# Identifying Knowledge Flows in Communities of Practice

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## INTRODUCTION

Knowledge sharing is a collective process where the people involved collaborate with others in order to learn from them (Huysman & de Wit, 2000). This kind of collaboration creates groups of people with common interest called communities of practice where each member contributes knowledge about a common domain (Wenger, 1998).

Communities of practice enable its members to benefit from the knowledge of each other (Fontaine & Millen, 2004). To achieve this, different techniques and technologies can be used, such as shared documentation, groupware tools, lessons learned systems, and so forth. Therefore, to increase and improve knowledge sharing in communities of practice, it is important to study the mechanisms used by a particular community and understand how the knowledge flows through its members (Guizzardi, Perini & Dignum, 2003).

This article presents a qualitative approach for studying and understanding how knowledge flows in communities of practice within organizations. The goal is to provide a methodological guide for obtaining useful information for the development of knowledge management tools for supporting *knowledge flows* in these communities.

The content of the article is organized as follows. First the importance of supporting *knowledge flows* in communities of practice is highlighted. Then, a qualitative methodology for identifying *knowledge flows* in communities of practice is described, followed by some examples from a study conducted in the field of software maintenance. Finally, we present our conclusions of this work and future research.

## MAIN BODY: KNOWLEDGE FLOWS IN COMMUNITIES OF PRACTICE

In a knowledge-intensive organization, employees constantly have to deal with a changing environment where knowledge is crucial to make decisions and adapt to these changes. To obtain the required knowledge for making those decisions, employees generate communities where each member collaborates with the others sharing knowledge about a common domain. On the other hand, to facilitate their adaptation, the organization's processes must become dynamic, that is, they must be designed to change based on the knowledge involved and on the activities performed by the members of the organization. Knowledge management (KM) can help address this issue, since it provides methods, techniques, and tools for facilitating organizations to become adaptable to these changing environments (Davenport & Prusak, 2000; Tiwana, 2000).

One of the main objectives of KM is to make available the appropriate knowledge, in the right place, at the right moment, to whoever needs it; therefore the flow of knowledge is very important for managing the knowledge of an organization (Nissen & Levitt, 2002). In fact, it has been considered the central component of a KM system (Borghoff & Pareschi, 1998). Communities of practice stimulate

this flow of knowledge through organizations, since knowledge flows easily in these communities because they enable face-to-face interaction between their members (Brown, 2002; Fontaine & Millen, 2004). Even though direct interaction between members of the community is very important for sharing their tacit knowledge, other kinds of knowledge transfer must be considered such as documents sharing. Hence, provision of mechanisms that facilitate, increment, and improve the transfers of both tacit and explicit knowledge into communities of practice it is required. Therefore, *knowledge flow* must be one of the most important issues for supporting KM in these communities, since the goal is that the knowledge of each member can be used by the others (Borghoff & Pareschi, 1998; Guizzardi et al., 2003).

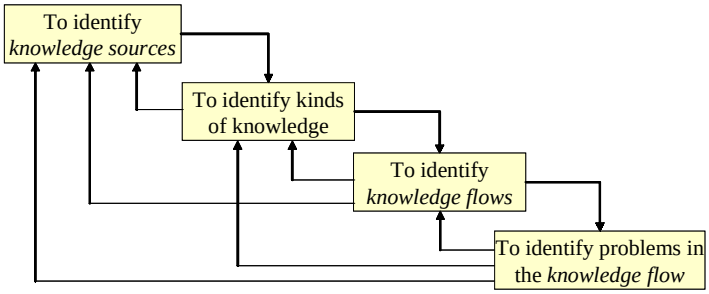
To provide support to the *knowledge flow* of a community, it is important to identify specific issues of the dynamics of *knowledge flows* in the processes and activities performed by the members of that community, as well as the social, cultural, and technological aspects which can affect those flows, in order to provide useful insights for the definition of requirements for designing KM systems that support the flow of knowledge in the community (Rodríguez, Martínez, Favela, Vizcaíno & Piattini, 2004a). A process modeling approach, as used in business processes reengineering (Curtis, Kellner & Over, 1992), can be appropriate for this purpose, since it provides techniques for analyzing technological and social aspects in organizations, as well as for modeling the dynamics of their processes. Once identified and understood how the knowledge flows through the community and which are the main elements that affect that flow, other approaches can be used for implementing the support systems—for example, an agent-oriented approach such as the proposed by Guizzardi et al. (2003, 2004).

