IT-supported Visualization and Evaluation of Virtual Knowledge Communities

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> *‚Mankind are to be taken in groups, as they have always subsisted. The history of the individual is but a detail of the sentiments and thoughts he has entertained in the view of his species: and every experiment relative to this subject should be made with entire societies, not with single men' (Ferguson, 1767).*

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CONTENTS

ACKNOWLEDGEMENT i
CONTENTS iii
OVERVIEW AND OBJECTIVE vi

1 The Economic Development and the Event of Knowledge Work.. 1

2 The Development of KM as a Research Discipline 10

2.1 Towards a Working Definition for the Term Knowledge 11
2.1.1 The philosophic Roots 11
2.1.2 Recent Reception of the Philosophical Approaches 13
2.1.3 Examining Boundaries and Properties of the Term Knowledge ... 14
2.2 Reviewing existing KM Approaches 22
2.2.1 Preliminary Concepts related to modern Approaches of KM 22
2.2.2 The first Wave of KM Concepts – Push Orientation 25
2.2.3 The second wave of KM concepts – Pull-orientation 39
2.2.3.1 Process oriented KM Approaches 42
2.2.3.2 Community oriented KM Approaches 45
2.2.4 Current Reception of KM in Corporate Implementations 48
2.3 Resulting Framework of theoretical KM Approaches 50

3 A network oriented Foundation of Knowledge Management in Organizations - Knowledge Networks 53

3.1 Early Organizational Theories and their Role for KM 54
3.2 Shift towards Organizational Sociology 58
3.3 Systems Sciences in Organizational Theories 61
3.4 Networks, Coordination and recent Organizational Theories 68
3.5 Organizational Network Structures 73
3.6 Implications for organization and network oriented KM 75

4 CoP as an Instance of a Network Organization and an Instrument of network oriented KM 79

4.1 Definitions and Basic Properties of Communities of Practice 80
4.2 Typologies of Communities 85
4.3 Community of Practice vs. other organizational forms 87

5 Organization and Coordination in CoPs.. 91
5.1 Integrating Communities into existing Organizational Structures 91
5.2 Practical Examples for CoPs in Organizations 93
5.3 Benefits for Organizations 97
5.3.1 Short term Benefits of Communities of Practice........................... 97
5.3.2 Social Capital 98
5.3.3 Trust 101
5.3.4 Understanding Costs to evaluate Benefits.................................. 102
5.4 Structural Properties of CoPs 102
5.5 Roles in a Community of Practice 105
5.6 Management of Community Structures - Pro and Cons..................... 107
5.7 What and How to manage 111
5.8 Tasks and Processes during the Community Lifecycle 114
5.8.1 Wenger's Community Lifecycle 115
5.8.2 IBM Lifecycle 116
5.8.3 Integrated Lifecycle 117
5.8.3.1 Preparation Stage.. 118
5.8.3.2 Build-time Stage.. 119
5.8.3.3 Run-time Stage.. 120
5.8.3.4 Decline Stage 122
5.9 Role of Measurement for Managerial Community Tasks 124

6 Information Technology to support Communities...................... 127
6.1 The Role of IT for running Communities 127
6.2 IT Applications for Communities 129
6.3 Computer-mediated Communication in Virtual Communities 137
6.4 Focusing Discussion Groups.. 142
6.5 Current Gaps and required Concepts 145

7 Towards CoP Transparency, Measurement and Evaluation..... 147
7.1 Measurement and Success Factors for Knowledge Networks 147
7.1.1 Measures from logging Community Activity 153
7.1.2 Measures from Group Theory Research 156
7.1.3 Measures from Social Network Analysis.................................... 158
7.1.4 Measures for Social Capital or Trust... 162
7.1.5 Measures for Knowledge Processes.. 164
7.2 Deriving a Measurement Concept for Communities of Practice......... 164
7.3 Social Translucence - adding Visualization to Measurement 170

8 A Tool for visualizing, analyzing and modeling Communication Networks of Knowledge Communities ... 174

8.1 Current Visualization Approaches ... 175
8.2 The Tool's underlying Graphical Visualization Method ... 182
8.3 Software Engineering Process and Software Framework ... 184
8.3.1 Requirements Profile ... 185
8.3.2 Software Architecture ... 187
8.3.3 Data Sources and Data Architecture ... 189
8.3.4 Intelligent Backend and Connectors ... 194
8.3.5 Frontend and User Interface ... 198
8.4 Applied Technical Frameworks and Algorithms ... 202
8.4.1 Graph Theory and Information Visualization ... 202
8.4.1.1 Social Network Visualization and Analysis ... 206
8.4.1.2 Spring Embedder Algorithm ... 208
8.4.1.3 The application of Java 3D ... 210
8.4.2 Animated Longitudinal Visualization and Analysis ... 213
8.4.3 Semi-manual Content Coding and Analysis ... 215
8.4.4 Automated Shallow Text Analysis ... 216
8.4.5 Implementing and extending Measurements ... 218

9 Case Studies for IT-supported Community Visualization and Analysis ... 221

9.1 Case Public Slashdot Discussion Group ... 221
9.2 Case Instant Messaging in a Manufacturing Company ... 223
9.3 Case Public Java Developer Forum ... 229
9.4 Conclusion ... 232

10 Outlook: Towards IT-supported People Network Management 235

11 Literature ... 238

12 Appendices ... 266

12.1 CoPs in corporate KM Approaches – Overview ... 266

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 sections:

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 the expert networks. However, the analysis results in the insight, that current IT is not at all satisfying the requirements of virtual Knowledge Communities in corporate applications. Especially, the important role of the community moderator and manager is unsatisfactorily supported. This person needs transparency about the large group he is responsible for. This implies the necessity of 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 consists of 55 factors in four domains and 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 CoPs with appropriate measures and visualizations, an extensive software solution which aids as an add-on to current community platforms has been developed. It is described in *chapter 8*. The primary challenge was to create insightful visualizations, which integrate 2D and 3D Graph Drawing Techniques for Social Network Analysis with Topic and Keyword Analysis methods and to merge this conglomerate with the measurement system.

Finally in *chapter 9*, three case studies are introduced to illustrate the application of the software solution and its benefits for providing a CoP moderator or manager with detailed insights about the structure and processes of his group.

In summary, this work addresses the following main questions:

1. What is the role of Communities of Practice in Knowledge Management?
2. What are necessary conditions for Knowledge Management concepts in order to be able to support Knowledge Work in People Networks?
3. How can communication networks of Virtual Communities be modeled in order to be analyzed and visualized to support moderators, analysts, and members?
4. What data offered by available communication means of CoP software provides most value for visualizing, analyzing, evaluating, and developing the virtual knowledge community?
5. How can Social Network Visualization be synergistically integrated with Topic and Keyword Analysis?
6. How should a software solution for automatic analysis of virtual expert groups and subsequent management support be designed?

1 The Economic Development and the Event 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 evolvement 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).

Although Product Life Cycles decreased, **product development times** increased from an average of 1.6 years in 1978 to 4.2 years in 1994, thus leading to a conflict situation for businesses (Perillieux, 1991:26): Higher investments have to pay back in a shorter period of time.

These market pressures where amplified during the recent major period of **recession**. In the European Union, the growth of the Gross Domestic Product[1] (GDP) went from 3.5 percent in 2000 back to just 0.6 percent (declining 2.9%) and was accompanied by declines of 3.4 percent in Japan and 0.2 percent in the United States (OECD, 2002b). A final source for competition was provided by the introduction of the **single market**. Since that, it contributed to a 30 percent increase in intra-EU trade of manufactured goods since 1992. Further it boosted direct investment within the EU. In 2000, these flows were twelve times greater than in 1992 (OECD, 2002a).

Next to the single market, the decreasing revenues in established locations pushed enterprises towards more **globalization.** Globalization can be indicated by measuring the amount of foreign direct investment. It has grown impressive 15 percent per year from 220 billion dollar in 1989 to 768 billion dollar in 1999 (OECD, 2000). Corporate activities mainly were aiming at „**lowering production costs** and/or gaining access to new markets. Firms engaged in labor intensive manufacturing, for example, sought to decrease costs by locating labor intensive operations in countries where wages were substantially lower" (OECD, 2002a:15).

Next to the foreign investment, strategic alliances show, that business is becoming more internationally oriented, networked, and complex. Between 1990 and 1998, 5100 **strategic alliances** were formed between enterprises (UNIDO, 2002:15). Even closer cooperation can be achieved via Mergers and Acquisitions (M&A). They increased by more than 500 percent between 1990 and 1999, rising from 153 billion to 792 billion dollars (OECD, 2001). These alliances allowed the access to new markets without investing in local production structures and enable the companies to concentrate on perfecting their profitable core competences (e.g. using a cost or a quality strategy), while simultaneously engaging in a complex cooperation network.

The short period for investments to pay back has not only been met by cost reductions, inter-organizational networks, and market entries but also by increased corporate investments in rather complex **Research and Development** (R&D) en-

[1] GDP is the total value of goods and services produced by a nation over a given period, usually 1 year.

deavors. For instance, in OECD countries[2], enterprises accounted for 69 percent of all R&D funding in these countries in the year of 1997 (UNIDO, 2002:15). There is not only a large share of funds invested by enterprises, but also a strong growth: Together, the four most important areas EU, US, and Japan raised their spending from 255 billion Euro in 1995 to 453 billion Euro in 2001 (cf. Figure 1). This is a growth of nearly 80 percent of research effort within just 6 years (European Commission, 2003a:29).

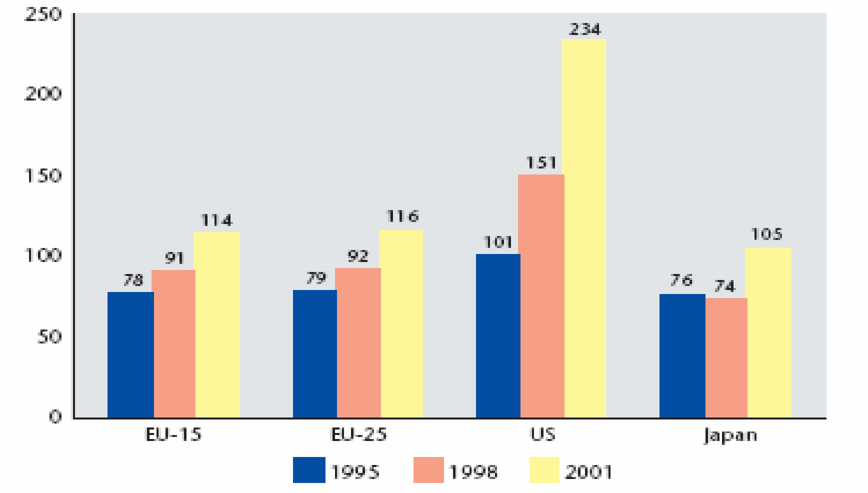

Figure 1: Evolution of Business Expenditure on R&D.
Source: European Commission (2003a:29)

This strong growth in R&D efforts also translates into an increase of **research personnel**: The business sector in the US, the EU and in Japan hosts about two million researchers. In the EU, there is currently an average of 5.68 researchers per 1000 employees. This number grew by 2.6 percent from 1996 (European Commission, 2003a:44). Following that, the EU patent applications rose by 10 percent to 107 patents per million people. Figure 2 illustrates that the main growth came from the Software and IT Services sector with 30 percent additional **R&D expenditure** annually (volume in 2002: approx. 15 billion Euros). Among the other contributing sectors were Pharma & Biotech (approximately 16 percent annual growth to 35 billion Euro), the Automotive sector (10 percent to 37 billion Euro), Engineering and Machinery (12 percent to 6 billion Euro) and Electronics and Electrics Sector (8 percent to 22 billion Euro). It should also be noted that the IT hardware sector hardly grew in R&D investments (only 1 percent) but remains

[2] Twenty countries originally signed the Convention on the Organisation for Economic Co-operation and Development on 14 December 1960. Since then a further ten countries have become members of the Organisation. Among them are: USA,UK,G,F,I,E,S,J,A.

on the first position in terms of volume (2002: 45 billion Euro) (European Commission, 2003a:33).

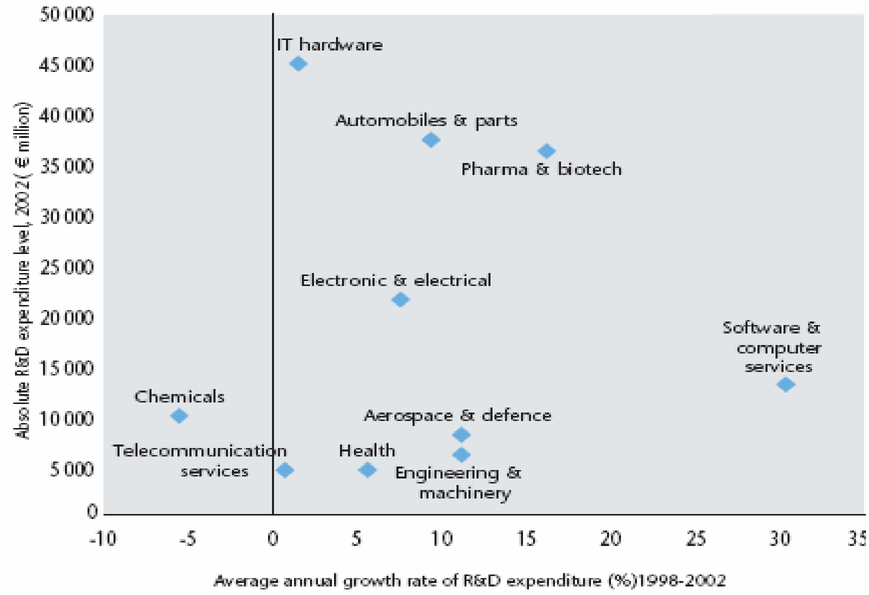

Figure 2: R&D Expenditure in selected Sectors – average annual Growth Rate, 1998-2002 and absolute level (in mill. EUR), 2002. Source: European Commission (2003a:33)

The aspect, that IT is the sector with the largest growth rate and with the largest volume also relates to the event of the **Information Society**, with its substantial cost savings and increases in speed of business processes. This can be illustrated by looking at the number of internet hosts. In Europe, this number increased from 0.6 million in 1991 to 12.4 million in 1996 (OECD, 2002b). Equally, the number of broadband connections doubled in the twelve months before October 2003 to almost 20 million connections across the EU (European Commission, 2004). This development is tremendously fueling the efficiency of business processes in inter-organizational global networks.

The increasing importance of **software** to support business transactions can also be substantiated by the growth in sold software products of 4.6 percent in the year 2004 in the European Union. According IT services grew by 2.6 percent in the same year. The current approach of businesses to reap the benefits out of their existing structure can be substantiated by the decreased investment growth rate. It fell from about 4 percent (period 1995-2000) to minus one percent in 2001 (European Commission, 2003a:12).

In such a competitive environment, two thirds of all companies frequently invested in new **innovations** which they subsequently introduced into their organization (ZEW, 2003). Taking the representative example of Germany in 1998, about 70 percent of all money invested into innovations was allocated to product innovations (IFO, 2001:74; also cf. Figure 3). The remaining 30 percent of innovations were allocated to process improvements.

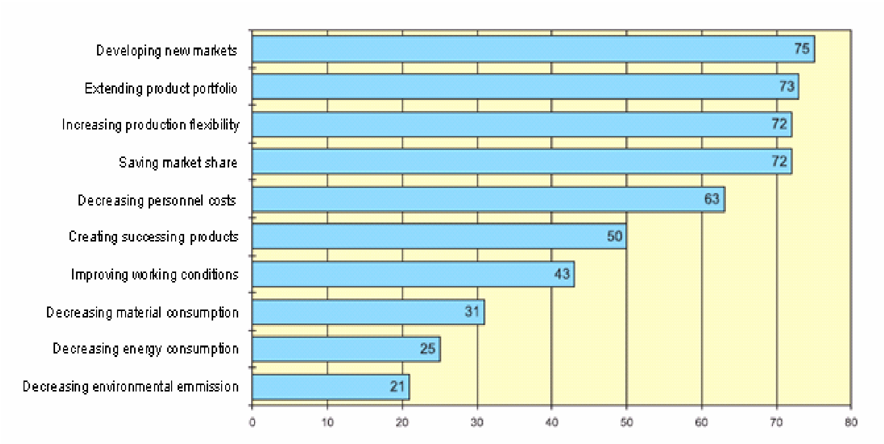

Figure 3: Targets for Innovation, Manufacturing Sector, Bavaria, Germany, 2000. Source: (IFO, 2001).

These innovation investments are inextricably related to the objective of achieving cost reductions. This can be illustrated by the following example. In 2001 in the machinery sector, about 3 percent of costs could be reduced by the relatively stable share of process innovation investments. This is a much smaller reduction as for instance in the automotive industry, which achieved 9 percent cheaper processes (ZEW, 2003).

In this situation of increased relevance of research and IT for supporting business transactions, the market share of the **high-tech industry** started to grow. In 2001, 8.4 percent of the EU's value added originated from high-tech and medium high-tech industries. The respective growth rate of this sector's value added was 1.84 percent for the EU between the years 1996 and 2001. The growth in the EU as a whole was near 0.5 percent - substantially less than the growth in value added of these industries for the same period. This is indicating important overall productivity gains in European high-tech manufacturing (European Commission, 2003a:78). Simultaneously, the share of medium- and high tech products in global exports rose from 58 percent in 1980 to 65 percent in 1997 (UNIDO, 2002:15).

To cope with the dynamic markets due to short Product Life Cycles, increased globalization, production complexity, and high-tech products, the employees require higher degrees in **education** and frequent training.

„High-tech employment in 2002 was 4.5% higher than in 1997 in the EU as opposed to an increase of only 2% in total manufacturing, (European Commission, 2003c),

> suggesting a strong link between R&D intensity, job creation and competitiveness." (European Commission, 2003a:80)

Following this trend, between 1998 and 2001 the EU produced 14 percent additional graduates. In the same area, in 2002 about 8.5 percent of the population aged 25-64 have followed continuous education or training. This number grew by 7.9 percent compared to 1997. (European Commission, 2003a:50). Of course this is influencing labor productivity (i.e. GDP per hour worked). It increased in the EU countries from 1997 to 2002 annually by 1.48 percent (in the US by 2.13 percent).

This **efficiency** effect of a qualified workforce can be illustrated by the drop of the total number of employees in the UK automotive sector from approximately 290 thousands in 1998 to 240 thousands persons in 2001 - although the sales value remained at a stable 42 billion Pounds. Gross Value Added as percentage of labor costs fell from 169 percent in 1997 to 126 percent in 2000. Compared to the small GDP change, this is indicating that with lower labor expenditure more Gross Domestic Product has been generated. The increased automation of 'simple' transaction processes, which reduce the demand for unskilled labor, is also observable in this industry: Stock Turnover increased from 6.6 in 1995 to 9.7 in 2001 indicating lower stock and faster and more efficient production processes (DTI Automotive Unit, 2004).

Another impressive indicator can be found in the machinery industry of Germany. Here, between 1980 and 1996, the overall amount of employees decreased by 13 percent. During that time, people without a certificate of their professional **qualification** did reduce by 51 percent whereas the share of people with a university degree rose by 64 percent. This shows the increasing average qualification levels of employees as the machinery sector is behaving similar to other branches (Lichtblau, 1998).

The increasing average qualification of employees implies the increasing role of the utilization of intellectual **(intangible) assets** as a major incentive for management:

> „Increased attention is being paid, for example, to the importance of the capabilities of human resources to firm performance – which would include the knowledge, skills and abilities of systems engineers, programmers and researchers." (OECD, 2002a:15).

The skilled labor, the event of complex high-tech products, and sophisticated Information Technology lead to the extension of core products by various augmenting **services** in order to cover the complete customer buying cycle including pre-sales, sales, and after-sales services. New augmenting business units (e.g. deconstruction, services) were emerging and often enough, they developed to become the most profitable business segments and growth areas around a particular mature technical solution. The general increase in services as compared to manufacturing can be substantiated by a recent survey. In 1958, 23 percent of the population of

Belgium, France, Germany, Italy, Luxembourg and the Netherlands worked in a farming job, 40 percent of the population worked in industry. By 2001, farming jobs have dropped to 4 percent and industrial jobs have dropped to 29 percent for the then 15 EU countries. The opposite holds for the service sector: Its share grew from only 37 percent in 1958 to 67 percent in 2001 and was hence the major source for new jobs (European Commission, 2003b:5).

A special subset of services with a highly skilled workforce and the application of expert knowledge is constituted of **Knowledge intensive Services** (KIS), which tremendously increased in importance.

> „Knowledge intensive services are defined according to the Eurostat definition as: post and telecommunications, computer and related activities, research and development, water transport, air and space transport, financial intermediation, real estate, renting and business activities, education, health and social work and recreational, cultural and sporting activities." (Eurostat, 2004)

The development of KIS is closely linked to the growing specialization of industries and the need for even more specialized services emanating from other service and manufacturing sectors. In 2001, KIS accounted for nearly 39 percent of EU's services' total value added. In Germany it even approached 50 percent. The value added produced by KIS shows positive growth over the period 1996 to 2001. On average the annual real growth rate has been 4.5 percent for the EU as a whole (Germany: -0.31 percent, UK 17.6 percent). In 2001, 37.3 percent of people employed in the EU worked in KIS causing a growth rate of 3.23 percent between 1996 and 2001 (European Commission, 2003a:83).

Developing Knowledge intensive Services plus complex augmenting services around the core product to cover the complete customer buying cycle implies, that vendors employ experts and extended their participation to include the planning and conception stages of customer projects. They thus develop towards project-driven business and invest much effort and upfront investments into applying their available expertise to the special customer demands and requirements. Due to this extended relationship between customers and vendors, very qualified sellers and technical experts can learn very much about the customers' problems and can more specifically apply their methodical and technological knowledge. This kind of occupation is increasingly important compared to the conventional production or the selling processes. The focus is moving towards a solution oriented business, consisting of highly flexible planning in strategic networks, customization, integration and implementation of the offered complex bundles of services and products.

As shown in the statistics, in such an environment, the main value added is not to be found in routinuous execution of business processes, which depreciates to become a prerequisite (i.e. fast order processing using modern IT). Rather, the value is generated with skilled experts and their knowledge intensive work (or Knowledge Work) like technology consulting, configuration, or engineering. The flexible management of exceptions in a complex customer project and the efficient execution of very individual customer requests become more important than physical transactions (which are getting apt to automation). The according management systems hence develop from optimizing transactions (like in business process engineering and management) towards including and emphasizing the problem-solving tasks needed for Knowledge Work in knowledge intensive activities.

Improving the current efficiency in such a knowledge-dependent business activities generally enables corporations to:

- improve time-related efficiency, due to increased speed of business process execution,
- improve cost efficiency, due to reduced double work and more efficient distribution of resources (including investments in knowledge generation),
- improve resource efficiency, due to reduced double work and shorter process durations or due to better process designs,
- support the capability to cope with complexity, due to employing self-regulating mechanisms,
- integrate important employees into the problem solving processes, by more connected, more diverse, more current communication structures between the people who execute knowledge intensive business processes,
- help to integrate related domains of the corporate value chain,
- help to integrate individual products and related services into a complex solution,
- help to manage distributed locations (improving logistics by improving knowledge sharing and information logistics, and
- improve the reflection about learning processes (eliminating errors) in a company. This feedback can be incorporated in incentive systems and process structures to reward positive structural ideas and changes for improved problem solving. It further can
- establish clear paths for efficiently reacting on new information ‚sensed' somewhere at the system's interfaces to its customers, production, processes, suppliers, technologies, or employees,
- support the transfer of generated knowledge to save effort for solving similar problems,
- support the transfer of knowledge between affiliations in countries with different technological and economic status (e.g. IT in 1st, 2nd, and 3rd world countries),

- help to ‚package' insights and knowledge as fixed structures to reuse them as a general solution to a class of problems,
- strategically develop certain knowledge domains to maintain and improve future competitiveness,
- identify and remove barriers for efficient structural adaptation as a reaction to learning processes resulting from solving business problems, and
- support the transparent communication of corporate capabilities and potent competencies to stakeholders in order to better substantiate ‚good will' and other tangible resources.

