2000

MITAIS for Articulation Information Requirements in Strategic Decision Support

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Abstract
Strategic decision-making is seen as an important area of research where the theory, methods and technologies can bring in a great deal of benefit to the whole enterprise at the executive level. The study of information requirements for decision-making reveals that the level of detail, granularity, format of presentation, and broad range of information type are unique for the applications at the strategic level. The provision of relevant information involves articulation of requirements based on the decision problems described by the executive manager. This paper presents the MITAIS approach that allows the user to describe a decision problem interactively and assists articulation of the problem into a presentation in a decision space, by prompting possible patterns of decision dimensions. It further aids a configuration of information requirements into an information space, which covers the information required for the described problem. A case study has been conducted using this approach to the use of the set of techniques of MITAIS.

Keywords: Strategic decision support, information requirements, information space, decision space, requirements articulation

INTRODUCTION

Strategic decision-making deals with issues at the corporate level, which are related to formulating vision and mission, setting goals and objectives for the direction, and forming polices and rules for the organisation. In order to make the right decisions at this management level, it requires a vast amount of information from various sources. Research in management science (Glaister, 1995; Boar, 1998) and IT for strategic management has paid considerable attention to improve the quality of strategic decision-making by enhancing provision of information (Anderson, 1999; Fox & Gruninger, 1998; Jarvis *et al.*, 1999; Liu *et al.*, 1999).

This paper aims to contribute to provision of information for strategic decision support from a methodological perspective by presenting MITAIS, a method for interactive articulation of information space. Following an introduction of basic concepts in MITAIS, a set of constituting techniques is presented. The method is applied to a case study in freight transportation to demonstrate its use. Finally discussions and conclusions are drawn.

THE MITAIS METHOD

The MITAIS method aims to enable users to articulate business problems and configure information requirements in an interactive fashion. It facilitates users during a query process to specify problems by describing the business terms, and then derive information requirements based on business knowledge and rules captured in the system (Liu & Ong, 1999).

There are two important concepts, *decision space* and *information space*, in the MITAIS method (Sun & Newton, 1995; 1997). These concepts are used to determine and present information required for the decision-making. In a business context, managers usually require information for certain purposes, for example, a performance on sales in certain locations and customer's satisfaction on certain types of product/service. These are the types of decision question that managers ask the systems to provide information. A decision question can be seen as a decision space, which consists of a set of dimensions equivalent to these business terms in the question. The information required to the decision space can be organised in the information space, which will be further mapped onto the decision space for providing the answer to the decision question (Sun *et al.*, 2000).

MITAIS Architecture

MITAIS provides a mechanism for a user to specify the question and further to articulate the question into a decision space. The required categories of information for answering the questions will be derived. Each category is mapped onto a dimension of the information space that defines the information requirements. The dimensions of the information space will allow conversion into a high-level query language that is used in an existing database or other information sources. The method consists of two major phases: *domain analysis and modelling*, and *configuring information space.*

Domain Analysis and Modelling

Domain analysis and modelling (Figure 1) 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 with 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.

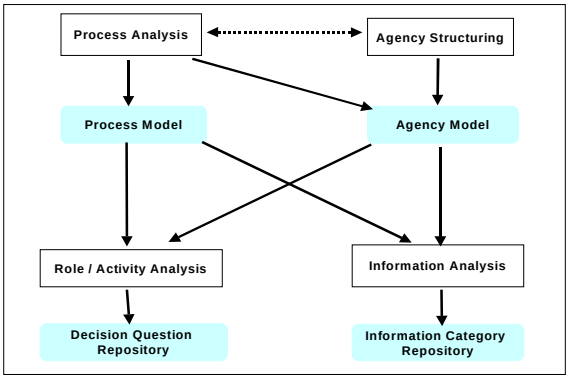

Figure 1 Domain analysis and modelling.