In the following section we present a qualitative methodology for identifying *knowledge flows* in communities of practice; this is a methodology that we have defined and followed to obtain requirements for the design of a KM support system for a software maintenance group.

## KOFI: A METHODOLOGY FOR KNOWLEDGE FLOWS IDENTIFICATION

To design and develop support systems, such as for KM, for communities of practice, it is important to consider the contextual issues of the customers or those who will use the system (Beyer & Holtzblatt, 1998). We think *knowledge flow* must be a central aspect for supporting communities of practice; therefore, to understand the context of those communities, it is important to understand which kinds of knowledge are important for the community, which knowledge sources they share and how to obtain that knowledge, which mechanisms they use to consult the sources, and how all of these interact in the processes and activities performed by the members of the community—in general, how the knowledge flows through the community (Rodríguez et al., 2004a). To obtain answers for these questions, we have defined a qualitative methodology to guide the process of identifying how knowledge flows in a community of practice, and how to provide support to facilitate, increment, and improve the flow of knowledge in the community by identifying the problems that affect that flow.

*Figure 1. Stages of the methodology for identifying knowledge flows*



## THE METHODOLOGY

The methodology is composed of four stages, as shown in Figure 1. In stage one the main sources of knowledge and information are identified and classified (documents and people); then, in stage two, the knowledge contained in those sources is also defined and classified; in the third stage the main processes and activities performed by the members of the community are modeled to identify the people involved, how they collaborate to complete their tasks, and how the knowledge and sources interact in those activities; finally, in stage four the main problems that can affect the flow of knowledge are highlighted through the definition of scenarios. The process proposed to carry out the above stages is iterative, since each stage could generate information to complement the others. For example, if we identify a new kind of knowledge source while we are modeling flows of knowledge, we can add the source kind to the ontology and then identify the kinds of knowledge that can be obtained from it.

In the following subsections we describe more details about each stage and present some examples about how they can be carried out. These examples have been obtained from a case study in a software maintenance organization, where a multi-agent knowledge management system was designed with requirements obtained from the results of the study (Rodríguez et al., 2004a; Rodríguez, Vizcaino, Martínez, Piattini & Favela, 2004b).

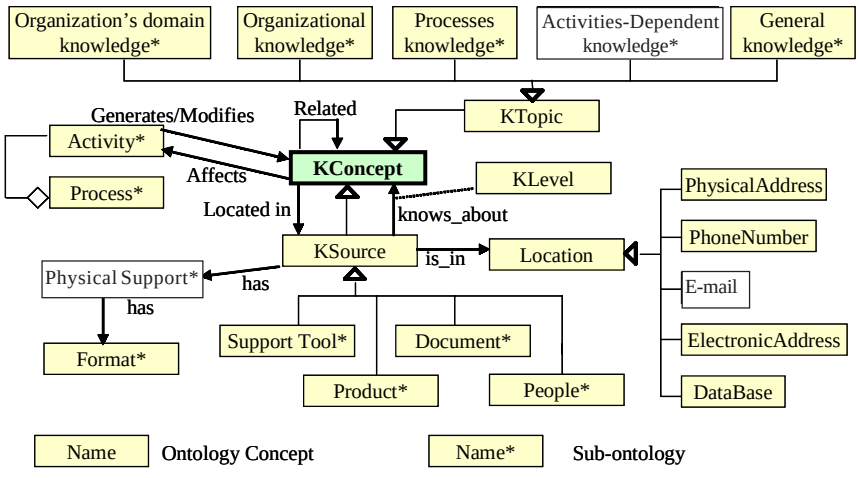
## IDENTIFYING AND CLASSIFYING KNOWLEDGE AND KNOWLEDGE SOURCES

The first step starts by identifying the main documents and people involved in the community. Then, in stage two, the documents are analyzed in order to define the kinds of knowledge that can be obtained from those, together with the kinds of knowledge that the people involved can have or require for their activities. Taxonomies can be defined to classify the knowledge sources found and the kinds of knowledge these sources have; also an ontology can be designed to help define the relations between the sources and the kinds of knowledge.