The list of benefits resulting from managing Knowledge Work and Knowledge is long and their realization is eminent due to recent economic developments. But how can this be achieved? The answer to this question is similarly the objective of the research discipline Knowledge Management (KM), which will be the primary perspective of this book. To prepare for an answer to this question and to identify innovation potential for appropriate technical support, the next chapter discusses the development of a body of theories around the idea of managing knowledge and Knowledge Work by the means of Knowledge Management.

2 The Development of KM as a Research Discipline

The research field of Knowledge Management 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.

2.1 Towards a Working Definition for the Term Knowledge

On an abstract level, two scientific strategies are applicable to arrive at a concrete definition of the term 'knowledge'. The first approach is to determine the concept's boundaries and its relation to other concepts in order to indirectly encapsulate the term itself. The second way involves the development of various classifications of sub-types to reflect on the various special properties of 'knowledge' emerging from the differences between the sub-types.

Before these two strategies shall be applied to create a working definition of the term knowledge and its related constructs, the theoretical discussion which stretched over several thousand years will be briefly examined. It actually started with first philosophical considerations which have created schools of thought that developed a philosophical understanding of the term. This helps to provide a basis for further explorations in the context of Knowledge Management.

2.1.1 The philosophic Roots

The philosophical debate about the meaning of the term knowledge is related to the field of epistemology and started with Plato and his philosophical theory called **Rationalism**. It assumes the existence of a priori existing knowledge. Plato calls this the divine idea and sees the actually perceived world as its only partially and fragmentarily perceived shadow. The only way to approach to the divine ideas and concepts is by means of deduction using reasoning. Plato further adds the notion of knowledge to be true: he sees knowledge ('insight') as a correct conceptualization together with its explanation (Plato, 1977:18).

However, Plato's pupil Aristotle disagreed with his teacher's approach. His **Empirism** assumes that no idea can exist without its sensual perceptibility - knowledge is solely and inductively created by sensual perceptions. Following his approach, recognition results in memories, multiple memories result in experience, and finally the stable and abstract essence of experiences results in knowledge about a concept (Aristotle, 1993:83). Later, Wilhelm von Occam (Nonaka and Takeuchi, 1997:65) tried to merge Platon's and Aristotle's perspectives by noting that abstract knowledge and the associated deductive reasoning prerequisites previously perceived intuitive knowledge, derived inductively from existing elements. However, the two opposing concepts determined the subsequent discussions. For example, Augustinus' and later Descartes' rational thinking followed Plato (Descartes, 1979:108) whereas Thomas von Acquin and later also Locke (1690:II§2) followed Aristotle. The opposition between Locke and Descartes even developed towards the two powerful directions of **British Empiricism** versus **Continental Rationalism**: Descartes wrote about his four strategies for rational thinking whereas Locke wrote his renowned 'Essay concerning Human Understanding'. There he concludes that only sensual perception can fill a mind, deductive reflection is the source which uses prior experience. The increasing importance of the notion of abstraction from experiences which began with the early Christian philosophers has later also been identified by von Glasersfeld (1996:93). In 1710, Vico explicates first constructivist arguments and partially preempts the later works of Kant by stating, that reason creates knowledge via analyzing how things are combinatorially constructed or produced (Vico, 1710).

A further integration was attempted by Kant, who assumed that knowledge is created when sensual perception and logical thinking are combined (Kant, 1980:45). However, Kant thinks of subjective and objective belief in something being true, which shows that he somehow tends towards the rational approach, which was assuming something objective outside perceptibility.

Marx emphasized the importance of interactions with the (and influence on the) environment resulting in an adaptation and thus adds the notion of **action**: Knowledge is created in the process of acting with things in a situation (cf. Russell, 1954). Things are recognized in a process of activities focused on the thing. This idea has later been further discussed by Heidegger (1986) and culminated in the emergence of Existentialism: Knowledge is not only generated by a reflection about perceptions, but by acting and reflecting on actions (also cf. Sartre, 1980)[3]. Finally in 1907, the concept of Pragmatism emerged. Here, one of this school's philosophers, John Dewey, notes that knowledge is useless if it is not implemented in actions to change the environment (cf. Nonaka and Takeuchi, 1997:40).

Later in that century, Constructivists like Ernst von Glasersfeld followed. They based their approaches on the biological conception of knowledge discussed by Piaget, who explained knowledge as a biological means of adaptation. This led Piaget to forego the idea of knowledge as a representation of an external ontology and led him towards an emphasis on cognition which results in structures for adaptation (cf. von Glasersfeld, 1996:107). Extending this thought, **constructivism** added the conception of a knowledge, which is not passively consumed, but actively created by cognitive functions for means of adaptation. Cognition is organizing experiences of the subject and is not able to create a final idea of an objective external ontology (von Glasersfeld, 1996:96). These more recent concepts elevated the discussion of the term knowledge from philosophy to natural sciences. The related disciplines which now increasingly contribute new insights which impact the notion of the term knowledge are focusing on human cognition (cognitive theory) and mental mechanisms to accumulate knowledge (connectionism, neural biology; cf. Anderson, 1995).

In summary, the philosophical discussion emphasizes the perception of the environment to generate experiences (as the essence of multiple memories) and the essence of experiences which comprise knowledge. The last aspect includes logical reasoning and rational thinking about practical experiences to further develop

[3] This is obviously pre-empting the Learning Processes developed by Argyris and Schoen (1996) which is described in chapter 3.3.

them towards abstract principles. This rational thinking later has been augmented with arguments for a ‘natural’ construction of a body of knowledge from past experiences in order to adapt to the environment. Here, abstraction helps to improve the insights stemming from initial experiences and thus to somehow approach an abstract hypothetical ‘divine’ idea in a second step. All these aspects emphasize the importance of researching human cognition. After all, only the application of such mental processes in continuous interactions with the according objects of the environment generates profound knowledge. The core concept so far hence conceives knowledge both as a process and a result of a cycle consisting of action, experience, cognition, reasoning, reflection, connecting and structuring information, adaptation, and again action. It is left to neural biology to explain the actual stored physical or informational essence which enables individuals to expand and utilize their knowledge using their brains.

2.1.2 Recent Reception of the Philosophical Approaches

In order to arrive at a concrete picture of the current usage of term knowledge, it has to be examined how the philosophical findings have been adopted by recent working definitions in the context of Knowledge Management approaches. Here, generally, it can be recognized that obviously for reasons of pragmatism - which seems to be necessary to communicate the complex concept of knowledge - most current KM approaches simplify the construct[4].

The primary dichotomy between Rationalism and Empiricism as established in the philosophical dialogue is being referred to again by Lehner (2000:143). In his discussion of KM approaches, he differentiates into knowledge as something objectively given and knowledge as something constructed. Further he emphasizes the sociological dimension of the term as it is always the knowledge of someone and thus bound to (sometimes multiple) people[5].

A rather detrimental approach, which restricts the added value of the concept of knowledge, has been proposed by Daniel Bell: He defines scientific and theoretic knowledge as a collection of structured facts and ideas, which allow a reasoned judgment or an **experimental result** and can be submitted and transported by means and media of communication (Bell, 1973:180). Although this conception relates to experimental experiences (Empirism), the notion of communicability restricts this definition to explicit knowledge (which can also be interpreted as in-

[4] For some approaches it has even to be warned, that they not only simplified for pragmatical reasons but arrived at a rather degenerated instrumentalization of the term knowledge, mostly to sell a related, usually rather unreflected and often technological approach under the more sophisticated and sometimes even mystified brand ‘knowledge’. These approaches are either briefly mentioned or even left out, as they did not contribute (but rather hindered) the evolvement of the discipline of KM.

[5] This aspect will be subject to a more detailed discussion in chapter 3.

formation). This may be useful in some scientific fields (i.e. engineering or communication technology), but it is a quite dangerous starting point for Knowledge Management.

The property of **truthfulness** is being put into the discussion again by Segler, who sees knowledge as the matter, which actors use to generate behavior with different degrees of 'truthfulness', reaching from objective insights to subjective beliefs (Segler, 1985:187).

As a final example, the knowledge definition of the Association of German Engineers (VDI) emphasizes the close relation to action: Knowledge is the structured experience derived from possible, executed, or observed actions of the past including the perceived objects and subjects (VDI, 1995). This notion of action is the most important adoption in KM definitions of knowledge.

Next to the implementation of philosophical findings, KM concepts also try to create an understanding of their core term and 'object' under consideration by identifying borders or properties of knowledge. These approaches will now be discussed.

2.1.3 Examining Boundaries and Properties of the Term Knowledge

After introducing the generic philosophical ideas about the concept of knowledge, two scientific strategies which help to advance the understanding of the term knowledge can be employed. The first is to actually discuss differences to related terms and hence indirectly and deductively define the boundaries of the concept to better understand the concept itself. The second is to break the term down into different categories of knowledge with more comprehensible sub-types. The latter strategy also leads to a set of descriptive properties to closer describe the qualitative aspects of the knowledge of some issue.

The first and most important terminological **boundary** that needs to be explored is between the terms knowledge and **information**. The most renowned definition of the term information comes from Bateson (1972:315), who said that information is a difference which makes a difference. To explain this short statement, Luhmann adds that the system, which processes the information, isolates an information from its environment, because it is relevant for the system as it changes the knowledge of the system in an intended direction (Luhmann, 1984:68). Information is actually only emerging when a system employs criteria for relevancies and evaluates all the surrounding symbols and data with it (Willke, 1998:8)[6]. Watson

[6] However, Willke creates the concept, that data gets information if it is put in a context of relevancies. Later again (other) relevancies create knowledge from the information. This system of double interpretation seems incorrect, because already the first upgrading procedure (data to information) requires the system to use internal criteria and

(1996:25) supports this idea by defining knowledge as the ability to use information purposefully. In the KM literature, Lehner (2000:142) gives a very illustrative picture for this aspect: In an integrated cognitive system, information is the dynamical component and knowledge the static one. Information transports and changes knowledge. The information is only information for that very system (Lehner, 2000:142).

This subjective value of information directly relates to another important term: **meaning** (or sense). Systems with knowledge need an objective for the information to mean something for the system. Information can not be selected without being relevant for the system. Otherwise the information which is provided to the system is noise, without beneficial effects for the system (Luhmann, 1984:98).

This meaning is influenced by continuities and existing structures. Luhmann states, that Information as differences also causes causality when it appears in certain patterns (like in a relation to a successful action, e.g. handling hot metal needs gloves). On a neural level, this can be metaphorically illustrated by the activation of higher neurons. They only react, if lower-level neurons have received a certain input signal in a certain combination. Hence the simultaneous signals constitute the causality for the higher neuron. The higher neuron can even be interpreted as an indicator for having identified causality in the environment.

Luhmann puts the whole aspect of meaning into a short sentence: Meaning is the difference between perceived actual situation and the intended and projected opportunities (Luhmann, 1984:100). This again leads directly to an intended successful action (also cf. Marx and the Pragmatists in chapter 2.1.1) which again refers back to recognition and information. It also relates to the idea of confidence in the belief of something being true (cf. Kant, 1980, chapter 2.1.1) as this reflects the confidence that the intended action or decision really results in the expected and projected successful result.

This finally fuels the discussion of the value of having knowledge: The construction of a knowledge network consisting of past, combined, refined, evaluated, and sometimes abstracted experiences (cf. Aristotle, 1993; chapter 2.1.1) yields in the improvement of the quality of a system’s manipulation of its actions and decisions (output) and eventually also leads to a better adaptation to its environment.

In a social system like an enterprise the environment necessarily contains other people. In such a social system, an action is also interrelated with these persons. Von Krogh and Roos (1996) build a relation between people networks and the term knowledge. Knowledge is the result of interaction of people in networks[7].

relevancies derived from prior experience (as what should provide an external set of relevancies as opposed to the internal set for knowledge creation from information?).

7 North (1999) states that von Krogh/Roos define three perspectives on Knowledge: Knowledge as the result of interaction of people in networks, knowledge as the result of personal experience, and knowledge as the processing of information. However,

A last boundary needs to be drawn between the terms **learning** and knowledge. As the gerundial form of the term learning implies, the emphasis lies on a process. Weick (1991:122) notes, knowledge creation is a form of learning. Gueldenberg (2001:159) gives a more detailed explanation: Learning is the processing and implementing of perceived and selected information into existing knowledge. It thereby also develops new knowledge. This is also supported by Lehner (2000).[8] However, this notion does not actually include the aspect of learning from abstract reasoning using the existing knowledge only and thereby restructuring and developing it further (or simply 'thinking').[9]

By now one gets the impression, that knowledge is an amorphous and somewhat mysterious structure which grows by information processing. This idea was pursued by the location theorists who conceived knowledge as a storage medium for the processed information (Gueldenberg, 2001:160). But this theory is outdated (compare Gueldenberg, 2001:161 and his notion of the 'old' location theory) as this level of comprehension could already be left behind by recent advances in neural biology (cf. Anderson, 1995 and chapter 2.1.1). For example, the cognitive scientist Sodian (1986) notes that cognitive structures are not the storage for knowledge, they are knowledge. This moves the discussion away from the idea, that knowledge is stored in storage media towards its locus in the connections (*between* the nodes). Here, Weick and Roberts (1993) confirm, that knowledge resides in patterns of connections not in indivuated local symbols. Simultaneously, this shows the difference between the terms knowledge and content as the concept knowledge (as a system with connections) is not synonymous to the term content (with its emphasis on resources/objects and less on structures). This rules out definitions which simply reduce knowledge as different types of contents stored in a memory system (like Baddeley, 1997 or Squire, 1992).[10] Here, a boundary between the terms knowledge and **memory** can be drawn. Memory is the structure on which knowledge can be employed, with knowledge being no object but a dynamic structure to generate action from information (also cf. Lehner, 2000:94).

the previous paragraphs show that this is only one consistent and logically connected perspective and can not be separated into three different types.

[8] Wiegand adds a further hypothesis to that discussion. It represents the idea which is also proposed by the theories on Organisational Learning: Collective knowledge is the product of many individual learning processes transcending individuals (Wiegand, 1996). This work will later show, how this is supported by theories on transactive memory systems etc. However, it is less an insight than a heuristic to manage a company in a dynamic environment

[9] This notion relates to Argyris and Schoen (1996) and their two forms of learning and further to Kim's OADI cycle stages Assess and Design (Kim, 1993).

[10] However, it has to be added that patterns can become symbols again, just like a square is a pattern of four lines which are a pattern of dots.

Luhmann says quite similarly: Memory is the apparatus which allows storing successful experiences for a reuse (Luhmann, 1984:75).[11]

Further terms related to the core concept knowledge can be found in Lehner (2000:141). They include intuition, competence, explanation, message, emotion, proof, intelligence, or wisdom and can be added to get a clearer picture of the term knowledge.

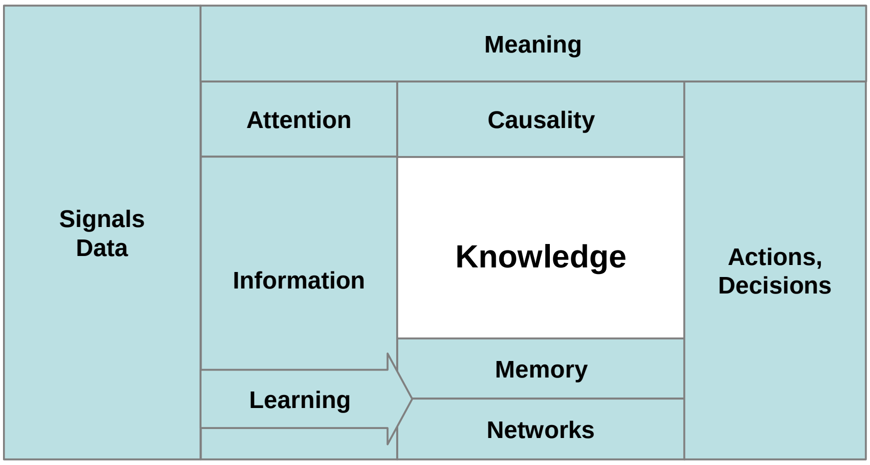

Figure 4: The most important Borders of the Term Knowledge.

In summary, the term knowledge can be approached by defining its borders (cf. Figure 4; the concepts are positioned in a way that reflects their connections). Following this strategy, knowledge can be understood as a mechanism which isolates information from its environment using attention as a filter. It accommodates the information, because it is relevant for the system as it improves the knowledge to enable a better achievement of the objective of successful actions and decisions in order to manipulate or adapt to the environment (identity, stability, growth). By this process the implemented information is being equipped with a meaning which is interdependent with causality which in turn steers the attention again. Simultaneously, the confidence about the individual estimate about the projected success of an action can reach from subjective believe (which could not be proved yet) to objectively reaffirmed ‘truths’ (confirmed by the environment). The meaning is also derived from the observations of the system’s actions. The knowledge is using the memory to work on and to store the information. The memory again is a network structure which is able to store new incoming information (and hence is also called a knowledge carrier) in a way that preserves consistency. This purpose-

[11] Lehner brings this division into the KM discussion: The organisational memory (OM) has the core functions acquire, store, and access to knowledge (Lehner, 2000:126)

ful addition of information to improve the knowledge of the system is also called learning.

For better applicability, this definition can be simplified as follows: Knowledge is a network of interpreted signals and data from the environment, which is continuously reorganized and made consistent by the processes of learning and thinking in order to derive and infer promising decisions and interactions for manipulating and adapting to the environment.

The approach to define knowledge by means of defining its borders requires a discussion of its generation, usages, and meaning. It thus yields in the conceptualization of knowledge as a residue, which remains after deducting all related terms around it. Although it renders knowledge an underlying foundation of all the other concepts, this leaves the actual term knowledge as a black box. However, a first important implication for the management of knowledge can be derived: By managing the processes of processing and connecting information as well as its relation to action and objectives, knowledge is indirectly positively affected.

A second strand of discussion tries to strategically approach the term knowledge by breaking it down into **classifications of types**. The idea is that by this procedure, the term gets more operative and beneficial interventions to positively affect knowledge can better be derived.

The first separation into knowledge types in the more recent literature can be traced back to Barnard (1938:235). He differentiated knowledge which is logically explicable by language and related to behavior versus irrational behavioral and non-verbalizable knowledge. However, this distinction later became famous under a different name. In 1966, coming from cognitive sciences Polanyi divided **tacit versus explicit** knowledge (Polanyi, 1985). This basic dichotomy later became the most important distinction in modern Knowledge Management approaches (compare Nonaka and Takeuchi, 1995 or Hansen et al., 1999).

A different type of classification includes categories which relate to the requirements of an organization and its employment of knowledge. Sackmann (1992) differentiates between dictionary knowledge of facts, directory knowledge of processes and actions, further recipe knowledge (shoulds) including rules and problem solving strategies, and axiomatic knowledge (why) of basic assumptions or cause and effect relations (cf. Gueldenberg, 2001:187). The concept of factual[12] dictionary knowledge is very close to Polanyi's explicit knowledge and Sackmann's **pro-**

[12] Interestingly Willke says, that declarative knowledge of facts is no useful category as is it the same as data (Willke, 1998:12). However, this does not recognize that the knowledge of the fact being true is the actual value of fact knowledge. Moreover, fact knowledge influences the framework of relevancies (sense/meaning, cf. Luhmann, 1984) to select information from the environment.

cedural directory knowledge is hard to transfer and hence resembles tacit knowledge. The last two types are more or less abstract types derived from the first two by logical reasoning. For example, if one knows the procedures for swimming, one can look at how it could be done more efficient and why this is so.

Another approach was proposed by Squire (1992). It is a bit more efficient and more detailed than Sackmann's. Squire classifies into declarative knowledge, which in turn consists of episodic knowledge about past events and of semantic knowledge of facts and concepts. Further, there is procedural knowledge about abilities, prepositions, and tacit elements. Finally he assumes meta-knowledge for planning and controlling actions (also cf. Lehner, 2000:84). So obviously the separation of **facts versus procedures** has been maintained and the more abstract types have been integrated into one type, thus making this structure easier. This trinity has later been reduced even more to the important distinction into factual and methodical knowledge or simply know-what and know-how (cf. Wiegand, 1996). However, Kim (1993) later substantiates the importance of the level of abstraction. He separates concrete routine knowledge and abstract framework knowledge and analyzed their relation to learning processes (Lehner, 2000:134).

Another interesting source of classifications is the Association of German Engineers (VDI). Already in the 1992, it preempted various dichotomies in its guideline 5007. It separated explicit versus tacit knowledge (taken from Polanyi), planning versus experiential knowledge (which is similar to theoretical and assumptive knowledge vs. practical experience), subjective versus objective knowledge (which is subjectively true versus inter-subjectively being confirmed as true), and logical rational insights versus fuzzy knowledge (which includes different levels of abstraction; cf. Lehner 2000:146). This notion of fuzzy or soft knowledge has later been extended by Rao and Goldman-Segall (1995) which utilize a spectrum from hard to soft to illustrate the level of abstraction and its role as a primary differentiator for different knowledge types. They differentiate hard and concrete data – semi-concrete know-how about technology, business rules and procedures, semi-abstract stories and myths, and finally abstract and soft knowledge about roles, structures and culture. In their approach, Rao and Goldman-Segall relate factual and process knowledge to the levels of abstraction proposed by Kim (1993) three years earlier.

The knowledge types introduced so far have been extended by the idea of knowledge in a group structure (remember Krogh/Roos (1996) and their definition of knowledge in a network of people). Following this idea, Schneider (1996) defines a mixture of explicit and tacit knowledge in a relationship network as **collective** knowledge and proposes it as an important source for competitive advantage as it is difficult to imitate and copy. To create collective knowledge continuous conversions between knowledge types (cf. Nonaka's model of organizational knowledge creation, 1995) are necessary. Combining the basic separation into tacit and explicit knowledge with a group context yielded the definitions of further types of knowledge as proposed by Wiegand (1996). Group knowledge can be explicit individual knowledge, tacit individual knowledge, explicit or explicable group knowledge, tacit group knowledge, and explicit vs. tacit individual knowledge which is dependent on group knowledge (cf. Lehner, 2000:119).

A very topic oriented categorization comes from Willke (Willke, 1995:330). He mixes factual and methodical knowledge types with knowledge about various topics and separates factual knowledge about structures, social knowledge about persons, time-related knowledge about processes (timing and synchronization), operative knowledge about projects (procedures) and cognitive steering and planning knowledge. With these types, he identifies different tasks (or dimensions as he calls it) for the management of knowledge.

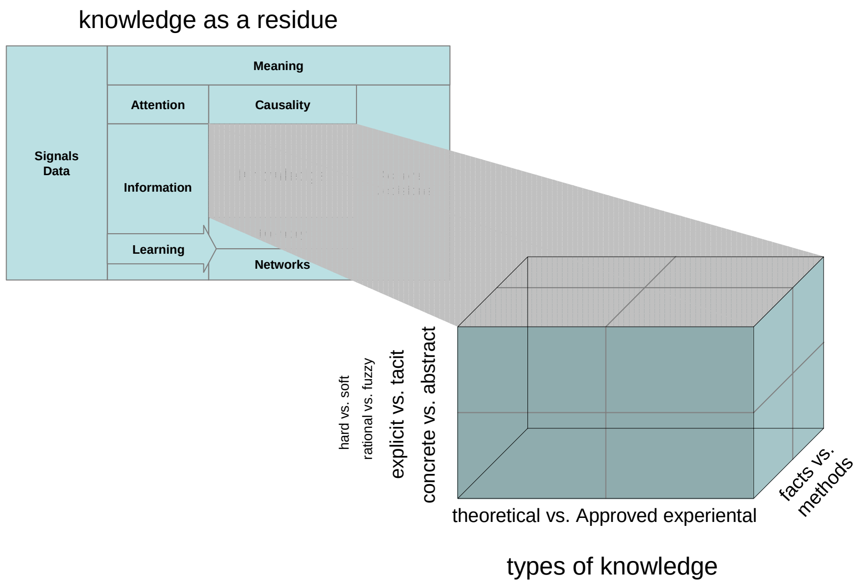

Figure 5: Approaching the Term Knowledge by segregating Sub-types.

North (1999:61) separates further categories by looking at the different values of knowledge. First he describes a connection between the types planning versus experiential knowledge and subjective versus objective knowledge. They all relate to the scope of validity of the knowledge: subjective, objective, or objectively valid under defined conditions, which is similar to scientific approved knowledge. This is simultaneously related to the degrees of confidence in a concept to be true. This results in the separation between meaning, believing, knowing and inter-subjective affirmation.

