# ORGANIZATIONAL KNOWLEDGE PATTERNS
## *Definition and Characteristics*

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Abstract: The importance of managing organizational knowledge for enterprises has been recognized since decades. Enterprise knowledge modeling contributes to this subject by offering methods, tools and approaches for capturing knowledge in formalized models supporting the lifecycle of organizational knowledge management. The paper focuses on reuse of organizational knowledge in different organizational contexts by using patterns. We argue that organizational knowledge patterns have to combine technical and cognitive qualities in order to support organizational knowledge creation and IT-supported knowledge reuse. The contributions of the paper are (1) to define of the term organizational knowledge pattern in relation to other pattern types, (2) to identify characteristics of such patterns, and (3) to examine two established pattern types from knowledge engineering to expose the key features of organizational knowledge patterns.

## 1 INTRODUCTION

The importance of managing organizational knowledge for enterprises has been recognized since decades. The expectation is that systematic development and reuse of organizational knowledge will help to improve the competitiveness of the enterprise under consideration. Enterprise knowledge modelling contributes to this purpose by offering methods, tools and approaches for capturing knowledge about processes and products in formalized models in order to support the entire lifecycle of organizational knowledge management.

The paper focuses on a specific aspect of enterprise knowledge management: organizational knowledge prepared for reuse in different organizational contexts by using patterns. The use of patterns in computer science has some tradition (see Section 2.1); in knowledge management and knowledge engineering patterns commonly provide reusable components or methods for well-defined problems in specific knowledge engineering contexts. However, such patterns focus more on technical characteristics than on cognitive qualities required for supporting organizational aspects of knowledge creation and management. We argue that organizational knowledge patterns have to combine technical and cognitive qualities in order to support organizational knowledge creation and IT-supported knowledge reuse.

If we consider information or knowledge-intensive industry or service sectors as an application context for such reusable organizational knowledge, the time to deployment and the required efforts become an issue. With time to deployment we denote the time from selecting a knowledge pattern to an operative use of this knowledge. Operational use usually does not only require a transfer of the knowledge captured in the knowledge pattern to the individuals in the organization supposed to use this very knowledge, but also the implementation of supporting IT systems, like work flow or information management support, by configuring existing platforms, executing the model as such or implementing new software systems. In the light of the ever increasing pressure for more efficiency and shorter time-to-market, the ideal organizational knowledge pattern would be easy-to-understand and easy-to-deploy. But what features should organizational knowledge patterns have in order to meet these requirements of being easy-to-understand and easy-to-deploy? How close are the many existing pattern types to this vision of “ideal” ones and how could they be enhanced? As initial contributions to these questions, the paper offers (1) the definition of the term organizational knowledge pattern in relation to other pattern types, (2) the


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identification of characteristics of such patterns, and (3) the examination of two established pattern types from knowledge engineering in order to expose the key features of organizational knowledge patterns. The research approach used is exploratory. Grounded in relevant related work, we propose a new concept and discuss its validity.

After an introduction to the background of this work (Section 2), the term of organizational knowledge pattern is defined and discussed (Section 3). In Section 4, the paper presents two different kinds of patterns: enterprise model patterns and ontology design patterns. Section 5 discusses the given definition and briefly compares the pattern types. A short summary concludes the work in section 6.

# 2 BACKGROUND

Two areas forming the background for work presented in this paper will be briefly introduced in this section: pattern use in computer science and enterprise knowledge modelling.

For more than a decade, *patterns* have been popular in computer science and were introduced for numerous areas. The seminal book on patterns was published by the "Gang of Four" (Gamma et al., 1995) and focuses on software design patterns. Many other books followed, basically offering patterns for all phases of the software development process, including analysis patterns (Fowler, 1997) and software architecture patterns (Buschmann et al., 2000). The pattern idea was adapted in other areas of computer science, like workflow patterns (van der Aalst et al., 2003) or ontology patterns (Blomqvist, 2005). Despite the many different fields addressed by these different pattern types, they share some characteristics:

- They are based on experiences and deeply rooted in the practice of the field.
- They are not meant to be used blindly as they are. You have to understand the core idea and adjust or apply it for the problem at hand.
- They do not only help to build software, processes or models, but also to communicate approaches within a team.

