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Virtual Knowledge Communities

IT-supported Visualization and Analysis

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BOOK OVERVIEW AND OBJECTIVE

According to an analyst prediction, by 2007 individual's time spent interacting with others in the virtual world will exceed physical interactions by a factor of 10 to 1. This impressive example shows that electronic media are becoming one of the main means for interaction. New technical solutions emerge and change the availability of communication, but also its speed and range. Especially, the application of these new communication channels for Knowledge Work in complex work domains is a development with much potential. Here, the mode of experts to form networks of contacts, from which they can draw resources to solve their business issues, is of increasing relevance for the competitiveness of the company. The related discipline of Knowledge Management has to react to this trend and needs to establish instruments for a systematical support of such knowledge and expert networks. The most relevant concept is called Community of Practice (CoP) or, if it utilizes electronic media as its primary means of communication, Virtual Community. The establishment of instruments for such network oriented Knowledge Management directs the attention to the role of the discipline of Business Informatics. With its research focus on developing innovative software applications to realize untapped corporate potential and thus to increase a company's competitiveness is the right perspective for the establishment of a novel IT support for Knowledge Management in Virtual Communities.

To develop the according approach together with a supporting software solution, this work has to take on a major challenge: As expert networks inherently build on social mechanisms, this book needs to bridge the wide gap between the necessary sociological analysis (which often enough is not guiding towards solving a problem) and the constructive and technical engineering of a concrete software system.

This leads to the following *key topics explored in this book*:

After analyzing current economic indicators to prove the necessity of *Knowledge Management* for maintaining competitiveness (*chapter 1*), the basic foundations of the discipline are analyzed (*chapter 2*). This includes a detailed discussion of the core term 'knowledge' itself (part 2.1) as well as a comprehensive overview of the development of KM approaches (part 2.3). This results in a timeline which shows the development of the research discipline of KM during the past decades.

In *chapter 3*, the underlying complex theories of systems sciences and sociology are developed towards an overview about properties and requirements of modern and *complex network organizations*. As a result, in part 3.6., novel and concrete implications for a modern and *network oriented approach to KM* are derived from this discussion.

In *chapter 4 Communities of Practice* are identified and described as a major recent concept, which is an actual instantiation of a networked organization for organizing Knowledge Work in expert groups. *Chapter 5* specializes on describing the main properties, roles, and *processes of a community* and its development through lifecycle stages.

The resulting picture of the basic mechanisms is then extended in *chapter 6* with an extensive discussion of *Information Technology to support expert networks*. However, the analysis results in the insight, that current IT is not at all satisfying the requirements of virtual Knowledge Communities. Especially, the important role of the community moderator and manager is unsatisfactorily supported. This person needs instruments for monitoring, measurement and evaluation, which is also emphasized by thought leaders and major institutions in the CoP area. Further, the sociability of the expert group needs to be improved.

To address these issues, *chapter 7* develops a comprehensive *measurement system for analyzing virtual Knowledge Communities*. It draws its measures primarily from sociological domains, such as Social Capital and Trust research and Social Network Analysis; but it also includes Knowledge Processes and plain structural analysis. To implement the conceptualized support for communities of practice with appropriate measures and visualizations, the concrete *software solution Commetrix* which can aid as an analytical add-on to current community platforms is introduced and analyzed in *chapter 8*. The primary challenge is creating insightful *visualizations*, which integrate 2D and 3D Graph Drawing Techniques for Social Network Analysis with topic and *keyword analysis* methods and to merge this with the comprehensive measurement system. *Chapter 9* incorporates the technical functionality from chapter 8 and introduces an according *methodical procedure for IT-supported community analysis*. Finally *four case studies* are introduced in *chapter 10* to illustrate the application of the software solution and its benefits for providing a community moderator or manager with detailed insights about the structure and processes of his group.