Ontologies are conceptual models for specifying meanings or knowledge about a common domain; they can be used to provide a framework for sharing these meanings or knowledge (Gruber, 1995; Maedche, Motik, Stojanovic, Studer & Volz, 2003). Therefore, ontologies can be used for specifying information sources and the knowledge they can have, as well as the connections between them, in order to develop a conceptual framework of these relations.

Figure 2 presents a general ontology used for classifying knowledge and its sources in the case study carried out. This ontology is used for identifying *knowledge concepts* (KConcept) which can be both *knowledge sources* (KSource) or *knowledge*

*Figure 2. A generic ontology of knowledge sources and knowledge topics*



*topics* (KTopic). The *knowledge concepts* involved in an activity can affect that activity in some way; for example, in order to perform an activity, some *knowledge topics* can be necessary or some *knowledge sources* can be required; moreover, an activity can generate or modify some topics or sources of knowledge. Some elements of the ontology have been defined as sub-ontologies, and their structure must be specified for the particular needs of the studied organization or community.

*Knowledge sources* can be people, documents, support tools (such as organizational memories, experience repositories, etc.), and the products developed or built by the organization. For example, in a software organization, the systems developed (source code and executable program) can be a very useful source of knowledge. Each *knowledge source* can have a specified physical support (such as paper, electronic file, audiotape, videotape, etc.) and a format (such as Word document, PowerPoint presentation, etc.); they can also have one or more locations which define how they can be consulted; and finally, the sources have a level of knowledge about *knowledge topics* or other *knowledge sources*.

*Knowledge topics* have been classified in five main groups:

1. those related to the organization's domain knowledge, for example, if the organization develops software for telephonic services management, it must know about the call fees of the different kinds of calls of each telephone company;
2. knowledge about the structure of the organization, its norms, its culture, and so forth;
3. knowledge about the processes of the organization, for example, the activities, the people involved, and so forth;
4. knowledge dependent of specific activities, for example the procedures or support tools used for performing the activity, and so forth; and
5. other kinds of knowledge that can be important, for example, it can be useful to know which employees speak foreign languages or have other skills that are not used in their daily work.

This ontology can be used for defining and classifying the kinds and sources of knowledge and how all these are related. This information can be later used for defining the structure of a knowledge base, for example, by specifying the most important knowledge topics for the organization, the sources of knowledge available and the kinds of knowledge that can be obtained from those sources.

In the third stage of the methodology, we have followed a process modeling approach to identify the flows of knowledge by modeling the activities performed by the community, the knowledge required and generated in the activities, the people in charge of them, and the sources of knowledge used, modified, or generated during the activities. This approach is presented in the following section.

## KNOWLEDGE FLOWS MODELING

A process modeling (Curtis et al., 1992) approach can be very useful to identify how the knowledge and

*Figure 3. An example of a model of activities performed by members of a maintenance group*