*Enterprise modelling*, in general terms, is addressing the systematic analysis and modelling of processes, organization structures, products structures, IT-systems or any other perspective relevant for the modelling purpose (Vernadat, 1996). Enterprise models can be applied for various purposes, such as visualization of current processes and structures in an enterprise, process improvement and optimization, introduction of new IT solutions or analysis purposes. Frameworks like GERAM and CIMOSA or the results of FP6-IP-ATHENA (Ruggaber, 2006) aim at supporting enterprise engineering in the large by providing reusable enterprise models for administrative and manufacturing functions commonly found in enterprises of a specific domain.

Enterprise knowledge modelling combines and extends approaches and techniques from enterprise modelling. 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" (Lillehagen and Krogstie, 2009). Enterprise knowledge modelling aims at capturing reusable knowledge of processes and products in knowledge architectures supporting work execution.

Enterprise knowledge modelling has a tradition of using visual models, which basically allow for adapting the language extension (i.e. the graphemes, vocabulary and syntax of the modelling language) to the application domain. This contributes to increasing social pragmatic quality, i.e. to what extent the stakeholders understand and can apply the models. Enterprise domains often are socially constructed and intersubjectively agreed upon, and enterprise knowledge models usually created as part of a dialogue among the participants involved in modelling.

# 3 ORGANISATIONAL KNOWLEDGE PATTERNS

This section introduces and defines the term "organizational knowledge pattern" in the context of relevant work from knowledge engineering (3.1) and from organizational knowledge management (3.2). We decided to contrast the requirements from organizational knowledge management, expressed as features of reusable knowledge which we chose to call organizational knowledge patterns, with characteristics of contemporary approaches for reusing knowledge which commonly are referred to as knowledge patterns.

## 3.1 Knowledge Patterns

The term knowledge pattern has been explicitly

defined by Clark, Thomson and Porter in the context of knowledge representation (Clark et al., 2000). 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" (Clark et al., 2000, 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 (Staab et al., 2001) 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. Compared to knowledge patterns, semantic patterns try to separate engineering knowledge from language-specific implementations instead of theories from domains they are applied in.

Knowledge formalization patterns have been proposed by Puppe as rather simple templates proven in practice for the (mass) formalization of knowledge (Puppe, 2000). Puppe puts a lot of emphasis on proven problem solving methods, which uncover implicit knowledge of experts.

## 3.2 Organisational Knowledge

In organization theory and management science different views on knowledge from an organizational perspective have been published and discussed. One important dimension often discussed is the distinction between two types of knowledge, which is based on the work of Polanyi (Polanyi, 1958): explicit knowledge and tacit knowledge. Explicit knowledge refers to knowledge that is codified, i.e. transmittable in a formal representation or language. Tacit knowledge is hard to formalize due to its personal quality of "simply knowing how to do something" in a specific context. Organizational knowledge includes both, tacit and explicit knowledge.

In this context, the paper follows the opinion of Nonaka that an organization cannot create knowledge without individuals, i.e. at a fundamental level, knowledge is created by individuals (Nonaka, 1994). The organization supports individuals and provides a context for knowledge creation. Organizational knowledge creation includes processes that organizationally amplify the knowledge created by the individuals and crystallizes it as part of the knowledge network of the organization.

Spender (Spender, 1996) discusses the term organizational knowledge from a perspective of organizational science and management science. The article comes to the conclusion of two parallel views on organizational knowledge. The first one separating the notion of knowledge from learning and memory, which essentially leads to a perception of knowledge as an asset of the organization, with its implicit conservation or constancy in quantity. The second view perceives knowledge as public good whose quantity and value is not diminished by sharing it and as a subject to extension and reshaping rather than conservation. Spender states that "Assets, as resources, are compounded with knowledge about their use, knowledge of a different type."

## 3.3 Organisational Knowledge Patterns

As motivated in the introduction, organizational knowledge patterns should combine technical features and cognitive quality and in an ideal case be easy-to-understand and easy-to-deploy. With easy-to-understand we address the challenge of providing knowledge to individuals in a way which for their context of use has the appropriate presentation and quality and thus eases the internalization of knowledge. With easy-to-deploy we target a representation of the knowledge which is adaptable to a specific organizational context and formalized or specified in a way that eases the provision of IT solutions supporting the knowledge use. As a contribution to promote these features, we propose to extend by Clark's knowledge patterns by supporting more explicitly the focus on providing characteristics for organizational knowledge. 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.
- The cognitive and technical quality of an OKP is adequate for the stakeholders, i.e. the OKP are developed and described for a defined context of usage with identified stakeholders.