In summary, this work addresses the following main topics:

1. The current societal development towards knowledge work and the main historical development of the discipline of Knowledge Management.
2. The role of networks in organizations and for Knowledge Management in order to support Knowledge Work in People Networks.
3. The role of Communities of Practice, its lifecycle and IT-support.
4. How can communication networks of Virtual Communities be modeled in order to be analyzed and visualized?
5. What data offered by available communication means of CoP software provides most value for measuring virtual knowledge communities?
6. How can Social Network Visualization be synergistically integrated with Topic and Keyword Analysis?
7. How should a software solution for automatic analysis of virtual expert groups and subsequent management support be designed?

1 The Economic Development of Knowledge Work

Understanding the objective of the discipline of Knowledge Management requires examining the event of Knowledge Work. Being largely based on expertise, this special type of work slowly grew in importance over the last decades and was fueled by recent industrial developments, which include:

- shortened Product Life Cycles, despite
- increased product development efforts, subsequently
- increased product and process innovation and
- increased investments in Research and Development,
- increased market share of high-tech industry,
- increased levels of education, which allowed for
- increased complexity of offered (and customized) solutions, which
- intensified customer relationships, and lead to
- the augmentation of core offerings with (Knowledge intensive) Services.

This chapter aims at substantiating these underlying economic trends in order to arrive at a very concrete representation and a clear understanding of the current industrial evolution towards the necessity of managing knowledge in enterprises. This situational review will provide the foundation for the subsequent theoretical discussion of the simultaneously emerging research field of Knowledge Management, which continuously strives to offer methodological approaches and instruments which meet the requirements of current economic needs.

Analyzing recent industrial developments, it can be recognized, that enterprises are increasingly facing the problem to manage highly innovative, complex and research-intensive products in mature markets. They have to survive in a well established competition with **low price margins**. This can be illustrated by analyzing the profit margin (i.e. return on sales) as an approximation. For example, in the German machinery sector, this margin fell from 3.5 percent in 1997 to a more or less stable yet small 2 percent in 2003 (Dresdner Bank, 2002).

Another challenging development is the dramatic **shortening of Product Life Cycles** (PLC). In the machinery industry it decreased from twelve years in the seventies to about seven years in the nineties. In the Information Technology sector, it even approached a record-low 5.3 years, which is less than half the duration of 11.1 years during the 1970s (Droege et al., 1993).

2 The Development of KM as a Research Discipline

The research field of Knowledge Management (KM) consists of various and only loosely connected scientific concepts. These concepts can be segregated into two developmental stages (or two ‘waves’) of KM. Prior to these two waves, there was an initial stage, which discussed the role of knowledge and Knowledge Management in an enterprise. This preliminary KM stage can eventually be traced back to Penrose (1958) and Taylor (1911), which implies that knowledge has always been an issue of interest for creating products and executing production processes (also compare chapter 2.2.1).

Of course, a thorough discussion of the utilization of knowledge in enterprises necessitates a scientific analysis and a subsequent definition of the term knowledge itself. Related approaches reach back thousands of years to Plato and his pupil Aristotle, which created the first foundations for the western comprehension of the term knowledge. However, it has to be added that no accepted definition of this complex term with its multitude of aspects could be generated so far. For example, only recently, the western scientific understanding of this term was challenged and influenced by Nonaka and Takeuchi (1995) who criticized the western basic approaches (Cartesian Dualism) and emphasized Japanese approaches which again added a new aspect to the topic.

Following these two main strands, the next sections will now first provide a short introduction into the approaches that conceptualize the term knowledge, before the preliminary KM stage and its development towards the discipline of KM is introduced. Afterwards, relevant approaches of the first wave of KM theories are briefly discussed and put into a framework which illustrates the applicability of their insights. This reduction to various ideas and the comparative classification shall enable to elicit and comprehend the diffuse theoretic body emerging in the discipline of KM during this first wave.

Finally, the approaches and challenges of the current second wave of KM research are added to identify the management of Knowledge Networks as a current challenge both for theory and practice, which subsequently constitutes the primary perspective of this book. However, it is not intended to see it as a new discipline; rather the roots and thoughts about this special view are collected and integrated in this chapter to arrive at a transparent theoretic framework for the subsequent development of practical KM solutions. All these theories are requiring a sound understanding of the core term ‘knowledge’ which will be discussed now.

