these users is important in determining the information requirements. To this end, the ontology chart and the business norms provide the point of departure in conducting such an analysis.

As can be seen from the ontology chart (cf. Figure 4), the employee is the generic type of agent who has responsibilities for handling products and services at different levels. The managers are concerned with the planning of products and services and monitoring of the quality. The drivers follow the plans and instructions to pickup and deliver freight to all customers, including individual, business and government. They also deal with the bill of lading, but not damage claims as the receiver must report damage or shortages through other channels. The above information can be represented as an agency model in Figure 6.

Figure 5: The request process.
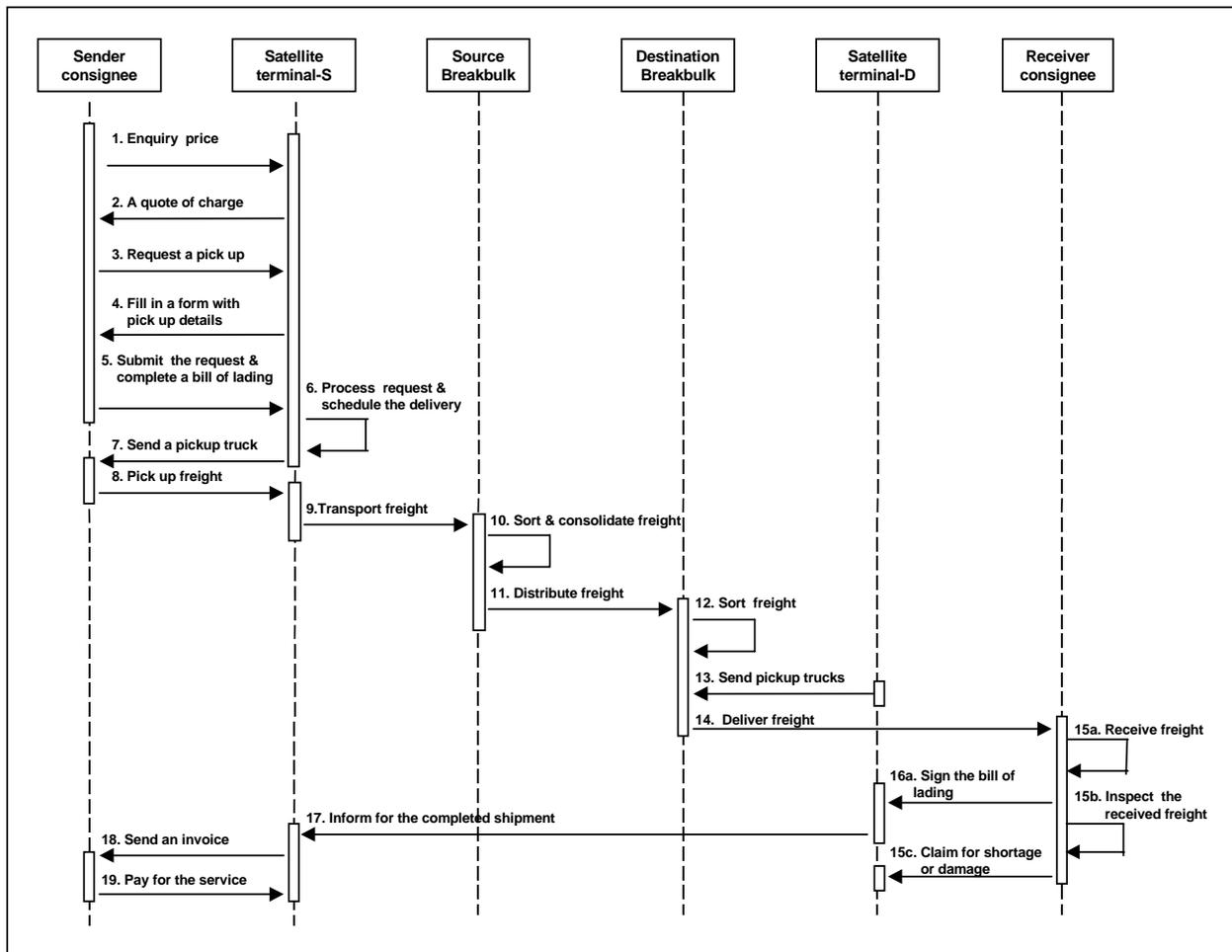
Building the business activity repository