The level of abstraction is used again for the differentiation between **generic** versus specific knowledge. Other interesting properties which not directly necessitate a dichotomy are the durability of knowledge (as the duration of its validity), and its uniqueness (or exclusiveness) versus commonness (North, 1999:61). The exclusiveness is not a direct property of knowledge but can be attributed if it is known who has knowledge about this issue.

All these approaches should not be seen as concurrent ideas; rather they conjointly define a set of properties which closer define the term knowledge (also compare Lehner, 2000:140). Following these approaches, knowledge can have qualitative properties like a high or low level of abstraction or validity. Further, it has content-related properties like a relation to facts, structures or methods, and finally there are hypotheses about looking at its occurrence in a group or in an individual (also compare Figure 5). Figure 6 gives a final impression about the variety of categories which can be employed to differentiate knowledge types.

A very comprehensive collection of knowledge types has been proposed by (Strube et al., 1996:799). The authors differentiate:

- General knowledge
- Common sense knowledge (culture-specific acquired during socialization)
- Analogical knowledge (for example imagery)
- Assertional knowledge (which is simply fact or the case)
- Conceptual knowledge (knowledge about the meaning of concepts and terms)
- Domain-specific (expert) knowledge (expertise)
- Episodic knowledge (related to specific cases)
- Explicit knowledge (conscious knowledge which can be documented or told)
- Erroneous or inappropriate knowledge (wrong assumptions, not yet verified)
- General knowledge (knowledge with unlimited validity in a certain domain)
- Heuristic knowledge (gives orientation for selecting alternatives without proof)
- Background knowledge
- Implicit knowledge (unconscious knowledge which obviously exists)
- Causal knowledge (knowledge about the relation between cause and effect)
- Control (or strategic) knowledge (knowledge which helps to provide orientation in a task sequence)
- Conceptual knowledge
- Meta-knowledge (knowledge about the application of other knowledge)
- Normative knowledge (norms)
- Problem-solving knowledge
- Propositional knowledge (knowledge represented by propositions)
- Procedural knowledge (knowledge about actions, sequences and movements)
- Qualitative (and quantitative) knowledge (knowledge about qualitative relationships
- Spatial knowledge (knowledge about the spatial arrangement of objects
- Rule-based knowledge (general procedural knowledge)
- Schematic knowledge (knowledge related to structures)
- Semantic (or terminological) knowledge (knowledge about concept hierarchies)
- Default knowledge (general standards, which sometimes have exceptions)
- Temporal knowledge (knowledge about the temporal sequence and order of events and states)
- Uncertain knowledge (includes the propability of being inaccurate)
- Incomplete knowledge (missing pieces)
- World knowledge (non-explicable meta-knowledge not related to language)

Figure 6: List of Knowledge Types. Source: Strube et al. (1996)

Summarizing, knowledge can be **defined** as the ability to utilize a learned network structure of information about facts and procedures in order to draw inferences on various levels of abstractions which help to plan and initiate successful actions with a certain level of confidence. Overly short, this could be reduced to knowledge as the ability to combine and apply a multitude of information to generate solutions.

2.2 Reviewing existing KM Approaches

After having introduced a working definition of the term knowledge, the aspect of an active and supporting system of interventions to foster and develop appropriate knowledge in an enterprise can be discussed. Here, the literature on Knowledge Management (KM) suggests a plethora of approaches. Subsequently, a reader who is interested in learning about KM often finds himself completely helpless, when faced with hundreds of mostly unrelated or even unsubstantiated ideas and concepts. The emergence of the research field was accompanied by a high eagerness to explain the complete perspective in very abstract approaches (usually showing boxes representing domains and relations between them). This completely underestimated the complexity of the endeavor. In the beginning, these approaches were very inconsistent and incommensurable. However, overtime, slowly a selection process started and some useful ideas survived. This section will now briefly review the most important approaches in the field with a special focus on European concepts. As outlined above, the event of the discipline can be separated into two major waves. The first one could be described as ‘finding identity’ and the second as ‘finalizing structures and useful analysis approaches’. However, even before these two waves, preliminary concepts slowly fueled the idea of a knowledge oriented perspective on enterprises.

2.2.1 Preliminary Concepts related to modern Approaches of KM

The idea of managing knowledge in a company is not new. The first implicit approach to deal with this issue in a corporate setting has indeed been pursued by Frederick W. Taylor as early as in 1911 (Taylor, 1983:38). In his scientific management approach, he managed his workers knowledge in a special way. His managers observed the worker’s actions and tacit experiences and explicated job descriptions from it to create standardized methods. However, it has not been treated as a source for knowledge generation and management. Further, it has not been included in conceptual models or in the creation of dynamic learning processes (cf. Pawlowski, 1994:16). Thus, Taylor did not recognize his workforce as a continuous source of new knowledge (cf. Pawlowski, 1994:16). Later in 1959, Edith P. Penrose recognized that it are not the resources provided for a production process but the services applied to the resources that matter. Such services are a function of accumulated experience and knowledge in an enterprise (Penrose, 1959). She was thus the first who saw the relation between experience, knowledge, services (as actions), and products. Still, she observed the issue but did not propose a theory to support a process, which supports the generation and reuse of experience or knowledge (Nonaka and Takeuchi, 1997:48). However, she implicitly anticipated the perspective of very modern approaches to Knowledge Management (KM) which aim to provide knowledge to support business processes (see section 2.2.3 on second wave approaches to KM).

Another pioneering line of thought was provided by Peter Drucker (1993). In the 1970s, he first talked about the related vocabulary including Knowledge Work, knowledge worker and Knowledge Society. Together with the concepts of a knowledge company proposed by Nonaka (1991), the topic of Knowledge Management emerged. Although, these two works were mainly responsible for the emergence of KM as a discipline, approaches from a multitude of disciplines related to the philosophical (and later economical) core concept of knowledge and knowing have influenced the emergence of KM. All these fields are necessary to consider in order to fully capture the rich body of theories subsumed under the integrative and inter-disciplinary umbrella of the new approach Knowledge Management. This multitude of perspectives and prior theories eventually renders the management of knowledge a truly integrated and multi-disciplinary approach. However, it has to be noted, that the claim to provide a holistic and complete KM approach which recognizes all underlying theories is conflicting with the pragmatic objective of corporate applicability. In order to understand the breadth of theoretical roots and the background of KM, the **related fields** and their connections will be very briefly introduced now. However, as each of the disciplines mentioned would require comprehensive introductions, this section will only give a first overview in the form of a list of concepts and their main relations. It is up to the reader to take this list as a starting point for further inquiry into the different preceding subjects.

The fundamental sciences related to KM include epistemology, which is the philosophy of consciousness and insight, and cognitive psychology, which analyzes the psychological learning processes and autopoiesis. Both of these fields relate to the previous sections. Epistemology tries to describe the concept of knowledge and insight to answer the question, how to achieve expertise from learning using philosophical theories and concepts whereas cognitive psychology approaches these two issues by examining the human apparatus of cognition using psychological experiments. From that basis constructivism emerged as a special instance of epistemology, which claims, that all insight is constructed by an individual. There is no objective ontology. That also influenced the branch of cognitive psychology which subsequently developed towards a research field called connectionism. It explains how the brain structure can perceive and think by using its connections of neurons. At a different level of observation, sociology analyzes social systems (which includes organizations and hence corporations). More recently sociological research has been influenced by systems theory. The latter serves as the general underlying meta theory and also allows connecting sociology with epistemology.

Another very important preceding research area of KM was the theory of Organizational Learning. It combines the introduced individualistic (epistemological) and the organizational (sociological) perspective and specializes on analyzing corporations. Primarily, Organizational Learning transfers and combines existing ideas and insights from other disciplines like autopoiesis from systems theory, learning from epistemology and cognitive psychology, or group processes from sociology and systems theory. They are employed for the analysis of learning processes in organizations (without actually establishing a novel theory). This application usually resulted in programmatic and normative suggestions (cf. Senge, 1990) or checklists for ideal processes and structures which connect learning to corporate success (cf. Krallmann et al., 1999:304). However, this branch of research reinvigorated the organic and sociological perspective as a plausible perspective for analyzing enterprises. In connection with engineering sciences and especially with computer science, the theories and approaches of Knowledge Management (which are discussed in more detail in the next chapter) extend these concepts of Organizational Learning on a more operational and process-based level with their focus on proposing improved technical support and implementation. This is also resulting in a strong link to another root of KM, namely Information Management and its technologies. A main contribution of the new KM approaches was it to develop a content-related perspective on the individual and organizational learning processes in companies (the artifacts that document and hence 'include' knowledge). The management of a multitude of knowledge-related content artifacts employs methods of Artificial Intelligence which deal with structures of knowledge-related entities. Here, the ongoing challenge of Knowledge Management is to combine the classical and complex contrast between engineering and human sciences. However, most KM approaches have no feasible approach for combining these two perspectives and therefore either deal with technological problems (like product oriented KM, Organizational Memory, or Information Retrieval), or with people-related issues (like process or human-capital related KM which is often very similar to Organizational Learning). However, this second branch is more capable of clearly differentiating itself from Information Management, which nevertheless serves as a basis science. KM concepts aiming at a true integration of both perspectives are usually only offering and discussing methods for a strategical level and are unable to be transferred to everyday operations.

Figure 7 summarizes the numerous disciplines and their joint contribution to the emergence of KM as a field of research. Please note, that the description of the fields has been abridged and simplified to enable for a maximum of transparency. In general, the six boxes on the right hand side comprise the technological influences on KM whereas the remaining boxes on the left hand side represent the people-oriented sociological impact.

After having introduced the preliminary influences and ideas which resulted in the distinctive discipline of KM, now the actual development of this field of research will be examined in more detail.

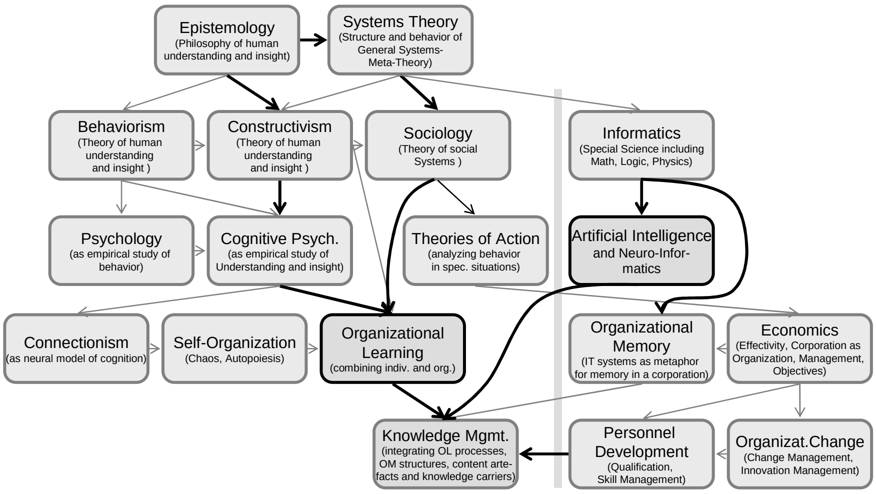

Figure 7: Overview about the Roots of Knowledge Management and their Connections.

Before the next chapter starts to introduce the approaches of the first wave of KM, it has to be noted, that generally, it is very hard to compare and summarize the approaches. Therefore, this chapter tries to identify the connections between the most influential concepts by chronologically arranging them on a timeline and by analyzing their scientific contribution to rendering a consistent theory and to develop applicable instruments. Here, it has to be warned, that the act of reconstructing a timeline is strongly subjective as it is subject to the author's focus and the selection of the 'main' idea or contribution. The primary problem is, that theories do not take into account each other completely, which is sometimes also intended to challenge existing theories. This results in heterogeneity and even incommensurability of new ideas which are not discussing all previous thoughts. Moreover, it is usually difficult to understand the tacit parts of many theories (mainly because the tacit understanding of the author's research object 'knowledge' can differ).

2.2.2 The first Wave of KM Concepts – Push Orientation

As already anticipated in the introduction to this section, remarkably in line with the economic cycle, Knowledge Management came about in two waves. The first wave went until about 2001. Following the general zeitgeist of the new economy, KM researchers and practitioners wildly proposed a multitude of approaches and opinions about how KM should look like. This left the student of the literature very confused and without a clear picture of how to employ KM. In this situation, risk friendly companies competed for being the first to have implemented the latest idea without actually checking feasibility and barriers beforehand. Some smaller companies even superficially implemented KM systems only for their communication strategy towards their shareholders without really employing the systems. However, this quick practical adoption resulted in a steep learning curve and a fast progress of theory development.

This book's approach to classify and evaluate the approaches is to position them in a way that highlights their contribution to the overall objective of the theory of KM: to generate an operative set of measures and instruments for corporate application, which are derived from a general and appropriate KM vision.

The following Figure 8 shows the employed roadmap concept for analyzing KM theory development in more detail. The applied scheme includes seven stages. It assumes that KM approaches advance by subsequently aiming at achieving two subsequent objectives. They first seek to precisely describe the problem, which KM is about to solve and hence relate to the question 'WHAT has to be done by KM?' – thereby pointing to the problem. In a second step, the discipline progresses towards proposing answers to the question of 'HOW can it be done?' which points to the (practical) solution. On every step, hypotheses on different levels of abstraction can be examined to advance the comprehension of an otherwise very unstructured evolvement of KM theory.

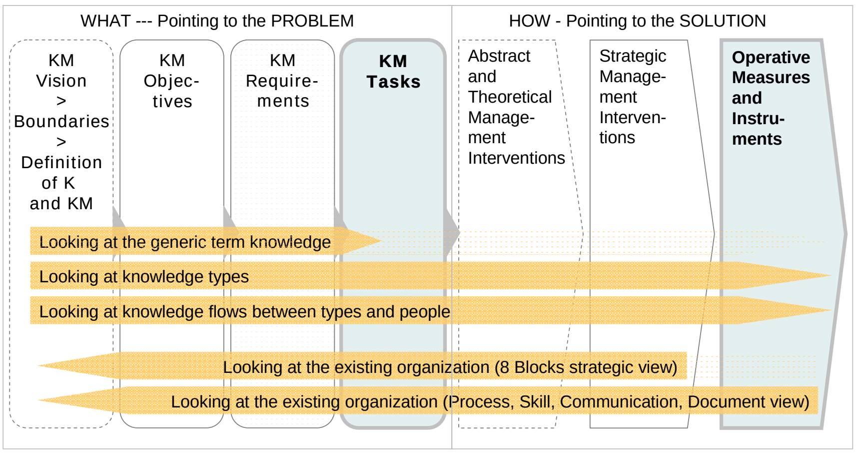

Figure 8: A generic Roadmap for the Development of KM as a Theory.

The broadest level of KM-related theoretical contributions includes approaches that discuss the vision for Knowledge Management (stage 1a) and the boundaries (1b) of the discipline. Here, the introduced preceding roots are discussed and extended. This gives a first high-level orientation for the overall research direction. Afterwards, on a more advanced level, authors worked (and continuously work) on a shared definition (1c) of what KM actually is. Using this definition, further approaches can discuss and propose the objectives (2) of managing knowledge and the respective requirements (3), which have to be fulfilled when Knowledge Management is to be introduced in a company. The most detailed level of theory evolvement is an elaborated and theoretically sound discussion of the actual tasks of a (holistic) management system for knowledge (4). However, up to this point, the according contributions have only clarified the problem but have made no suggestions for *how* the actual management of knowledge should look like in practice. This subsequent solution oriented domain of KM theory starts with first approaches towards abstract and theoretical management interventions (5), followed by a more detailed description of strategic management activities (6). The most advanced concepts target the derivation of practically applicable operative measures and instruments (7), which have of course to be based on all other stages of KM theory development. This whole sequence of evolutionary steps (1 to 7) can be perceived as a top-down approach to developing KM theory. These steps will now be utilized to classify and allocate the various introduced KM theories of the first wave in order to create transparency about the underlying progress in theory development.

As introduced in the previous section, a first major inspiration for KM theory was provided by the preceding Organizational Learning theory[13]. It analyzed corporate learning processes and as a by-product discovered the idea of managing the results of learning processes: experience, memory (storing experiences) and finally knowledge which can be employed using this memory[14]. For example, Hedberg analyzed in 1981 (Hedberg, 1991) the concept of Organizational Memory. According to him, it determines the cognitive processes of information processing for the whole organization, which constitutes the structural basis for Organizational Learning processes. He creates the link between the processes of learning, the organizational memory structure which is utilizing learning processes as input, and knowledge which is needed to subsequently utilize the Organizational Memory. This concept of Organizational Memory has been analyzed more exactly by Wegner in 1987 who suggested the concept of a Transactive Memory System, which is a mutual dependent system of knowledge storage. People scan individual memory using communication to socially combine found elements (Wegner, 1987:191). According to the classification scheme proposed in Figure 8, these first contributions tried to render a rough description of the concepts of knowledge and of Knowledge Management but only as a by-product. They approached this topic's borders from the outside and framed a first rough vision of a discipline, which later should evolve to become KM.

In 1989, Pautzke (1989) focused directly on the element knowledge and isolated it from the learning processes and memory structures in order to analyze its proper-

[13] Compare for previous section for a very brief overview about the sequential relations of preceding related theories.

[14] Also compare the concepts related to the term knowledge in chapter 2.1.3.

ties in more detail. This description led to the segregation of different layers of knowledge, reaching from accessible individual knowledge to inaccessible individual and collective knowledge. Although he creates a first typology of the organization's knowledge base as the knowledge, which can be utilized by the organization, the model is very abstract and of low utility for corporate practice as it does not allow for deriving systematic ways of how to employ this asset. Still, he contributed to the later discussion of knowledge types (also cf. section 2.1.3) and their role for different KM activities and he directed the focus to the abstract potential (which relates to the **vision**) of trying to manage the knowledge in a company.

Also in 1989, Kleinhans conceives knowledge to be managed as an object which can either exist directly or can be accessed and isolated via the knowledge carriers (as a 'container' subject). This perspective on knowledge does not take into account the complexity of the concept of knowledge as defined by epistemology. Still, this reductionism enabled Kleinhans to determine a technical, personnel, and an institutional problem **domain** for the field of KM. This is emphasizing the multiple relations to Human Resource Management and Organizational Science. He also includes Computer Science, thus identifying the potential of extending the related concept of Information Management. In this way, Kleinhans outlines a **boundary** of the discipline KM and gives a first and very rudimentary outlook on its **objective**. Subsequently, researchers in these disciplines recognized the discussed potentials, implicitly adopted this pragmatic perspective, and started researching knowledge and its management in their disciplines.

One early example of how this momentum influenced other disciplines is the conceptualization of different application layers of Information Technology by Hanker in 1990. He supposes the four layers: support of operative processes, management support, competitive strategy, and finally organizational strategy including Knowledge Management as the highest level (Hanker, 1990). This also shows that KM initially has not been positioned at the operational end.

By analyzing the structure of Organizational Memory in a company, Walsh and Ungson (1991:64) are also indirectly contributing to the field of KM by extending and operationalizing the concepts of the above authors. They identify six different knowledge carriers (i.e. repositories): people (which store experience using technical support and knowledge carriers), culture (storing values and soft issues), transformations including processes and individual activities, structures (and the according roles), ecology (workplace), and external archives. Although the authors explicitly focus on relevant information and its locus, they also analyze how the information is stored and retrieved from a 'retention facility'. They outline a preliminary picture showing which knowledge **domains** have to be managed in a company, implying the big scope of this endeavor. Next to helping to define broad domains for a KM initiative, i.e. working on culture, people, and processes, they see the actual artifacts as only indirectly accessible results of people's interactions, or cultural and business processes. This results in a clearer picture of the theoretical **boundary** of KM and its major objectives, as the authors suggest, *where* KM has to intervene.

An early and very influential concept of how to manage knowledge also rests on a typology of knowledge. It was produced in the same year by Nonaka (1991)[15]. Nonaka did not work with locational properties of different knowledge domains, but with the properties of different knowledge types. By this, he directly relates to previous epistemological research by applying Polanyi's (1985) separation into tacit and explicit knowledge. He is relating this concept to the individual level and much more important, he links it with the Organizational Learning perspective when he analyzes knowledge creation at the individual and organizational level. Here, he identified four important types of knowledge transfer, namely Socialization, Externalization, Combination, and Internalization[16]. Nonaka also manages to provide a first empirical validation of a KM concept (which is up to now not provided by many 'approaches' in the field) using an analysis of product and process development in Japanese enterprises.

With this approach, Nonaka's primary theoretical achievement was to shift the research focus away from Walsh and Ungson's restrictive conception of knowledge as an object in a retention facility towards the flow, conversion, and transfer between different forms of knowledge on different organizational levels. This change in perspective has the advantage to not limit Knowledge Management to storing artifacts but to look for the actual transfer, communication, and development of knowledge in social processes between people. This also strengthens the position of conceiving knowledge as bound to people. Next to bringing KM theory in compliance with the connectionist discovery that knowledge is a network structure of interrelated information (neural networks), the actual challenge of KM is hence less the systematical storage which can be left to Information Management but rather the utilization of the domain of tacit knowledge. The lack of a practical implementation shows that Nonaka's approach does not provide a real operative and prescriptive procedure for improving Knowledge Management in a company but it aids as a preliminary think tool. However, from the perspective of KM theory advancement, the division into knowledge types and the focus on the flows between them influenced the definition of the scope and the **objectives** of the discipline very much. Nonaka furthermore contributed to the analysis of objectives and requirements for knowledge transfer, when he suggests five prerequisites for knowledge generation in organizations: intention (vision), autonomy of employees, fluctuation (dynamics), redundancy, and internal heterogeneity. The move-

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[15] However, the most complete work was the co-production of Nonaka and Takeuchi published in 1995.

[16] This is why this model is also referred to as SECI-Model. This work will not describe such theories in more detail, as a plethora of descriptions can be found in other documents, including the internet.

ment towards such a corporate environment is a first **strategic objective** of knowledge oriented management. In the years 1992 to 1995, Nonaka went to extend his first paper to a book and many concurrent approaches tried to build on his ideas.

Somewhat not incorporating this development, in 1993, Albrecht (1993) framed a second trinity of domains next to the one of Kleinhans in 1989. It consists of Knowledge Resource Management, Human Resource Management (HRM), and Knowledge Technology Management. He managed to propose a first list of **generic tasks**, which can be attributed to the discipline KM (Albrecht, 1993:102). They included the combination of knowledge orientation and strategic vision, the creation of a knowledge-oriented corporate culture, the development of a knowledge strategy, the strategic management of human resources and of knowledge oriented technology as well as the practical implementation of the knowledge related strategy. However, there is no concrete suggestion of what these steps contain and how they should be executed. Still, this list of tasks also shows that a knowledge manager has no novel and distinct field of expert work, but rather integrates existing perspectives like HRM, IT, Strategy, and Leadership and emphasizes their important interconnections.

In the year 1996, the momentum of the discipline increased again. The existing rudimentary theoretical foundation for the **objectives** of KM was improved by the work of Grant (1996), who explored the resource based view of KM and found an economical foundation for the role of KM, which also substantiates the importance of this discipline for management. According to Grant, enterprises exist because of the limited capacity and capability of the human brain to acquire, store and process knowledge. This results in specialization, which requires coordination to solve complex solutions. Markets are unable to manage this coordination, because they can not mobilize tacit knowledge. That is why enterprises allow individuals to integrate their special knowledge. KM is therefore the creation of conditions which allow the employees to build collective knowledge.

Unsatisfied with the many normative but unproved hypotheses, assertions and inapplicable KM objectives which have been proposed in the first half of the 1990s, Schneider (1996:34) worked towards more **operative requirements** of KM. He identifies three necessary shifts in theory:

- from concentrating on ideas and proposals towards supporting people and their ability to generate ideas and proposals,
- from employing documentation and data storage towards reuse and develop data in interpersonal networks, and
- from informed experts towards networked and shared learning.

More generally, he proposes a concept with the elements combining existing knowledge, generating new knowledge, improved documentation, and systematic observation of the environment to increase knowledge. He furthermore stresses the importance of capturing the economical benefits and costs to create a controlling and management around these tasks. Schneider differentiated the three generic domains technology, organization and employee and derived a list of more operational tasks for each domain, including connecting and integrating IT, decreasing organizational hierarchies, hiring diverse people, awarding creative experiments, assigning free budgets, emphasizing teams and empowerment, creating a learning culture, implementing mentor programs or yellow pages, and developing trust among the employees. On a very abstract level it can be observed that all his tasks relate somehow to networking. This first implicit anticipation of a very fundamental underlying mechanism of supporting Knowledge Work will be later discussed and elevated to become the main perspective of this book and its developed contribution to Knowledge Management.