3 A network oriented Foundation of Knowledge Management in Organizations - Knowledge Networks

During the introduction of the development of KM as a research discipline, the previous chapters already implied the strong connection of Knowledge Management and organizational theories. KM is actually conceived as a means of organizational development which aims at the creation and utilization of knowledge in an enterprise. As already outlined in section 2.2.1, Lehner notes that KM has some roots in the discipline of Learning Organization and has been motivated by the related discussion of new organizational forms which accommodate for the increased importance of data, information, knowledge, communication and information flows (Lehner, 2000:225; Schneider, 1996). Wiegand (1996) even understands an organization as a knowledge storage facility and Willke proposes that KM is all about creating an intelligent organization via competence management, qualification, and the ability to learn (Willke, 1996).

A further clear indicator for KM's dependence on organizational theories is implied in the extensive definition of Knowledge Management as proposed by Snis (2001): Knowledge Management is the management of the organization towards the continuous renewal of the organizational knowledge base. This means e.g. creation of supportive organizational structures, facilitation of organizational members, or putting IT-instruments with emphasis on teamwork and diffusion of knowledge (as e.g. GroupWare) into place. If knowledge itself is regarded as the capability for effective action, then knowledge is also related to organizational activities.

As KM obviously happens in an organization and tries to analyze and influence its structure, processes and values, it is dependent on the theoretical conceptualization of the construct 'organization' itself. Organizations are thus the object under consideration, which implies that the understanding of organizations determines the structure of Knowledge Management programs. In other words, it has to be known what an organization actually is before appropriate Knowledge Management can be developed in an organization.

In this context, it has to be warned, that an insufficient consideration of the complex underlying organizational mechanisms³⁰ leads to a reduced probability of success and a lower acceptance of the KM measures which are based on such a

³⁰ This problem is sometimes found in business informatics, which is often reducing organizations to machines and structures.

4 Communities as an Instance of a Network Organization and an Instrument of network oriented KM

As the previous section showed, corporate organizations consist of a mixture of formalized structures and rules which exist to achieve the corporate objectives and a more informal network-like organizational structure, which directly connects related individuals and thus expresses the sociological aspect of corporate organizations. The constituting element of such an organization as a social system is continuous and recursive communication between the system's elements.

The organization can be segregated into various sub-structures (which constitute sub-systems). The official sub-systems as employed by management are organizational units, work teams, or project teams. Following the currently predominant rationalist approach to organizing an enterprise, they are usually very formalized in their tasks, scope, and membership.

The last chapter discussed the shift of attention towards sociological approaches of organizing in order to deal with current challenges like fostering knowledge sharing, enabling organizational learning from practice, improving problem solving, or managing complexity. One result of this change in emphasis is the increasing discussion and corporate application of an ever-existing but still underemployed organizational form, which is targeted exactly at meeting these requirements – the Community of Practice (Brown and Duguid, 1991; Steward and Brown, 1996; Wenger, 1998; Wenger and Snyder, 2000). Such Communities of Practice can be regarded as an organizational form, as they are also classified as a social group, which is self-referentially emerging from interaction and communication. This form is virtual as often it is not leaving its informal status and subsequently its borders are hard to observe (Henschel, 2000) due to its 'invisibility' (Steward and Brown, 1996:2).

The concept of Communities of Practice is not new: in medieval centuries, communities of merchants and craftsmen developed and achieved official status as guilds. They already had an economic and a social aspect. Their members exchanged news and experiences, defined norms and together formed a social foundation for the economic and individual development of the participants.

After the importance of systematically utilizing human knowledge has been recognized and the discipline of Knowledge Management emerged, the potential of this special social configuration which is deeply embedded in a work context has been re-discovered (Snyder, 1999:9).