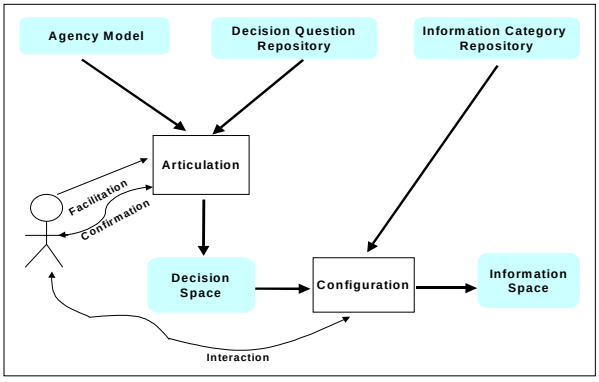

Figure 2 Configuring Information Space.

This phase produces the following deliverables.

- **Process models** are produced from the process analysis. These models represent the work processes of the problem domain.
- **Agency models** are created based on the process analysis and analysis of agent structure (i.e. agency structuring). This is a conceptual model that identifies agents, their roles and relationships.
- **Decision question repository** is a collection of decision question related to the problem domain. This repository is the result from the role/activity analysis, which examines agents in each role and their management and decision-making activities involved. This repository contains all the possible questions from the agents in their roles, which will be used to facilitate an articulation process 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 information space (Figure 2) carries out two analyses: *articulation of decision space* and *configuration of information space*. The articulation of decision space takes input from the agency model and the decision question repository. It enables a user to express the question concerned and facilitates the user to specify the question in a more articulated manner. The user will have opportunities to interact during the process and to confirm the interpretation of the question in terms of dimensions of the decision space. The decision space is composed of several dimensions, each of which is represented by a business term (e.g. sales, product, customers, time and location). A question is normally made of a combination of several such terms.

The configuration of information space maps a decision space, with the input from the information category repository, onto an information space. The information space is formed by a number of information dimensions. Each dimension corresponds to a category of information. For example, the category of information on location can be one dimension, which can be tuned at any level of granularity: country, province and district. The process of 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 question, but may answer the questions to varying extents. In such cases, the user can interact during the process to determine, e.g. temporal and spatial granularity, any additional dimensions, and chronicle coverage.

APPLYING MITAIS IN FREIGHT TRANSPORT

To illustrate the techniques in MITAIS, a case study is adopted from Roadway Express, a large American freight transport company. Internationally, this company has an extensive network to run their operations in over 70 countries in six continents. The network operates on a multiple mode of transportation by air, rail, and water. Within North America, the two types of transport, over-the-road operation between cities and local pickup and delivery, constitute the major operations. 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 the linehaul transportation to another city.

The Freight Operations

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

- **Stock and shares**: The company has a very elaborate stock and shares system that is linked with staff performance and loyalty.
- **Operations planning:** All the freight activities involved in docks, breakbulks, satellite terminals, and the coordinations of transit are planned based on the information stored in various information systems.
- **Safety planning**: Safety is managed and planned regarding to linehaul, local P&D, and dock movements and garage procedures.

- **Product and services**: This area is the key, primary business area 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.

Based on the above analysis of the entire business system, the area of Products and Services is analysed and represented in a Use Case diagram in Figure 3 (see Booch *et al*., 1999 for Use Case diagrams). The actors are grouped according to their types of responsibility. For example, satellite and breakbulks are two types of service centre and they inherit the characteristics of the service centre. Within the area of Products and Services, the freight transportation is the key process, around which all other business functions are built. Therefore to understand and capture this process is essential in modelling the business domain.

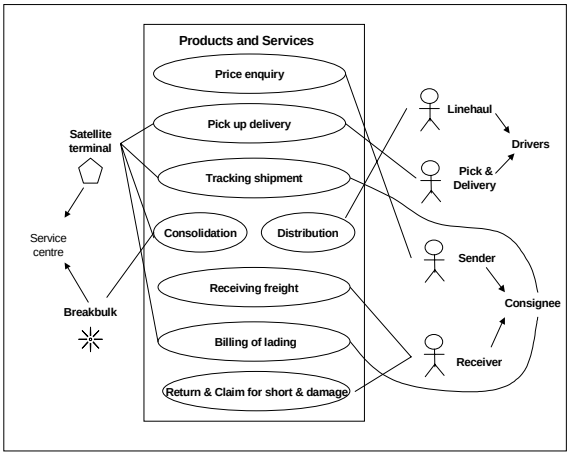

Figure 3 The business area of Products and Services.