A business activity repository is the container, which collects the activities decomposed from the business processes identified from the ontology chart. They are treated as business objects, which encapsulate the business rules and information required. The advantage of creating this repository is that the activities can be selected in a flexible manner to constitute an activity space. The available activities can also be reused and customised according to the change in business operations.

The role/activity analysis together with the business norms provides a description of the freight operations and leads to the creation of a business activity repository. Building a business activity repository takes three steps:

Step 1: Decomposition of business activity

The base techniques are inspired by the concept of activity theory developed by Bodker (Bodker 1991). Each individual activity can be conducted by a set of actions, in which users want to achieve a certain purpose. In the example of ordering, an "ordering" activity can be achieved by carrying out the set of actions: `getting quotes`, `assessing quotes`, `placing an order`, followed possibly by `e-Tracking`. In order to realise these actions, a series of corresponding operations are required that need resources, including tools, materials, and information. The action of `getting quotes` can be executed by accessing the online Rating & Routing tool to get quote based on shipment location and shipment characteristics. The outcome of step 1 is the sets of decomposed activities into actions, plus the sets of operations associated with the actions.

Figure 6: Agency model for responsibility definition.
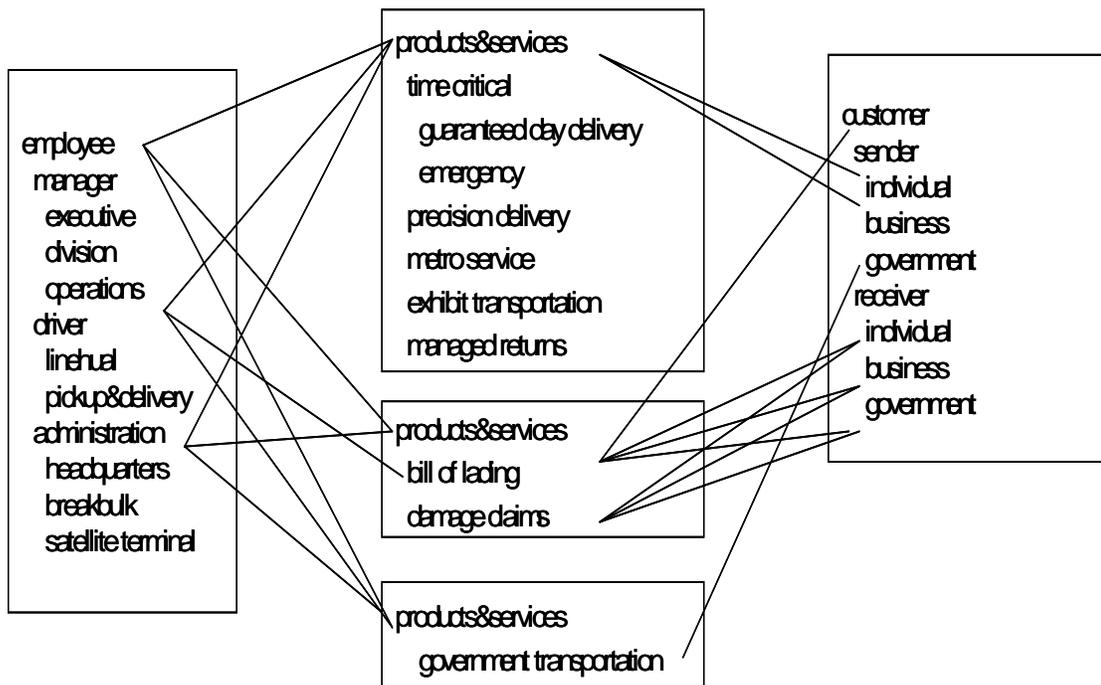
Step 2: Generalisation of activity patterns

