Context-Driven Information Demand Analysis in Information Logistics and Decision Support Practices

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Abstract

Decision making and knowledge intensive work requires information supply tailored to the need of the user in question. Context management is considered a key contribution to this objective. The paper investigates context definitions and representations from two different viewpoints: information demand analysis and decision support. Discussion and comparison of these viewpoints includes enterprise models as a source for information demand analysis, ontologies and object-oriented constraint networks as representation technique and correspondences between information demand context and context in decision support.

Introduction

Making decisions, solving problems, and performing knowledge intensive work require readily available information. Today, many different approaches exist to provide users with streamlined information and knowledge to better support them in the process of decision making and problem solving. Among these approaches are context-based decision support and problem solving (Smirnov et al. 2005) and Information Logistics, a demand-driven approach to information supply (Deiters et al. 2003).

The context-based approach to decision support focuses on dynamic problem modeling and solving for decision support. It involves integration of knowledge represented by multiple domain ontologies into context sensitive knowledge. Context sensitive means (a) that knowledge relevant to a problem at hand or situation is integrated, and (b) the integrated knowledge is linked to information sources providing up-to-date information. Main technologies supporting this approach are *ontology management*, *context management*, and *constraint satisfaction*.

While context-based decision support focuses on providing information necessary to solve problems Information Logistics has a similar but somewhat wider perspective on providing users with information. From an Information Logistics point of view only information considered relevant with respect to such aspects as time, location, organizational role, and work activities should be provided to the users. Development of methods, tools and techniques for the analysis of information demand (ID) is the core of the information demand based approach to Information Logistics.

The paper is devoted to a study of context models used within information demand analysis and decision support approaches. The first part of the paper will introduce the information demand viewpoint including relevant definitions and the role of enterprise modeling. The second part focuses on use of context in decision support, which encompasses representation means and decision making stages. The third part finally compares the two viewpoints and draws conclusions.

Context as Dimension of Information Demand

Ongoing research at Jönköping University aims at developing methods, tools and techniques for analyzing ID and to develop systems providing demand-driven information supply. The starting point for work in this area is the following definition of ID:

> Information Demand is the constantly changing need for current, accurate, and integrated information to support (business) activities, when ever and where ever it is needed.

Among other implications, this definition implies that

- models representing ID need to be able to capture the dynamics of information demand in order to reflect changes over time,
- the context, in which the demand exists, as well as some mechanism for understanding when a switch in context takes place has to be provided.

The above clearly identifies the complexity of ID as a concept. It has been proposed that this complexity can be handled by breaking down the concept into several different but interconnected dimensions as *Context*,

Situation, *Information Demand*, and *Plan/Agenda* (Lundqvist & Sandkuhl 2004).

To be able to support activities and provide integrated information it' is necessary to capture and evaluate information about these activities. Thus the concept of *Context* is considered to be the most important aspect of ID defining the settings in which the users' ID exists.

Many different definitions of context exist in areas such as ubiquitous computing, contextual information retrieval, etc. but for the purpose of information demand analysis, context is here simply defined as:

> An Information Demand Context is the formalized representation of information about the setting in which information demands exist and is comprised of the organizational role of the party having the demand, work activities related, and any resources and informal information exchange channels available, to that role.

In this definition, several important concepts can be identified, the central of them being the *Role*. Thus, when *Context* is mentioned here it is considered to be the context of a particular role. It could be argued that it is equally relevant to speak of an ID as related to a specific activity and that some resources are necessary to perform some activities no matter who performs them but *Role* is nevertheless the one concept that in a natural way interconnects the others.

In its simplest form *Role* can be described as a part of a larger organization structure clearly defined by it's responsibility within that structure. Associated with that role are a number of activities that fall within, as well as define, the responsibility of that role. Furthermore there are a number of different resources available to a specific role that can be utilized to perform particular activities. Such resources might be anything from information systems to devices or machines used in the activities. Not all resources are available to all roles and not all resources are suitable for use in all activities, hence the connection between *Role*, *Activities*, and *Available Resources*.

Finally it is proposed that an information demand context incorporates *Contact Networks,* which describe the informal information exchange channels that exist between peers despite not being based on, or formally represented in, any organizational structures, process descriptions, or flow charts. Such informal structures might be based on anything from personal networks, the comfort of turning to other individuals with whom a common interests or the same educational or demographical background is shared. These structures are brought into an organization by individuals but connected to a role since the model above does not include humans but rather the formalized view on humans as roles within an organization.

