Information Demand Patterns

Capturing Organizational Knowledge about Information Flow

Kurt Sandkuhl
Institute of Computer Science, The University of Rostock, Rostock, Germany
and
School of Engineering, Jönköping University, Sweden
Kurt.Sandkuhl@uni-rostock.de

***Abstract*—The work presented in this paper aims at contributing to reduced information overload in organizations. We propose to capture organizational knowledge about the typical information demand of an organizational role in an information demand pattern, which can serve as basis for analyzing information flow problems and developing organizational and technical improvements. The contributions of this paper are (1) the concept of an information demand pattern, (2) the structure for textual descriptions of such patterns, and (3) experiences from the development and validation process. The approach is based on an industrial case and illustrated by an example pattern. The main achievements are validated research results, i.e. the concept of information demand patterns and actual patterns.**

Keywords: Information demand; organizational knowledge pattern; information logistics; information demand pattern

I. INTRODUCTION

The work presented in this paper aims at contributing to reduced information overload in organizations by capturing reusable organizational knowledge about information demand in so called information demand patterns. Information overload has been a phenomenon observed and discussed in the literature since many decades. One of the pioneers of computer-supported collaborative work, Vannevar Bush, foresaw already in 1945 that it would not be possible to manage all information we collect in our "bewildering store of knowledge" [13]. Simpson and Prusak discussed in 1995 [14] a conceptual model for reducing overload by using quality attributes to information.

Nowadays, information overload is also perceived as a problem in enterprises. Today's enterprise information systems usually support well-defined work flows and routine activities by sophisticated solutions. But for exceptions from daily routine, ad-hoc tasks or seemingly unstructured activities, quickly finding the information needed is a challenge. Some studies show that users spend a lot of time in searching for the right information causing unnecessary delays and costs. An example is [17] showing that 2 out of 3 top or mid-level managers participating in a study among Swedish enterprises perceive an information overload due to "far too much information" (37%) or "too much information" (29%). Since accurate and readily available information is essential in decision making situations, problem solving and knowledge-intensive work, an improved information supply would contribute significantly to saving time and most likely to improving productivity.

The paper aims at contributing to the reduction of information overload by bringing together experiences from organizational knowledge management and pattern-based reuse in information system development. We propose to capture organizational knowledge about the typical information demand of an organizational role in an information demand pattern, which can serve as basis for analyzing information flow problems and developing organizational and technical improvements. The contributions of this paper are (1) the concept of an information demand pattern, (2) the structure for textual descriptions of such patterns including an example, and (3) the development and validation process in an industrial case.

The remaining part of the paper is structured as follows: Section II describes the background for this paper and introduces related work. Section III presents an industrial case motivating the work. Section IV introduces the concept of information demand pattern, including a definition of the term, the structure of pattern descriptions and an example. Section V describes the development process and validation of this pattern. Section VI summarizes the work and discusses future work.

II. BACKGROUND AND RELATED WORK

A. Organizational Knowledge Patterns

Background for the work presented in this paper is research in enterprise knowledge modeling with the objective to make organizational knowledge reusable by applying techniques from enterprise modeling.

In general terms, enterprise modeling is addressing the systematic analysis and modeling of processes, organization structures, products structures, IT-systems or any other perspective relevant for the modeling purpose [18]. Enterprise knowledge modeling combines and extends approaches and techniques from enterprise modeling. The knowledge needed for performing a certain task in an enterprise or for acting in a certain role has to include the context of the individual, which requires including all relevant perspectives in the same model. Thus, an essential characteristic of knowledge models are "mutually reflective views of the different perspectives included in the model"

 ISBN: 978-1-61208-158-8

[8]. Enterprise knowledge modeling aims at capturing reusable knowledge of processes and products in knowledge architectures supporting work execution [19].

In this context, we define the term organizational knowledge pattern as follows:

An organizational knowledge pattern is a formalization of knowledge for a recurring organizational task abstracting from organization-specific aspects, which is of value for an organizational actor and an asset for an organization.

In the context of this definition, the following characteristics of organizational knowledge patterns (OKP) have to be emphasized:

- OKP need to represent organizational knowledge, not individual knowledge, i.e. support the organizational knowledge creation process, the organizational context for use of knowledge by individuals as opposed to supporting knowledge creation of an individual.
- OKP address recurring organizational tasks and at the same time abstracting from a specific organization, i.e. like most other kinds of patterns in computer science is the description of the core elements independent from the actual solution for an organization.
- OKP are expressed in a formalized way, which requires a formal language or at least a structured representation. Thus, OKP are explicit knowledge.
- OKP are an asset of the organization, i.e. are not only a resource as such but capture knowledge about the resource's use. This means they do not only capture how to use the pattern (as for many computer science patterns) but how to use the resource.
- An OKP is of value for an organizational actor in its original form and / or its adaptation for a specific organization.