Schneider's concept is a good example of how theories began to transcend the academic and unprogressive discussion of the problem domain and moved towards a **solution perspective** with first generic suggestions of 'how' to do KM.

A clear indication of this development has also been given by Reinhardt and Beyer (1997), who propose a set of questions for a structured KM Analysis: How well is information identified and acquired? Is tacit knowledge sufficiently being provided to others? Is the system of communication channels appropriate or are there barriers for communication? Which assumptions determine activities? Is there openness to change and diversity? Together, these questions provide a first guidance for practical implementation of a KM **analysis** but miss the necessary underlying procedure and methodology to comprise a theoretical KM approach in its own right. However, the authors' contribution somehow preempts the strong analytical touch and (inverted) bottom-up-approach of KM found in the second wave concepts, discussed in the next chapter.

Schueppel (1996:192) suggests a further but more methodical generic **analysis**. It starts with the determination of 'knowledge elements' and analyzes individual and collective learning processes around these elements. Then, barriers for these learning processes need to be identified in order to derive appropriate changes of the organization. Although this concept starts by looking at knowledge elements (topics), it is very generic and does not systematically relate the identified problems to appropriate solutions. Hence, it is not providing much operative guidance for KM projects as it is not much related to the everyday operations and work tasks. However, the perspective of analyzing learning processes again highlights the strong relation between KM and Organizational Learning.

Another approach towards KM **domains** which stresses the connection of learning and KM was suggested by Willke (1996). He claims that the creation of an intelligent organization rests on concepts for competence management, qualification, and the ability to learn. To some extend, this approach is similar to Human Resource Management but uses a new terminology, thus its insight is similar to that of Schneider who published his concept in the same year. The two previous approaches of Willke and Schueppel imply the difficulty to operationalize the existing (organizational) learning theory to support operational business tasks.

A contrary example, which is very operative but hardly includes people or learning, is the rather technical Lifecycle Model of KM by Rehaeuser and Krcmar (1996:20). It suggests **abstract tasks** which include the management of sources (identify, generate, and capture), of knowledge carriers (storage) and resources (artifacts), knowledge supply (provision of knowledge to problems, refinement of knowledge), knowledge demand (interpret supplied knowledge and act), as well as communication and processing infrastructures (personnel, organizational, technical). The model is descriptive, but not proposing directions for actions (North, 1999:167). Its focus on explicit knowledge allows for a very concrete approach and shows that concepts for documentation and IT-related tasks of KM are far easier to establish than strategies targeting tacit knowledge. However, it is actually not meeting the core challenge of KM, because if the people oriented perspective (i.e. tacit and collective knowledge) and the learning processes are excluded, this perspective does not exceed the conventional idea of information management.

Analyzing the two different strands of concepts implied by the previous contributions, Schueppel (1997:187) could categorize two generic families of approaches which focus two **domains**: human oriented and technology oriented KM. Driven by sociological and psychological insights, the first defines individuals as the central knowledge carrier and aligns KM close to Personnel Management. The latter is only focusing explicit knowledge which should actually be called information.[17] He stresses the importance of combining human capabilities with supportive technology into an integrative approach. KM theories which belong to the realm of Organizational Learning need to merge with information management instruments towards an integrated Knowledge Management. This integrative approach is necessary to move towards the next step in KM theory advancement, the proposition of a set of practical management activities, which utilize appropriate instruments and technologies. It eventually prepares for scientific answers to the question of *how* to arrive at a KM solution.

A further important insight of the approaches after 1996 was a **central knowledge (management) process**, from which KM measures could be derived. It was found, that the concepts can only become more operational, if the activities are more specifically oriented towards special aspects of a knowledge flow. This strategy is based on the preliminary knowledge process found in Nonaka's knowledge transformation approach. The concept has now become extended to operationalize the set of KM measures.

[17] How could the ability to connect information and to apply it to solve a problem with a promising action be explicated? Also compare for this book's working definition of knowledge on page 21.

Christmann-Jacoby's and Maas' (1997:23) conclusion, that KM is the process of knowledge acquisition, finding, and structuring contains a first segregation into a knowledge process, although they do more relate to Organizational Learning than to KM. Reinmann-Rothmeier and Mandl (1997:22) also proposed general KM **activities**. They include information dissemination, information selection, the creation of knowledge networks, storing knowledge, distributing knowledge, exchanging knowledge, applying knowledge, and evaluating actions to create new knowledge. With these KM activities they prepare for a very detailed model of a knowledge process, the renowned 'Eight Building Blocks Model' of Probst et al. (1997). Here, the authors utilize the knowledge related activities to break down the knowledge flow into six basic elements in order to move towards more **operational interventions** which are directed at improving the individual elements. The heuristic is that when KM supports each building block, the overall knowledge flow improves. The six elements are knowledge identification, knowledge acquisition, knowledge creation, knowledge dissemination, knowledge utilization, and knowledge storage. The authors embedded these elements in a feedback loop of knowledge planning and controlling, thereby constituting the actual management layer of KM. However, North identifies only little support for implementation and a missing link to operative processes (North 1999:167). An interesting aspect of this model is that it has been derived on a forum on Organizational Learning together with many practitioners. The knowledge process elements resemble learning phases. Compare for example Pawlowski's (1994:21) identification, generation, diffusion, integration, modification, and action. Again, the transition from Organizational Learning to KM and the addition of IT aspects can be identified. The model of Probst et al. (1997) has been generated deductively by analyzing practical requirements and working towards a KM vision. This is quite contrary to most other approaches which start by outlining the vision of KM. This bottom-up methodology can provide for the necessary connection to business operations and is thus a very important shift[18]. However, the preceding theoretical contributions where also necessary to establish a vision of what should actually be observed and analyzed in practice. Further, the bottom-up direction of Probst et al. raises the question, whether the different captured aspects are able to be integrated into a consistent project or KM vision.

A further concept related to the knowledge process is called Framework of integrated KM and was proposed by Reinhardt and Pawlowski (1997). The authors employ a learning cycle model to identify several types of KM analysis. Phase one is called Identification and includes an analysis of recognition and information acquisition. The next phase Diffusion is comprised of a communication channel analysis plus the related communication barriers. In the Integration phase, it is asked, whether new knowledge is ignored or integrated. The last element, the Action stage, asks if knowledge is getting applied. This analytical concept follows a

[18] (Also cf. the adversely directed arrow on the bottom of Figure 8)

qualitative approach of going into companies in order to talk about these issues in an interview. Subsequently, change management and **organizational development measures** are proposed. By this, the method very much resembles Schueppel's (1996) previously published analytical instrument which analyzed learning barriers (see above). Further, it is a rather abstract approach which is not directly related to the everyday work tasks (North, 1999:155). Neither there is a set of measures related to identifying weaknesses nor are operative suggestions given for KM implementation and improvement (North, 1999:167). Finally, the question is how these processes differ from Organizational Learning Theories as they analyze the processes of knowledge acquisition which is simultaneously the classical domain of learning research.

Probst's bottom-up approach which included practitioner's expertise in KM also shows that meanwhile, the increase in practical KM initiatives allowed for the analysis of first corporate case studies to verify the approaches, identify barriers and observe the status quo of KM theory development and its application in enterprises. The increasing opportunity to actually observe KM activities in enterprises also advanced theory development.

In an empirical study, Bullinger et al. (1997:39) identified the creation of organizational networks, the methodical development of knowledge in the company, training, and the transfer of best-practices as important **project elements** for German companies. Less important than expected was storing expert knowledge. Among the most relevant barriers the authors observed a lack of time (which is an indicator for low priority), missing attention to the issue, missing transparency, motivation, and transfer processes. A big potential is being projected for IT which can be employed to integrate knowledge supply and demand systematically with a supporting platform (Bullinger, 1998). Such empirical insights can subsequently emphasize the important contributions (and the expected barriers) of KM instruments, which needs to be taken into consideration by researchers.

One year later, Davenport (1998) reported about the most important KM **project domains** for American firms and also shows practical strategies and barriers. According to him, in practice the term KM boils down to creating knowledge bases, increase access to current knowledge, and to create infrastructures. This is quite contradicting with the above findings of Bullinger et al. (1997). Davenport identified project elements which are important for KM success, namely working on organizational structure, knowledge structure, culture adaptation, integrated terminology, motivation schemes, and knowledge transfer on various communication channels. He sees the danger, that if practitioners can not systematically identify what knowledge to work on, they tend to risk information overload by the introduction of their KM technologies. Among the barriers Davenport identified missing mutual obligation, divergent contexts and cultures, low levels of trust, low acceptance of knowledge due to time restrictions or missing opportunities to meet, and finally role constrained and superstitious learning.

Next to this operative verification of KM approaches by surveying corporate initiatives, a further interesting line of thought emerged in 1998. The first event of a process oriented view on KM can be noticed. It augments the perspective of segregating the knowledge (management) process by observing the processes executed by the experts.[19]

In this context, Kuehn and Abecker (1998:185) segregate a product perspective (which looks on knowledge documents in Document Management Systems and hence treats knowledge as an object) and a process view, which looks on social communication processes and their technical support by groupware and workflow management systems. Although the initial dichotomy is similar to Schueppel (1997), it is a first approach towards a process view. However, the actual relation to business processes was created by Wargitsch (1998:17). He demands, that KM should look at the object knowledge *and* the business processes which generate it. By this the scientific management of Taylor (1911) and the first preliminary conclusions of Penrose (1958; see above) finally re-enter the KM discipline.

So far, it can be generalized, that the dichotomical categories developed to better explain the strands of KM theory obviously can be allocated to the broad concepts ‘product’ or ‘object’ and ‘processes’ or ‘communication’. On an abstract level, this is the contrast between watching an element as knowledge or the relation between elements (which is again highlighting the initial shift in focus of Nonaka, see above). This duality remarkably resembles early discussions in neural biology where the theory of knowledge as a stored imagery in the brain was slowly replaced by the view that knowledge resides in the networks of connections *between* neurons (cf. Anderson, 1995).

In 1999, the main dichotomy became empirically substantiated by Hansen et al. The authors analyzed many corporate instantiations of KM and empirically verified the two main KM strategies, which the authors named Codification and Personalization. The underlying insight is not new: the management of knowledge has to focus tacit knowledge using personalization and learning strategies, but for rather standardized fields, practitioners indeed employ a codification strategy with a strong focus on IT support. Moreover, it was found, that companies tend to focus one of the two strategies - showing, that real integrative KM as theoretically proposed for years has not reached corporate practice at that time.

The empirical findings also imply a very important further differentiation, which can help to understand the two sides of KM as a part of an integrative approach. Knowledge transfer can be separated into *direct* knowledge transfer (directly between people) and *indirect* knowledge transfer (indirectly via knowledge objects or artifacts, like documents). This distinction also shows that there are actually two process oriented perspectives possible (which is somewhat dissolving the di-

[19] This later specialized towards a business process and a network oriented perspective. Also compare chapter 2.2.3.

chotomy of Kuehn and Abecker, 1998:185). There is a process for direct communication between people but also one for indirectly documenting the insights of people to internalize them afterwards. If Wargitsch's idea is also to be included, the question is now, how the business processes interrelate with these processes of knowledge exchange. [20]

With all the empirical insights, the discussion about required KM **project elements** and procedures was furthered by Seidel and Lehner (1999). They proposed a set of **project packages** targeted at corporate culture, incentive systems, information systems, and finally at leadership/management systems. This also shows the role of IT; it only covers one quarter of a KM project.

Without really relating his work to his predecessors but by analyzing their shortcomings, North (1999) proposed a further KM approach called 'Knowledge Market'. He claims that it is empirically sound, because it has been developed in a corporate project. It consists of three elements or organizational layers. First, the framework conditions (like a vision) and the incentive system are getting defined. Then supportive knowledge market rules are set, including the definition of clusters of interests (North, 1999:233), best practices, individual experts, centers of excellence, or networks as a visible hubs, and push vs. pull elements of the KM initiative. Finally, from this concept, processes and structures for operative KM are derived for the knowledge carriers person, network, process, and organizational unit, using different media. Among these operative measures are structured processes for knowledge integration like best practice transfer or benchmarking, coaching of knowledge development via a moderator, matching interests, and structuring projects. Despite introducing three layers **from strategic to operations**, the derivation of operative instruments and their final combination and implementation is not really integrated and supported by systematic rules, although this level is the most challenging element of a KM procedural model.

Instead of detailing the lack in implementation guidance of the previous contributions, North and Papp later tried to shed some light on the first steps of a KM project, when they suggested a system of initial situations which precede KM (North/Papp, 1999) in order to categorize KM project activities: KM can either start with new IT and Knowledge Management Systems (KMS), with the establishment of a CKO, with best practice and knowledge exchange, or with top-down strategic initiatives. Although these situations were intended as paths, the subsequent **suggestions for activities** are quite hypothetical and how to develop them is not discussed at all. The collection of situations even shows, that the authors want to start with some measures, which are not derived from a goal – a typical push oriented concept, which is representative for the approaches before 2001.

[20] This question will be further examined in the chapter on second wave concepts. They produced an own section of process oriented KM.

It can be observed, that the approaches which intended to propose procedures for KM implementation increased after 1998. Still, their underlying push oriented perspective is resulting in top-down procedures which derive business activities from a conceptual KM strategy or in out-of-the-box solutions which just have to be implemented in order to end up with successful KM. For example, the three instruments suggested by North (see paragraph above) actually do not derive their application field.

The premature and somehow unsatisfactory stage of KM theory development during these years can be further substantiated by highlighting some conclusions drawn by Lehner in 2000 (Lehner, 2000:231), which also summarize the status quo. There is consensus, that KM is a systematic procedure to identify, collect and store knowledge in an organization. However, concurrent approaches show that there is no consensus about how to actually do that. Hence, this missing clarity about 'how' to do KM is highlighting the poor system behind all existing approaches and their lack of interrelation. Hence, taking the initial maturity model of KM theory development in Figure 8 on page 26, the solution oriented stages have been tried to approach by theories but during the first wave, they have not yet satisfactory solved this challenge.

The restrictions of the underlying push orientation of the introduced approaches can also be implied by the reflexive summary of Lehner (2000:261). At this time, typical KM project procedures were starting with the definition of the organizational responsibles and their task profiles[21]. Taking these specifications as a starting point, the continued with the establishment of the according incentive system, then set up the IT system, and defined objectives. There is no general preceding stage of situation analysis, despite first individual analytical concepts like e.g. from Schueppler (1996).

Economically, this push orientation resulted in the predominance of a rather technical perspective similar to Information Management (Lehner, 2000:144). This again was propelled by an increasingly simplified focus on explicit knowledge artifacts, i.e. documents or contents (thus information) despite the theoretical proposition, that KM requires a comprehensive sociological element because human knowledge carriers have to be included. This implies a big need of improving corporate applications of information systems and Information Management to remain competitive. However, following this development, around 2000, most corporate projects technocratically concentrated on implementing some KM software and thus did not really changed their way to manage Knowledge Work. Sometimes the budget was only spent for enriching the intranet, without recognizing the other necessary project domains including change, incentive, human resource,

[21] Without telling, how these tasks can be derived. Actually the definition of the role to carry out tasks is the final step after important tasks have been identified from business situations.

process, and communication management. This is also substantiated by a survey of KPMG (2003). The strong dependence on technology led to the undermining of theories by New Economy software suppliers. They managed to bring the term KM into close relationship to their software products and thus affected its usage. This lead to the problem, that big companies increasingly associated KM with their software products (often equipped with a completely subjective and product-related implementation method). Being dependent on these small and shallow software products, which often were far from being a mature application, the discipline of KM was heavily affected by the economic downturn in 2001, which eliminated about 90 percent of all ‘KM’ software vendors[22]. As only few organizational measures for learning and knowledge transfer were in place, the product-centered KM approaches became affected, too.

In conclusion, the first wave of approaches moved towards pushing KM structures and technologies into a company using a top-down approach. The theoretical research was not applicable, as the researchers at that time usually only separated the fields into various segments, which (were and) could not be translated into practical project-methods or organizational operations and structures (‘concept giants’ vs. ‘implementation dwarfs’). This irritated companies, which preferred to apply a simpler but working KM concept by choosing and implementing applicable software packages (e.g. via simply visiting software exhibitions). All corporate projects concentrated on selecting often very fancy KM platforms or other IT components relevant for KM. This resulted in too much hype of consultancies and technology vendors, who only repackaged their methods or products to sell it under the new label KM. Usually this resulted in acceptance barriers, as complexity increased because there is simply one more application to be used by the workforce. Mostly, IT responsibles where allocated as project managers. They viewed KM from their technical perspective and often enough did not check beforehand the acceptance of the used tools in the various departments. The focus was on documentation and codification: trying to build huge databases of relevant documents was hence the major objective of a first wave of KM that was technology driven and enthusiastic about artificial intelligence.

Knowledge Managers did not employ any strategy or tried to influence corporate culture towards the motivation of sharing knowledge. They also neglected the necessary creation of back office structures and reengineering of knowledge intense processes. Often enough the budget was just calculated for the IT implementation, and hence there was no money left for change management, training, internal marketing and the like.

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[22] In an internal KM project conducted in 2003, a software survey resulted in the insight that out of about fourty vendors which offered what they call KM solutions before 2001, only about four survived to offer their product in 2003. This is by far a more realistic number to serve the required market demand for KM software.

Finally, the inability to measure investments led to considering expectations as an investment rule. As money markets prove, this behavior leads to a very unstable behavior, as expectations can suddenly decline. In corporate KM, the boom immediately declined as soon as the expensive projects were running as the acceptance and usage of the provided tools was disappointing. However, there are also examples (e.g. Siemens, PriceWaterhouseCoopers, or Ernest and Young), where enough additional effort has been made to augment the tool with various organizational measures. Moreover, the successful approaches regarded the tools not as their primary focus but as what they are – tools to support something with IT. These companies managed to become successfully employing KM to generate more effectiveness in their divisions.

Immediately after the economical recession of 2001, only little interest for KM was left in companies. They preferred to deal with their core business issues although this is a very dangerous ignorance given the background of the increasing role of Knowledge Work. During these times of cost-reduction and down-sizing (cf. chapter 1), a big advancement for the improvement for the operative implementation of KM was the idea of applying the business process perspective to Knowledge Management. This perspective shifted the focus away from technology-driven push strategies towards demand-driven pull strategies. It is able to connect KM to the operations as it proved successful in analyzing knowledge workers demand and gave a proxy for the efficiency potentials of supporting knowledge work and knowledge workers. With this trusted co-concept Knowledge Management moved towards more analytical approaches which are dominant in the second wave of KM theory evolvement. The people and the actual work situation and environment moved into the focus.

2.2.3 The second wave of KM concepts – Pull-orientation

Around the year 2001, KM approaches changed their focus towards the analysis of a company using a KM perspective. This was due to the decreased interest of enterprises in trying Knowledge Management methods and the increased pressure to move away from abstract top-down methods towards an improved, direct and conceivable link to corporate practice and restrictions. In this successive second wave of KM approaches, which will be analyzed in this chapter, the instruments became more operative, the projects more focal and the project managers more risk avers and rational. A core set of methods emerged and can now be implemented into corporate practice. This correlation to the economical cycle also implies that to a large extend the field of KM has initially been bound to the somehow immature self-understanding of the new economy. However, the subsequent mature approaches should not be ignored just because of this initial stage of adolescence.

The effect may have been fuelled by the insight, that there is no single valid theoretical KM solution possible for the multitude of corporate settings. The concepts emanating from this development can be regarded as belonging to a 'second wave' of KM theory evolvement.

As this wave is still quite young and not as dispersed as the previous, it can not be represented well on a timeline. However, the most important contributions are discussed and listed in Figure 10 on page 52.

Opposite to the technology and top-down oriented push strategy of the first wave, the approaches in this segment can be characterized as pursuing pull oriented Knowledge Management which starts by identifying the demands of Knowledge Workers. Afterwards, they derive KM applications and methods. Here obviously a thorough method for requirements analysis is fundamental.

To support this endeavor, the corporation as the object under consideration needs to be modeled from a knowledge perspective. Here, an overview about the actual KM related entities (which can be analyzed) in a corporation is helpful. A model, which supposes a very general yet comprehensive such overview is the KM entity model of Trier (2003, 2005) shown in Figure 9. It assembles all relevant entities together with their interrelationships on a very aggregated level and can thus serve as a starting point to analyze a company. The respective model elements are process/activity, document, employee, and topic. These elements have been found necessary to analyze in corporate KM projects conducted by the author. Connecting these four main entities automatically directs the focus to very relevant relationships between the concepts. For example, an author is connected with other authors, with topics, his documents and of course with the processes or activities he is responsible for.

The KM entity model now allows for allocating different approaches to check for their coverage of the four domains and their interrelations. For example, the early KM approaches of the first wave, which treated knowledge as an object, focused on the entity document with the attached authoring person and the related topics or other documents. This perspective thus ignores the entity process/activity and various relations between authors and processes as well as the direct knowledge exchange between different authors. The limitations in terms of a low coverage of the model's KM entities lead to reducing KM to Information Management and Data, Document, and Content Management.[23]

A further and very widespread approach to collect requirements for an analytical methodology for KM is to follow the sequence of business activities of the respective employees and hence the relation between the entities employee and process activity. If now the potential application of KM instruments to support important knowledge objects and topics related to the activities of the business processes is

[23] Which is of course a very important aspect (and result) of a KM implementation, but not its primary objective.

concerned, this process analysis is called process oriented Knowledge Management (also cf. Wargitsch, 1998, who first explicitly demanded this perspective).

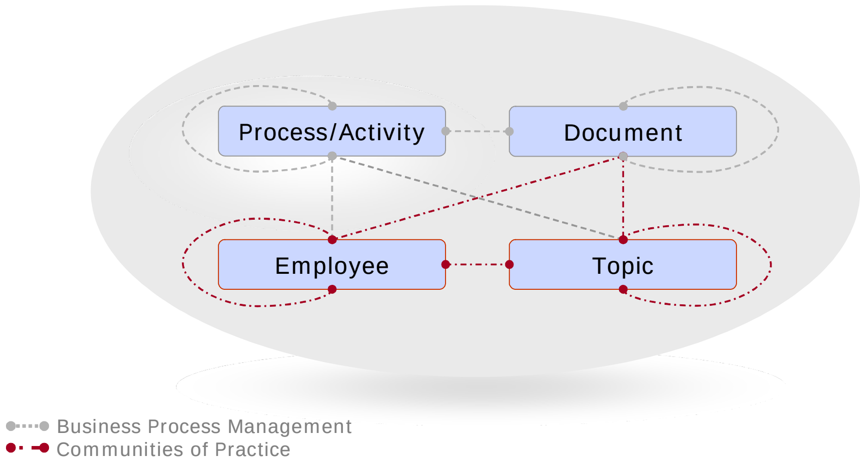

Figure 9: The KM Entity Model.

The KM entity model highlights the importance of the business process oriented approach to KM. It covers the process (as a sequence of activities), the attached responsible person and the related documents necessary for the transactions. Still, the domain of topic is missing. Here, recent modeling approaches for knowledge intensive business processes extended the conventional method in exactly this direction to increase the coverage of the entities in the KM entity model. The main innovation has been the introduction of topic elements into process models (see for example Gronau et al., 2003). Still, the numerous interrelations between employees, connections between employees and topics or topics and documents, or dependencies between documents are not included. There are two directions possible to overcome this limitation. First, process orientation can move towards a multi-perspective approach, which only uses processes as their main orientation but then also includes document structures and other network views on the KM entity model. The alternative option is to employ a different primary perspective. It has to be an analytical perspective which starts from the actual knowledge carriers, the people who do the Knowledge Work, and includes their networks and various connections to topics, documents, and processes. Whereas the business process oriented approach assumes codification and defined task structures as the primary objective, the network oriented approach starts from the employee and is less deterministic as it assumes that task structures are a changing contextual result. However, both approaches can be combined.

