

Context Driven Spontaneous Knowledge Exchange

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Abstract. The way we work is changing fundamentally. Broadly available mobile networks give us the technical opportunity to be more flexible in time and space. The better understanding of learning organizations leads to a re-organization of business processes. There is also a trend to make the Internet more “intelligent”. This paper discusses how contexts can be used to manage the exchange of knowledge in mobile spontaneous networks. We motivate and introduce a new concept called *knowledge port*, which is an extension of Topic Maps and Semantic Web. This approach seamlessly integrates nomadic employees in the knowledge management policy of their company. It can also be used to offer location based knowledge.

Introduction

There are three major trends changing our daily live. Firstly, broadly available mobile communication networks allow people to be autonomous in space and time. Employees do not necessarily have to be in their office for every kind of job. With the help of wearable devices and cellular phones they keep connected to their company wherever they are. Secondly, there is a better understanding of processes in so-called learning organizations. We begin to understand why some companies are more creative and flexible than others. Thirdly, there is a trend to make the Internet more “intelligent”. The initiative Semantic Web and the ISO standard Topic Maps define how semantics can be attached to arbitrary documents in the WWW without changing the documents itself.

How do these trends influence each other? A more intelligent Internet can improve the way employees of learning organizations communicate. Mobile networks have introduced new and more dynamic communication structures into companies.

This paper examines how these three trends can be merged. It will be discussed how Semantic Web and Topic Maps can support knowledge management. It will be discussed what happens when knowledge exchange takes place. We will consider how Topic Maps or Semantic Web can be used to manage automatic knowledge exchange in spontaneous mobile networks. A new concept (*knowledge port*) will be introduced. Knowledge ports enable communication control on a semantic level. It will be shown how knowledge ports can be used to establish location based information services.

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Knowledge in Learning Organizations

Nonaka and Takeuchi investigated processes inside a learning organization [NoTa]. They distinguish between explicit and tacit knowledge. Explicit knowledge can be found in documents, models - in short in everything that can be printed. Tacit knowledge is a mental model, a skill (management skill, mechanical skill) or others. Only explicit knowledge will be discussed in this paper.

They also investigated relations between information and knowledge. Information describes a singular result or action, e.g. a measurement or a dedicated event. In contrary, knowledge is basis of actions and to achieve a result. Knowledge does never stand for its own or alone. It is always used in a context. The relation between context and knowledge will be discussed in more detail.

Nonaka and Takeuchi as well as Senge [Sen] have stressed that a learning organization cannot be seen as a closed system. It is open and interacts with other systems and its environment. These interactions comprise knowledge exchange. Knowledge exchange takes place whenever two systems have the ability to communicate. Knowledge exchange takes place in personal discussions, with help of newspapers, whenever employees change the company and so on. This exchange takes place, even if it is not perceived. Knowledge management can help to understand the underlying principles and the knowledge flow in this intertwined complex system. New software concepts and modern mobile smart devices might help to establish and organize new channels of knowledge flow. This is the topic of this paper.

In the next chapter the relationship between context and knowledge will be discussed. Some existing approaches to define context will be investigated. It will be seen that existing standards are very flexible in describing context but they lack on concepts to define knowledge exchange.

Context

This chapter discusses the relationship between explicit knowledge and its context. Explicit knowledge can be found in documents of different types, e.g. pictures, models, programs, papers, comments to papers etc. Explicit knowledge can be stored in data bases or content management systems. An intranet solution can be used to make it accessible to the company staff. This situation is common to most of us. Full-text search engines should help to find documents. But usually they produce a lengthy unstructured list of documents. Full-text search lacks the “understanding” of the context of documents.

A context is very helpful to organize documents and their relations. There are different kinds of context, e.g. topical or location context. A topical context is usually a collection of terms and their relations of a dedicated domain of discourse, e.g. a research area. A topical context is used to organize documents from a topical point of view. A topical context can be used to state *semantics* of documents [SW]. A location context is used to attach documents to locations.