B. Related Work

For more than a decade, patterns have been popular in computer science and were introduced for numerous areas, like software design, information modeling or business processes. Although there is no generally accepted definition of the term pattern, most publications in the field get some inspiration from Christopher Alexander's definition: "Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" [3]. Whilst Alexander's focus is on the solution, many pattern approaches in computer science focus more on capturing proven practices or an advice on, how to approach certain problems.

The seminal book on patterns was published by the "Gang of Four" [7] and focuses on software design patterns. Many other books followed, basically offering patterns for all phases of the software development process, including analysis patterns [5], data model patterns [8] or software architecture patterns [9]. The pattern idea was adapted in other areas of computer science, like ontology patterns [12] or groupware patterns [10].

Concepts, methods and technologies for identifying, capturing and reusing organizational knowledge have been subject of research in organizational sciences and industrial engineering since more than two decades. Patterns of organizational knowledge, such as task patterns [15] or workflow patterns [11] are a recognized contribution to this area. The term knowledge pattern has been explicitly defined by Clark, Thomson and Porter in the context of knowledge representation [2]. They define "a pattern as a first-order theory whose axioms are not part of the target knowledge-base, but can be incorporated via a renaming of the non-logical symbols" [2, p.6]. The intention is to help construct formal ontologies by explicitly representing recurring patterns of knowledge, so called theory schemata, and by mapping these patterns on domain-specific concepts. Staab et al. [4] investigated the use of so called "semantic patterns" for enabling reuse across languages when engineering machine-processable knowledge. Semantic patterns consist in this approach of one description of the core elements independent from the actual implementation and for each target language a description that allows for translating the core elements into the target language.

III. INDUSTRIAL CASE

The industrial case defining the context for work presented in this paper is taken from automotive industries and focuses on engineering change management in a networked organization with different suppliers. One partner is the business area "seat comfort components" of a first tier automotive supplier with the main product development sites in Scandinavia. The seat comfort products mainly include seat heater, seat ventilation, climate control, lumber support and head restraint. One of the sub-suppliers of this first tier supplier is performing different surface treatment services of the metal components. Surface treatment in this context includes corrosion protection, different technical coatings to achieve certain functionality or decorative coatings in order to reach matt, lustrous or colored surfaces.

As part of the project "infoFLOW", which runs from 2006 - 2011 and includes 7 industrial and academic partners, the engineering change management process between the supplier and sub-supplier was analyzed including the different work steps involved, the roles included on both sides, the information and documents exchanged between both partners, common causes for problems in operations and the needs and goals of improvements. The process is geographically distributed involving engineers and specialists at several locations of the automotive supplier and sub-supplier. A large percentage of the produced components are parts of product families, i.e. various versions of the components exist and have to be maintained and further developed for different customers. In this context, managing different versions of specifications, change requests and production orders including their validity and date of effectiveness is of crucial importance. The results of the process analysis were captured in enterprise models and later used in the development of a method specialized on information demand analysis.

Selected results of analyzing the engineering change process are:

 ISBN: 978-1-61208-158-8

- In both enterprises, many different persons involved in the change management are having similar roles, like on sub-supplier side different key account managers for different projects from the supplier or on supplier side product managers for different customer projects ordering surface specific treatments at the sub-supplier.
- The change management process as such is well-defined and agreed on. However, in daily practice the number of "exceptional" and "emergency" actions is significant and causing many situations where the defined process is not followed.
- Conventional business process improvement approaches were tried, but did not lead to significant improvements, which most likely is based on the large number of exceptions.
- Many change requests are time critical; not implementing them accurately or timely will cause high costs for supplier and sub-supplier, e.g. by coating thousands of metal components wrongly, which will not be accepted by the customer and have to be disposed.
- The roles perceive information overload, and at the same time an information "underload": a lot of task-related information is available and continuously reaching them, but the really relevant information often is "lost in the information flood" or not reaching them.

Based on these results it was decided to use an approach for improving the process based on the information demand of the roles. To find reusable solutions applicable in several enterprises was considered an important goal and given priority in the project.