Once the activity dimensions are clearly identified in *Step 1*, an activity space can be generated according to the context where the business activities are taking place. A representation of activity space is given as follows:

$$A \ = \ \bigcup_{i=1}^{n} Ci \ ,$$

$$C \ = \ \bigcup_{j=1}^{m} Pj \qquad \{P_j \ \in \ C_i\}$$

where
A – activity space,
C – action,
P – operation, usually described by business terms.

An activity space A may consist of n sets of actions, and an action C may include m sets of operation. One P must belong to the action(s). In the example of "ordering", the actions are defined as C_1 = getting quote, C_2 = assessing quote, C_3 = placing an order, and C_4 = e-Tracking. Subsequently, the operations are P_1 = shipment location, P_2 = shipment characteristics, P_3 = consignee contact, P_4 = order quantity, P_5 = payment terms, P_6 = e-mail, P_7 = type of request, P_8 = special request. So $A = \{C_1, C_2, C_3, C_4\}$; $C_1 = \{P_1, P_2, P_8\}$; $C_3 = \{P_1, P_3, P_4, P_5\}$; $C_4 = \{P_6, P_7\}$. This activity space A contains the business terms, which will be used to find matched information dimensions to form an information space. This way of representing activities, actions and operations provides flexibility that allows the business practice changes to be incorporated easily. The presentation of activity, action, and operation applies to each business process for representation of the activity tuples, and the collection of these tuples will be stored in the business activity repository.

Step3: Extraction of business terms based on the business norms

Once the terms have been identified in the activity tuples, an extraction of terms into a standardised definition is carried out in this step. A list of definitions of the terms is produced in a *dictionary*, which provides reference of the terms to the business norms. For instance, BN2 in Table 1 is represented with its definition in the following form in the dictionary.

BN2 (EnteringOrder)
IF sender wishes to enter the pick up details
  THEN sender
  is *obliged*
   to state their contact information, pickup location, shipment destination and shipment information.
where
EnteringOrder := contact_info|pickup_Loc|Dest|Shipment_info

The following definitions are made based on the example operation of freight transportation and by examining the business norms.

Location := global|country|city|breakbulk|satellite-terminal
Time-period := [year|quarter|month|week|day]
Products&Services := TimCri|PreDel|MerSer|ExhTra|ManRet|FreSer|DamCla|BiOfLad|GovTra
ShipmentCharacteristics := weight|class|expanded-services
RequestType := PRO|bill-of-lading|P.O.|booking-No
Driver := longhaul|P&D
Consignee := sender|receiver
ServiceCentre := headquarters|breakbulk|satellite-terminal
CargoClaims := accident|injury|damage|shortage
RequestQuotation :=contact_info|Products&Services
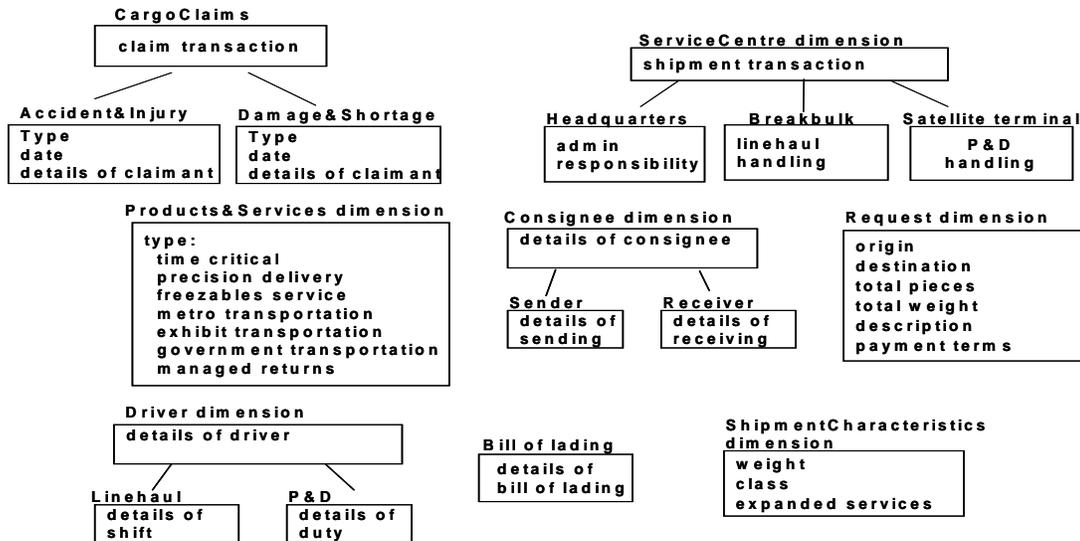Operator := +|-|average|sum|>|<|comparison