We propose to use the term organizational knowledge pattern in order to emphasize that explicit organizational knowledge is represented and on the other side the technical quality of knowledge patterns is reached. Furthermore, the intention is to expose from an organizational perspective the weakness of today's knowledge pattern types and the discussion in the knowledge representation community. At the same time the value and the suitability of today's knowledge pattern developments as a basis for considerations from an organizational perspective.

# 4 REUSABLE ORGANISATIONAL KNOWLEDGE

Reusing organizational knowledge has been subject of research activities for many years. Two approaches for capturing organisational knowledge were selected for further discussion in this paper and shall be presented in this section: task patterns (section 4.1) and ontology design patterns (4.2.). These developments were selected since they use different perspectives on organisational knowledge, and since they have already been used outside academia in an organisational context.

## 4.1 Task Patterns

The concept of task pattern is a result of the EU-FP6 project MAPPER. In this project, collaborative engineering was supported by adaptable models capturing best practices for reoccurring tasks in networked enterprises. These best practices were represented as active knowledge models using the POPS* perspectives. Active knowledge models are visual models of selected aspects of an enterprise, which cannot only be viewed and analyzed, but also executed and adapted during execution. The POPS* perspectives include the enterprise's processes (P), the organization structure (O), the product developed (P), the IT system used (S) and other aspects deemed relevant when modelling (*).

The term "task patterns" was introduced for these adaptable visual models, as they are not only applicable in a specific company, but are also considered relevant for other enterprises in the application domain under consideration. Task pattern in this context is defined as "self-contained model template with well-defined connectors to application environments capturing knowledge about best practices for a clearly defined task" (Sandkuhl, 2010). In this context, self-contained means that a task pattern includes all POPS* perspectives, model elements and relationships between the model elements required for capturing the knowledge reflecting a best practice. Model template indicates the use of a well-defined modelling language and that no instances are contained in the task patterns. Connectors are model elements representing the adaptation of the task pattern to target application environments.

The representation of a task pattern consists of the description of the problem addressed by the task pattern, a knowledge model proposing a solution for the problem addressed, and a rationale behind the solution, i.e. an explanation about the most important preconditions, principal results and most important work steps.

## 4.2 Ontology Design Patterns

In a computer science context, the aim is to efficiently produce high quality ontologies as a basis for semantic web applications or enterprise knowledge management. Despite quite a few well-defined ontology construction methods and a number of reusable ontologies offered on the Internet, efficient ontology development continues to be a challenge, since this still requires a lot of experience and knowledge of the underlying logical

theory. Ontology Design Patterns (ODP) are considered a promising contribution to this challenge. In 2005, the term ontology design pattern in its current interpretation was mentioned by Gangemi (Gangemi, 2005) and introduced by Blomqvist and Sandkuhl (Blomqvist and Sandkuhl, 2005). Blomqvist defines the term as "a set of ontological elements, structures or construction principles that solve a clearly defined particular modelling problem". Ontology design patterns are considered as encodings of best practices, which help to reduce the need for extensive experience when developing ontologies, i.e. the well-defined solutions encoded in the patterns can be exploited by less experienced engineers when creating ontologies.

The two types of ODP probably receiving most attention are logical and content ODP. Logical ODP focus only on the logical structure of the representation, i.e. this pattern type is targeting aspects of language expressivity, common problems and misconceptions. Content ODP often are instantiations of logical ODP offering actual modelling solutions. Due to the fact that these solutions contain actual classes, properties, and axioms, content ODP are considered by many researchers as domain-dependent, even though the domain might be considering general issues like 'events' or 'situations'.

# 5 DISCUSSION

After defining the term of organizational knowledge patterns in section 3.3, the purpose of this section is an application of the characteristics and their initial validation by investigating to what extent the patterns type presented in section 4 is an organizational knowledge patterns. Furthermore, we will briefly discuss whether or not the concept of organizational knowledge patterns helps to achieve reusable knowledge easy-to-understand and easy-to deploy. Table 1 shows the characteristics of OKP introduced in section 3.3 and to what extent task patterns show these characteristics. The purpose of this comparison is to illustrate the borderline between knowledge patterns and organization knowledge patterns. Not only offering reusable organizational knowledge, but also making the context of its use explicit, requires the inclusion of the task to be performed. Task patterns meet this characteristic, ontology design patterns do not. All other characteristics are equally met by both developments.