5 Organization and Coordination in Communities of Practice

After having established a distinction between the Community of Practice and other organizational forms, the actual relation of the community to the rest of the organizational structure is of interest. Although it is neither a team nor a formal organizational unit, a CoP has relationships to these other forms and usually members of communities are simultaneously associated to one or more of these organizational structures, too. This results in a synergy in subject fields but a competition for work time, which again raises the issue of measurement and evaluation. Costs and benefits of simultaneously belonging to multiple groups have to be estimated in order to ensure an efficient allocation of every employee's time for a systematic employment of such a multi-dimensional structure.

The following sections will first discuss the issue of how to connect communities to the rest of the organization. Afterwards, practical approaches to install communities in enterprises are introduced to give an impression of their organization. In corporate applications, the mixture of supporting emerging communities and the purposeful definition of such groups leads to a complex management issue. Although communities can inherently not be managed by conventional means, enterprises want to influence their development and their work. The resulting question of how to actually support and coordinate Communities of Practice in enterprises also relates to the issue of changing dynamics and changing properties as Communities of Practice are subject to a lifecycle which is related to their maturity.

5.1 Integrating Communities into existing Organizational Structures

The integration of recognizable communities into an organization is a major challenge. There are various and complex dependencies to consider. A thorough understanding of the connection between a CoP and the organization is necessary.

A theoretical approach to conceptualize the relation between the organizational structure and a community is the **Hypertext Organization** of Nonaka and Takeuchi (1997). Its primary concept is the parallel co-existence of three different but related contexts within an organization: On the central layer of the business system, the operative transactions are conducted. It can either employ a bureaucratic functional or a process oriented organization. A further element of the model is the project team layer, where multiple project teams are developing new knowledge, for example in new product development projects. Finally, there is an underlying

6 Information Technology to support Communities

The previous chapters introduced the environment and the main structures and mechanisms of Communities of Practice. If such communities are to be supported by means of Information Technology, all these aspects generate a multitude of different requirements for the software system. The following chapter analyzes the role of Community Software, its development in the last year and in the future. The main features are elicited and reviewed in order to give a picture of the state of the art of current platforms from a Knowledge Management perspective. However, this evaluation will emphasize, that current software support ignores many of the above requirements, i.e. the role of coordination and monitoring, the challenge of identifying and communicating benefits, or the aspect of life-cycle stages and dynamic involvement. Such identified gaps are the focus for the subsequent discussion of a prototypical software application presented in the last chapter, which aims at improving the IT support for Knowledge Workers and moderators.

6.1 The Role of IT for running Communities

Although communities do not necessarily need an IT platform for their work, it is widely recognized nowadays, that IT can play a major role in efficiently supporting large groups of geographically dispersed experts (e.g. Hildreth et al., 1999). This is especially important for international enterprises, where regularly similar functions are spread across different divisions. Examples are local sales departments or decentralized product development departments using a component strategy, like in the automotive sector. The most value of IT platforms is added by the opportunity for one-to-many and many-to-many electronic communication over a central virtual location. This implies fundamental challenges for a CoP Manager when migrating from decentralized communities to centralized and transparent IT platforms.

A good example for the increasing importance of IT support during the stages of the community lifecycle is British Petrol p.l.c. In the beginning, they conducted formal meetings in order to exchange expert knowledge. Next to such planned events, a large number of informal and unidentified networks existed without any rules. After the implementation of the community initiative, these groups became visible and officially recognized (cf. the maturity stages model of Wenger, 1998; see chapter 5.6). The identification of these groups increased public attention and hence the relevant groups attracted more members and grew in size. Over time, the members existed in geographically very widespread locations and face-to-face contact became increasingly expensive. To compensate for the size, the communities were supported with a very sophisticated IT platform, which provided features

7 Towards Transparency, Measurement and Evaluation for Communities of Practice

In the previous section, a gap in technically utilizing the CoP's rich body of communication data for improving community work and community management was identified. This section will now develop appropriate methods to provide the required insights into the actual structure of the knowledge workers and their activities using their electronic communication data as a source. For that, the first issue is to establish a perspective on a Virtual Community, which takes into account the key findings of all previous chapters. Among them,

- the main objective to develop and share knowledge and the support of related knowledge processes,
- the relationships between people, their organizational affiliation in processes, their contributions (documents) and topics (according to the KM entity model),
- the forming of topic related groups or clusters of experts,
- the resulting establishment of a dense communication network with many channels for informal information flows which extend the hierarchical formal architecture,
- the different network roles in such communication clusters, and
- the ability for moderators, members, external stakeholders or analysts to actually observe, analyze and document all these aspects.