Artificial intelligence research has put a lot of effort in defining models and tools that are capable of describing such contexts. One powerful approach is an ontology. “An ontology is the specification of a conceptualization”. [Gru95]. What does this mean? Conceptualization comprises the analyzing process of a domain of discourse. As the result of this process a couple of concepts and their relationships are identified. In order to define a topical context we would identify at least one concept: *Topic*. We would also identify relations between *Topics* which make it possible to define a hierarchy of *Topics*. An ontology can be compared to class diagram of an object-oriented design.

In order to define an actual context, concepts must be instantiated. Two instances might be created from the concept *Topic*, e.g. *topic “Knowledge Management”* and *topic “Mobile Devices”*. There are relationships between them. They will be worked

out in this paper. Instances can be compared to objects in an object-oriented design. Both, ontology and their instances form a knowledge base [NoMG]. There are a couple of different strategies, tools and algorithms to find contradictions or new knowledge in knowledge bases. This is out scope of this paper.

A knowledge base can also be used as the required context. But how can explicit knowledge be combined with a context?

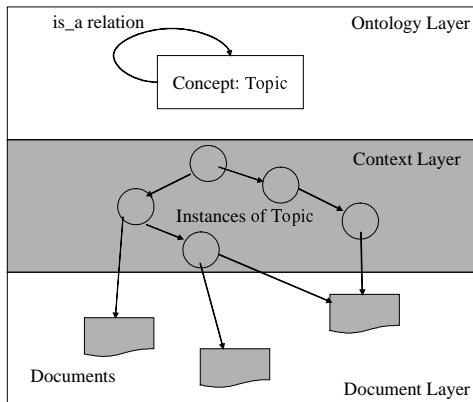


Fig. 1. Example of a topical context, its ontology and documents

There are two approaches solving this problem: The Semantic Web initiative [SW], [Hef] and the ISO/IEC standard Topic Maps [TM]. Both are developed for defining topical contexts. For this reason they offer languages to define concepts and instances. In Topic Maps concepts can be described by TOPIC TYPES and instances by TOPICS. Semantic Web offers at least two languages Darpa Agent Markup Language [DAML] and Simple HTML Ontology Extension [SHOE]. SHOE uses the key words CATEGORRY and INSTANCE whereas DAML takes CLASS and INSTANCE. The Topic Map standard is not as flexible as Semantic Web is.

Both standards provide one important feature: both allow users to attach an arbitrary document in the WWW to a topical context. In Topic Maps this link is called OCCURRENCE. In terms of Semantic Web it would be said: Documents get semantics. *This feature is the bridge between knowledge bases and documents in the World Wide Web.* In other words, this feature makes it possible to attach explicit knowledge to a topical context.

Figure 1 illustrated the relationship between concepts, instances and documents. There are three layers. The upper layer (*ontology layer*) contains concepts (e.g. the concept *Topic*). In the middle layer (*context layer*) reside instances that are derived

form concepts. As already mentioned, it can be used to define different kinds of contexts, e.g. topical but also location contexts. The lower layer (*document layer*) is the domain of documents containing explicit knowledge. Documents are linked with instances, e.g. via occurrences.

Knowledge Exchange

Imagine two colleagues meet at a conference. They begin discuss their current interests, ideas and publications. After a while they agree on exchanging some documents, links or bookmarks later via E-Mail. The same happens during nearly every discussion at trade shows, during business talks but also in private discussions like this: “When I’m back home I’ll call you and give you the name of this nice cookery book” or “I’ve forgot the name of this new band. I’ll find it out and call you back or send a SMS”.

What happens more formally? At first, both partners negotiate a context (e.g. research field, business interests, cooking, music). After this, they can start talking. During discussion they might decide to exchange something. There are three things they could exchange: documents, topics or references to documents or topics. In the first case a complete document would be exchanged and a knowledge instance would refer this newly arrived document. In the second case, a new topic would be introduced and/or references between topics would be changed. In the third case, only a knowledge instance would add new references or change existing ones. In any case the sender would consider if he or she is willing or allowed to deliver knowledge to the recipient. Let’s summarize the steps of knowledge exchange:

1. finding a common context
2. testing on mutual interest of knowledge exchange
3. testing on the right of knowledge exchange
4. knowledge exchange

How can Topic Maps or Semantic Web help to support this process?