EnteringOrder specifies contact information, pickup location, and shipment details. Location includes the terms of global (international), a country, a city, a breakbulk within a city, or a local satellite terminal. Time-period is an array, which contains a range of period of time, i.e. year, quarter, month, week, and/or day. Products&Services

covers the available services such as time critical, precision delivery, metro service, exhibit transportation, managed returns, freezables service, damage claims, bill of lading, and government transportation. ShipmentCharacterisitcs defines the elements of weight, class, and expanded services based upon which a quote is computed. RequestType specifies the ways of tracking shipments. Driver can be the longhaul driver who transits large quantity freight in long distance, or P&D driver who delivers freight to local customers. Consignee is a customer who can be either sender or receiver of freight. ServiceCentre can be a contact point at its headquarters, a breakbulk or a satellite terminal. CargoClaims includes accident or injury whilst driving on the road, operating at the docks, vehicle repairing at garages, or damages and/or shortages from goods delivery. In the last definition RequestQuotation, customer contact information is required as well as Products&Services, which is defined before. This reuse of the definition reinforces the consistency and integrity in the dictionary.

The terms in the dictionary can be altered and extended with changes in the domain operation or business norms, in order to understand new and re-defined terms. The activity tuples and definitions of the terms constitute the business activity repository.

Figure 7: Examples of information dimensions for the freight transport.

CargoClaims
claim transaction

Accident&Injury
Type
date
details of claimant

Damage&Shortage
Type
date
details of claimant

ServiceCentre dimension
shipment transaction

Headquarters
admin
responsibility

Breakbulk
linehaul
handling

Satellite terminal
P&D
handling

Products&Services dimension
type:
    time critical
    precision delivery
    freezables service
    metro transportation
    exhibit transportation
    government transportation
    managed returns

Consignee dimension
details of consignee

Sender
details of sending

Receiver
details of receiving

Request dimension
origin
destination
total pieces
total weight
description
payment terms

Driver dimension
details of driver

Linehaul
details of shift

P&D
details of duty

Bill of lading
details of bill of lading

ShipmentCharacteristics dimension
weight
class
expanded services

Information Analysis

The main task for this stage is to generate patterns of information space. These patterns will be the candidates for determination of the information space. With reference to the ontology chart and agency model (cf. Figure 2), the candidate dimensions are identified to form patterns of information space. A pattern can serve information required to the activities that share common information dimensions but at possibly different granularity. The patterns of information space and all information dimensions are stored in an

Building Information Category Repository

The information category repository for the freight transport system contains a collection of information dimensions, as shown in Figure 7. In the service centre dimension, for example, three types of service centre are organised in an inheritance hierarchy, as they share some common properties (such as they all have contact details), while each has different responsibilities in the freight operations.