These additional aspects will enhance the content oriented work and methodically complement the current log analysis to improve the effectiveness of utilizing virtual CoPs as Knowledge Management instruments. The two major issues and objectives for the development of such an extension are namely transparency and evaluation. Both require an underlying set of factors (in the form of measures or model elements) to capture the actual community in an appropriate model, which then can be analyzed.

7.1 Measurement and Success Factors for Knowledge Networks

A method to establish a measurement system which aids in the facilitation of Communities of Practice is the initial identification of general success factors.

8 A technical approach for visualizing, analyzing and modeling Communication Networks of Knowledge Communities

The analysis of Communities of Practice and their most important elements, properties, and tasks, the description of the management role, the introduction of the current state of the art in community-related software applications, and the identification of important gaps of current CoP platforms highlight the requirement to provide an add-on to the existing IT solutions, which helps to achieve higher levels of transparency for Virtual Communities and which is thus enabling its users to better employ this valuable organizational structure of experts for a network oriented Knowledge Management.

This chapter will now elaborate on the requirements for an approach which accommodates according functionality for visualization and evaluation of otherwise invisible expert networks emerging in virtual communication and collaboration.

The application of such software consists of the following main issues:

- technical access to data sources,
- refinement of data to achieve information using a measurement system, and
- visualization of the information and provision of a sophisticated user interface to match the business objectives and requirements of the community manager (see Figure 54).

The main principle in the application of a community visualization and evaluation tool is to start from user requirements. Here, the moderator of a CoP has been selected as the most important role for using the tool. The moderator puts forward a series of business objectives (block 1 in Figure 54), which have to be matched with the available data sources (block 2). For that, the data structures need first to be accessed and captured. The next issue is to implement useful measurements which bring the original data closer to the business objectives (block 3). A final component is the visual interface which links the moderator with the elicited information from the original data (block 4).

Alternative roles with individual requirements can be members or researchers of communities. The first group will require personalized views on their surrounding virtual space with added functionality for navigating and filtering structures. Researching analysts have similar requirements as managers. However, researchers are not necessarily interested in exerting an influence on changing the develop-

9 A method for IT-supported network-oriented analysis of virtual communities

Next to a comprehensive technical support, network oriented analysis of virtual communities requires a methodical approach to acquire relevant data in order to properly capture the current situation and to identify potential for possible interventions, which can then implemented to support group interaction and efficient group structures (also cf. Trier and Bobrik, 2007). Possible applications of such a network-oriented analysis include:

- The improvement of informal or formal collaboration via targeted selection and support of roles, which nurture informal knowledge flow within the organization,
- The identification of important but peripheral or even isolated experts (as carriers of knowledge) together with improving the channels of their transfer of knowledge,
- Faster and more efficient cross-departmental information flow and communication via suggesting teams or employees from different parts of the organization that should engage in loose contact,
- Identification and support of individual talents or engaged groups in selected subject areas,
- Merging informal structures of different companies (e.g. after a merger), departments, business processes, or teams, or
- Creating general awareness of informal information transfer within a corporation.

The method for IT-supported analysis of virtual communities is relating to the general procedure of business-oriented systems analysis (cf. Krallmann et al., 2007). It includes the stages project initiation, (As-Is) analysis of the current situation, deriving the change concept (i.e. generating a sound concept with the intended changes), development, and implementation.