The network oriented approach to Knowledge Management will now be discussed and derived in more detail throughout the subsequent sections of this book. For this people network oriented approach, the existing network oriented approach of

Communities of Practice (CoP) constitutes the main analytical perspective and KM instrument (e.g. Allee, 2000; Enkel et al., 2002; Seufert et al., 1999). As part 4 will show, they actually contain networks of people which are gravitating around topics (Wenger, 1998) and documents. Returning to the KM entity model in Figure 9, CoPs comprise a different content-, people-, and network oriented perspective next to the transactional and process oriented perspective or the explicit knowledge objects (document) perspective. In this way, CoPs are a valuable and complementing instrument within Knowledge Management in corporations (Enkel et al., 2002).

Summarizing, the main contribution of the KM entity model is that KM needs to provide for a better transparency about the enterprise, by managing not objects but the multiple relations between entities and moreover between the various instances of one entity: e.g. which employees are related or which documents are related. With this approach two major strands of analysis and management can be revealed: next to process oriented KM, a people and network oriented KM approach is to be applied to cover the complete requirements of corporate Knowledge Management. This is in line with the two main KM strategies proposed by Hansen et al. (1999), namely Codification and Personalization (see section 2.2.2). Figure 9 also shows, that the process oriented and the people- or network oriented perspective are indeed very complementary so that a combination of both approaches might also be possible. This is thus substantiating the idea of combining Codification and Personalization (Hansen et al., 1999) despite Hansen's hypothesis of mutual exclusiveness in actual corporate applications.

The two perspectives together form the main concepts of the second wave of KM theory contributions. After the year 2000 the KM discussion moved away from 'concept giants' to focus on a more operative level (however, still recognizing the important strategy and management layer). Both second wave approaches were increasingly discussed, analyzed and developed to enable a more effective management of corporate knowledge. The two main strands will now be briefly introduced to complete the longitudinal observation of how the discipline of Knowledge Management evolved.

2.2.3.1 Process oriented KM Approaches

Starting in 2001, the disciplines of Knowledge Management and Business Process Management merge towards an integrated process oriented Knowledge Management approach. Next to the explanatory categorization of the last section, in an alternative explanation approach, which also aims at classifying different research approaches, Abecker et al. (2002) differentiated three different layers. Both approaches differ in their perspective. Whereas Trier (2005) proposes the main entities or domains and identifies differences between approaches by analyzing their coverage and main perspective of these entities, Abecker et al. try to establish layers of different granularity in order to position business process-oriented knowledge. On the top layer, strategic business process oriented Knowledge Management is a top-down perspective, which derives knowledge objectives from the long-term business objectives. The bottom layer deals with KM design based on communication analysis and diagnosis. It primarily deals with communication aspects of knowledge work and develops appropriate methods or tools. It is thus very hard to be separated from the middle layer, where Abecker allocates approaches of business process oriented design, where methods and tools for business process analysis are extended to meet the new requirements of Knowledge Management[24]. This middle layer is dealing with modeling methods derived from business process management and the modeling of existing processes to find potential for improvement. Here it has to be noted, that although differentiating layers might look like a feasible approach to segment the various KM approaches, this concept does not create the impression, that in practice actually every layer must be instantiated in a meaningful KM approach. Strategy has no use if there is no connection to processes and communication. This is why in this book, the entity oriented segmentation as presented in the last chapter is preferred. However, the three levels can also be interpreted as a maturity model, as the one introduced in Figure 8 and are thus similar to the classification into two waves pursued in this book (a first wave of strategic analysis and a second wave of a complementary application of process and network based KM, similar to Codification and Personalization). With this perspective, network oriented KM appears as the most advanced and most detailed approach.

The main existing approaches which belong to Abecker's process category are introduced now, although it has to be added that all lack in specification. The main contributions to this field are CommonKADS, Promote, BPO-KM (GPO-WM in German), and KMDL. Additionally, a further approach will be introduced, which has been developed in practical project work by the author to aid as a project procedure for process oriented Knowledge Management projects (POKM method).[25]

The CommonKADS approach (Schreiber et al., 2000:17) is a method which initially was developed in a big European Research Program to generate a methodical support for knowledge engineering.[26] This established approach to Knowledge Engineering has been developed long before 2001 but influenced the second wave KM concepts and their capturing of knowledge intensive business processes to a large extend. Although its original objective of constructing a program that can perform a difficult task adequately is completely different, its process of Knowledge Acquisition can be regarded as similar, because Knowledge Acquisition includes the elicitation, collection, analysis, modeling, and validation of knowledge

[24] In central Europe they comprise the predominant part of current KM approaches.

[25] An overview about current process-related approaches can also be found in the work of Remus (2002:37).

[26] This related discipline of KM is mainly analyzing a corporate domain to generate knowledge-based systems, like for instance expert systems.

for Knowledge Engineering and Knowledge Management projects (Milton, 2003). The according Knowledge Acquisition (KA) techniques have been developed to help with the elicitation of knowledge from an expert. Obviously, they focus the same issue of examining and analyzing knowledge intensive business processes. However, the special methods for documenting the expertise of a knowledge worker are not completely applicable in business process oriented KM. This is supported by Abecker, who comments, that the method contains only a few KM-specific concepts and focuses technical infrastructures (Abecker et al., 2002). Another example for the divergence can be derived using the interview structure for domain-knowledge elicitation provided by CommonKADS (Schreiber et al., 2000). It consists of the steps identifying a particular sub-task, ask the expert to identify "rules" used in this task, take each rule, and ask when it is useful and when not. This rule based approach gives no special procedure to ask for the topics of expertise and their relation to the process.

A further approach is the PROMOTE method (Hinkelmann et al., 2002), which integrates strategic planning with the evaluation of Knowledge Management and Business Process Management. The intended scope of the approach covers the analysis, the modeling, and the execution of knowledge intensive processes. It extends the more general method of Business Process Management Systems (BPMS) including strategic decision, reengineering and resource allocation, workflow and performance evaluation. The additional KM related steps are creating awareness for enterprise knowledge, discover knowledge processes, create operational knowledge processes and organizational memory, and evaluate enterprise knowledge. The second element, discovering knowledge processes, deals with capturing knowledge intensive business processes. In the underlying reengineering stage of the BPMS method, process knowledge is getting documented. It consists of the sequence of activities and its related employees, organizational units, necessary data, application systems, and resources. The PROMOTE method now extends this process knowledge to additionally capture functional knowledge, consisting of the identification of knowledge intensive activities, the description of relevant knowledge flows, and the identification of knowledge flows between persons and processes. Although this approach introduces a systematic orientation for the necessary elements to be captured in the context of knowledge intensive business processes, a detailed description of how to elicit these additional items in a KM project and a discussion of the actual pitfalls in the practical implementation would be beneficial.

The next process oriented approach after 2001 is BPO-KM (in German: GPO-WM®) by Heisig (2003). It proposes a method for a process oriented analysis and design of Knowledge Management Solutions. Within this procedure of eight steps, the KM Audit analyzes the fundamental conditions including the evaluation of existing IT systems, the analysis of the information- and knowledge culture, and the determination of the demand for information and knowledge. The main focus of this step is the identification of potential for improvement of the existing utilization of knowledge in the business context. The subsequent step analyzes knowledge intensive processes to identify strengths and weaknesses or possible improvements. Further, the process- and task-related demand for knowledge is identified. Unfortunately, the procedural model does not propose any methods which explain how to capture and model processes on a detailed level and hence, this approach results in a rather strategic analysis of business processes and concentrates on the identification of strengths and potentials for the utilization of knowledge.

A final sample approach of the second wave of KM is currently being developed: KMDL® (Knowledge Modeling Description Language) and the related tool K-modeler. It aims at providing a structured procedural model and the necessary tools to identify and model knowledge intensive business processes. Based on classical process modeling notations, this model includes topics and their properties in the generated model. Using the model, different KM measures can be derived (Gronau et al., 2003).

An own process oriented KM (POKM) project approach has also been developed in corporate projects in the years 2002 to 2004 (Trier and Mueller, 2004). A special focus is put on a detailed method for capturing knowledge intense processes in an interview. It hence it extends the existing broad perspective on this aspect of KM projects. It allows for insights into questions like how to comprehensively capture expert processes, how to store the collected information in a structured way and how to design supporting instruments and materials in order to generate a high quality data set, which subsequently is utilized to derive Knowledge Management measures.

These procedural models are just some examples of the multitude of available approaches. They all provide a comprehensive theoretical model which can help to plan and execute a process oriented KM project. However, their practical execution in corporate settings necessitates detailed procedural specifications of how to actually execute the proposed steps. Further methodical discussions and foundations are required for issues like how to comprehensively capture expert processes, how to store the collected information in a structured way, and how to design supporting instruments and materials in order to ensure a high quality data set, which subsequently is utilized in every type of KM project to derive management measures.

2.2.3.2 Community oriented KM Approaches

As section 2.2.3 already identified, the conventional process oriented approach is not covering relationships between knowledge workers and relations of knowledge objects to a topic. Rather, it employs the process model as the main connecting location, e.g. as the indirect link that can be found between two similar experts. The implicit assumption is that they share their process (and work) context and are hence related. Different topics are arranged along the process. However, there exists a direct relation to the community oriented approach: Knowledge Work in knowledge intensive business processes consists of information processing activities; these are consisting of information acquisition processes. One main method to acquire information is to actually ask related people. Over time a content oriented cooperation and a special yet informational network structure between related people emerges next to their process oriented business tasks. The resulting groups are called communities and comprise a complementary view on knowledge work with a topic or a knowledge carrier oriented perspective[27]. It allows for deriving and observing networks of topic oriented knowledge-objects (i.e. topic taxonomies or semantic networks) or networks of experts in topics (i.e. social networks).[28] As shown in section 2.2.3, this second strand is represented by the research on Communities of Practice and constitutes an instance of the 'person-to-person' Knowledge Management strategy, that Hansen et al. named Personification (Hansen et al., 1999).

The community approach is also implicitly contained in Kuehn's and Abecker's (1998; also see section 2.2.2) concept of the process-centered approach, which mainly understands KM as a social communication process. It regards knowledge as something, which is closely tied to the person who developed it and which is shared mainly through person-to-person contacts. The main role of IT is hence to help people communicate knowledge, not to document or store it.

The communication-centered community approach (or Personification) augments the management of information resources management by dealing with the actual environment in which people can develop and share knowledge.

Hansen et al. (1999) even frame their Codification vs. Personalization dichotomy in a way, which proves the high value of the community approach for the difficult issue of sharing tacit knowledge:

> "Thus Hansen, drawing on social network analysis has developed a more contingent view of KM. This argues that the relative emphasis on KM strategies (personalization or codification) and associated network links (strong or weak) need to vary according

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[27] A knowledge carrier is carrying knowledge and is hence a person. However, it has to be noted, that some approaches also regard a document as carrying explicit knowledge. Still, this practice should not be adopted, as according to epistemology (part 2.1.1) it only carries information.

[28] An alternative but generally consistent differentiation is being supposed by North et al. (2000). The authors segregate between technocratic, expert oriented, and ecology oriented (networks) Knowledge Management. Whereas the technocratic approach is currently moving towards process orientation (using the business process as the nucleus around which knowledge processes happen), the expert oriented approach should rather include a perspective with multiple experts in networks. North's approach is obviously seeing the difference between expertise, which is profiled and made transparent to others in yellow pages and the active connection and communication between experts in communities, thus forming a social network.

> to (i) the purpose of the task at hand (exploration versus exploitation) and (ii) the kind of knowledge that is important to achieve it (tacit or explicit)." (Swan, 2001:3)

The community perspective on KM is obviously important for knowledge exploration with a high share of tacit knowledge. Taking this to the extreme, it could even be argued, that sharing of tacit knowledge is the only true concern of KM as sharing explicit knowledge via codification is actually touching the less complex (but still required) domain of Information- and Data Management and the results of such systems however have been disappointing (Roschelle, 1996; Davenport and Prusak, 1998; cit. in Hildreth et al., 1999:349). Instead, Communities of Practice should thus be the dominant perspective for approaching a management of knowledge in an enterprise. This is also substantiating the KM Entity Model and the entities to be covered by KM, as introduced in section 2.2.3.

The difficult challenge of transferring tacit knowledge and the role of communities are also analyzed by other researchers. Hildreth et al. (1999) interpret the theory of Legitimate Peripherical Participation (Lave and Wenger, 1991) as a direct link between Socialization of Nonaka (as a theoretical option for transferring tacit knowledge in a company, section 2.2.2) and communities as a means for socialization in a distributed organizational setting.

> "As a first step towards the management of such knowledge we need to understand the social processes that govern its construction and its sustenance in an organization. Lave and Wenger (1991) suggest that soft knowledge is created, sustained and shared through Communities of Practice by a process called legitimate peripheral participation (LPP). They describe how groups are regenerated by newcomers joining and eventually, replacing existing members. The newcomers learn from "old-timers" through co-practice that is graduated, permitting them to undertake more central and critical tasks. In so doing, they not only learn the domain skills associated with the practice but they also learn the language of the community, its values and its attitudes. Through this kind of participation newcomers move from peripheral positions to more central ones and in so doing are transformed into old-timers. Membership is legitimated though participation and participation is legitimated through membership." (Hildreth et al., 1999:350)

Hildreth et al. further relate the Community of Practice to actual knowledge types it generates:

> "We can discern three trajectories of soft knowledge construction in these communities. Firstly there is the gathering of domain knowledge (for example, how to solve a particularly tricky diagnosis problem). Secondly, the construction of knowledge of work practices specific to the community (for example, knowledge of an individual machine's idiosyncrasies and how they are catered for). Finally there is the knowledge that the community constructs about the competencies of its members." (Hildreth et al., 1999:350)

A final statement which highlights the importance of a shift towards a people-centered perspective on Knowledge Management as represented by the Community of Practice comes from Swan (2001), whose "research indicates" that:

> "It seems more likely that the key to achieving coordinated action does not so much depend on those 'higher-up' collecting more and more knowledge as on those 'lower-down' finding more and more ways of getting connected and interrelating the knowledge each one has." (Swan, 2001:8)

Obviously, there is a socially constructed nature of knowledge itself to be found at the core of Knowledge Management. This is why this book is looking at this perspective and trying to find approaches to manage knowledge in an enterprise by capturing and analyzing its networks of people. However, in order to leave enough room to thoroughly elaborate the related issues of this book's main topic, community oriented approaches are just briefly mentioned in this section in order to allow for a complete time line of Knowledge Management theories at the end of chapter 2.2. The theoretic notion of social construction of knowledge is derived and discussed as a part of this book's approach of a community and network oriented Knowledge Management in part 3. All details on community related definitions, classifications, structures, processes, benefits, gaps etc. are introduced in chapters 4 to 6. Finally, a novel technical solution to aid the community and people-network perspective and to develop a comprehensive instrument for network oriented KM is described in part 7.

2.2.4 Current Reception of KM in Corporate Implementations

To enrich and complete the picture of how the discipline of KM is constituting and evolving, this general section will finally introduce some findings from a recent KM report of KPMG (2003) which reflects the actual corporate application of Knowledge Management approaches. Simultaneously, this integrates part 1 on economic developments with the current sections about the respective theories.

Among the respondents of the survey, obviously even during recession (or simply because of it), Knowledge Management has been considered a strategic asset by four out of five companies. 78 percent believe that they would even be missing out on business opportunities by failing to successfully exploit available knowledge. If asked for quantifying these impressions, companies estimate that, on average, six percent of revenue as a percentage of annual turnover or budget is being missed from failing to exploit knowledge effectively.

There is one more positive indicator, the interest of board members. They are the ones who allocate budgets and bring KM into the divisions. So it is vital to get them excited about the topic and the survey proves that in half of the companies, the involvement of the board members increased in the past three years. Although it just the half, as it may be argued now, it is sufficient a number to make KM a prospering concept.

The difficulties in measuring returns from KM projects can be implied, when 64 percent of the survey's respondents say their project's ROI is unknown. Of the remainder, 27 percent report ROI above required company level and nine percent report ROI at required company level. The results of KM projects indicate where the improvements come from, that save money. Four out of five Companies use Knowledge Management to realize synergies among units, two thirds accelerate innovation or reduce costs, three quarters achieve higher customer added value, 70 percent improve quality, and one quarter is trying to reduce exposure to risks (26 percent). 50 percent of companies report that these improvements resulted in clear financial benefits and returns. Among the non-financial benefits, companies experienced quality improvement (73 percent), increased teamwork (68 percent), increased speed and response (64 percent) as well as better decision-making by frontline workers (55 percent).

Interesting is also the project size or in other words the average KM spending. It is less than two percent of revenues. It can be inferred, that the cost of KM is relatively low in comparison to the business opportunities it can exploit. In comparison with 50 percent that reported financial effects and three quarters, that report non-financial benefits, KM hence seems to be a useful investment.

Often it is advisable to start with KM in a pilot area. To answer the question of what division to pick, the business areas which applied KM are of interest. However, there is no single most relevant area to be found. Rather, KM is widely spread throughout the company and there is actually no area, where there are no improvements possible. The core application is found in areas that are close to the market and the customer like marketing and sales, service delivery, and delivery with 53 percent, followed by operations with 51 percent. 32 percent operate KM in the distribution channels and 26 in procurement. In the areas, that are not directly located at the value chain, i.e. the back office, KM is applied as well. 43 percent use it in functional areas like human resources or R&D and 36 percent in strategy.

Many insights can be won, if the major barriers are analyzed that were encountered when introducing a successful Knowledge Management in a company. In 50 percent of the companies KM was not being integrated in the business processes and subsequently generated problems. Only about 25 percent state, that their KM system is rarely used, hence, the acceptance of such systems seems to be possible to achieve. Four out of five companies claim, that KM is not being treated as a daily priority, but rather as something carried out only in special occasions. This is also implied by the 60 percent that feel, that not enough time is being allocated to KM activities. It is a business activity that does cost time in the first moment but saves it later and that effect is often not being accepted by business managers. Interesting is also, that the creation of a knowledge-sharing culture is being seen as a major obstacle by two thirds of the respondents.

This survey proves again, that a sophisticated strategy and the according tool is not the primary issue. Rather, the practical barriers to overcome lie in the actual connection of the expertise of knowledge-sharing groups of people to everyday business issues.

2.3 Resulting Framework of theoretical KM Approaches

After having reviewed the development of two stages of theoretical contributions to the research discipline of KM and after having introduced the macro-economic environment and micro-economic corporate adoption of KM methodology, a brief summary of the resulting framework can be generated.

Taking the maturity model of KM theory evolvement of Figure 8 as a broad guidance, the two waves can be illustrated as shown in Figure 10. The various introduced theories are summarized and the main interrelations are coded as directed edges. On the left hand side, a broad timescale is added to show the chronological order. The gap in theory development in the mid nineties can be observed as well as the two strands of the second wave after the year 2000. The current book adds two main ideas at the end of the time line – the KM entity model to link process and community oriented approaches and later, the modeling and analysis of communication networks in order to improve CoP management which in turn furthers network oriented KM (see chapter 7 and 8).

Finally, to enable the reader to compare this classification approach the very comprehensive categorization of Earl (2001) is related to the two waves categorization[29]. This enables to compare the approaches and helps to arrive with a more objective perspective. In his distinction of different methodological strategies of KM approaches Earl (2001) identified seven 'schools' of thought:

1. "Systems school" which tries to codify knowledge in databases or expert systems,
2. "Maps school", which tries to map knowledge or the knowers (e.g. yellow pages),
3. "Process school", which tries to improve business processes with the storage and transfer best practices,
4. "Trading school", which tries to manage intellectual property,
5. "Organizational school", which is based on the concepts of social networks,
6. "Spatial school", which redesigns the physical work spaces, and
7. "Strategical school", chiefly based on Grants (1996) resource based view of the firm, which tries to change the strategical view on the firm.

They can be aligned with the first and second wave categories introduced in the previous chapters: Documentation is the technology-driven approach of the first

[29] The classification introduced by Abecker et al. (2002) includes the three stages (strategic, business process level, communication level) and has already been discussed and related to the two waves classification in chapter 2.2.3.1.

wave (Earl even notes, that they did not come far), similar the strategic approaches belong to the first wave's concepts and their idea of top-down management, the Process School is obviously the process oriented categorized as an important strand within second wave. Intellectual Capital and Spatial School are not discussed in this book at all, still both comprise parallel concepts. The former aims at linking corporate accounting with Knowledge Management and the latter includes architectural design. Finally, the Maps and Organizational school indeed together form exactly the perspective this books adopts. Although providing a comprehensive classification, this scheme does not convey the various logical and chronological relations as it is done in the lifecycle oriented two waves approach.

Following this strategy, the next sections will derive, discuss, and explain the increasing role of the network oriented perspective in organizational theory in order to show that a network oriented Knowledge Management is required to support such structures of intelligent organizations. Then the support of such a network oriented KM with IT applications is discussed to derive a concrete solution from business requirements in chapter 8.

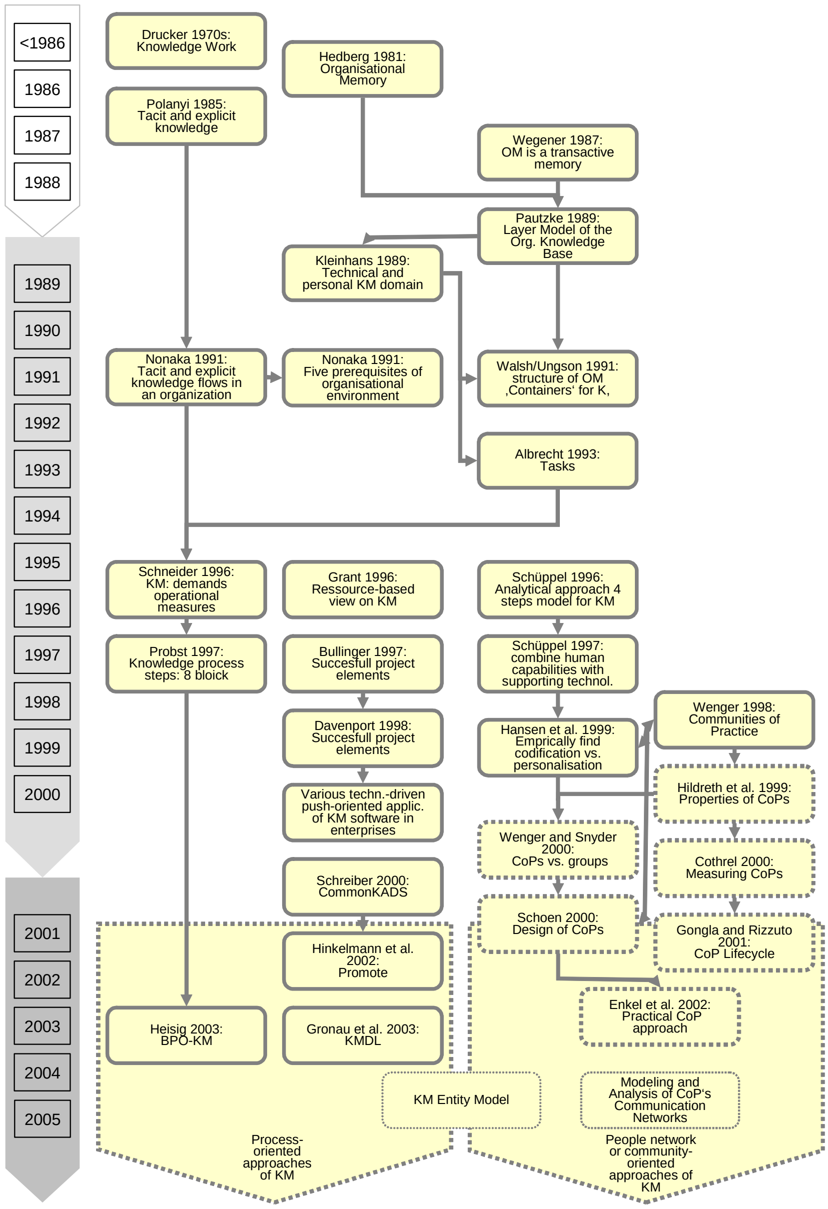


Figure 10: The Time Line of KM Theory Evolvement.

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 mechanisms[30] 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.

rudimentary organizational foundation and the related limited understanding. Here, it can often be recognized, that approaches which conceive Knowledge Management as Document Management and Information Management employ a reduced understanding of the organization, in which they are to be embedded in.