The Use Case model describes the actors who interact with and responsible for the activities they involved. Based on this conceptual model, an interaction model, which captures the detailed behaviour of the freight transportation can be derived in Figure 4. In the interaction model, it presents the sequence of the procedures from an enquiry from a sender customer, to the transit of the freight, and to the delivery of the goods to a receiving customer with all messages flow among them.

Agency Structure in the Company

The targeting user group that the MITAIS method is intended to help includes the executives at the corporate level and their management teams, because they are most likely to require information for strategic decision-making. Therefore identification of the roles and responsibilities of these managers is important in order to derive the questions concerning their decision-making and further to derive the required information, as seen in Figure 5. The employee is the general type of actors who have responsibilities for products and services at different levels.

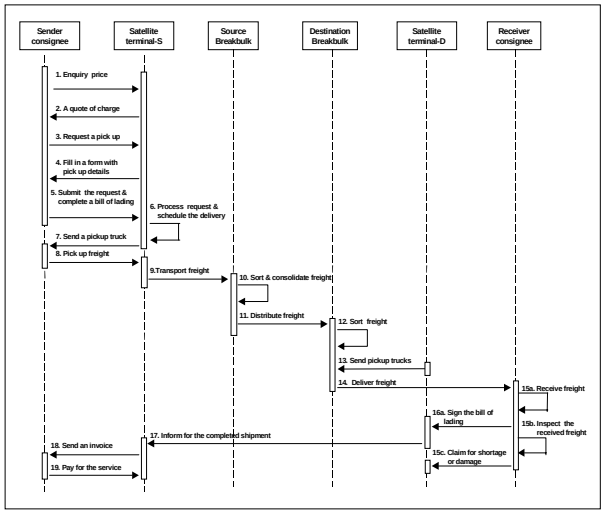

Figure 4 Freight transportation from customer to customer.

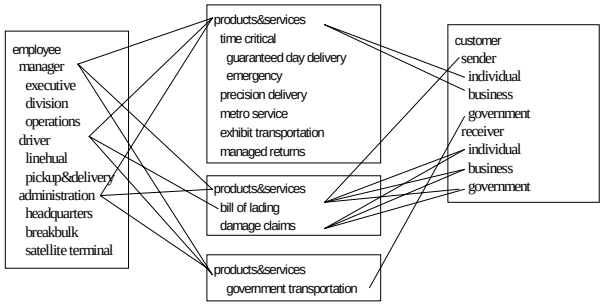

Figure 5 Agency model for responsibility definition.

The managers are concerned with 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 bill of lading, but not damage claims as the receiver must report damage or shortages through other channels. This is why these is no line between the driver and damage claims.

Building the decision question repository

Questions generated and stored in the repository will be related to aspects of operations in the freight transportation. Other aspects, such as finance, marketing, engineering and operations, can be analysed in the same way.

The role/activity analysis and the resulting matrix of responsibility provide an understanding of the freight operations and lead to build a decision question repository. Building a decision question repository takes three steps:

Step 1: Identification of decision questions

The outcomes of the process model and agency model can be used as sources for generating decision questions. The following questions are some examples with respect to the freight transportation.

1. What is the average of shipments per working day for this year?
2. What is the average length of haul?
3. What is the average of shipment weight?
4. What is the percentage of damage claimed?
5. Compare the percentage of damage claimed between this year and the last two years.