Accordingly, the procedural model for IT-supported network analysis is comprised of the stages

- Project initiation,
- Definition of the network boundaries,
- Data collection and refinement,

10 Case Studies for IT-supported Community Visualization and Analysis

After the required technical and methodical approaches have been introduced and discussed, the resulting approach for IT-supported community visualization and analysis can be illustrated in several case studies in order to demonstrate its ability to support transparency and subsequently evaluation of virtual expert groups. Suitable datasets can be found in open discussions, of which some may be moderated by a commercial entity. Examples are product discussion groups, where customers share knowledge about complex software or hardware products, or e-mail communication networks emerging in corporate communication processes. Other related domains are project collaboration, manually captured network data in research and development departments, communication in call centers, etc.

This chapter will first show the exploratory case study of a non-commercial news-group called Slashdot.org which informally discusses latest news. A further example, which will be briefly introduced (anonymized), is focusing on ego-networks an Asian manufacturing company, which used instant messaging to coordinate their knowledge workers. Then, a Java developers and help forum is examined. Finally the method for IT-supported network analysis will be demonstrated with the actual e-mail network data of an energy company.

The cases demonstrate different analytical domains of network analysis. The cases relate to the according methodical procedure as introduced in the previous chapter and especially the stage visualization and analysis (chapter 9.4). This chapter now focusses the main technical functionality of the supporting software to give an idea of the diverse analytical options the analyst has with IT-supported network analysis.

10.1 Case Public Slashdot Discussion Group

The first case for testing and applying the software solution is a sample dataset of a discussion in the public news oriented community board Slashdot. This set is kept small to allow for an easy demonstration of insights. The communications between authors have been collected via automatically connecting to the website that hosts the conversation. Slashdot archives are stored using the hierarchical paradigm which is translated into the generic database structure via the connector. The software-specific properties which can be derived are maintained. In Slashdot, the most interesting individual property is the evaluation of authors. From this data the author network as shown in Figure 79 is being generated. As described in

11 Towards IT-supported People Network Management

The approach towards the IT-supported visualization, analysis, measurement, and evaluation is just a step towards a more professional application of virtual communication networks. They have various advantages for corporations, which have yet to be discovered and tested. For example, such communication channels allow for permanent expert groups which can replace teams that only meet once in a while. The Virtual Community can asynchronously and on-demand work on topics, even if the people are geographically distributed (which is already given, if they work in different departments). Further advantages are threaded and systematic dialogs in topic areas, which are automatically protocolled in a persistent and accessible communication archive together with related documents. This results in the ability to host much larger groups in the Virtual Community as it would have been possible in a face-to-face community, which allows for integrating more expertise.

All these advantages together with the ability to keep track of the development and evolution of the virtual communication network using IT-supported monitoring can eventually lead to People Network Management (PNM) supported by Social Network Intelligence Software (SNIS), which is uncovering the complex structures and their exchange mechanisms to better understand Social Capital and its access to distributed resources in people networks. Further it enables to understand and support informal communication to utilize it to generate value for the employees and subsequently for an organization.

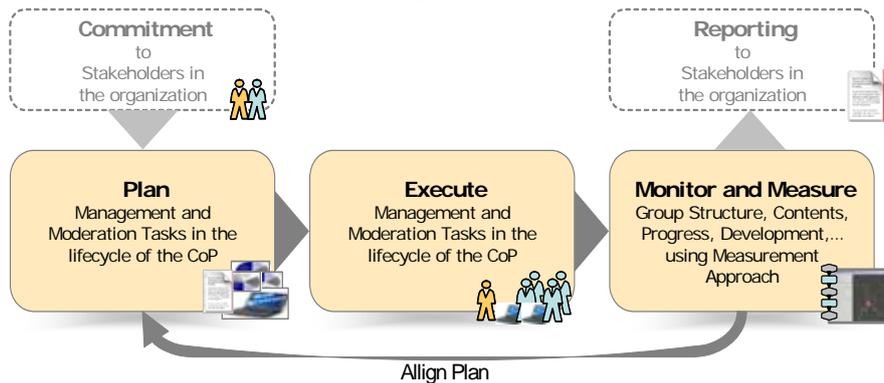


Figure 89: A concept for People Network Management in a Virtual Community using Social Network Intelligence Software.

12 Literature

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