PROVISION OF CONTEXT-SENSITIVE ENTERPRISE KNOWLEDGE FOR DECISION SUPPORT
An Approach based on Enterprise Models and Information Demand Contexts

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Keywords: Ontology, constraint networks, context sensitive decision support, enterprise model, information demand.

Abstract: In this paper an approach for deriving abstract and operational context for context-sensitive decision support, and thereby also parts of information demand contexts, from enterprise models is presented together with some thoughts on how this can be utilised in the efforts of trying to provide users with current, correct, and relevant information with respect to the tasks such users perform within organisations. The different steps involved in the process of deriving context from enterprise models is explained by means of different representations of an example model produced in earlier research done by the authors.

1 INTRODUCTION

The idea of supporting business professionals or "white-collar workers" in the solving and performance of problems and work related tasks by means of different types of information systems is well established today. However, despite the ever-increasing number of systems and approaches tried many of the old issues related to getting the "right" information for specific tasks or problems to the "right" user remain. On top of this many of the systems and approaches intended to improve the situation have introduced a number of new problems and thus to some extent made the situation worse. Today the problem no longer is to find information but rather how to select the relevant information from the massive amount of information available in and to organisations. As it has been shown in several investigations done over the years, one of the bigger ones being Delphi Group's (2002), the current situation regarding information (over)flow, reuse, and organisational memory is problematic at best.

1.1 Related Research

The research presented in this paper builds heavily on work within the areas of Information Logistics, Information Demand modelling and analysis, and Decision Support as well as the combination of these areas.

Several similar approaches to demand driven information supply for supporting decision-making exist. One example is a methodology for information requirements analysis for data warehousing systems (Winter and Strauch, 2003). The methodology supports the entire process of determining information requirements for a targeted decision process. The information requirements are defined as the type, amount, and quality of information that a decision maker needs to do his/her job. The methodology starts with an analysis of actual information supply and creation of an information map. Information demand is determined based on typical questions relevant to the targeted decision process. The information demand derived based on these questions is matched against the information map. The matching reveals non-covered information requirements.

The DDIU (Data Demand and Information Use) conceptual framework (Foreit et al., 2006) does, much in the same manner, supports evidence-based decision making for health systems. The DDIU framework explains the context in which decisions are made and how this context influences the demand for data, the use of information, and the

Levashova T., Pashkin M. and Lundqvist M. (2007).
PROVISION OF CONTEXT-SENSITIVE ENTERPRISE KNOWLEDGE FOR DECISION SUPPORT - An Approach based on Enterprise Models and Information Demand Contexts.
In *Proceedings of the Ninth International Conference on Enterprise Information Systems - AIDSS*, pages 88-93
DOI: 10.5220/0002396700880093

collection and availability of data. Information demand in this framework is specified by decision makers or other stakeholders. Data resources are aligned with the decisions they would support, and vice versa. For identification of gaps (areas where useful data were readily available but not used) in the information flow a visual context is provided.

The research concerning information demand issues and the research being done by the authors individually have a lot of core concepts in common. As a consequence, it was decided to put effort on trying to combine the individual approaches of the authors in order to produce added value to both areas in terms of more efficient analysis methods, tools and systems.

2 INFORMATION DEMAND

As an attempt to solve at least some of the problems mentioned in the introduction, the area of Information Logistics has been suggested as a way to “strike” at the core of information overflow related problems. Achieving this is attempted by making sure that, users of information systems are provided only with the “right” information at the “right” time and place (Deiters et. al., 2003). However, right information at the right time and place implies that something must be known about the users and the needs motivating their use of an information system. That is, right information, time, and location require some knowledge of what right means for the specific user with respect to his/her current situation and problem(s).

As a consequence of these implications different methods for the analysis and modelling of information demand (Lundqvist, 2005) as well as a number of related definitions (Lundqvist and Sandkuhl, 2004), has been developed by the Information Engineering Group at Jönköping University.