IV. INFORMATION DEMAND PATTERNS

Starting from a definition of the term information demand (Section IV.A), this section introduces the definition and structure of information demand patterns (Section IV.B) and presents an illustrative example (Section IV.C).

A. Information Demand

The notion of information demand is closely related to work in two areas: information logistics and information retrieval. The main objective of the research field information logistics is improved information provision and information flow [6]. This is based on information demands with respect to the content, the time of delivery, the location, the presentation and the quality of information. The research field information logistics explores, develops, and implements concepts, methods, technologies, and solutions for the above mentioned purpose.

As part of the information logistics research, Lundqvist [1] investigated the nature and characteristics of information demand (ID) in an enterprise context in an empirical study involving 3 organizations and 25 informants. The conclusion from the study is information demand of employees in an organization is to a large extent based on the organizational role, i.e. the information demand of a person is based on the roles and tasks this person has: "*Information demand depends on the role and tasks an entity has within a larger organization. If the role and/or the tasks change, so too will the demand" [1, p. 60]*. This role-centric perspective with task and responsibilities as primary characteristics has been the starting point for developing the approach of information demand patterns.

Information retrieval aims at retrieving relevant information meeting the needs of a user, which are expressed by a query. In this context the aspect of relevance of information is of high importance. Saracevic [16] considers several types of relevance, e.g. algorithmic, topical and cognitive relevance. The underlying concept for algorithmic relevance is the relation between the query features and the search result. Topical relevance is the relation between aboutness of content objects and query. These two relevance concepts are important for retrieving information meeting the demand of a user, but do not contribute to explaining information demand as a concept. Here, we consider cognitive relevance of higher importance, which is the association between perceived information need of the user and information presented to the user based on retrieval results.

B. Definition and Structure of ID-Patterns

The general idea of information demand patterns is similar to most pattern developments in computer science: to capture knowledge about proven solutions in order to facilitate reuse of this knowledge. In this paper, the term information demand pattern will be defined as follows:

An information demand pattern addresses a recurring information demand problem that arises for specific roles and work situations in an enterprise, and presents a conceptual solution to it.

An information demand pattern consists of a number of essential parts used for describing the pattern:

A statement about the *organizational context* where the pattern is useful. This statement usually identifies the application domain or the specific departments or functions in an organization forming the context for pattern definition.

Problems of a role that the pattern addresses. The tasks and responsibilities a certain role has are described in order to identify and discuss the challenges and problems, which this role usually faces in the defined organizational context.

The *conceptual solution* that resolves the problem, which for information demand patterns includes three parts:

- *Information demand* of the role, which is related to the tasks and responsibilities, is described as part of the pattern, i.e. the different parts of the information demand are identified
- *Quality criteria* for the different parts of the information demand include the general importance of the information demand part, the importance of receiving the part completely and with high accuracy, and the importance of timely or real-time information supply
- a *timeline* indicating the points in time when the different information parts should be available at the latest

The *effects* that play in forming a solution. If the needed information part should not be available or arrive too late this might affect the possibility of the role to complete its task

 ISBN: 978-1-61208-158-8

and responsibilities. The effects described in the pattern include

- Potential economic consequences
- Time/efficiency effects, i.e. whether the role will need more time for completing the task or will be less efficient
- Effects on improving or reducing the quality of the work results
- Effects with respect to the motivation of the role responsible
- Learning and experience effects
- Effects from a customer perspective

The above parts of a pattern are described in much detail in the *textual description* of the pattern, which is the main way of representing an information demand pattern (see Section IV.C for an example). Additionally, a pattern can also be represented as a *visual model*, e.g. a kind of enterprise model. This model representation is supposed to support communication with potential users of the pattern, as it illustrates the information demand context, including

- the relation of the role to co-workers and other roles in the organization
- the relation between the different parts of the information demand and IT system in the enterprise, which are potential source of this information
- the relation of tasks and responsibilities to processes in the organization

C. Information Demand Pattern Example

In order to illustrate the pattern approach, the information demand pattern "material specification responsible" was selected. Due to space limitations, only the textual description is presented, i.e. the visual representation is not included. The textual description follows the structure introduced in Section IV.B. The first element is the context where the pattern is useful:

Context:

The context for this pattern is manufacturing industries, in particular automotive industries and automotive suppliers. When developing new products or variants of the existing product families, usually a team of many different engineering disciplines is involved. One role in this team is the material responsible who is supposed to make sure that the applied materials meet the quality requirements of both, the customer of the supplier and the supplier as such. This role requires experience and accurate information about the material characteristics, test results, customer requirements, supplier information etc., which usually originate from different information sources and actors. The pattern describes the information demand typically experienced by the role responsible for contributing to product design processes.