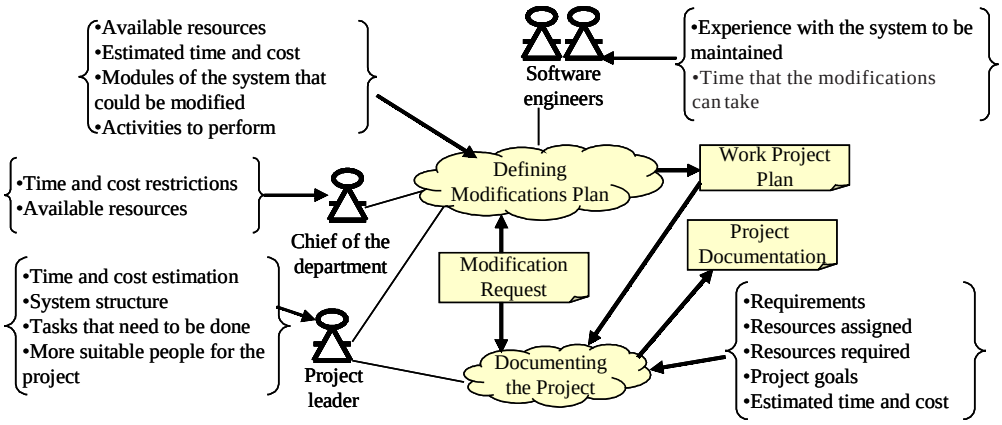


*Table 1. Schema used to identify knowledge in decision making*

| | | |
|---|---|---|
| **Role** | Project leader | |
| **Activity** | To define modification plan | |
| **Decision** | To define required resources | |
| | To define main tasks to perform | |
| | To assign tasks to the participants of the project | |
| | To estimate the time the project would consume | |
| **Knowledge** | Previous projects' experiences | |
| | Requirements and restrictions of the project | |
| | Abilities and experience of each of the possible participants of the project | |
| **Sources of information** | | |
| **Name** | **Information** | **Consulted at** |
| Chief of the department | Available resources; time and cost restrictions | Telephone, Physical address, Email |
| Software engineers | Experience with the system that will be modified; time that could consume the modifications; time availability | Telephone, Physical address, Email |
| Previous projects' documentation | Resources required by previous projects | Documents' files, modifications' logbook |

sources of information are involved in the activities performed by the community. To do this, the main activities of the processes carried out by the community must be identified, as well as the decisions that the people involved must make while they perform those activities. A graphical modeling technique, such as rich picture (Monk & Howard, 1998), can be used to model these activities. Rich pictures are cartoon-like representations that identify actors, roles, their concerns, and some of the structure underlying the work context. Thus, these kinds of representations can be useful to model the people and roles involved in some activities, the knowledge required by them to perform the activities, and the sources they consult or those that could have information to help them to complete their activities. These models can be later used to analyze how the knowledge flows through the group while its members perform their activities.

Figure 3 illustrates an example of a graphical model, which shows the main activities performed in the definition of the modification plan carried out by the group studied. The model shows the people involved in those activities, the knowledge they have together with their relevance to the activities modeled, and the main sources used, created, or modified in the activities.

Once the activities have been modeled, the next step is to define the decisions that must be made by the people involved. To do that, we used the schema shown in Table 1. This schema helps to identify the knowledge that the people in charge of the activities must have to make the decisions required, and the sources they consult to obtain information that helps them to make those decisions. At this step, it is important to identify the mechanisms that people can use to consult the sources, as well as those used to

*Table 2. An example of a problem description scenario and an alternative scenario*

| | |
|---|---|
| **Kind:** | Expert finding (knowledge sources management) |
| **Problem description:** | |
| Mary is a software engineer that must make some changes in the finances system. Since her knowledge in the domain of finances is not good enough, the changes to the system are taking more than a week of the estimated time. At the end of the week, Susan, the chief of the department, while she was checking the advances of the project, detects the delay and asks Mary the reasons of that delay. Mary tells Susan the problem and since Susan has experience with finances, she tells Mary how the problem could be solved. Finally, Mary solves the problem the same day. | |
| **Alternative:** | |
| When Mary decides to solve the problem of the finances system, the tool where Mary manages her tasks detects this action. This tool knows about Mary's knowledge, and identifies the kind of knowledge that Mary needs to make the changes in the finances system, so the tool identifies that Mary probably will need to consult some sources of knowledge and decides to search for those sources to help Mary do her Job. The tool founds some sources that can be relevant to the task Mary will perform, thus the tool informs Mary about it. Then, Mary decides to see the kind of knowledge those sources can have, and based on that, decides to consult Susan who is one of the sources found by the tool. | |

share the knowledge generated in the activities—for example, the documentation of the modifications' plan in Figure 3.

The analysis of the activities performed by the members of the community, using the graphical model and the information from the tables, are later used to understand how the knowledge flows through the community, and what techniques they use to share and obtain that knowledge. Finally this analysis can help to identify the problems that are affecting that flow. We next describe how scenarios can be used for this purpose.

## SCENARIOS FOR IDENTIFYING FAULTS IN THE KNOWLEDGE FLOWS

In the fourth stage of the methodology, the models generated in the previous phase are analyzed to find the problems that could be affecting the flow of knowledge—for example, if the information generated from the activities is not captured, or if there are sources that could help in performing some activities, but they are not consulted by the people in charge. In this stage, *problem scenarios* can help identify how the problems detected affect the *knowledge flow*, and how these could be addressed. These *problem scenarios* could be later used to obtain design requirements to the development of tools to address these problems, since scenarios enable the identification of design requirements for software systems and make feasible the participation of users during the requirements specification stage (Chin, Rosson & Carroll, 1997).