The core concept of Information Demand Analysis aims at deriving what is referred to as Information Demand Context (IDC), capturing the context in which information demands exist, i.e. deciding what the –right– in relation to information, time, and location refers to. It has been argued that such IDCs can be derived from a number of sources within an organisation but it has also been suggested that a particular suitable source for this is Enterprise Models (EM) (Lundqvist, 2005) describing many or all aspects of an organisation, e.g. products, processes, organisational structures, resources etc. Such an approach to deriving IDC has, as has been shown in earlier work made by the authors (Levashova et. al., 2005), many similarities to the area of context-sensitive decision support. In the joint research a model of a fictitious bike producing enterprise has been used as an exemplifying EM.

3 CONTEXT-SENSITIVE DECISION SUPPORT

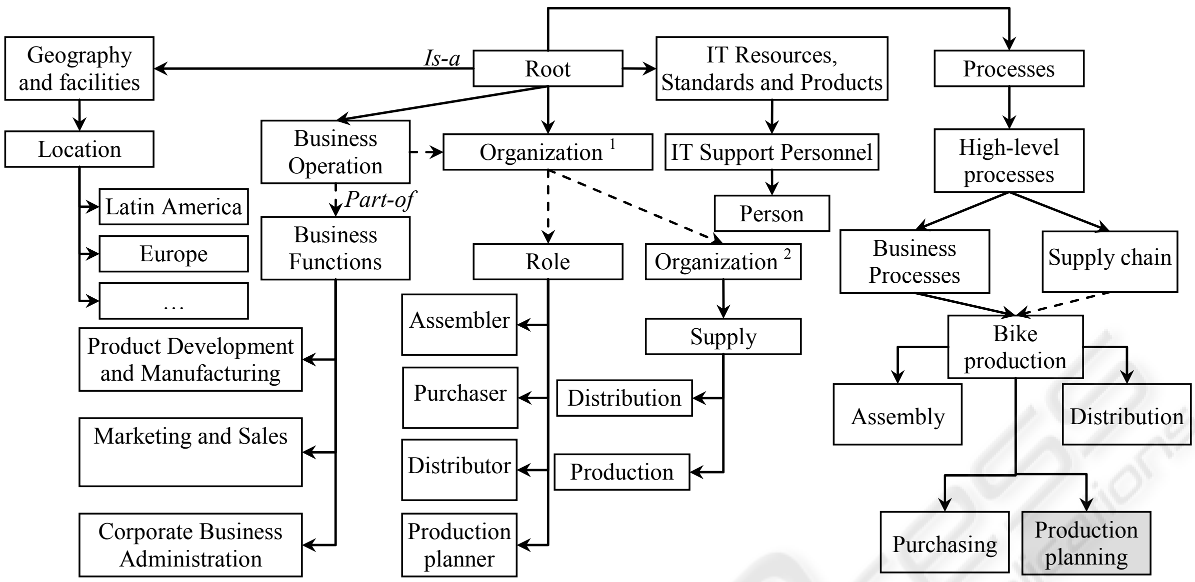
The purpose of the presented approach to decision support is to model a situation or a problem formulated by a user as requests to a Decision Support System (DSS). The problem or the situation is modelled in terms of context. Two types of context are used; abstract and operational. *Abstract context* is an ontology-driven model integrating information and knowledge relevant to the solving of the problem. *Operational context* is an instantiation of the abstract context.

DSS according to this approach has two distinct main phases: (1) the preparatory phase and (2) the decision making phase. At the preparatory phase models of DSS components (domain ontology, user profile, and information sources) are created. All the models are represented by means of an object-oriented constraint networks (OOCN) formalism. The domain ontology is supplied with links to the user profiles and information sources. The links mean that class attributes of the ontology get values provided by the users or information sources. At the decision making phase abstract and operational contexts are produced.