Deriving Information Demand Context

Contextual information can be derived in many different ways and from many different sources, such as interviews with different roles within an organization, work- or information flow analysis, or various kinds of process modeling methodologies. When trying to reduce the effort necessary, there are mainly two ways to do this; (1) by utilizing already existing knowledge about the object being analyzed and (2) generalize and reuse knowledge gained from the analysis of similar objects. One particularly suitable source for deriving large parts of the contextual information necessary, and thereby utilizing existing knowledge, are Enterprise Models (EM).

Enterprise Modeling has been described as the art of externalizing enterprise knowledge. This is usually done with the intention to either add some value to an enterprise or share some need by making models of the structure, behavior and organization of that enterprise (Verndat 2002). The motivation often given to why enterprises should be analyzed and modeled is that it supports management, coordination and integration of such diverse things as markets, processes, different development and manufacturing sites, components, applications/systems, and so on as well as contributes to an increased flexibility, cleaner and more efficient manufacturing etc. Such models usually include (Verndat 2002), business processes, technical resources, information flow, organizational structures, and human resources. If business processes are considered to be sequences of *Activities*, technical resources and information to be *Resources*, organization to be the structure in which roles (humans) can be identified, these model elements also correspond well to the different aspects of information demand context presented above.

Context-Based Decision Support

The approach to context-based decision support aims at modeling the user's (decision makers', and other participants' involved in the decision making process) problem and solving it. The concept "problem" is used for either a problem at hand to be solved or a current situation to be described. The problem is modeled by two types of context: abstract and operational. *Abstract context* is a knowledge-based model integrating information and knowledge relevant to the problem. As knowledge representation means ontology model is chosen. *Operational context* is an instantiation of the abstract context with data provided by information sources.

Decision making is a complex process where a large number of factors can have an effect on a single problem. To naturally take into account the various factors and constraints imposed by the environment, the mechanism of object-oriented constraint networks (OOCN) (Smirnov et al. 2003) is employed. The problem is modeled by a set of constraints. Constraints can provide the expressive power of the full first-order logics (Bowen 2003) that is tended to be used as the key logics for ontology formalization.

Problem solving within the model of decision making process (Simon 1987) suggests resolving a problem by selecting a "satisfactory" solution. Within the approach the

problem expressed by a set of constraints is to be solved by a constraint solver as *constraint satisfaction problem* (CSP). A result of CSP solving is one or more satisfactory solutions for the problem modeled.

CSP model consists of three parts: a set of variables; a set of possible values for each variable (its domain); and a set of constraints restricting the values that the variables can simultaneously take. To express the problem by a set of constraints that would be compatible with ontology model and with internal solver representations, the formalism of OOCN is used. Typical ontology modeling primitives are classes, relations, functions, and axioms. A correspondence between the primitives of the ontology model and OOCN is shown in Table 1.

Table 1. Primitives of Ontology Model and OOCN

Ontology Model	OOCN
Class	Object
Attribute	Variable
Attribute domain (range)	Domain
Axioms and relations	Constraints

Decision support within the approach is considered consisting of two stages: a preliminary stage and a decision making stage. The *preliminary stage* is responsible for preparedness of a decision support system to make decisions. Activities carried out at this stage are:

- Creation of semantic models for components of a decision support system. The following components are defined: *information sources*, *domain knowledge*, and *users*. These components are modeled as follows: *domain knowledge* is modeled by ontology model; semantics of *information sources* is described by *information source capabilities* model; *users* are modeled by *user profile* model. All the components are represented by OOCN formalism;
- Accumulation of domain knowledge. The approach relies on an availability of sufficient domain knowledge represented by multiple ontologies using the internal representation. As a repository for the collected knowledge an ontology library serves. The domain knowledge is collected before it can be used in problem solving and decision making. Knowledge collecting includes phases of knowledge representation and integration;
- Coupling domain knowledge with information sources. In order to obtain up-to-date information from the environment, ontologies are linked to information sources (sensors, Web-sites, databases, etc.) that keep track of environment changes. Applying the internal representation, attributes of domain ontology and attributes of the representations for information sources and users are linked by associative relationships.

The *decision making stage* concerns integration of information and knowledge relevant to the problem, problem modeling and solving. The starting point for this stage is the user request containing a formulation of the user problem in a user presented view. Based on the results of request recognition the knowledge relevant to it is searched for within the collected knowledge, extracted, and integrated. Ontology-driven knowledge integration enables to involve methods of consistency checking for the integrated knowledge. To operate on the extraction of relevant knowledge, its integration and consistency checking *ontology management* techniques are used.