To avoid problems resulting from limited underlying organizational theory, this chapter now briefly reviews and reflects selected organizational theories. Similarly to the introduction of KM as a discipline, a general chronological approach will be applied. The underlying hypothesis is that if an increasing role of network orientation in an organization can be found, then only a network oriented KM can support the knowledge work in such structures. Starting with the first appearance of the idea of a social network in an organization, the analysis progresses towards the discussion of the very important influence of systems sciences before modern theories about network organization are presented. Finally, the few existing theoretical contributions from the field of KM itself are included to identify a collection of theoretical implications for a foundation of KM, which culminate in a list of direct requirements for network oriented KM. These theoretically sound requirements can finally help to guide knowledge managers in their creation and support of an environment in which people can develop and share knowledge.

To anticipate the main conclusion, the following section shows, that KM has primarily to consider the networks of organizational and social actions between employees in an enterprise or as Sachs puts it:

> "If only the organizational (explicit structural) features of work are considered in designing work and the importance of learning is left out, there will be negative consequences in the conception and implementation of [organizational] design". (Sachs, 1995:38).

3.1 Early Organizational Theories and their Role for KM

A comprehensive historic overview about existing organizational theories has been provided by Wyssusek (2004:250). He identifies Scientific Management as a physiological-technical approach (1910-1920, Taylor etc.), further the bureaucratically-administrative approach (1920-1930, Weber etc.), the motivation oriented approach (1930-1940, Mayo, Roethlisberger, Dickson, etc.), the decision oriented approach (1940-1960, Simon, March, Barnart, Kirsch, etc.), the systems oriented approach (1950-1970, Parsons, Etzioni, Luhmann, Bertalanffy, etc.), and the interaction oriented approach (1980-2000, Weick etc.). This development in organizational theories coincides with different assumptions about the role of the people. Starting with conceiving people as a factor of production and a responsible for administrative tasks, the perception changed towards accepting motivation, decisions, complexity, or even sense-making as triggers for human behavior in organizations. Subsequently, the individual act in social group contexts is expressed by the systems and interaction orientation of modern approaches. This role of the individual in the organization is additionally influenced by broad economical and scientific trends like mass production with low wages, career development, or automation and Information Technologies (as described in chapter 1).

The previous sections already showed, that even in the first organizational conceptualizations (e.g. Taylor, 1911), some interesting implications for the management of knowledge resulted. For example, Taylor, representing the first group of physiological-technical approaches in the above classification, observed his worker's actions and tacit experiences and captured this knowledge to create job descriptions from it. This technocratic concept called 'Scientific Organization' hence divided labor into small repetitive sequences to organize manufacturing. It has developed from the famous pin-maker example, which was published by Adam Smith in the very influential book 'Wealth of Nations' about 150 years earlier (Smith, 1767). But interestingly, only a couple of months before Smith's book was available, Smith's teacher Ferguson objected to this origin of the mechanistic perspective on organizations as machines. By this he almost simultaneously initiated the opposite school of thought, quite contrary to Smith's first contribution to economic and organizational theory. Ferguson wrote: ‚Mankind are to be taken in groups**,** as they have always subsisted. The history of the individual is but a detail of the sentiments and thoughts he has entertained in the view of his species: and every experiment relative to this subject should be made with entire societies, not with single men' (Ferguson 1767:I1). With this, Ferguson emphasizes the important role of groups and their underlying structures and processes.

Despite Ferguson's challenging thoughts, the ideas of his pupil Smith and later those of Taylor about the division of labor and the subsequent mechanistic metaphor of an organization as a machine dominated the organizational and economical theories until the early 20th century. However, Baecker (1999:18) remarks, that Taylor was progressive in the sense, that he replaced the existing nepotism with a more rational system. Finally, his approach included aspects of emancipation and expressed mistrust for the societal traditions.

At that time, the sociologist Durkheim was the first to challenge the dominant theories by stating that collective life is not emerging from individual life, but on the contrary, it is the other way around - the latter develops from the first. In the context of an organization, Durkheim emphasizes, that the division of labor requires a worker to not only concentrate on his specific task, but also to remain in continuous contact with his neighboring functions to recognize their demands and changes. This relates to the importance of **social embeddedness** to improve the existing division of labor (Durkheim, 1977:320). The sociologist concludes that the division of labor needs to also create solidarity in order to avoid the break up of growing social communities in times of increasing competitive pressures to survive. Here, Durkheim differentiates **mechanistic solidarity** (social relationships**)** between similar individuals and organic solidarity between diverse but complementary individuals. In sophisticated and complex organizations (or societies), the organic (i.e. complementary) social relationships dominate as the division of labor and the subsequent specialization of the people is high (Wyssusek, 2004:228). This is one of the first instances where sociological thoughts intermingle with theories of how to organize enterprises. Simultaneously it is a pioneering inroad into the concept of networked organizations and their according management.

In 1960, Mayo reinvigorates this sociological perspective of Durkheim in explaining the results of the famous Hawthorne-Experiments (Mayo, 1960:124). A discussion of the organizational-sociological role of the Hawthorne-Experiments has been provided by Etzioni (1967:56-82). Under the direction of researchers of the Harvard University in the 1920s and 1930s George Elton Mayo conducted a series of experiments in the Hawthorn-Factory of Western Electric to substantiate a scientific position that is opposing the scientific management movement of Taylor and which is showing, that **social factors** in groups are important for a firm's success. In his experiments, he finds, that a person's "desire to be continuously associated in work with fellows is a strong, if not the strongest, human characteristic. Any disregard of it by management or any ill-devised attempt to defeat this human impulse leads instantly to some form of defeat for management itself" (Mayo, 1949:111).

Mayo's colleagues, Roethlisberger and Dickson later built on the results of the Hawthorne Experiments, when they proposed their management theory of 'Human relations'. A main constituent of this was the concept of an **Informal Organization** (Roethlisberger and Dickson, 1947:558):

> "Many of the actually existing patterns of human interaction have no representation in the formal organization at all, and others are inadequately represented by the formal organization. […] The blueprint plans of a company show the functional relations between working units, but they do not express the distinctions in social distance, movement, or equilibrium […] nor does a blueprint plan ordinarily show the primary groups, that is, those groups enjoying daily face-to-face relations. Logical lines of horizontal and vertical co-ordination of functions replace the actually existing patterns of interaction between people in different social places. The formal organization cannot take account of the sentiments and values residing in the social organization by means of which individuals or groups of individuals are informally differentiated, ordered, and integrated. Individuals in their associations with one another in a factory build up personal relationships. They form into informal groups, in terms of which each person achieves a certain position or status. […] Informal social organization exists in every plant and can be said to be a necessary prerequisite for effective collaboration. Much collaboration exists at an informal level, and it sometimes facilitates the functioning of the formal organization. On the other hand, sometimes the informal organization develops in opposition to the formal organization. The important consideration is, therefore, the relation that exists between formal and informal organizations." (Roethlisberger and Dickson, 1947:558)

In this context, for Mayo, an important consequence of man's desire to associate is the shift from focusing individuals towards focusing groups. Subsequently, means have to be developed to enable the management of this new ‘object’ under consideration and which provide insights about the **social group** as a foundation for managerial actions. (cf. Wyssusek, 2004:314). This directly supports the notion of network oriented Knowledge Management in a network oriented organization.

Although social relationships between people defy formalization, and by that also render measurement, control and management difficult, Mayo beliefs in the opportunity of a **targeted influence** on social groups: “The eager human desire for cooperative activity still persists in the ordinary person and can be utilized by intelligent and straightforward management” (Mayo, 1949:19). This management approach includes the development of ‚social skills’. By means of this skill, management should commit itself to the continuous process of studying human situations – both individual and group – and should run its human affairs in terms of what it is continually learning about its own organization (Roethlisberger and Dickson, 1947:604).

These conclusions show, that in the context of the Hawthorne experiments, the original focus on conventional psychological stimulus-response-mechanisms has been extended by the observation of influential social factors. Like for example, Wyssusek (2004:311) shows, this is also proving, that the sole reception of psychological results, as often been found in the subsequent literature, has been an incomplete influence on organization sciences. Rather, the Hawthorne experiments can be seen as a major breakthrough and milestone for the development of a sociological perspective and subsequent sociological managerial instruments in enterprises. This closely relates to instruments to support knowledge exchange directly between individuals. However, Nonaka and Takeuchi argue, that although Roethlisberger and Dickson criticized Tayloristic approaches of Scientific Management and perceived the employee as a social being in a group context, they did not manage to construct usable theories and hence the Management Theory of Human Relations was and often still is dominated and consumed by scientific approaches (Nonaka and Takeuchi, 1997: 49).

From these findings, in the era of decision oriented approaches to organizational theory, March and Simon developed their comparison between **organizations and organisms**: Organizations are assemblages of interacting human beings and they are the largest assemblages in our society that have anything resembling a central coordinative system. The high specificity of structure and coordination within organizations – as contrasted with the diffuse and variable relations among organizations and among unorganized individuals – marks off the individual organization as a sociological unit comparable in significance to the individual organism in biology (March and Simon, 1958:4). This metaphor is another illustrative example for the development towards a notion of intelligence and knowing in an organization.

3.2 Shift towards Organizational Sociology

The previous section discussed the fundamental and preliminary shift to the application of a sociological perspective on organizations. Taking this view, Scott (1986:86) defines organizations as social structures, created by individuals with the goal to conjointly pursue defined objectives.[31] He created a summarizing matrix typology which can be utilized to segregate the conventional bureaucratic approaches (compare Max Weber, 1972) from the emerging systemic perspective.

	Rational systems (emphasizing structural dimension)	Natural systems (emphasizing process dimension)
Closed systems (emphasizing internal dimension)	Rationally designed bureaucracies	Formal structures are less important than informal relations
Open systems (emphasizing system-environment relations)	Resource- and environm. dependencies of organization	Organization-internal exchange relations - persistence

Figure 11: Typology of organization-sociological Approaches. Source: Scott (1986)

In his analysis of organizational approaches, Scott identifies two differentiating factors: first the organization can be perceived as a rational or as a natural system and subsequently it can be segregated between a closed and an open system.

This matrix now allows depicting the shift of the underlying assumptions in organizational theory which has already been implied in the previous section. It is a shift from the left to the right column. The first approach emphasizes and examines the structural properties and determinants. Following Scott (1986:45), such a rational system is an organization that pursues very specific goals with a community with very formal and restricted social structures. It requires clear objectives, a high degree of formalization to standardize the behavior of the organizational members (elements) and the creation of a structure which is independent of the individual interests (Scott, 1986). Obviously, the physiological-technical approach of Taylor's Scientific Management (Taylor, 1911) and the bureaucratically-administrative approach by Weber (1972) fall in this category. Among their disadvantages are limited responsibility for actions which is replaced by the objective to perfectly execute atomic tasks without understanding the whole, the application of rules and control actions for their own sake, and the neglecting of the effectiveness of informal relationships to solve problems. However, this structure works well in

[31] This corresponds with the common German opinion represented by the definition of Kieser and Kubicek (1993:4). They define an organization as a social construct, which is continuously persuading an objective and is having a formal structure, which is being formed and aligned to the objective by its members.

a stable environment, where people can become specialists and no exceptions disturb the system.

The alternative perspective, which is represented by the second column of Scott's matrix, focuses on the dynamic processual behavior in a (closed or open) system. In this paradigm, members of an organization participate in informally structured **collective activities** because of their common interest in the continuing existence (persistence) of their system. Whereas the rational system's perspective focuses the structure of the organization, the foundation of the alternative view is to conceive organizations as consisting of people with much less emphasis on predefining their structure. This structure is not defined but emerging from longitudinal power and exchange relationships. This is finally producing an alternative primary source of advancement, which is also responsible for the approaches' names: Whereas rational organizations are defined and developed with the help of a rational (top-down) plan, the natural organization approach is determined by its natural (bottom-up) developments, which interact and form an additive movement or stabilization. Because of these properties, the second alternative is also called micro-political approach. The organization is a whole consisting of interdependent interactions or 'games' by relatively autonomous individuals (Ortmann et al., 1990:55). The visible organizational structures emerge as a codification of compromises which have been agreed upon in corporate power and exchange relationships – a micro-political construction of formal structures (Ortmann et al., 1990:68). Obviously, the role of communication and knowledge exchange between interacting experts is implicitly included. Eventually, the organization is lead by dominant coalitions pursuing different interests (Pfeffer and Salancik, 1978, cit. in Scott, 1986:156). The natural organization is a further theory which is emphasizing the importance of autonomous work in groups of people, especially in times of dynamical environments and disturbances affecting the organization from the outside. Recapitulating the actual economic situation as introduced in chapter 1 suggests that these structures become more important in the current economic situation.

In 1938**,** Barnard gave another early definition which follows this strand of explanation of organizations. He views organizations as **systems of action**, consciously coordinated by communication, which introduces action, controlled information processing, and communication as tools for sense making. The main concepts are hence actions, information processing and communication. Following Barnard, the main challenge of organizing and organization is the integration of actors with different (complementary) objectives. Again groups are a potent means for this approach.

On an abstract level, the two general paradigms of organizing – rational versus natural - have also been compared by Baecker (1999:19). He differentiates into a well-defined system with pre-determined states (trivial machine) and defined transitions and into a poorly-defined system with unknown transitions between different states which changes over time. If now a person is confronted with the well-defined system with fixed rules that do not change, his limited rationality and his lack of being challenged will disturb this system: The person will employ all his limitations including misinterpretations of inputs, ignorance of errors or his immanent objective to maintain static stability and there is no such system, which would work with this simplification over a longer period of time. On the other hand, if the person is confronted with a poorly-defined system which is hostile, surprising, and instable, just like a modern organization, he will manage to establish a role and a position within it. He directly reacts to his related persons: The system consisting of a poorly-defined system and people with limited rationality is developing towards a well-defined system. Baecker explains that the well-defined system did not challenge the person, but people want to be challenged. They only want to be defined by a system, which they can define in turn (influencing the structures to respect them). People seem to have unconscious abilities for information processing which are only activated by unclear situations. They prefer gossip to clear information and autonomously select trusty information sources and collaborators.

Although these two perspectives of rationalist versus systemic (or natural) organization are opposites in their paradigm, in practice both do not need to be mutually excluding each other. Rather they get combined when organizations have areas, in which formal rules are dysfunctional or even inapplicable for efficient results. Here, informal rules like role definitions, action patterns and expected behaviors extend or replace and specify rough formal rules. By that, the organization can adapt these areas to the changing situation. This implies, that especially fast adapting areas, e.g. with high potential for innovation or with close contacts to dynamic competition[32], are apt to follow the systemic paradigm or in other words: these domains need to build their organizational structure on loose and systemic group work. A further generic but very important example for such areas is knowledge work with its varying results and difficult formalization.

Looking at these organizational areas in more detail, the systemic paradigm is leading to change at the 'borders' of the system: The direct contact of the workforce with the customers is not being avoided anymore and the top-management can restrain from the responsibility to exactly prescribe a-priori what the tasks of the employees should look like as the base must now decide based on environmental signals. This leads to the competitive competence to allow and manage increased levels of complexity within the company. This in turn requires self-organization with organizational structures that are able to reflect and react to its own irritations and incorporate its own history in its actions. Systems Science replaces the rationality oriented approaches of organizing (Baecker, 1999:12). The

[32] Examples may be Research and Development, Pre-Sales, or Service. With increasing customer orientation, the influence of market dynamics affects 'deeper' layers and segments of an organization.

only prerequisite is hence, that the company provides the necessary ‘space’ (freedom and autonomy) to let such structures grow and optimize.

Deal and Kennedy (1982) express this duality when they form their concept of secondary jobs. They are no formally defined jobs, but jobs in the **relationship network** of an organization, jobs as spies, story-tellers, priests, souffleurs, etc. This is another very illustrative concept which leads to the notion of simultaneously participating in the actual business processes or projects and in a network of employees which exchanges and utilizes experiences for solving problems and influencing the organizational actions and developments. Later, in chapter 4, the organizational form of Communities of Practice will be introduced to serve as an instance to analyze this mode of work in greater detail.

3.3 Systems Sciences in Organizational Theories

The previous chapter introduced the two opposite paradigms of organizing and their according employment in different organizational situations. The paradigm of Systems Sciences has been identified as being applicable for supporting knowledge work in highly dynamic segments of the organizational structure. Their main theoretical contributions will now be reviewed in more detail to augment the foundation of network oriented Knowledge Management with an abstract systemic layer.

The analysis of organizations as an open and dynamic social system is the perspective of the discipline of systemic thinking. The according strands of theoretical analysis are **Systems Theory** (Bertallanffy, 1950), Cybernetics (Wiener, 1948), Information Theory (Shannon und Weaver, 1949) and its application to sociological systems thinking (Parsons, 1937; Luhmann, 1984). The role of systems sciences for organizations is analyzed by Baecker (1999), who demands the creation of a terminology which is located at the intersection of Systems Theory and Organizational Theory. Systems Theory delivers the necessary degree of abstraction whereas sociology provides the necessary societal relations.

Ludwig von Bertalanffy developed the initial systemic framework with his General Systems Theory (GST). It was built on principles from physics (thermodynamics), biology and engineering. Just like the metaphor of organizations as a natural system, his theory focuses on complexity and interdependence between the system’s elements. From the environment, the technical system receives signals and inputs which are processed and transformed within the system and finally outputs are transmitted to the environment again. The transformation processes within the system are determined by the elements and the relations between the elements (Grochla, 1970:557). A system thus consists of elements in mutual interaction**.** This tremendously resembles the process of knowing using knowledge and hence once more suggests the presence of KM elements in organizational theories.

The theory's strong philosophical dimension includes the analysis of the human mind and society. Here, next to Bertalanffy's analyses, further pioneering contributions can be attributed to Mead (1934, cit. in Weick, 1995:65) who concluded that **social processes precede individual minds**. Similar to the comprehension of Durkheim, Mead describes mind as a social phenomenon:

> „It is absurd to look at the mind simply from the standpoint of the individual human organism; for, although it has its focus there, it is essentially a social phenomenon; even its biological functions are primarily social.[…] We must regard mind, then, as arising and developing within the social process, within the empirical matrix of social interactions.[…] The evolutionary appearance of mind or intelligence takes place when the whole social process of experience and behavior is brought within the experience of any one of the separate individuals implicated therein." (Mead, 1934)

With these statements, Mead was a predecessor of symbolic interactionism, discussed by Blumer (1973). Their main object under examination is how individuals and groups interact in order to create identity through the continuing interaction with others and how these processes interrelate with objective actions.

Similarly, in his Theory of Social Constructivism, Vygotsky (1930) claims that **knowledge is socially co-constructed**, which is a negotiation process by which shared understanding is reached about a "knowledge object" or knowledge "artifact". Later in the 1960s, Berger and Luckmann (1966) continued this line of thought in their concept of the social construction of reality. This substantiates the notion of knowledge creation in a natural organization. The social settings enable the Knowledge Workers to co-construct a joint competence by interacting with each other to share experiences in their topic-oriented expert networks.

Subsequently, Systems Theory was applied for sociology by Parsons and later by Luhmann. Their contributions can aid as an abstract foundation for the natural organization, described in the previous chapter. The main elements under consideration are structures, relations and interactions between persons. The elements of these systems (i.e. persons) have their own values and objectives (Schwaniger, 1995:15). Parsons (1951) examined social systems as systems of social acts**.** He hence focused on the unit act and the interaction of the members of social systems and identified different sub-systems, like the personality system (individual goal attainment, motivations, desires), the social system (responsible for integrating individual systems components and influencing the interaction of social actors), and finally the cultural system (framework of norms).

Looking from systems theory, Luhmann conceives organizations as social systems, which are solely consisting of communication acts related to each other (Bednarz, 1988). Hejl**,** another representative of systems sciences, explains enterprises as an organizational form emerging from interaction between people (Hejl, 1984). The major role of communication for an organization is emphasized by Barnard (Barnard, 1938), who defines organizations as systems constituted by actions, which are coordinated by communication.

Sociologically oriented systems scientists thus imply, that a major issue for understanding organizations is to understand their communication and their ability to communicate. Communication is hence one of the key concepts of the 20th century (Baecker, 1999:22) and the constituting element of social systems. Hence, if an organization restricts communication patterns it also restricts emerging and adapting social patterns from taking effect in problem solving procedures in dynamic environments. Here, a strong link can be found between networked organizations, communication as their primary means of coordination, and learning as an outcome of communication. The available theoretical approaches which aim to explain this relationship and the complexity of communication are discussed now. This substantiates the understanding that Knowledge Management should not only document communication, but should utilize the networks of communicating people as these include meaningful dialogs which are representing the constructed knowledge.

The relation between communication as the core concept, learning and knowledge has been analyzed by von Glasersfeld (1996:48). According to him (also see section 2.1.1), knowledge is actively generated and not captured from the environment because communication is not transmitting meanings and semantics but only coordinates communication partners. Knowledge thus emerges from experience, learning and communication between people.

Following this direction, in the sociological and hence organization oriented discussion of communication, slowly the term ‘communication’ has been liberated from the engineering comprehension of messages (constituted of packages) transmitted between senders and receivers (Shannon and Weaver, 1949). The main point is, that the processing of sense and meaning of the messages does not happen in the communication itself, but in the ‘processing units for meaning’ - the heads - of people who participate in the communication (Baecker, 1999:53). Communication thus does not only happen in the channel but in the heads. It develops towards a means for self-referential organization in a group of actors with mutual perception and hence becomes an ‘emergent’ phenomenon, which cannot be easily explained due to its complexity. It develops collective argumentation processes, by which individual knowledge is shared in an organization (Probst and Buechel, 1994:21, cit. in Henschel, 2000:16). Communication leads to structures and rules for further communication. These rules are changing over time, form unconsciously and are hard to explicate and codify (Henschel, 2000:16).

Communication is hence no transmission, but - just as the early empirists and later systems scientists and constructivists propose - construction. The receiver of signals has many options for understanding what has been sent and hence enjoys a high degree of freedom. This ambiguity of communication is due to its dual character. It contains elements of informing and influencing (‘Information’ and ‘Mitteilung’, Luhmann, 1984). The information aspect wants to transport the mere fact (e.g. ‘this is an apple’), whereas the influencing aspect includes the context. It contains hints like the following: It has been said now, it could have been said something else, the sender wants to imply something, or the message can be interpreted by the sender and the receiver. The receiver can chose if he prefers to interpret the implication or the mere fact. Hence communication is not just simple information of someone. This is an important aspect to consider: Allowing transmission and storage of information is not KM as the sender and the context are excluded and thus much value of the communication itself is lost.

Especially in dynamic domains of an organization, communication is more effective than information. Here, Baecker (1999:23) argues that the special intelligence of people in their interaction with poorly-defined systems is their intelligence to utilize communication (to add value). Analyzing an organization thus prerequisites the understanding of its communication. This is an important implication for establishing Knowledge Management in a company: supporting people networks in natural organized systems has to focus the analysis of the people's communication. This major implication is therefore focused in the chapters 7 and 8.

A further outcome of communication is discussed in the systemic communication theory of Watzlawick et al. (1985, discussed in Henschel, 2000:16). It assumes cyclic relationships of causes and effects. Every action invokes a reaction that is affecting the actor again. Watzlawick concludes that a connection between persons is formed by iterative communication relations and can either be influenced by purposefully defining communication rules (rationalist organization approach) or can emerge from continuing interaction. From these insights, Watzlawick et al. (1985:56) derive a concept of communication similar to the approach of Luhmann. He frames the second axiom of communication theory: Every communication has a content-aspect and a relationship-aspect, where the latter determines the former and thus constitutes a meta-communication. Thus, next to Luhmann's notion of influence ('Mitteilung') Watzlawick puts the relationship-building aspect of communication. This is establishing a link between communication in networks and the social relationships between people discussed by the discipline of sociology.

Schulz von Thuns (1981) finally integrates these two perspectives in his four aspects (or layers) of communication: He proposes the content-related aspect, the relationship-aspect between sender and receiver, the appell to stimulate behavior (i.e. action) of the receiver, and a self-explanation ('Selbstoffenbarung') about the wishes and motivations of the sender. From this concept Winograd and Flores (1987:78) form a classification of communication types, including:

- conversation for action, which targets at triggering action,
- conversation for possibility, which is preceding conversation for action and deals with detailed questions of the intended action,
- conversation for clarification also precedes the action and identifies the objective of conversation for action, and

- conversation for orientation that aims at creating a shared reference framework, which is necessary to collaborate within a social system.