Step 2: Generalisation of the questions

In this step, the questions composed in step 1 are transformed into generic tuples in the following format:

{subject, operator, quantifier, <generic-qualifier>}

The five questions in their corresponding generic tuples are thus generalised:

1. {What is the average of shipments per working day for this year?}
   ⇒ {subject = shipment, operator = average, quantifier = ton, <generic-qualifier = location, time-period>}
   where: location = global; time-period = [working-day, year]
2. {What is the length of haul for safety driving?}
   ⇒ {subject = haul length, operator = average, quantifier = mile, <generic-qualifier = location, time-period>}
   where: location = unknown; time-period = [unknown]
3. {What is the average of shipment weight?}
   ⇒ {subject = shipment, operator = average, quantifier = ton, <generic-qualifier = location, time-period>}
   where: location = unknown; time-period = [unknown]
4. {What is the percentage of damage claimed?}
   ⇒ {subject = damage claimed, operator = void, quantifier = %, <generic-qualifier = location, time-period>}
   where: location = unknown; time-period = [unknown]
5. {Compare the percentage of damage claimed between this year and the last two years.}
   ⇒ {subject = damage claimed, operator = comparison, quantifier = %, <generic-qualifier = location, time-period>}
   where: location = unknown; time-period = [1997,1998,1999], the time-period in this question can be instantiated in three actual years.

Step3: Extraction of generic terms

Once the terms have been identified in the generic tuples, an extraction of terms into a standardised definition is carried out in this step. A list of definition of the terms is produced in a meta-structure. The following definition is made based on the operation of freight transportation.

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

Shipment := "transportation of freight from a sender to a receiver".

Driver := linehaul|P&D

Consignee := sender|receiver

ServiceCentre := headquarters|breakbulk|satellite-terminal

Cargo Claims := accident|injury|damage|shortage

Operator := +|-|average|sum|>|<|comparison

Location includes the terms of global (international), a country, a city, a breabulk 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. *Shipment* is defined as transportation of freight from sender to receiver, which has a standard data type in an information category repository. *Driver* can be linehaul 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 points in headquarters, a breakbulk or a satellite terminal. Cargo Claims include accident or injury driving on road, operating at docks, vehicle repairing at garages, or damages and/or shortages from goods delivery.

The terms in the meta-structure can be altered and extended as the domain changes, in order to understand new and re-defined terms. The generic tuples and definitions of the terms constitute the decision question repository.

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 that answers the decision question. With reference to the process analysis and agency structuring (Figure 1), the candidate dimensions are identified to form patterns of information space. A pattern can serve answer(s) to the question(s) that share a common information dimensions but at possibly different granularity. The patterns of information space and all information dimensions are stored in an information category repository.

Information Category Repository

The information category repository for Freight Transport contains a collection of information dimensions. Figure 6 shows these information dimensions. 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 freight operations.

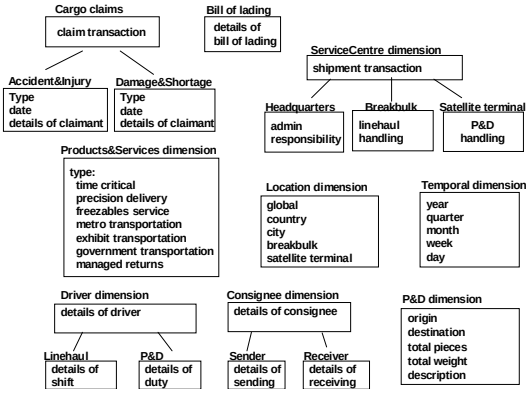

Figure 6 Information dimensions for Freight Transport.

The patterns of information space for Freight Transport are tailored of the dimensions available from the information category repository. One pattern of information space, e.g. *information space pattern for shipment*, is constituted as shown in Figure 7. The information space pattern for shipment is represented in the central box, and it contains the dimensions of SvericeCentre, Temporal, Driver, Products&Services, Location, and CargoClaims. The Output in this pattern can be pre-processed into total tons, total tones of LTL, total tones of truckload, total miles, and total miles between accidents. These generated information dimensions for the decision questions, which require calculations. This can useful for handling the complicated type of information requirements.

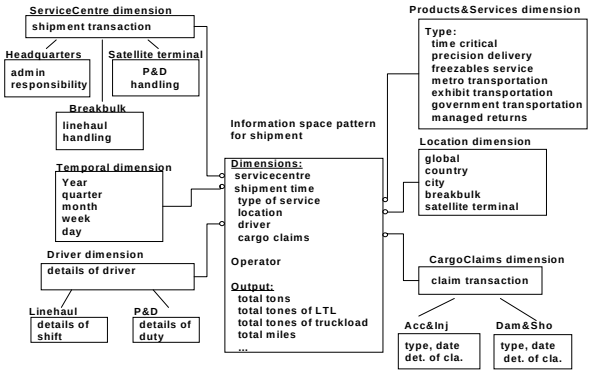

Figure 7 A pattern of information space of shipment.