A scenario is a textual description of the activities that people might engage in while pursuing a particular concern (Carroll & Rosson, 1992). Hence, the *problem scenarios* can be structured as a story of particular problems detected from the analysis of the information obtained in the previous stages. Then these scenarios can be studied in order to discuss how those problems can be tackled. Table 2 presents an example of the description of a *problem scenario* obtained from the group studied and an alternative scenario where the knowledge sources are provided by a system. These kinds of descriptions can provide insights, which can later be used for defining requirements for developing support tools focused on addressing the problems identified.

As we mentioned before, the methodology has been applied in a case study in the software maintenance field (Rodríguez et al., 2004a). The first two phases of the methodology helped us to identify the main knowledge sources available for the members of the maintenance groups, as well as the kinds of knowledge these sources have. This information was useful for developing a knowledge base to help find knowledge sources for maintainers to do their jobs. Then, the third phase guided us in identifying the activities where these sources are involved, the kinds of knowledge required or generated in those activities, and the mechanisms maintainers used to consult those sources or to obtain the required knowledge; that is, this last phase helped us to identify how the knowledge was flowing in the maintenance community. Finally, the scenarios defined in the fourth phase were used to obtain design requirements to develop a knowledge management system for helping maintainers to reduce the loss and waste of knowledge by facilitating the search of knowledge sources related to the activities they perform (Rodríguez et al., 2004a, 2004b).

## CONCLUSION AND FUTURE POSSIBILITIES

The flow of knowledge is a very important factor for communities of practice, since one of the goals of these communities is to provide an environment where their members could share knowledge with others in order to learn together. Thus, for providing support to these communities, we think that the flow of knowledge through their members must be considered a central aspect of the design of the support tools. To address these issues, in this article we presented a qualitative methodology for studying how the knowledge flows through communities of practice in organizations, and how to identify the problems that can be affecting that flow, in order to use all this information to provide tools to support the flow of knowledge between the members of a community. The proposed methodology has been applied in a case study in a software maintenance group, where an appropriate knowledge management system according to the results obtained in this study has been designed.

We think it is important to consider the particular aspects of each community to provide better support for its particular needs. Thus, it is important to identify the knowledge needed by the members of the community, the sources they use to obtain that knowledge, the particular processes and activities carried out by them, as well as the main decisions they must make. All these aspects are considered by the proposed methodology.

Nevertheless, in order for the methodology to be more useful, we consider it necessary to provide tools for managing the information obtained by applying it—for instance, tools for defining the structure of the ontology of knowledge and knowledge sources, and for capturing information about the specific knowledge topics and sources in a knowledge base that could be later used by the tools developed to support the community. At the moment, we are working on providing this kind of support for the methodology.

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## KEY TERMS

**Graphical Process Modeling Technique:** A technique for representing models of processes with a graphical notation.

**Knowledge Concept:** A concept that is part of an ontology used for defining and describing the knowledge related with a community, such as the kinds of knowledge or the sources of knowledge.

**Knowledge Flow:** Defines how the knowledge flows through the activities performed by a community according to the kinds of knowledge and knowledge sources involved in the activities, the mechanisms used by the people involved in the activity to obtain or share that knowledge, and so forth.

**Knowledge Source:** A source of information which can be useful to obtain knowledge for practical application such as know-how, know-what, know-where, and so forth—for example, lessons learned or members of the community.

**Knowledge Topic:** Definition of a particular area of knowledge useful for a person or the members of a community.

**Ontology:** An explicit and formal representation of a shared conceptualization. Ontologies are conceptual models for specifying meanings or knowledge about a common domain.

**Problem Scenario:** A textual description of a problem observed in a community studied, which has the form of a story that illustrates the problem and possible solution alternatives.

**Process Modeling:** Collection of techniques used to model systems' behavior. These models help in analyzing the current state of organizations as facilitators of organizational learning.