According to the OOCN formalism, an ontology is represented by a set of *classes*; a set of class *attributes*; a set of attribute *domains*; and a set of *constraints*. The set of constraints comprises (1) *taxonomical* (“is-a”) relationships, (2) *hierarchical* (“part-of”) relationships, (3) *class cardinality* restriction, (4) *class compatibilities*, (5) *associative* relationships, and (6) *functional* relations. Support for this formalism is included in the Web-DESO tool (Smirnov et al., 2002).

The tool used for modelling the bike producing enterprise uses XML as an internal representation of information that is compatible with the OOCN formalism. Table 1 shows correspondences between the EM, its representation in XML, and the OOCN formalism.

In the first attempts of combining the different approaches to Information Demand Analysis and Context-sensitive Decision Support a file containing such an XML-representation of EM was used as the source from which the domain ontology (Figure 1) was derived (Levashova et al., 2006b). It comprises around 500 classes, 2500 class attributes, 400 part-of relationships, and 850 associative relationships. The domain ontology does not contain instances though.



[1] A hierarchically organized Organization with a number of formal positions and a number of roles that can be performed by individuals or Organization Units, as well as some key people for the kind development that the model is covering.
[2] Organization units that constitute the business and some of its high-level positions. Positions are formal elements of an Organization.

Figure 1: Domain ontology (part of): taxonomy and hierarchy views.

Table 1: Correspondence between Enterprise Model, XML, and OOCN representations.

EM	XML	OOCN
Object	Object	Class
Container	Object	Class
Instance	Value set	A set of attributes
Range	Data type	Domain
Parent-children relationship	Type-of; Child-link	"Is-a" constraint
	Part-link	"Part-of" constraint
Named relationships but "Type-of"/"Of-type"	Relationship	Associative constraint

Attribute values can be calculated by the DSS based on the set of functional constraints specified in the ontology or they can be taken from information sources. The EM contains references to various files that provide the required information.

For example, in the domain ontology part (Figure 1) the class "Geography and facilities" defines the locations that comprise the enterprise. The use of the object type ranges from individual rooms, buildings, and cities to countries and regions.

These locations are stored in a database that is considered to be an information source. This information source provides values to the attributes specified in the class "Location" and its subclasses.

Access to the information sources is provided through Web-services, which are responsible for the interaction with these sources in the following ways:

- representation of information sources by means of the OOCN formalism;
- querying information sources;
- transfer of the information to the DSS;
- information integration;
- data conversion.

Figure 2 presents some screens of the Web-DESO tool illustrating the way of linking the domain ontology and information sources in general and the database with locations in particular. In the domain ontology the method for the location definition is introduced (lower screen). This method connects the Web-service responsible for the interactions with the database of locations by passing the URI of the Web-service as an argument to the method. The OOCN-formalism then handles method arguments as attributes. The method outputs the name of the location and its address. The name of the location is the name of a plant, an office, or some other organisation located at a certain address. This name along with the other address characteristics will instantiate the attributes specified in the class "Geography and facilities" (upper screen). This is specified through functional constraints. In earlier joint research efforts (Levashova et al., 2006a) abstract contexts describing the role activities within the enterprise