There can be more information space patterns made according to the different types of decision questions and the different intentions on finding answers.

CONFIGURING INFORMATION SPACE

In the phase of configuring information space, *articulation of decision space* and *configuration of information space* will take place to determine the relevant information to decision questions.

Articulation of Decision Space

To make decisions, the managers of Freight Transport require information on operations of freight transportation. The questions listed in the last section are typical in operations and planning. However, the managers can ask their questions in many ways. Sometimes questions are expressed in a clear structure and sometimes they can be general. Consider this question:

"What is the average of shipments per working day for this year?"

This question is clearly expressed in those terms that are defined in the decision question repository. The terms used in the question are:

Shipment	- a pre-defined term as "transportation of freight from a sender to a receiver"
Working day	- defined as a time-period
Year	- defined as a time-period
Average	- a pre-defined operator

Therefore the articulation mechanism can locate a generic tuple:

{subject = shipment, operator = average, quantifier = ton, <generic-qualifier = location, time-period>}

This generic tuple can be further instantiated by assigning specified values to the qualifiers, hence this is obtain:

{subject = shipment, operator = average,
quantifier = ton,
<generic-qualifier = global,
time-period = [working-day, 1999]>} (A)

Sometimes, a question could be general, or lacking sufficient restrictions. For example,

"What is linehaul mileage between accidents?"

With the terms contained in this question, a matching tuple can be located in the decision question repository:

{subject = linehaul between accidents, operator = sum, quantifier = mile, <generic-qualifier = location, time-period>}

However, this question presents some ambiguity, as it does not specify the restriction on location and time-period. This leads to an impossibility of instantiating the tuple with specific values. In this case, the *facilitation* and *confirmation* facilities will assist the interaction between the user and the system to further articulate the question. As a result, the missing values of location and time-period can be elicited, hence this is obtain:

location	a value has to be specified by the user, for example, global or a country.
time-period	a value has to be specified by the user, for example, a year, a quarter, or a month.

Once the user has supply with additional information, a tuple can be instantiated:

{subject = linehaul between accident, operator = sum, quantifier = mile,
<generic-qualifier = USA, 1999>}

The decision spaces described in the above expression (A) will be used to configure information spaces.

Configuration of Information Space

Following the process of configuring information space, an attempt is made in the first place to match the tuple in expression (A) with a pattern of information space from the information category repository. As the mapping is successful, the information space for the expression (A) is configured (Figure 8). Within this information space, information provided satisfies the user's original question.

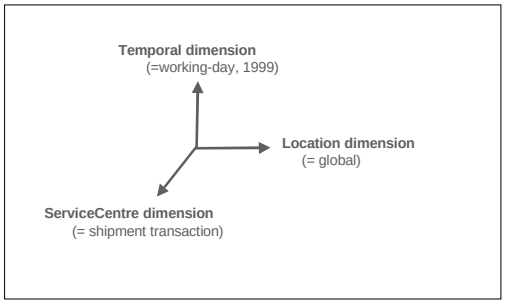

Figure 8 An information space.

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

DISCUSSIONS AND CONCLUSIONS

The MITAIS approach enables interactive articulation of decision problems and information requirements for strategic decision support. This can enhance the capability of information systems for decision support. With current information technology, each dimension in the space can be mapped onto an entity in database's terms (e.g. student), or sometimes an attribute (e.g. 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 SQL, XML and the like 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.

Information contents in the information space for answering the question may be stored in various sources, e.g. databases, files, spreadsheets, and web pages, within companies or public domain sources. Before information is pulled out from these sources, a clear understanding of users' information requirements can be made through the MITAIS. This is the main contribution of this research work to enhancing information systems for strategic decision support.

Acknowledgements

Roadway Express is acknowledged for allowing the authors to have access to their business process from which the case study is drawn.

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