The pattern is supposed to be useful for manufacturing enterprises producing products with high demands to material characteristics developed in distributed teams of engineers.

The next part is the problem addressed by the pattern:

Problem:

The pattern addresses the general problem of unnecessary shortcomings, product design or production problems caused by the materials used. This includes the following problems, which were observed by practitioners in product design projects:

- *Changes in customer requirements affect the required features of the material, but this is difficult to detect in the change description. Thus, the material responsible does not receive this information, although changes in the material or adjustments would be necessary. Long-term effects could be production problems, acceptance failure by the customer or quality problems due to shortcomings in the material.*
- *Test results or policy changes, possibly from other business areas of the company using the same material, indicate that the use of the material should be changed. This information is not reaching the material responsible, as this role is not part of the respective work process or organization unit where the relevant information is produced.*

It follows the information demand, which is based on the task and responsibilities of the role under consideration:

Information Demand

The information demand is based on the tasks and responsibilities of the role. The tasks of the material responsible include

- *Responsibility: the material selected for a certain product version fulfills all desired quality attributes, including customer requirements, internal policy, laws and regulations, sustainability, manufacturability*
- *Establish suitable test methods for the material (for example by selecting the appropriate ones or initiating new developments) and initiate tests continuously validating the desired quality of the material*
- *Specify material characteristics to be used in procurement*

The information demand of the role material responsible consists of:

- *To receive information about all change requests from the customer side that possibly could affect the material of the product under design or manufacturing*
- *To get all information about changes in company-internal policies or in public laws and regulations regarding the use of the material in the company's products*
- *To receive all information about customer complaints or complaints from the production site regarding the material*
- *To get all relevant information from material testing w.r.t. test results of the material in question and regarding modification or new developments regarding the test methods and test processes*
- *To get all information from the supplier side regarding changes in the characteristics of the material*
- *To receive reports and complementary information from certification organization, domain organizations or clusters regarding the material used.*

The quality criteria for the above information demand information uses three levels:

- Decisive: you can't manage without this information
- High: it is very important to have, but in worst case you could complete the task without
- Nice to have: you will manage without this information, but the result will be not as good as with this information

For each pattern, the quality criteria are summarized in a table, which includes the information demand (left column),

the general importance of this information, and the importance to get the information accurately, as soon as possible (here: in close to real-time) and completely. Below is the table for the example pattern:

Information Demand	*General importance*	*Accurate*	*In real-time*	*Complete*
Customer Change Requests	*decisive*	*Decisive*	*high*	*Decisive*
Policy, law, regulation changes	*high*	*High*	*high*	*Decisive*
Complaints from own production	*decisive*	*High*	*decisive*	*High*
Customer complaints	*decisive*	*Decisive*	*high*	*Decisive*
Test results	*high*	*High*	*high*	*High*
Changes on supplier side	*high*	*High*	*high*	*High*
Complementary information	*Nice to have*	*Nice to have*	*Nice to have*	*Nice to have*

Table 1: Quality criteria for the information demand of the role "material specification responsible"

The effects of not receiving the needed information or of receiving it to late is described in a short text and in a table. We will only include an excerpt of the text due to space limitations:

Effects

If the needed information should not be available or arrive too late this will have effects on the work of the material specification responsible:

- *Economic effects: the economic consequences could be: in worst case costs for recall of non-functional parts; increased cost for the component or product, reducing the profit margin for the supplier; increased level of investment in production equipment*
- *Time/efficiency of the task: production or product design will need much more time and will be less efficient. An example is when replacing one failing material, one extra test loop is required for the validation of the complete product*
- *Quality improvement or reduction: the quality of the products is positively or negatively affected by this information. Examples are: late reinforcements of the product, due to failing materials, might result in reduced performance, for instance in mechanical comfort level*
- *[…]*

V. PATTERN DEVELOPMENT AND VALIDATION

The elaboration and validation of the concept of information demand pattern in general and of actual information demand patterns for specific organizational roles was performed in an iterative way consisting of various cycles, including both structure and content. Figure 1 illustrates the overall approach.