The patterns of information space for the freight transport are tailored to the dimensions available from the information category repository. One pattern of information space, e.g. *information space pattern for delivery*, is constituted as shown in Figure 8. The information space pattern for delivery is represented in the central box, which contains the dimensions of *Consignee*, *Driver*, *Products&Services*, *Bill of Lading*, and *CargoClaims*. The Output in this pattern can be pre-processed into total cost and receipt. These generated information dimensions are useful for

producing reports on the freight operation and market forecasting. More information space patterns can be made according to the different types of the business activities and the different intentions on performing the actions and operations within the activity.

Figure 8: A pattern of information space of delivery.
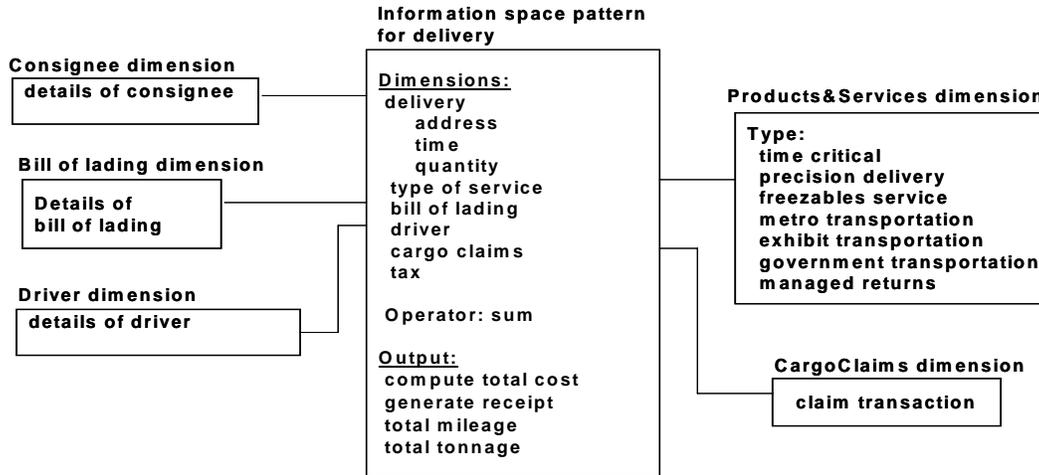
CONFIGURING INFORMATION SPACE

In the phase of configuring information space, *articulation of activity space* and *configuration of information space* will take place to determine the right information requirements.

Articulation of Activity Space

Information requirements are not always easy to specify, especially when the e-business system is complex and requires information related to many issues for various users. The articulation process can assist users to identify the business processes in a more articulated way therefore the information requirements can be elicited. There are two main sub-procedures involved as *Facilitation* and *Confirmation,* which enable the user to interact in the articulation procedure, as guided by Figure 3.

Facilitation

Facilitation aids users in articulating activity spaces by providing the business knowledge and norms. When a business process is clearly identified, it can be directly converted into an activity tuple, with no need for facilitation. Sometimes, however, users may wish to change the granularity in the activity tuple, the facilitation is then required for the user to do so. In the facilitation process, there are no fixed patterns, which users must follow. Users have the control over the articulation, not the system, so the interaction can be carried on or stopped at any detailed articulation level when the user is satisfied.