Henschel (2000:19) summarizes the analysis of communication in organizations by stating, that it is not the individual which is the subject of an intervention, but the structure which is emerging from the communication between individuals. Organizational design and development has thus primarily to be concerned with communication processes within a social system. This comprehension of Knowledge Work in organizations by management of network structures (thereby elevating the network to become a management object in its own right) will provide the theoretical foundation for the support of groups of networked experts. It will be introduced in the subsequent chapters of this book.

Next to the important link between communication and knowledge, the connection between **knowledge and learning** is another important aspect, where systems sciences provides valuable contributions for a theoretical foundation for understanding Knowledge Work in a networked organization. Here, Baecker (1999:11) argues that systems refer to complexity, complexity refers to self-organization, and self-organization refers to reflection. This is why systems sciences relate and prepare for organizational learning theories. In a systemic view on an enterprise, the reflection about actions, experiences and the according organization are providing the prerequisite for learning processes. Following this connection, in the beginning of the 1980s the introduced classic works from Vygotsky, Mead, or Berger and Luckmann were resulting in a general and recognizable change in learning theory: a shift from a capturing and storing hypothesis towards the hypothesis of practical participation, which is embedding knowledge in practical action (cf. Sfard, 1998).

For example, Lave and Wenger (1991) employed an according learning theory in their work, which defines learning as process of **social construction**. The knowledge remains in the contexts (and heads), where it has been generated. For the authors, learning, thinking and knowledge are constituted by relationships between people, which are acting in, with, and through a socially and culturally structured world (Lave, 1997: 67).

Brown, Collins und Duguid (1989) come to the conclusion, that knowledge and action are reciprocal categories: knowledge is always **situational knowledge** and is being generated by action. This means, that the situation is fundamental for all cognitive activity: knowledge is related to an action and not to an object, knowledge is related to a context and is not abstract, knowledge is generated in interaction between the individual and its environment, it is neither objectively defined nor subjectively generated. It emerges as a functional element of interaction and not a truth (cf. Bereiter, 1994). Again this conflicts with the predominant idea of current KM initiatives to explicate and store experiences in knowledge bases.

Hutchins (1996) finds that **knowledge is** not simply a matter of an individual's mental representations, but is frequently **distributed** among the abilities of group members and the artifacts that they use. Accordingly, knowledge is co-constructed by interactions among people and their shared artifacts, including prominently by means of negotiation practices that result in establishing a common ground for understanding (also cf. Vygotzky, 1930; see above).

General Systems Theory, its application to sociology, the analysis of the human mind in a society and the related conception of learning as social interaction eventually lead to the application of systemic thinking to organizations and organizational theory. The main branches are the theory of Organizational Learning and the Learning Organization as well as Systemic Management approaches. The notion of learning is again hinting the strong relationship to the management of knowledge.

The discipline of Organizational Learning applies the notion of feedback processes and communication relations to examine individual and interindividual or organizational processes for learning (often simply considered as adaptation) in organizations. Such learning is a characteristic of an adaptive organization. It senses changes in its environment and adjusts. Accordingly, this includes learning from experience and implementation of individual experiences into organizational learning cycles. Here, Argyris and Schoen (1978:20) distinguish between two modes of learning with an increasing degree of reflexiveness: single-loop and double-loop learning. Single-loop learning includes the observation of the difference between expected and obtained outcomes. This difference is used by individuals, groups or organizations to modify their actions without affecting the underlying values. Double-loop learning includes the reflection about underlying values and assumptions that lead to the obtained action and their subsequent modification. This is comparable to a change in the existing routines to create new ways and opportunities for decisions and actions. March and Olson (1975) link individual and organizational learning with individual beliefs in a feedback loop. Individual beliefs lead to individual action, which is then generating organizational action (for example following the micro-political mechanisms, introduced above). This organizational action can cause a response from the environment, which is processed by the individual and may affect and improve its individual beliefs and subsequently its action over time. However, organizational learning is not simply the sum of individual learning's, as individuals that learn can also be employed in organizations which are not learning. The model of Kim (1993) integrates Argyris with March and Olson and focuses the analysis of the underlying information flows in the organizational learning loop in order to detect interruptions: an individual action could for instance be rejected by the organization for political or other reasons. Related to this field of Organizational Learning is the concept of the Learning Organization. The latter applies the theoretical findings of organizational learning to propose normative recommendations about how to create organizations that continuously and effectively learn. An example is Senge's approach of the five disciplines of a Learning Organization (Senge, 1990). They include Personal Mastery, which is the individuals' creative approach to their personal development. A second discipline is mental models, which highlights that organizations are affected by underlying assumptions of its individuals. Shared visions comprise the third element and suggests, that the integration in enterprises are not only ensured by hard coordination mechanisms like orders but also by shared visions, assumptions and objectives. Senge further proposes the development of team learning to extend individual learning. Finally, as the fifth required discipline for organizations which are able to learn and adapt in a dynamic environment, Senge proposes system thinking including the analysis of cause-and-effect chains and feedback-loops.

Such approaches towards Organizational Learning demand self-responsibility and rich coordination and communication between employees, teams and project groups. This is consistent with the requirements demanded by systems theory. Existing approaches to solve problems are continuously discussed, challenged and improved and require a high amount of flexibility in organizational structures.

However, theories about Learning Organizations and Organizational Learning see **learning as adaptation**. That is why they did not yet produce a theory about knowledge creation (Nonaka and Takeuchi, 1995:61). They face the dilemma of simultaneously requiring stability or efficiency through routinization and flexibility, innovativeness and readiness for change.

Next to Learning Organizations, another strategy to apply General Systems Theory to organizations is the systemic management theory (e.g. Schwaninger, 1995:4). Its main assumptions include that organizations as open systems exchange material, energy and information with their environment. Further, they are complex, interconnected and dynamic entities, they are self-referential[33] and operationally closed (i.e. can not be determined by the environment). The mutual relations of the elements are determined by social and natural rules and comprise the formal and informal structure of the system (Kirsch, 1969:665). The degree of complexity of the system is determined by the various relationships between the elements (Luhmann, 1984:37). The border is being generated by a difference in complexity, which is being reduced within the system (Luhmann, 1984:37). The development of sub-systems can cause an increase in the system's complexity and the steering and regulation is keeping the system in a dynamic equilibrium and under control.

Systemic management theories also integrated ideas of cybernetics. Cybernetics is a further branch of systems science, which has been developed from mathematics and communication technology. It analyzes the steering of systems and looks for universal rules and properties which are working like a regulation mechanism for

[33] The concept of self-reference assumes that the development and adaptation of properties and behaviour in systems (the achievement of an equilibrium state) is dynamically produced by the system's elements and the operations between them. It cannot be determined by the environment and depends on the pre-defined adaptability of the elements and their structure (Luhmann, 1984:25).

a system to keep it in some equilibrium (Ulrich et al., 1976:138). Major insights of this technological perspective have been applied to organizations in the discipline of management cybernetics. For example, Stafford Beer has applied cybernetic insights about the function of the human central nervous system to organizations and discovered a structural similarity between living systems (organisms) and organizations. Further, Burrell und Morgan (1979) analyzed the metaphor of an **organism** to explain organizations. They examined general principles of open systems in an organization, like for example system borders, processes, inputs, outputs, homeostasis, subsystems or mutual dependency.

In such a systemic analysis the focus is hence on the observation of the relations and interactions between elements rather than the analysis of the elements and their properties. Linear causal relationships are replaced by **feedback loops** (Henschel, 2000:15). Thus, incorporated complexity, connectedness and dynamics are necessary aspects to consider for modern organizational management.

Summarizing, systems sciences concluded that social processes precede the individual minds, which means, that knowledge is socially co-constructed. This alone shows the inadequacy of treating knowledge as a storable object, which can be transferred between people. Rather knowledge emerges from communication and learning in a group. It can even be distributed over a group. Communication is actually the means by which knowledge networks are created. Systems Sciences also refer to learning processes in organizations. If knowledge is socially co-constructed and learning is the means to generate knowledge, then learning is social, too. This leads to the distinction of individual and organizational learning processes which are interrelated and comprise feedback loops. Finally, theories of Organizational Learning also demand for rich means of coordination between largely self-responsible people and a high demand of flexibility in the organization. In such loosely structured parts of an organization, learning is a way of adapting the corporation to the requirements of its environments. With this behavior learning and subsequent knowledge work require a corporate environment which is similar to an organism. It can be concluded again, that KM has to provide methods for exactly such an environment and thus has to support communication networks of people in their problem-solving processes.

3.4 Networks, Coordination and recent Organizational Theories

Whereas systems sciences discuss the terms system, knowledge, learning, and communication together with their interrelations, their conclusions only implicitly support the idea of choosing networks as an organizational means. A reason for this is that Systems Sciences conceive themselves as an abstract theory, which is not directly discussing the set up of organizational structures.

Based on ideas of organizational learning via rich and effective corporate communication, recent theories apply systems science to directly discuss the properties of networks. This strand of discussion more directly supports the argumentation, why networks of experts are a suitable perspective for KM activities.

	Market	Hierarchy	Network
Normative Base	Contracts, Ownership	Employment contracts	Complementary strengths
Communication Means	Prices	Routines	Relationships
Method to overcome conflict	Bargaining, Law Suits	Administrative Order and Control	Mutuality, Reputation
Flexibility	High	Low	Medium
Commitment between parties	Low	Medium to High	Medium to High
Atmosphere, Climate	Accuracy, Mistrust	Formal, Bureaucratic	'open-ended' mutual advantages
Preferences of Actors, Decisions	Independent	Dependent	Interdependent
Mixed forms, adaptations	Repeating transactions, Hierarchical contracts	Profit Centers, Market-rules, Internal Prices	Formal Rules

Figure 12: Markets versus Hierarchies. Source: Powell (1996:221)

Starting from the assumption that the spectrum of available positions is reaching from markets on the one end to bureaucratic hierarchies on the other, the question is now, which organizational structure fits the needs of modern organizational approaches best. Whereas markets have a very high flexibility as prices help to connect unknown parties, hierarchies work with routinuous, pre-defined, and inflexible exchanges between fixed partners. In markets, the commitment between the parties is lower as in hierarchies. Between the extreme positions of markets on the one hand and hierarchies on the other, the network structure can be located. Its communication is based on mutual relationships and the reputation of the members of the network. The flexibility is much higher than in hierarchies but still lower as in markets.

In market transactions the exchange is specified in detail, trust is not necessary and contractual commitments are supported by legal rights. In the contrary, network-based exchanges have undefined sequential transactions in the context of a common pattern of interaction. Sanctions are more normative than legal; the underlying relation replaces the goods (Kowol and Krohn, 1995).

However, it has also to be considered that in practice the borders between the three paradigms often dissolve as mixed forms exist. A network can establish formal rules or hierarchies, a hierarchy can implement market mechanisms (e.g. in profit centers) and markets can work with repeated transactions. This is a very important implication for managing networks, as there is some degree of freedom in the adoption of an appropriate amount of formalization. The comparison between markets and networks is summarized in Figure 12.

The previous chapter on Systems Science already identified the important role of communication for effective organizational structures in dynamic environments. This communication is a means of coordination between organizational members. The mode (or the means) of coordination is simultaneously the main differentiator to segment the available structural paradigms for organizing. Next to the division of labor and its segregation of general tasks into work packages, coordination is the second important basic principle of all organizations (Kieser and Kubicek, 1992:95). There are five coordination mechanisms: mutual coordination (informal communication), personal order (hierarchical coordination with formal authority), standardization and automation of work processes (programs), standardization of work products and outputs (Plans), and standardization of required qualifications of the employees. Mintzberg relates these forms of **coordination to complexity** (Mintzberg, 1992:13): With increasing complexity of the work processes, the preferred coordination mechanism shifts from mutual interactive coordination to hierarchical commands and then to standardization (first of work processes, then of work outputs and then of qualifications), but only to finally shift back to mutual and interactive coordination. This sequence substantiates the link between the dynamic environment, the resulting increase in organizational complexity and the shift to interactions in networks of experts.

The same result has been provided by Baecker (1999:10), who argues that the increased level of inherent complexity within organizations should not be perceived as a problem, but as the solution. Complexity is the requirement to allow the system to make errors, detect them, and learn from them (Baecker, 1999:34). This in turn requires redundancies, variety and even barriers which divide clusters in the system to stop external disturbances from affecting the whole structure. If the environment is not observed and ignored in the present, the reality will cause the problems later (Baecker, 1999:35). Baecker further continues (1999:36), that increased levels of complexity can be accommodated by moving from bureaucratic structures to communication and hence to network structures. He is thus in line with the findings of Mintzberg.

The two authors' contributions produce a very interesting result, which substantiates, that Knowledge Work in a network is more capable of handling problems, than Knowledge Work in a pre-defined (hierarchical or process oriented) business setting with fixed transaction processes.

Another theory which derives an appropriate form of coordination and control from different organizational settings is proposed by Ouchi (1977). He establishes the two dimensions measurability of output and asymmetry of knowledge and information. If the output is measurable and the information asymmetry is high, a market-like coordination mechanism based on prices is suitable. If the information asymmetry is low but the output is difficult to measure then hierarchical orders and process control should be applied. However, if the output is difficult to measure and the **information asymmetry** is high, Ouchi suggests mutual and interactive self-coordination with its immanent social control (cf. Figure 13). This constitutes another argument for adopting a networked organization for Knowledge Workers. Their output is difficult to measure and they generate benefits because they complement each other. This also implies the likelihood of a high degree of information asymmetry between the different combined fields of expertise.

	Information and Knowledge Asymmetry	
	low	high
Output difficult to measure	Instruction and Control of Execution (Processes)	Self-regulation with social control, self-control
Output easily measurable	Instruction and Control of Results	Control of Outputs, Prices

Figure 13: Selecting the appropriate Form of Coordination. Source: Ouchi (1977)

Here, the special organizational form of a network enables the flow of information and influence from the top to the bottom and vice versa, but also horizontally through the relations (Stamps and Lipnack, 2000). Barley (1996) comes to a similar conclusion: If in an organizational structure, knowledge and capabilities were generated **domain-specific**, the work is less determined by the vertical chain of command (influence) but rather by (lateral or) **horizontal communication** and collaboration between different groups.

The network delivers fix points for the combination of order and chaos in the organization. Every employee must be enabled to purposefully switch between the processing of expected and unexpected information, the necessary orientation is provided by a network, which is offering **active connections** (for coordination and communication), but even more importantly connections, which potentially can be activated on demand in special situations (Baecker, 1999:26).

A further substantiation for the important role of **informal mutual interactive coordination** as the usual means for generating solutions and decisions in corporate practice has been developed by Cohen et al. (1972:2). In the 'Garbage Can Model' the authors state that an organization is a collection of decisions, which look for problems, further of topics and emotions which look for situations to be applied to, of solutions which are looking for questions, for which they can be the answer, and finally of people working as deciders who look for work. In other words, a set of problems meets a set of solutions in situations where a set of people needs to make decisions under time constraints. It is a common aspect of modern organizations which are characterized by limited rationality (as it is impossible to utilize all available information for one decision), further by a variety of individual objectives among the individuals and coalitions, and by an orientation to past experiences and rules which are consulted prior to estimating future results. The occurring situations lead to feasible but not necessarily optimal decisions for that decisive situation. This model shows that the time and the constellation of meetings between people are affecting the decisions of a company. Thus the organization should support opportunities for the right people to meet e.g. by electronic means of communication. The organizational structure is actually regulating this combination of people and their access to decision processes and thus the quality of the decisions.

The network structure for organizations is also being supported by the emergence of a new technological paradigm, centered on information and communication technologies (Castells, 2000). The network paradigm even extends to the whole economy, which is according to Castells characterized by the fact, that its capacity of generating knowledge and processing information determines the productivity and competitiveness of economic units. Another indicator is that the network appears as a new form of economic organization. This can be a network of firms or segments of firms. Large corporations internally de-centralize as networks; small companies connect themselves using networks.

A related development which was also fueled by the growing ability to represent, execute and control business processes via electronic means is the approach of **Virtual Organizations**. Such virtual organizations can exist within and between organizations. Intra-organizational virtual organizations imply the absence of static structures. Such an enterprise has no hierarchy, no organization chart and no divisions with specified task descriptions. One main assumption is that modern computer and telecommunications networks reduce the costs of coordination in a way, which is allowing firms to achieve production benefits without incurring the higher transaction costs (Malone et al., 1987).

However, the virtual organization as described in these approaches is a special situation, where the complete enterprise can exist without hierarchical coordination structures. Still, the notion of a virtual organization emphasizes the aspect of adding a heterarchic structure to current organizational architectures in order to handle specific situations of coordination and leads to the assumption, that it can be established in parallel to the conventional organizational structure.

As the most recent theoretical debate, Postmodernist assumptions substantiate the importance of the network principle for modern organizational structures: Boje and Dennehy (1993) describe the constituting principles of a postmodernist organization as work teams of multi-skilled workers, working in flexible networks with permeable boundaries and flat hierarchies. Efficiency decreases with specialization, formalization, routinization, fragmentation, and division of labor. Postmodernist organizations employ a high degree of people-centered leadership and decentralized control.

3.5 Organizational Network Structures

After having reviewed organizational theories and their contribution to the question if and how networks can be a suitable form of organizing Knowledge Work, this chapter will now have a closer look at the constituents of a network.

In order to approach this special organizational structure, it has to be defined first: Teubner defines a network as a decentrally regulated system of collaboration between autonomous actors. It should be a lose form of cooperation, which should neither only consist of arbitrary interaction nor should it own the density and stability of cooperation in a formal organization (Teubner, 1992). A social network is hence an informal, person oriented, trust-based, reciprocal, exclusive interaction relationship which is lasting over time between heterogeneous autonomous, interdependent actors, who voluntarily cooperate to conjointly achieve a surplus and for that reason integrate their plans and actions (Weyer et al., 1997:64). Such networks are social systems, in which acting persons are bound by relationships. By their interactions they constitute the network structures, which are in turn the basis for their future actions.

The classification of networks and their definitions help to assemble the theoretical properties of network structures in organizations. They include indefinite, sequential transactions within the context of a general pattern of interaction. They rest on normative sanctions as the parties of a network pursue their own interests at the expense of others (Powell, 1996). The chances for opportunism are restricted by social norms. Networks have a high degree of openness, transcendence, and ambiguity. Such networks help to assess tacit knowledge within and outside the organization. Powell (1996:225) argues that it is hardly possible to put a price tag on qualitative issues like innovation and experiments, know-how or special approaches to production. These aspects of organizational activity can neither be dealt in a market nor communicated in a conventional corporate hierarchy. Networks are resting on social relationships, trust and reputation, which can be a cheaper control mechanism as supervision by authorities. These issues are discussed in more detail in the section 5.3.3.

Empirical research on social networks confirms the importance of networks in organizations from a very different perspective: It has been found, that interactions of people captured over time form a **network structure via communication** (Brass, 1985; Krackhardt, 1991). On a more detailed level of analysis, this branch of research also found out, that a network is usually not homogeneous, but employs some structural properties. There are clusters and structural holes. The configurations of the actors' relations differ and so do their roles in the network. For example, an actor who connects several clusters can benefit from his function as a bridge or broker. Further, some ties between actors are stronger than others. Such strong ties relate to increased loyalty and trust due to the ongoing informal interaction between the authors. On the other hand, strong ties can also prevent the actor to establish new ties for example due to social pressures and lock-in effects. The individual properties of actors within networks also relate to power structures. Some prominent actors attract much attention from others (i.e. are often asked) and thereby are influential for the development of the whole network. Others are simply very active and thus influence the network development. These properties which relate to network structures are very important for the analysis and evaluation of people networks. Chapter 7 will hence introduce a broad variety of such micro-level network properties in order to develop a system for evaluating and comparing individual network structures.

In summary the previous section showed, that modern approaches of organizational theory emphasize the systemic perspective. Here, organizations have to be observed as a system consisting of elements and relationships. In a complex organization with a multitude of competing objectives and coalitions, the organization cannot be treated as something rational anymore. Instead, limited rationality in decisions should be accepted. Sociological approaches help to focus the complex coordination constituted by interaction and communication between individuals. The network as a structural paradigm emerges in the society and as an efficient means for organizing (appropriate domains in) organizations. Webber summarizes this shift with a strong emphasis on its scope:

> "The most universal challenge that we face is the transition from seeing our human institutions as machines to seeing them as embodiments of nature. Even on a large scale, nature doesn't change things mechanically: You don't just pull out the old and replace it with the new. Something new grows, and it eventually supplants the old." (Webber, 1999:178)

Similar to the relations between the root sciences of KM, the following figure shows a more detailed summarizing overview about the connections between the multiple introduced contributions of organizational science.

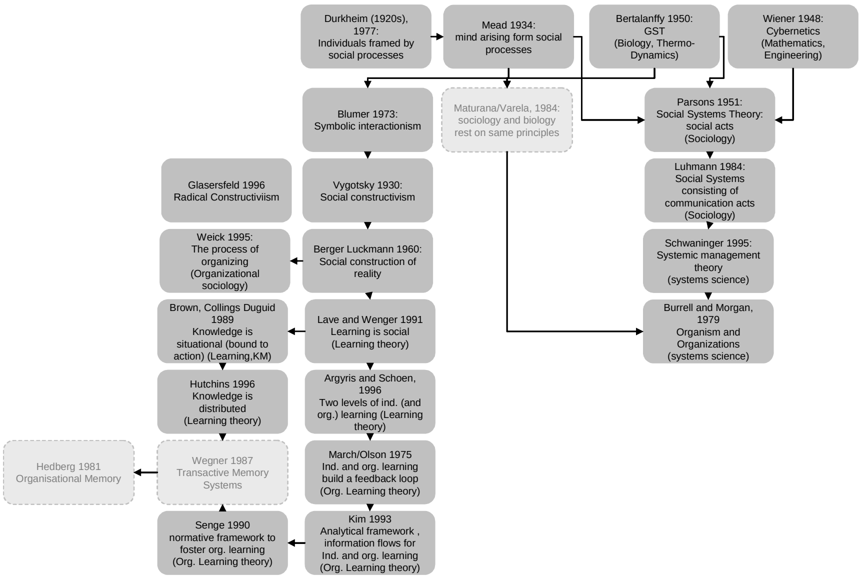


Figure 14: Overview about systemic Sciences and their application to Organization.

As outlined in the beginning of chapter 3, Knowledge Management within an organization is simultaneously dependent on the organizational properties and affects them with its measures. Therefore, KM should regard the various requirements put forward by this complex comprehension of modern organizational theory and move from a management of document collections towards supporting networks of communicating people.

3.6 Implications for organization and network oriented KM

Next to the requirements identified from the analysis of organizational approaches, there exists a body of literature which directly discusses how these organizational requirements should translate into KM concepts.

For example, Bonifacio and Camussone argue that a KM system has to be inherently social:

> "A KM system cannot aim only at making explicit the implicit knowledge of individuals, but rather at facilitating the creation and social dissemination of practical knowledge. This happens by encouraging the creation and vitality of the Web of informal relationships, which feeds the system of Communities of Practice also through the use of open, weakly structured and mainly collaborative technologies (like groupware systems), capable of supporting the creation of traditional, or even Virtual Communities." (Bonifacio et al., 2004)

Thus the authors support the identified requirements and propose an extension of the objective by a more subjective approach to KM. Knowledge should no longer be treated as something general and abstract (like it is done in the codification strategy). Rather the social and contextual nature of knowledge shows, that knowledge is a phenomenon which manifests in social relationships. The authors regard knowledge thus as a practice. This implies, that a knowledge manager needs to be concerned about supporting business processes by documenting knowledge representing artifacts, like documents or contents and simultaneously needs to manage social learning processes in communities. Thus the **social learning process and the artifacts** it creates as knowledge objects need to be managed. This position is substantiating the argument put forward by the KM entity model in chapter 2.2.3, namely to integrate process and network (people- or community-) oriented Knowledge Management approaches.

The underlying cognitive approach of the KM theory of Bonifacio and Camussone refers to the constructivist theories introduced in the previous chapters: Information is interpreted (by applying previous experiences and beliefs) and not simply received. The emphasis is shifting from uncertain knowledge to ambiguous knowledge.