As indicated in Section II, the concept of information demand patterns is inspired by other work in computer science. Thus, the initial work on elaboration of the concept "information demand pattern" (marked as "1" in figure 1) focused primarily on the structure of such patterns based on the literature in the field. The validation of the initial structure ("2" in figure 1) consisted of checking this structure for internal consistency and soundness, and using it for capturing a very simple pattern example. The elaboration of the first actual pattern using the initial pattern structure consisted of selecting a simple but sufficiently complex organizational role and developing the content of the pattern for the selected role (step "3"). Afterwards, the initial content of the pattern again was validated by checking internal consistency and completeness, and by using own experiences (step "4"). Steps 1 to 4 form the first iteration, which was performed in a lab environment without involvement from actors outside the research team.

The second iteration started with the next elaboration phase for the pattern structure (step "5"), which was based on experiences from elaborating and validating the first actual pattern (steps 3 and 4). Improvement of the pattern structure and the following step of validation for the improved version (step "6") now also involved additional actors, namely the industrial partners of the infoFLOW project. Later iterations (i.e. steps beyond "8") included elaboration and validation activities involving actors outside the project team and outside academia. The different iterative development steps did not change the structure of patterns significantly, but mainly contributed to a refinement of the level used for describing the quality criteria, the effects and the timeline.

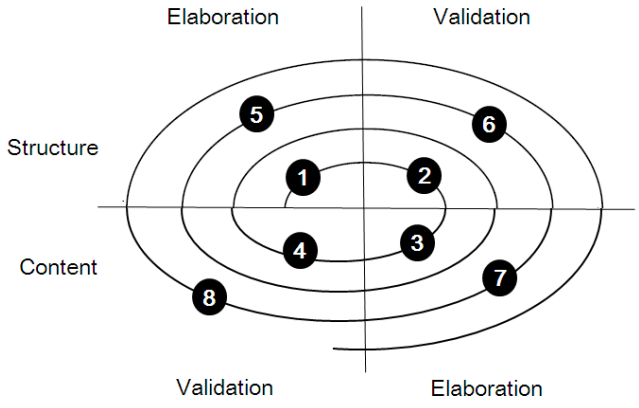

Fig. 1. Iterative process of elaboration and validation of information demand patterns.

The pattern presented in Section IV was developed in the context of the industrial case introduced in Section III by analyzing a number of enterprise knowledge models with focus on reoccurring roles and their relations to processes and infrastructure resources. All enterprise models addressed different parts of collaborative product development in

 ISBN: 978-1-61208-158-8

networked enterprises. The focus of the analysis was to identify roles reoccurring in the different models and indicating a specific information demand. The selected role "material specification responsible" appeared in several models developed. The information demand of these roles was derived from the textual descriptions accompanying the enterprise models and the scenario descriptions developed in the modeling process.

The pattern was validated in two steps: The first version was presented, discussed and refined during an infoFLOW project meeting. This included a walkthrough the visual model and a in-detail discussion of the textual description. The revised version was presented to an industrial expert in the field who proposed changes and improvements, primarily regarding the effects to be expected and the required information quality. This refined version was again discussed in a project meeting.

VI. SUMMARY AND FUTURE WORK

The paper presented an approach for capturing organizational knowledge about the information demand for an organizational role in information demand patterns. Starting from task and responsibilities of a role, these patterns identify the information needed for the role under consideration, the required level of accuracy, completeness and timeliness, a typical timeline, and the economic, quality, efficiency and customer effects of receiving the information too late of in insufficient quality.

In their current development state, information demand patterns are supposed to contribute to explaining and investigating operational problems in an organization caused by information lack of a role:

- Patterns help to analyze and identify information demand problems. If an organization detects information problems in a certain part of the organization or intends to identify improvement potentials, a pattern can be used to compare the typical or desirable solution described in the pattern with the current situation in the organization
- Patterns identify and specify abstractions that are above the level of single solutions in specific enterprises and provide a common vocabulary and understanding for information demand problems.
- Patterns are a means of documenting solutions to information flow problems.
- Patterns help to manage information supply complexity by dividing larger information flow problems in smaller "modules", which can be expressed in patterns.

Future work will focus on four main aspects

- Increasing the number of patterns, applying them in organizations and evaluating the benefits of the information demand pattern approach
- Extending the patterns toward solutions for information supply, i.e. how can the information demand described in a pattern be supported by IT-solutions or organizational measures
- Investigate and define the process of adaptation of an information demand pattern to another context of use
- Development of a method for pattern development and refinement, including technical support for pattern management, like a pattern repository.

ACKNOWLEDGMENT

The research presented was financed by the Swedish Knowledge Foundation (KK-Stiftelsen), grant 2009/0257, project "Demand Patterns for Information Logistics (infoFLOW-2)".

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 ISBN: 978-1-61208-158-8