Confirmation

Confirmation provides users with the opportunity to clarify whether the actions and operations are defined correctly, before the system finalises an activity space. Confirmation is also optional but may be useful to prompt users especially for complex business process. It may happen that an irrelevant term has been chosen in C_n, a wrong level of granularity for P_m, or the terms have been selected wrongly by a mistake. It is important in this case that the user is able to adjust the result of understanding; in order to make sure that the activity space represents the intention.
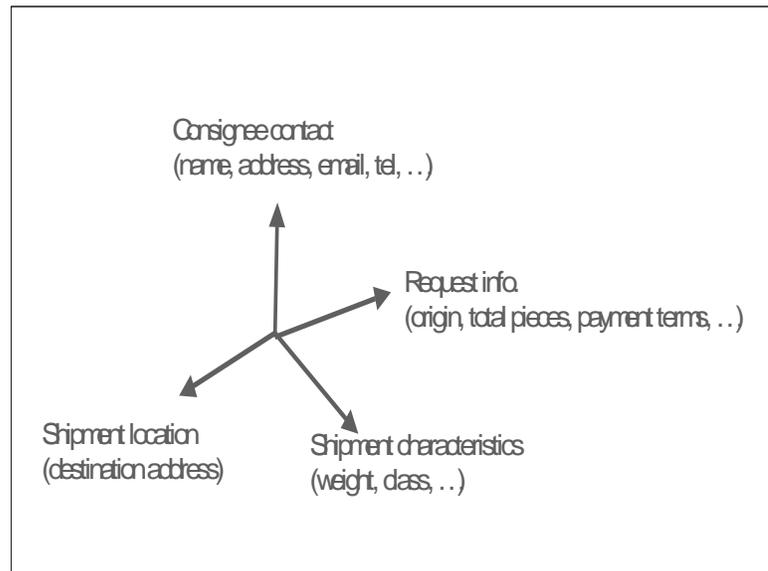
Figure 9: Configuring an information space.
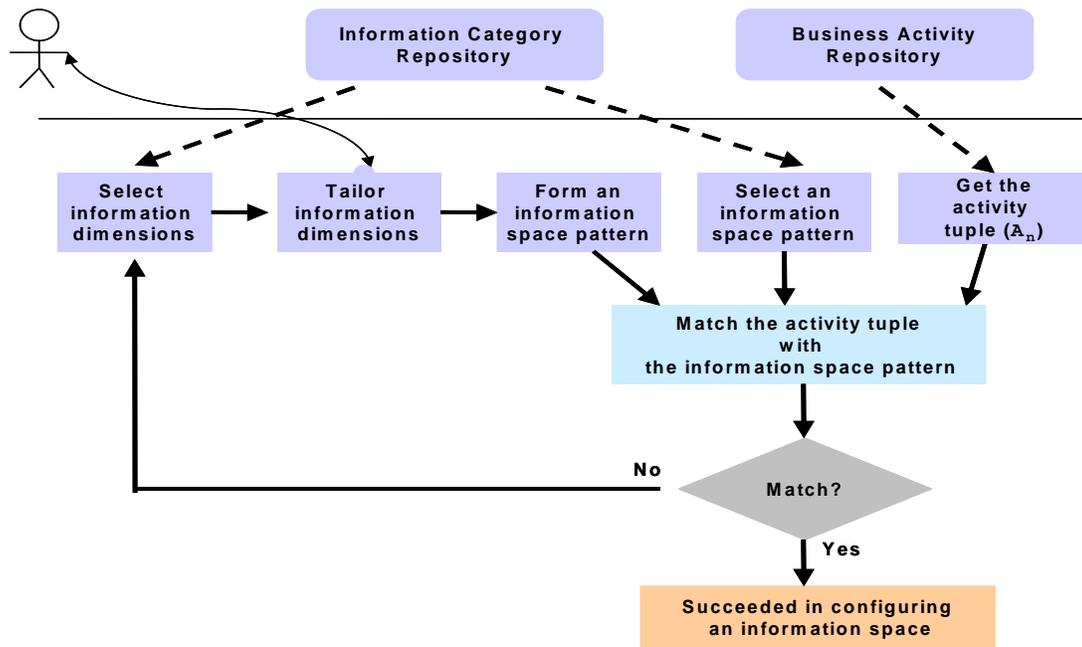
Configuration of Information Space

Following up the basic concepts of DIRES, one can see that the activity space and the information space are interrelated. A business process can be presented by a set of activity space, which possess information dimensions described by the business terms in P_m. These terms are the basic items relating to information dimensions. Each information dimension is linked to information stored in various data sources (e.g., ERP, a data warehouse and a public domain database on the net). In order to retrieve the information required by the activity space, the corresponding information space must be accessed. The configuration procedure starts with taking the activity space from the business activity repository and the information space pattern from the information category repository and then run through several steps to match the information space with the activity space, as seen in Figure 9.