Step 1 is supported. If both partners are equipped with a knowledge base they can figure out whether they have the some context in their knowledge bases. For example Topic Maps provide a construct called *Public Subject Indicator*, which can be used for this task.

Step 2 and Step 3 are not directly supported neither by Topic Maps nor Semantic Web. In Step 1 both partners have found out whether there is a common context. But having for instance the same topics in a knowledge base does not necessarily mean that both partners are also interested and allowed in exchanging something. Step 1 ensures that both partners talk about the same thing. Step 2 ensures that they are generally interested in exchanging something. Step 3 ensures that both partners are allowed to deliver and/or receive something from this dedicated partner.

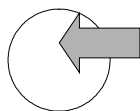
Step 4 is supported by Topic Maps and Semantic Web. Both provide exchange formats for knowledge: XML Topic Maps [XTM], Darpa Agent Markup Language

[DAML] and Simple HTML Ontology Extension [SHOE]. Knowledge Query and Manipulation Language [KQML] can be used as communication language. Topic Maps and Semantic Web are developed to define and transfer topical contexts. They can be used for step 1 and 4. Steps 2 and 3 are supported neither by Semantic Web nor by Topic Maps. In the next chapter an extension is suggested that overcomes this limitation. This extension is called *knowledge port*.

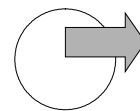
Knowledge Port

Topic Maps and Semantic Web combine techniques from artificial intelligence with WWW and attach semantics to the Web. Knowledge ports combine this idea with mobile devices, which can establish spontaneous communication channels. Knowledge ports introduce semantics and knowledge into spontaneous networks. Knowledge ports are an additional feature of the context layer. A knowledge port declares a knowledge instance to be open for knowledge exchange. An instance is now open to retrieve new documents or instances or references to them. It can be said “an instance has a knowledge port” or more specific in a topical context: “A topic has a knowledge port.”

There are two kinds of knowledge ports. An instance with an incoming knowledge port (IKP) is allowed to add new documents or relations to other instances whereas a



instance with an outgoing knowledge port (OKP) is allowed to deliver references or documents. To symbolize a knowledge port we add an arrow to the circle which stands for a knowledge instance. An arrow pointing into the circle stands for an IKP. If it



is pointing out an OKP is symbolized. The knowledge port is the missing construct in the context layer. A user can still define a context with help of an ontology and instances. But *Knowledge ports allow to state interest in exchanging knowledge of a dedicated context*. In a topical context, knowledge ports act as semantic filter for input and output of knowledge. Knowledge ports are a proper construct to add access rights. Security features are not discussed in this paper.

Knowledge Ports in Mobile Spontaneous Networks

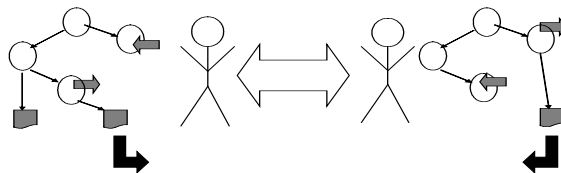


Fig. 2. Knowledge Exchange in Mobile Spontaneous Networks

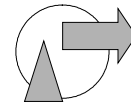
Figure 2 illustrates the use of knowledge ports in a spontaneous network. There are two nomadic user equipped with mobile devices, which contain knowledge bases.

(The figure only shows instances and documents). There are two knowledge ports in both knowledge bases. Fortunately, at both sides the knowledge ports are attached to the same topics. Furthermore, one user has an IKP at a topic whereas his partner has an OKP and vice versa. We call them *corresponding knowledge ports*. Corresponding knowledge ports state a mutual interest in knowledge exchange.