The table also illustrates some of the future research needs. To validate the characteristics of being of value for an organizational actor and an asset for the organization requires additional efforts and probably a new perspective in validation.

Table 2: Comparing task patterns and ODP based on characteristics of OKP.

| Characteristic of OKP | Task Pattern | Ontology Design Pattern |
|---|---|---|
| For an organizational task | Task patterns are capturing specific organizational tasks | Ontology design pattern in general do not address tasks, but capture best practices for "engineering ontologies". |
| Are recurring | Task patterns were developed with the intention to be reused in various enter-prises; reuse has been reported in some cases | Ontology design patterns are available for reuse and numerous cases of reuse have been reported |
| Abstracting from organization specific aspects | Task patterns need to be configured and adjusted for the target organization, i.e. the pattern provides an abstraction from a specific organization | Ontology design patterns need to be configured and adjusted for the target ontology, i.e. the pattern as such provides an abstraction from a specific solution |
| Formalization of knowledge | Task patterns are formalized in a modelling language | Ontology design patterns are captured in ontology languages |
| Asset for organization | The evaluation of task pattern use confirmed economic advantages for the organizations using them. An investigation whether task patterns are considered an asset was not performed yet. | In organizations developing or using ontologies, we expect this characteristic to be met. However, an investigation towards this aspect was not performed yet. |
| Of value for an organizational actor | The evaluation of task patterns shows acceptance by the actors involved, i.e. it is assumed that they are of value for them | Ontology design patterns are expected to be of value for ontology engineers, i.e. in organizations developing or using ontology, this characteristics will be met |
| Stakeholder adequate quality | The evaluation of task pattern showed adequate quality for both, IT-experts and organizational stakeholders. | The quality is deemed to be considered adequate for ontology engineers. |

The main difference between knowledge patterns (section 3.1) and organizational knowledge patterns is the organizational focus, which is emphasizing the importance of also representing the context of knowledge use in order to be able to reduce time-to-

solution. The lessons learned from task pattern use and the positive results of the economic evaluation in this context (Sandkuhl, 2010) are supporting this perspective but are far from sufficient. Much more and systematic evaluation has to be performed.

The ambition of organizational knowledge patterns to be easy-to-understand has to be discussed in the context of the intended use of these patterns. Aiming at organizational knowledge management, different groups of stakeholders are involved, including business professionals applying the context part and IT specialists using the technical part of the patterns. Involvement of non-IT-professionals in model development and use and effects of notation on model understanding have been subject to numerous research activities. There is an opinion that visual models with stakeholder adapted terms and language extensions increase pragmatic quality. This view supports our proposal to apply visual modelling languages. Again, more work is needed.

# 6 SUMMARY AND FUTURE WORK

The work presented addresses the subject of organizational knowledge patterns as contribution to systematic development and reuse of organizational knowledge. The contributions of this paper are the definition of the term organizational knowledge pattern in relation to other pattern types from computer science, to identify characteristics of such patterns, and to examine task patterns and ontology design patterns in order to expose the key features of organizational knowledge patterns.

One of the purposes the definition of organizational knowledge patterns was to make explicit what the commonalities and what the differences to related terms in knowledge engineering are. Organizational knowledge patterns and established knowledge patterns show a number of commonalities, like separation of structure and solution, capturing of recurring knowledge, or use of formalization. Future work on organizational knowledge patterns will benefit from having these commonalities in mind and of trying to apply and transfer experiences from knowledge pattern use to organizational knowledge patterns.

From a computer science perspective, sound and fairly mature technological concepts for representing and deploying knowledge patterns exist, but more attention should be paid to organizational aspects, like business value and deployability.

Further work has to be spent on refining the requirements of patterns being easy-to-understand and easy-to-deploy. The concept of being easy-to-understand could be refined by using work from model quality or the physics of visual languages. For easy-to-deploy, classifications for the formalization of models and specifications, like the differentiation between executable and enactable, would be relevant when detailing this concept.

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