If no directly matching pattern is found, the configuration identifies the information dimensions and selects them from the information category repository. Once this set of dimensions is collected, the matching process cannot be started before they are put into a pattern. A tailoring process takes place to organise the dimensions in the pattern. This tailoring is not always a straightforward process. It may involve an interaction with users, especially when there is ambiguity in selecting a dimension. The users therefore can clarify with the process to ensure that the information dimensions in the pattern are the right ones. Finally, these confirmed dimensions are formed into the pattern and the next round of matching starts. The configuration is completed when the information space is successfully constituted. As the mapping result, the information space for the activity tuple of $A_{ordering}$ is configured (Figure 10). Within this information space, information provided satisfies the user's original requirements.

Figure 10: An information space.

Consignee contact
(name, address, email, tel, …)

Request info.
(origin, total pieces, payment terms, …)

Shipment location
(destination address)

Shipment characteristics
(weight, class, …)

However, the matching process may not be always fully successful. In such case, the configuration facility will allow the user to select relevant information dimensions manually from the information category repository, and further tailor them into an appropriate pattern of information space.

RELATED WORK

E-business systems should be designed to possess adaptability of business changes. Modelling of business changes involves normally management and execution of business activities based upon which business services are provided. A widely adopted modelling framework is the Enterprise Architecture (EA) (Zachman, 1987).   EA provides a comprehensive approach to the design of structure and operations of an enterprise. It consists of defining base artifacts and rules and conditions with which the artifacts form the implementation patterns. Requirements for e-business systems in terms of business functions, data structures, and IT application components can be derived using EA (Maedche *et al*. 2003). It is recognised that EA does not emphases business processes which represent business behaviour of the enterprise. As the Business Architecture (McDavid 1999) defines, a process is a complete sequence of business behaviour that is triggered by an event and controlled by norms (Stamper 1980, Liu 2000). This invokes interactions between the business and stakeholders. Each stakeholder may play multiple roles with corresponding responsibilities. With the involvement of the stakeholders, the e-business systems are required to provide the right information to the right users. Subsequently, the design of e-business systems depends rigorously on requirements specifications. Some software development approaches and methods, such as agile modelling (Ambler 2002, Abrahamsson 2002), unified modelling language (UML) (Jacobsen 1994, Booch 2005), and business process modelling (White 2004, Motik *et al*. 2002) provide an organisation with the capability of understanding its internal business activities as well as collaborating and conducting business transactions between the organisations. Such an ability of sharing information between firms and responding to the business ecology is essential for an organisation (Fedorowicz *et al*. 2004).

There are a number of agile modelling approaches for information systems development. Scrum (Takeuchi and Nonaka 1986) is developed based on industrial process control theory which enables flexibility, adaptability and productivity in software development. It focuses on software development processes which control the processes and prevent the chaos caused by unpredictability and complexity. Scrum does not provide any specific software development methods, but requires management practices and tools. In contrast to Scrum, Feature-Driven Development (Plamer and Felsing 2002) does not require any specific development process, but provides the methods and techniques for designing critical systems. This approach puts stakeholders in the centre of the design.

The methods and techniques assist to model roles, artifacts, goals, and timelines. It, however, does not have the technicality for requirements analysis and systems design. Rational Unified Process (RUP) (Kruchten 2000, Jacobsen 1994) is an industry standard software modelling method. This method was originally developed to cater for the entire software product process within which the software architecture is applied for tracing and managing the requirements of a system that changes over time. By using UML, users are provided with flexibility in customisation of software applications. RUP suits requirements of e-business systems development, but it does not provide clear guidelines for design and deployment.