The four steps of knowledge exchange can take place. Both mobile devices can automatically detect identical topics. Afterwards they check on corresponding knowledge ports. Access rights are checked (not illustrated in figure 2). In the end a knowledge exchange takes place symbolized by the dark arrows: Two documents are exchanged.

Location Based Knowledge Ports

In the previous discussions knowledge ports were mainly used for topical contexts. *Location based knowledge ports* can be used to combine topical and location context. We can add co-ordinates to a knowledge port. Depending on the network this can be longitudes/latitudes or simply a single number that stands for a W-LAN cell or cell in a GSM or UMTS mobile network. Whenever someone enters this space a knowledge exchange can take place as it was described above.



We use a triangle to symbolize a *location based knowledge port*. It might be read as a symbol for a landmark or a base station in a cellular network. The figure above illustrates a location based outgoing knowledge port.

Location Based Knowledge Exchange

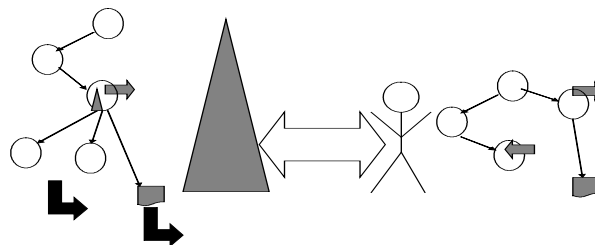


Fig. 3. Location Based Knowledge Exchange

Figure 3 shows an location based knowledge exchange. On the left hand side there is a sender, e.g. W-LAN sender. The sender offers location based knowledge. A nomadic user has entered the hotspot of the sender and the four steps of knowledge exchange take place. Again, corresponding knowledge ports are detected and knowledge is exchanged. Such a scenario could be used to deliver information e.g. of tourist information but also an advertisement from a shop to passers-by. With the help of location based knowledge ports knowledge exchange takes place based on topical *and* location context.

Implementation

We have begun to implement a system supporting knowledge ports. We call this system “*Shark*” - shared knowledge. We use Topic Maps for our knowledge base, namely TM4J [TM4J]. It is a free implementation written in Java. We are about implementing a client on Palm OS. We use SyncML [SyncML] to keep both knowledge bases in sync. Our first mobile tests will take place in a W-LAN environment. The mobile clients will use KQML to exchange knowledge via knowledge ports. We plan to use Bluetooth devices as client devices when they are available.

Summary and Outlook

We live in a post industrial society. Knowledge has become an economic factor. In this paper we have discussed how knowledge management, mobile communication networks and a more intelligent Internet can change our communication structures. An extension of Topic Maps and Semantic Web has been introduced, called knowledge ports. Knowledge ports make it possible to manage knowledge exchange (spontaneous and location based) on a semantic level. Knowledge ports help to extend knowledge management systems to mobile employees. Knowledge ports can also be used to deliver for example advertisement or location based tourist information. Knowledge ports are an emerging feature of the combination of semantic networks and mobile technology. But there are other possible synergies:

- From a broader perspective a number of single knowledge exchanges accumulate to a flow of knowledge. It seems to be very promising to bring both approaches together.
- The discussions in this paper completely ignored how knowledge can be displayed on the current limited devices. The problem is: How can the appearance of knowledge be adapted to different devices? Furthermore, how can the transfer of knowledge be adapted to band width restrictions of communication media?
- And last but not least, compiling knowledge is usually an expensive and time consuming task. Knowledge is already an economical factor, that means: Knowledge is a value. Therefore it should be investigated how mobile and spontaneous networks could offer methods like micro payment.

Currently, the way we work is changing fundamentally. We have been working with a lot of material for ages. But now we begin to understand how we work with *soft* materials like information, data and knowledge. We have understood its value. On the other hand mobile technology brings more autonomy for each of us. It can give us the chance to spend more time in talking and discussing, whereas our mobile equipment keeps in contact with our company and friends. But it also helps us to collect and deliver the things we are interested in – partly automatically. In the near future there will be a mobile semantic network around us. We can keep in contact with it whenever we like, wherever we are and if we like.

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