The consistent knowledge is considered as an *abstract context* that is an ontology-based problem model supplied with links to information sources that will provide data needed for the given problem. The linked information sources instantiate the abstract context producing the *operational context* that is the problem model along with problem data. Obtaining information, its organization in contexts, and context versioning are *context management* issues.

Context-Based Decision Support for Information Demand Definition

In order to compare the two different viewpoints on context presented, dimensions of information demand combining the two viewpoints have been identified.

The user plays different roles depending on the activities this user carries out and other factors. E.g., within a decision support system the user plays the role of a decision maker and, as well, can have several more roles within the organization.

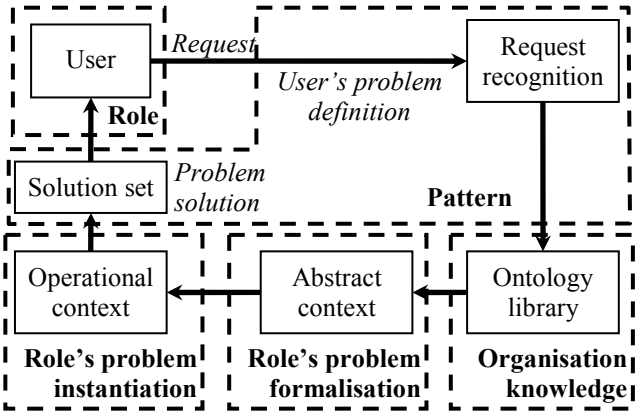

Figure 1. Dimensions of information demand within decision support

The ontology library can include ontologies representing organization knowledge that can be considered to be domain knowledge. Organization knowledge is made up of knowledge about organization structure, activities carried out by the organization, resources deployed, an organization strategy, etc. This knowledge captured by the abstract and operational contexts reports what part of organization knowledge is useful in the context of a given problem. Accumulation of knowledge in the library allows transforming tacit knowledge into explicit one through its formalization.

The abstract context modeling the user's problem can be considered as a formalized model of the problem defined by a certain role. From the information demand perspective an abstract context states information demand as need for integrated information to solve the user problem.

Consequently, the operational context being an instantiation of the problem model describes information demand as constantly changing need for current and accurate information.

The user requests along with the set of problem solutions are considered as a step towards derivation of reoccurring patterns of information demand. The user request formulates the problem at hand under certain settings and conditions. The solution set contains problem solutions for the given problem situation. An analysis of the requests and respective solution sets is supposed to allow deriving common problems and a general solution for a particular problem or problem type. Furthermore, the analysis is thought to be helpful in the identification of types of problems intrinsic to the particular role.

By accepting Enterprise Models as a source for capture of information demand and contextual information derivation, such models is considered to provide with beneficial ideas and knowledge for the decision support in a business application.

Within the decision support approach users are modeled by user profiles. The structure of a profile provides structure elements for storage and accumulation of information characterizing the user and his/her activities. Some of these elements, e.g. organizational belonging, activity, etc. can be adopted from the Enterprise Models.

Knowledge in the Enterprise Models is based on is believed to serve as domain knowledge to be included in the ontology library. Different Enterprise Models can provide different viewpoints on the enterprise knowledge; additionally, they can supplement knowledge of each other.

Conclusions

In order to simplify and shorten the process of developing Information Logistical- and context-based decision support applications as well as ensuring the quality and usefulness of such applications the underlying information demands of the users need to be known. It has been suggested that such demands can be identified and realized through the understanding of the setting in which they exist, i.e. the context in which a user has a particular problem. It has also been shown that one possible source for deriving information demands are Enterprise Models that externalize existing knowledge about an enterprise and thereby shorten and simplify the process of identifying such demands.

The study of context models used within the information demand analysis and decision support approaches facilitate the identification and representation of information demand dimensions intended to be used in the identification of information demand patterns.

The context model used in the decision support approach reflects the needs for integrated information to solve the user problem and for up-to-date and accurate information. The context model of the approach to information demand analysis is believed to be beneficial to the decision support approach in the way it takes into account information that is sensitive to the user role, not only relevant to the user problem.

The two approaches are mutually beneficial in information and knowledge formalization. The decision support approach relying on formalized information and knowledge is a step toward formalization of personal and tacit knowledge taking place while informal information exchange. This formalized knowledge can enrich the ontology library with new knowledge. The explicit formalization of the user's problem within the decision support approach is supposed to enable the identification of problem types intrinsic to the particular role as well as facilitate the derivation of information demand patterns.

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