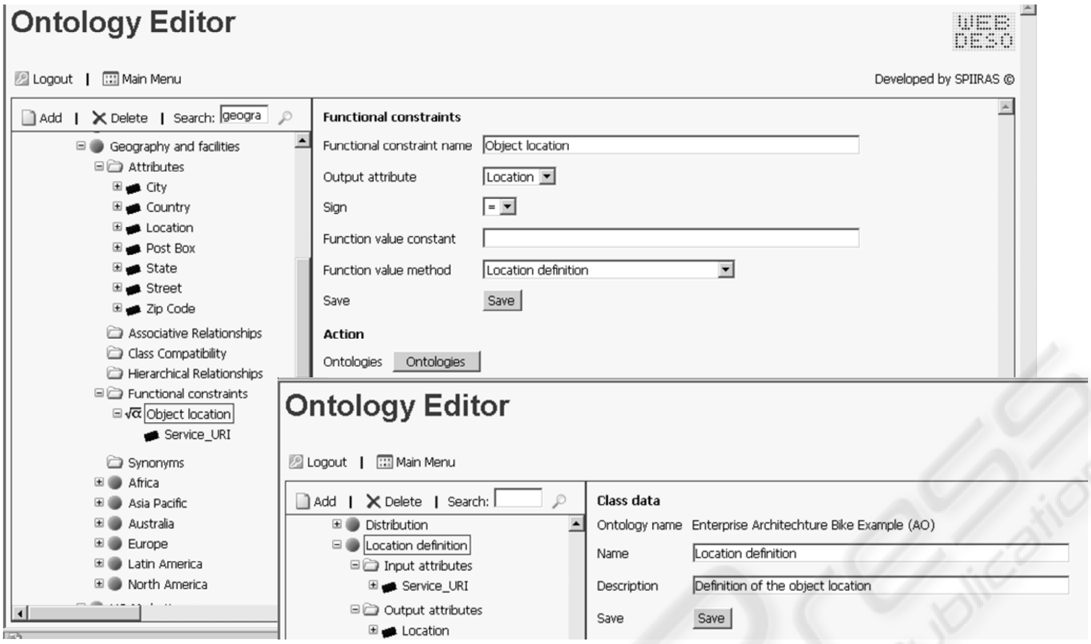


Figure 2: Linking domain ontology and an information source.

were produced for the roles introduced in EM (Figure 1, class "Role"). Those were rather large contexts describing what information one filling a certain role needs on the whole. Moreover, since solving a specific task as part of a certain role often involve and affect other roles, and tasks related to them, the contexts included practically all the information the EM contains.

For the purpose of this paper an exemplifying task, production planning (the shaded box in Figure 1) performed by the role production planner, has been chosen as an illustration of how the ideas presented here can be used in practice. A context modeling this task will include knowledge relevant only to this particular task within the specific role. Abstract context is produced from the domain ontology based on a set of keywords corresponding to the meaningful words contained in the user's request to DSS. Knowledge surrounding the keywords is captured so that it would be relevant to the user request and to the inference supported by OOCN. Here producing abstract context is illustrated for the keywords "production planner" and "production planning". "Production planner" is the name of a role, "production planning" is a name of an activity, among others, performed by this role.

Unlike the domain ontology, the main purpose of the abstract context is to collect knowledge relevant to the task rather than to provide a well-formed knowledge classification. The abstract context produced for the task in question is a two-level, class taxonomy (Table 2) expanded with part-of, associative, and functional relationships. The classes of the top level are used as a way to determine the type of knowledge the classes of the bottom level belong to. The top-level classes specify inherited attributes for the classes of lower levels. The classes of the bottom level are the ontology classes most specified; they provide a complete specification for the instances of these classes.

An explanation of the knowledge included in the abstract context is given below. The explanation aims at clarifying the associations between the classes that are not given in Table 2. According to the OOCN formalism the associations in the context are represented by associative relationships. The words corresponding to this kind of relationships are italicised in the text that follows.

Production planning is a bottom line process for the business process of bike production. The bike production process *is used* by the business function of product development and manufacturing. The *input* for the bike production process is information about the sales plan. The bike production *is affected* by a business strategy for the improvement and expansion of research and development. In production planning application functions and services of commodities and product purchasing *are used*. These services *are provided* by the applications listed in Table 2 in the "Bottom level class" column for the "Application" row. All of them are of the mainframe type. The applications

Table 2: Classes entered into the abstract context for the task of production planning.