There are other agile methods, i.e. eXtreme Programming (Beck 1999), Crystal, Orange (Cockburn 2002), Dynamic Systems Development Method (Stepleton 1997), Adaptive Software Development (Highsmith 2000), and Open Source software development (O'Reilly 1999). A common feature of the agile family methods shows that they place more emphasis on people, interaction, working software, customer collaboration, and change, rather than plan, development process, and design techniques. In comparison with the agile methods, UML and business process modelling methods focus on the design and deployment of software systems. UML provides a range of modelling techniques for capturing requirements of stakeholders, information flow, interactions between stakeholders and software systems, and activities and events in systems. Business process modelling methods enforce business perspective, such as business goals, processes, and responsibilities of stakeholders in the processes and their communications. These modelling aspects are also required by e-business systems.

These architectures together with the modelling techniques can be adopted as the methodology for designing e-business systems. However, most of the current methods do not facilitate the analysis and design of the business processes and technical systems in an integral manner, because they are developed with their specific purposes. It may cause difficulties to verify the requirements for the systems when these methods were used in their separation. The DIRES method is developed to integrate the strengths of the current methods that allows a unified deign for e-business systems. Furthermore, through the case studies conducted in this project and previous studies (Sun *et al.* 2000, Sun and Liu 2001, Liu *et al.* 2001, 2003), it has demonstrated the DIRES method is adaptable, scalable and extensible in modelling e-business systems. The method can also be used as a supplement to other mainstream methods such UML. Such a combination allows industrial users to enjoy the mainstream design notations and techniques while DERES analysis of the business domain and requirements builds a firm foundation before the technical design is conducted.

CONCLUSION AND FUTURE WORK

The DIRES approach enables interactive articulation of information requirements for e-business. It allows the designer to start the analysis from a vague problem statement and subsequently moving on to capturing more concrete information requirements of the proposed e-business system. The understanding of the business processes and related business norms allows analysts to further decompose the business processes into business activities, actions and operations. Furthermore, the specific meanings of the business terms can be defined by examining the business norms. An output of this analysis is described in the activity spaces. These activity spaces can only present how actions are executed and what resources are required. They cannot be used to retrieve information from data sources. There is therefore a need to have information spaces, which are constituted by a set of dimensions associated with entities in the database's terms (e.g. consignee, and Products&Services), or sometimes an attribute (e.g. receiver's address, quote, and shipment time). A space may be equivalent to the database tables or aggregation of several tables. Based on the information space, it is possible that high level query languages, such as XML and the like, could use their data binding methods to form an executable query statement for information retrieval. The use of information space also provides significant potential to cope with business change. When new information requirements are derived from new business needs, a corresponding information space can be flexibly constructed by configuring the basic information dimensions.

Toward this end, a number of tasks have been identified for further work to refine and disseminate the research outcome. As the focus of this research has been the investigation of the theory and the development of the method, no software tool to implement the DIRES method has been developed. It would be more beneficial to the research community of e-business systems development if various DIRES techniques can be implemented as a set of software modules. The current work has not considered any learning ability during the articulation of activity space and configuration of information space. As there is a rich component of business style and experience involved in

these two processes, it would be valuable to learn from individual cases so that the effectiveness in determining information requirements can be improved. A possible aspect for this enhancement is the utilisation of artificial intelligence and agent technology. Intelligent agents can be assigned to each individual user to monitor the context where the decision on the information provision is made, and to assist the mapping between the activity space and the information space. The collection of this kind of knowledge will enable the extension of the business activity repository and the information category repository, in order to incorporate the new business requirements.

The further work also includes a refinement of representation for activity space. The actions in the activity space can then encapsulate the business terms as well as business norms in a formal syntax. In such a way the configuration procedure will become more robotic. To this end, there is a need for the further development of a formal syntax in a logic form for the formulation of business norms. At the current state of the research, business norms are specified in natural language (i.e. English). A formal syntax will address the problem of different interpretations of the specifications by different designers. It will also provide a formal ground for shared understanding and cooperation among designers and developers.

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