Top level class	Description	Bottom level class
Bike production	A collection of processes to purchase parts, assemble and distribute bikes	Production Planning
Business Functions	Functions of the business, normally used at a very high level	Product development and manufacturing
Information Flow	Information transferred from one process to another	Sales plan
Strategies	A statement controlling what the business intends to do to achieve its goals and objectives	Improve and expand research and development
Application Function	A function or service provided by one or more applications to assist one or more user processes	Commodities purchasing
		Product purchasing
Application	The business applications, operational, planned, and phased out	BUYBUY - Purchasing
		Resource consumption reporting
		Operations preparation and planning
		Warehouse management
		Mtrl Req'ts
		SALFOR - History-based sales forecaster
Geography and facilities	Geography defines the locations that comprise the enterprise. The object type ranges from individual rooms, buildings, and cities to countries and regions	Location
Application Building Block	An architectural element used to build one or more applications	Our purchasing system modifications
		Our MRP modifications
Mainframe	A mainframe-based computer, consisting of a hardware platform and an operating system	Mainframe
IT Support Personnel	The personnel available for IT maintenance and development	Person
Competence/Skill	An object describing the condition and areas of human capabilities or abilities	DB2
		COBOL
Application Product	A named piece of business-oriented software offered by an external or an internal vendor	IBM MRP

are located in different countries in several plants and offices that are instances of the geography and facilities class. Some of the applications *use* a specially developed application building block, providing some system modifications.

The applications *need* IBM mainframe-based database system for relational databases "DB2" and COBOL language. The applications *are implemented* by IBM MRP (mainframe-based product for production planning) and the applications *are supported* by the members of the IT-personnel that are instances of the class "Person".

In terms of information demand the abstract context produced can be interpreted as follows: the production planner needs, for performing the task of production planning, a sales plan, information about relevant parts of the business strategy, applications (and their building blocks) supporting planning functions, certain databases and programming languages, and to some extent also personnel with competence and skills that might contribute to the planning activities.

Producing operational context, i.e. providing the user with the needed information, is then done by selecting attribute values from the information sources and computation of the related values. For instance, in order to obtain a sales plan the production planner has to indicate the planning period that he/she is interested in. Referring to the example with application locations the production planner can assign some criteria to select the location of the applications he/she intends to use. This selection (and only it) influences the value for the attribute of "the current cost of IT support for the process" specified in the class "Production planning".

If the user profile contains some statistics based on which user preferences that have been identified the selection criteria can be taken from this profile. In other cases they have to be entered directly by the user. For this a special user interface is used, one that is developed specifically for each case but since the enterprise model used as a basis for the research done so far describes a fictitious enterprise no such interface exists yet. Based on the user criteria, DSS sends requests to the Web-services.

Finally the Web-services query the information sources, get query results, and then pass them on to the operational context.

4 CONCLUSION

During previous performed research referenced in this paper it has become clear that Information Demand Analysis and Modelling as an area (and thereby also Information Logistics) has a lot to benefit from applying ideas, concepts, and techniques from the context-driven approach to decision support. However, research performed by the authors has up to this point focused more on deriving information demand contexts and thereby identifying information demands rather than on matching information demands and information present in various kinds of enterprise systems. In this paper some first ideas concerning how the matching between information and information demands can be performed within decision support systems based on the initial generation of IDCs from an enterprise model has been presented.

It is believed that continued research on this subject could prove to be most useful for information logistic systems as well as for decision support systems since it could lead not only to the automatic identification and derivation of information demands in relation to work tasks but also the matching of such demands to enterprise information as well as semi-automatic provision of such information, all this based on one single enterprise model. If successful such an approach would not only greatly decrease the amount of analysis required when building systems supporting knowledge and information intensive work-related tasks, it could also contribute to the reduction of information overflow in everyday working situations.

ACKNOWLEDGEMENTS

Parts of the presented research are due to CRDF partner project # RUM2-1554-ST-05 with US ONR and US AFRL, projects supported by the Russian Academy of Sciences # 16.2.35 and # 1.9, grant # 05-01-00151 of the Russian Foundation for Basic Research, and grant # IG 2003-2040 from the Swedish Foundation for International Cooperation in Research and Higher Education STINT.

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