This requirement for KM to include a systemic perspective and the according philosophical principles is also discussed by Wyssusek et al. (2001) in their approach called socio-pragmatic Knowledge Management. The authors criticize the common idea of knowledge being 'transmitted' via Information Technology:

> "The occasionally assumed transmission of knowledge by information systems is only a derived phenomenon which results from the fact that some humans "coincidentally" already have acquired the interpretation patterns they need in order to interpret signs supplied by information systems in the appropriate manner." (Wyssusek et al., 2001)

Following the authors, it is not adequate for KM to focus on the relation between object and individual alone. Rather, "individual action can only be adequately described if its embeddedness in shared processes of setting goals and purposes is considered as well. Reasoning about individual action must therefore regard it as being derived from common action with its norms and cultural specifics". This is applying the arguments of Durkheim to the field of Knowledge Management. Further the authors relate to the construction of knowledge in a social setting:

> "Since we regard the processes of cognition as constituted by communities, it is our judgment that a theory of knowledge must be supplied which takes this fundamental prerequisite into consideration. […] The primary goal of knowledge management is no longer a mere transmission of knowledge, but the facilitation of reconstruction of knowledge within the affected workforce. […] Already within the scope of the conception of knowledge management in an organization and the planning of relevant methods, community plays a central role." (Wyssusek et al., 2001)

A similar opinion was given by Nassehi (2000). He builds on the central role of communication for knowledge creation and suggests not regarding individuals or their minds as the carrier of knowledge, but the social dynamics of communication relations. With its self-referential sequence, it can generate cognitive operations, which so far have only been attributed to humans. Nassehi refers to Luhmann who defines knowledge as a cognitive stylization of communication with a tendency for dynamic changes by learning. Similarly, Swan et al. (2000) argue that **KM is about connecting people** with people and people with information to enable collaboration and community networking. This finally also clarifies the role of IT in KM. Knowledge Management practice has to focus the human side and IT is just the enabler for this endeavor.

As a conclusion of this chapter's extensive discussion of network-related organizational theories, the following list summarizes the main requirements for the according network oriented approach of Knowledge Management:

1. Establish a network structure for collaboration, especially in areas with a high degree of change.
2. Establish a KM approach that is focusing on communication.
3. Carefully configure the extent of formalization and foster social control.
4. Give room for self-organization and adaptation of the employees.
5. Support problem-related communication of people in networks.
6. Support learning processes as social co-construction of knowledge in social groups and support the translation of insights into individual knowledge.
7. Support communication in a network by providing multiple means of lateral communication for the experts, which can be activated on demand.
8. Consider the situative aspect of knowledge, which is related to action.
9. Incorporate history in new actions and foster double loop learning.
10. Let people carry out parallel 'jobs' in the relationship network of the organization.
11. Enable the creation of mutual relationships between complementing experts.
12. Analyze and evaluate the emerging network structure between experts to improve interventions.

These twelve aspects are important for the framing of a network-oriented approach for KM and the underlying support with IT.

Summarizing, the network oriented approach to Knowledge Management can be **defined** as the extension of the document-based support of knowledge intensive business processes to systematically support a further and very important mode of knowledge work: the formation of direct and indirect informal and personal contact networks, which utilize communication to connect knowledge workers in topic-domains and thus develop a valuable source for their productivity.

This approach considers the requirements of modern intelligent organizational architectures to cope with highly complex and dynamic environments. However, this perspective can then be integrated with the other documentation and process oriented perspectives (also see section 5.1 on the integration of communities in the organization).

4 CoP 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).

Here, a community is playing an important role for the generation, the transfer and the application of tacit knowledge. It follows the paradigm of socially constructed knowledge, which for transfer requires personal networks in which it is disseminated slowly via repeated social interactions (cf. Wyssusek et al., 2001; Swan, 2001). With its self-organizing information logistics, this structure is more suitable for supporting information processes in a dynamic environment as the pre-defined and limited communication flows of the formal organizational structure. Therefore communities require special attention as a complementing instrument for Knowledge Management.

The focus is moving away from systematically storing various information objects (e.g. by using taxonomies and information retrieval technologies) towards dynamic and problem-centered recombined patterns of relationships between individual employees with their tacit knowledge and its practical application to specific business problems. The employee connects his experience with information from the social connections within his people network to a knowledge, which he can utilize to solve his concrete problem. By repeating such a selection of communication partners as information sources, a topic oriented group of people is forming and connecting: Knowledge Work is thus accompanied by the participation in an informally developing knowledge oriented community. In exchange he contributes to his colleagues' problem solving quests. Such a pattern of direct people-to-people connections is representing the personalization approach, first introduced by Hansen et al. (1999).

This Community of Practice therefore represents the appropriate concept to discuss the support of knowledge-driven employee networks, which are vital for modern organizational forms. They can thus be perceived as an 'instance' of a social organization and due to its special advantages can qualify as a suitable and even central instrument for corporate Knowledge Management.

4.1 Definitions and Basic Properties of Communities of Practice

A first clarification of the organizational phenomenon 'Communities of Practice' can be achieved by analyzing the various approaches to define the term.

First works in analyzing the properties of communities came from the area of sociology. For example Hillery (1955) demanded that a community requires a locus (shared geographical location) and interaction. Although the requirement for a co-location has later been omitted, interaction is a constituting factor. However, it is not necessary that members communicate actively, rather there has to be the opportunity to communicate. This again requires the existence of a communication channel and the consciousness about the existence and the belonginess to the community.

In the 1990s several authors worked on the application of this special group form to enterprise needs. Their work resulted in a detailed discussion of the main properties of Communities of Practices.

A first definition of Brown and Gray (1995) already highlights the limited group size, the relationship developed from continuous collaboration, a common purpose, and the access to each other's knowledge. The groups do also often remain informal and even invisible for the majority of organizational members (also compare for Steward and Brown, 1996:2).

> "At the simplest level, they are a small group of people who've worked together over a period of time. Not a team, not a task force, not necessarily an authorized or identified group. What holds them together is a common sense of purpose and a real need to know what each other knows." (Brown and Gray, 1995)

Brown and Gray also find that over time communities also develop a shared understanding as a shared cognitive base (Brown and Gray, 1995:81). The definition of Snyder in 1997 also emphasizes the aspects of this relation to learning and of informality which together directly refer to the social learning theory, introduced above.

> "Communities of Practice consist of people who are informally as well as contextually bound by a shared interest in learning and applying a common practice." (Snyder, 1997)

The relation to knowledge creation is discussed again by Brown and Duguid in 1998.

> "Collective practice leads to collective knowledge, shared sense-making, and distributed understanding that doesn't reduce to the content of individual heads." (Brown and Duguid, 1998:96)

In 1998, Etienne Wenger, who is often referred to as the thought leader and the pioneer of the business application of Communities of Practice, contributed his definition, which is often cited, though it actually names no new aspects and is very similar to the one of Brown and Gray, three years earlier.

> „A Community of Practice defines itself along three dimensions: its joint enterprise as understood and continually renegotiated by its members, the relationships of mutual engagement that bind members together into a social entity, the shared repertoire of communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.) that members have developed over time." (Wenger, 1998:2)

The notion of a continuously negotiated focus shows that there are no predefinitions of tasks but rather complex dynamics which advance a community. Wenger further adds, that CoPs can also transcend organizational boundaries (Wenger 1998) and later develop properties like a strong sense for community and intensive cooperation (Wenger and Snyder, 2000: 139).

Another proponent of a corporate application of Communities of Practice is McDermott. He stresses the mutual help for problem solving and the aspect of aligning the member's practices and ideas into a common approach to a topic field. This shows that its members share interests or activities.

> „Communities of Practice are groups of people who share ideas and insights, help each other solve problems and develop a common practice or approach to the field." (McDermott, 1999)

A final refined definition of Communities of Practice by Wenger (Wenger et al., 2002) which is describing the corporate embeddedness of a CoP defines it as a group of people, bound to the organization as an informal structural unit with voluntary and reporting-independent participation of members who share a concern and a passion about a knowledge domain, care collectively about this domain (stewarding) and apply the shared practice in their business processes.

Most definitions of Communities of Practice employ the term group. This term can be further specified.

Sociology regards a group as a social system, which is constituted by communication processes (e.g. Schein, 1980:146). It is thus similar to the understanding of the concept organization as introduced in the previous section.

Gebert and von Rosenstiel (1992:122) define a social group as comprised of direct interaction of members over a long period of time, shared values, norms, and objectives, the perception of being a part of a social whole, and the formation of roles within a group.

It can be differentiated into small groups of up to five members and large groups of 20 to 25 members (Schein, 1980:146). However such a restrictive border is problematic as factors like the assigned tasks, qualification etc. are influencing factors. Further, as will be described later, the choice of communication medium strongly affects the appropriate or possible group size. Another dichotomy is the differentiation of primary (emotionally bound, close, e.g. family) and secondary groups (more rational, pursuing tasks) (Staehle, 1991:243). Finally formal and informal groups can be differentiated. The former usually stem from formal organizational structures to achieve a defined goal (like a persistent division or a temporary project team) and employ a power hierarchy. The informal groups are spontaneously formed by ongoing relationships and contacts. This differentiation is often not easily possible (Staehle, 1991:246) as both types usually employ some formal and informal aspects at once. Informal groups often develop informal leaders.

A final concept of group research, which is important for Communities of Practice, was presented by Tuckman (1965:384). He segregated four phases of group development, which are also to be found in the development of CoPs: forming, storming, norming, and performing.

The main constituting properties of CoPs are thus (also compare for Nickols, 2000):

- a strong sense of identity tied to the community,
- the practice itself is not fully captured in formal procedures, and
- people learn and become seen as competent in concert with others.
- Continuing mutual relationships – harmonious or conflicting (i.e., regular, work-related interactions, rough or smooth).
- shared ways of doing things together, e.g. common practices,
- a rapid flow of information between and among members,
- quick diffusion of innovation among members,
- conversations which come quickly to the point,
- problems which are quickly framed due to a common understanding of the milieu in which they all operate,
- broad consensus among the members about who is "in" and who is "out",
- shared awareness of each others' competencies, strengths, shortcomings and contributions,
- common tools, methods, techniques and artifacts such as forms, job aids, etc. ,
- common stories, legends, lore, "inside" jokes, etc., and
- evolving shared language (e.g., special terms, jargon, "shortcuts" such as acronyms, etc.).

Similar to this list, Hildreth et al. (1999) assembled a visual overview about the main properties of Communities of Practice (also cf. Figure 15). Central are the properties of community, situated learning, dynamic evolution, social interactions, participation, communication, a common purpose, a common background experience and a common language. Possible additional characteristics are informality, success stories, similar working areas, and voluntary participation.

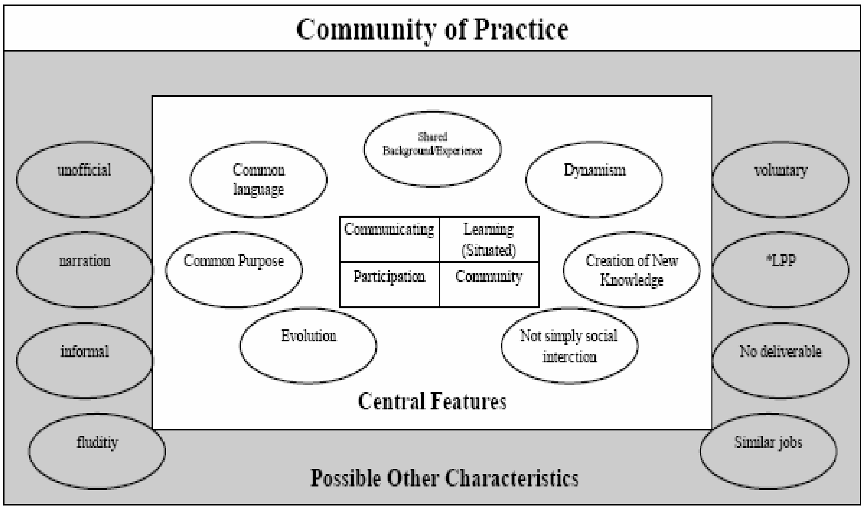


Figure 15: Central Elements of Communities of Practice. Source: Hildreth et al. (1999)

The introduced properties of Communities of Practice have been applied by Hildreth et al. (1999) to establish a method, which can support the identification of CoPs in an enterprise. In their questionnaire aiming at the identification of CoPs in a company with 1500 employees, they analyzed if the following five properties could be found:

1. Are you in regular contact with colleagues/peers doing similar jobs in other locations ('similar jobs' in distributed locations)?
2. Do you talk with colleagues/peers in other locations when they have a problem to solve (problem solving)?
3. Do you share projects with colleagues in other locations (common purpose)?
4. Do you swap anecdotes/experiences with colleagues in other locations (narration)?
5. Do you learn from discussions with colleagues in other locations (common language, narration and Legitimate Peripheral Participation; also cf. Lave and Wenger, 1991)?

These properties can finally be summarized in a general **definition**: A Community of Practice is an invisible and informal structure with a limited size and emerging from voluntary participation and interaction which over time establishes working and social relationships. Its informality and invisibility invoke complex group dynamics which are focused around knowledge, expertise and learning for solving problems in a central topic domain which over time integrates, forms, maintains, and develops a shared cognitive base and shared resources.

4.2 Typologies of Communities

The term community can be broken down by classifying special forms with special properties. However, it is difficult to create a clear separation or to assign real CoPs to one of the theoretical categories. Still, this also implies the dynamic and transcendent character of this organizational structure. Nevertheless, the attempts to build categories can help to outline several specific properties which help to further the understanding of CoPs.

A widespread differentiation is made between Communities of Interest (CoI) and Communities of Practice (CoP). The main differentiator is the notion of development towards an objective. Here, a CoI is a group of people with shared interests that does not develop knowledge (e.g. problem solving methods) to achieve a joint competence in a defined subject field. As the name already implies, usually this special form emerges in open internet communities which bring together special interest groups, like for example for gardening or home improvement issues, software users, or collectors. However, they also share their expertise in a topic domain and hence there is no clear separation possible (cf. Wenger, 1998). Figure 17 implicitly includes a comparison of the properties of both forms, as proposed by Wenger and Snyder (2000), as their Informal Network[34] is a type of a Community of Interest.

A different terminology but the same differentiation is made by Reinmann-Rothmaier (2000). She separates innovation oriented from communication oriented communities, which again implies the orientation towards a general objective - or in other words: the progress - as the difference. However, Reinmann-Rothmaier concludes, that innovation also prerequisites communication and thus this classification is only employable for illustration. A solution for this problem could be to simply detect the notion of innovation in the individual community or the evolvement of expert clusters.

A further distinction is suggested by Wenger et al. (2002). They classify helping communities, best-practice communities, knowledge-stewarding communities, and innovation communities. Helping communities are focused on community relationships to help each other solve everyday problems, e.g. by posting requests for help in a threaded discussion and respond to other people's questions. One example is Schlumberger which connects its scientists and engineers. Best-practice communities are focused on practice, develop, validate and disseminate the according methods and practices - for example engineers and operators at Ford Motor Company, who describe new practices and assess effectiveness and benefits. Knowledge-stewarding communities are focused on explicit knowledge and organize, upgrade and distribute knowledge used every-day. One example is Cap

[34] However, as a Community of Practice is also an informal network, this is why this very general term is not used outside the figure.

Gemini Ernst & Young and its communities, which focus on finding, organizing and distributing documents according to topics. Innovation communities are rather focused on tacit knowledge to foster unexpected ideas and innovations. One example is DaimlerChrysler and its communities which encourage engineers to assess new directions in research and which provides a channel for innovation. Again, this distinction cannot be utilized to separate actual instances of CoPs as a knowledge-stewarding community shares best practices to help each other and thereby supports innovation (e.g. as refining best practices).

By looking at the members and their affiliations, a final classification identifies three categories: business-to-business communities, employee-to-employee communities, and business-to-customer communities (Cothrel, 2000:2). Although the term employee-to-employee community is describing the same as the more common term Communities of Practice, introduced above, the term business-to-business community emphasizes the special constellation when members come from different autonomous organizations, which usually collaborate alongside the supply chain. The communities are employed as a single point of information. An example for such an integrative approach is the joint business-to-business community 'Covisint' which has been initiated by General Motors, Ford Motor Company, Renault/Nissan, and Daimler-Chrysler. Members are purchasers, sellers, constructors, engineers, and suppliers. The platform fosters the interaction among these people from different companies with tools for online-collaborative development (Covisint, 2002). Another implication is the application of moderated communities to maintain and improve customer interest and customer relations with business-to-customer communities. They are also often referred to as customer community or consumer community. The customers can exchange information about products (like for example a software application or a software development environment for a programming language). The enterprise hosts the community platform and learns about the customer's problems, interests and opinions to subsequently incorporate this knowledge in market strategy and product development.

	B2B	B2C	E2E
Members	Customers, suppliers, distributors, etc.	Customers	Employees
Objectives	Stronger relationships Insight Efficiency Innovation Revenues	Stronger relationships Insight Lower customer acquisition costs Revenues	Stronger relationships Insight Efficiency Innovation Revenues

Figure 16: Community segments of Cothrel (2000).

A further special type of community is the Learning Community. It employs professional lecturers or external consultants to qualify a group of learners. This can be done in class-rooms or in E-Learning courses. The actual Learning Community is emerging during the learning process, after the students achieved an atmosphere of trust and mutuality to help each other. Usually this special type of community ends after the courses are over (short life-span) but various contacts between the group's members remain and improve the participant's personal informal networks within the company (cf. Trier, 2002).

Finally, a very important distinction can be made between designed versus grassroots communities. The latter are also called bottom-up or emerging CoPs (cf. Schoen, 2000:118). The difference is, whether distributed Communities of Practice have evolved from initial informal contact between members or from an official imposed grouping (also cf. Hildreth et al., 1999).

This last property is very important for the employment of CoPs in an enterprise. The selected degree of formalism already starts with the initial creation of the community (bottom-up by members or top-down by management). It largely affects the opportunities for management intervention. This aspect is discussed in the chapter 5.8 on management tasks throughout the active life of a CoP. Further, the aspect of designed structure is also the main differentiator in the comparison of CoPs with other forms of group work in an enterprise. This comparison is required to fully understand the special configuration of this mode of group work. This is why this issue will now be discussed in more detail.

4.3 Community of Practice vs. other organizational forms

Despite the many properties which are necessary to call a group a Community of Practice it is still difficult to define, how big the differences to the existing organization need to be to constitute an informal community entity. Here, North et al. (2000) note, that otherwise everything in a company could be segregated into overlapping community groups as all these groups have a joint learning and working process with a shared vocabulary and methodology. Another difficulty is it to combine or compare it with other informal organizations and communities. This is why it is necessary to further differentiate Communities of Practice from other organizational forms like formal organizational units (i.e. business division) or projects, but even more from existing working teams.

Some of the differences were already implied in the definitions like the aspect of membership (or composition): In a CoP, members get invited. Their participation is mostly voluntary and self-selected, whereas in a formal organization membership is predefined by hierarchical reporting procedures. Similarly, project team members are also pre-defined by some senior management person.

A CoP's purpose is it to exchange knowledge and to develop the members' capabilities; it is not directly aimed at accomplishing a business task like in a project team or at delivering a product or service like in a formal organization. Hence, its general independence of concrete tasks is a special property.

Further dimensions are bonding (cohesiveness) and duration, which help to differentiate CoPs from project teams or formal work groups. An important aspect is the major role of a common identity and mutual commitment in a CoP – this identity is as cohesive as the achieving of project goals in a project team or organizational goals in a formal work group. Further the duration of a community is as long as the topic is interesting for its members. This makes it an interesting alternative for project members which have finished their work in a project, but are still interested in the general topic. They can connect to CoPs to keep updated in their field of expertise and to contribute their valuable insights to other business issues.

	Communities of Practice	**Formal Work Group**	**Project Team**	**Informal Network**
Purpose	To develop members' capabilities; to build and exchange knowledge	To deliver a product or service	To accomplish a specific task	To collect and pass on business information
Composition	Members who select themselves	Everyone who reports to the group's manager	Employees assigned by senior management	Friends and business acquaintances
Bonding	Passion, commitment, and identification with the group's expertise	Job requirements and common goals	The project's milestones and goals	Mutual needs
Duration	As long as there is interest in maintaining the group	Until the next reorganization	Until the project has been completed	As long as people have a reason to connect

Figure 17: Comparing CoPs and other organizational Forms.
Source: Wenger and Snyder (2000)

Next to a comparison between CoPs, formal workgroups and project teams, the literature discusses the difference between teams in general (not only for project work, where it is tied to a specific assignment, after which the group disbands) and Communities of Practice (cf. Storck and Hill, 2000).

If a team is not working in a project, it is assigned to a specific function or process. Often, it consists of very heterogeneous roles which together are solving tasks. These tasks often change. A team is usually smaller than a community. The degree and frequency of interaction in a team is on average higher than in a community. Teams coordinate by shared goals, communities have shared fields of interest. Teams are mostly admistratively defined and their roles are determined. Hildreth et al. (1999) call this the legitimizing process. They claim that in a team, legitimizing occurs by role assignment, whereas in a CoP legitimacy is established through interaction about its practice. They work more often on shared artifacts than communities where the exchange of personal artifacts is higher. A team does more often report on its output and activities. Accordingly, there are more control mechanisms. Quite contrary, a Community of Practice employs very little control mechanisms. It usually defines its own agenda, objectives and duration (Wenger and Snyder, 2000). Hence, it can also be formed spontaneously. It redefines itself according to the needs of its members, which also implies that its purpose is targeted at the member's interests and needs (Storck and Hill, 2000). The following table shows an alternative and detailed comparison of teams and CoPs:

Teams	Communities of Practice
Team relationships are established when the organization assigns people to be team members.	Community relationships are formed around practice.
Authority relationships within the team are organizationally determined.	Authority relationships in a Community of Practice emerge through interaction around expertise.
Teams have goals, which are often established by people not on the team.	Communities are only responsible to their members.
Teams rely on work and reporting processes that are organizationally defined.	Communities develop their own processes.

Figure 18: Comparing Teams and CoPs. Source: Storck and Hill (2000)

As already indicated in the introduction of the term Virtual Community, these classifications show different archetypes of organizational forms. However, in practice there are no such clear borders. For example, in a Virtual Community, physical communication can also play a major role (e.g. to create trust). Similarly, a Community of Practice can develop towards a team or a task force: It could establish some semiformal system of rules, roles, and hierarchies (e.g. newcomers versus seniors) and could define the achievement of a specific result or objective as its primary goal. However, the main differentiating factor is not the absence of structure but the origin of its definition. It is specified from the community itself. This is also implying the complexity of the issue of coordinating, steering, or managing such groups without to overly disturb their underlying group dynamics. This issue will be discussed in great detail in the next chapter.

5 Organization and Coordination in CoPs

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 knowledge base layer. It is responsible for recategorizing existing knowledge and putting it into new contexts. This layer is no instantiated organizational unit but it emerges from the conglomerate consisting of knowledge carriers (experts) and means for documentation or storage of knowledge. All three layers co-exist in an organization and comprise a dynamic feedback loop: As soon as projects are finished, people distribute their achieved knowledge in workshops and documents to infuse the business layer. They can as well personally move back to the operative work. From this concept, Henschel (2000) develops the implication that organization members are simultaneously assigned to a business unit, a project, and the community.

Nonaka's concept implies that Communities and the formal process or project organization are two parallel domains in the enterprise, which have to be combined efficiently. This issue has been discussed by North et al. (2000). The authors see the arising challenges in the desire to legitimize the Knowledge Community. Such a legitimization is usually connected to the access of resources, i.e. time for participating in the communities or financial resources for experiments and implementations. Further it is related to the expectation to produce results. Here, another challenge for the integration of communities in organizations is that the group is utilized or instrumentalized by the organization. Enterprises could be tempted to assign projects like restructuring or preparing decisions. In this case, such an intervention is likely to change the community into a task force. The question is, whether this foregoes the initial internal impulses which let the community emerge or whether the community continues to exist next to the task force.

Being involved in 'two worlds', members can perceive conflicts between their loyalty for the Knowledge Community and the loyalty for their division. Here, the communities sometimes create an autonomy, which fuels solutions that have no chance for implementation. This can lead to insights or efforts, which can not be applied to the 'normal' value generation processes in the business units.

Another very important relation between a CoP and an organization is that if the enterprise provides required time and budget, this generates a demand for controlling and monitoring. Here, it is vital, that results and progress of Knowledge Communities are actively reflected, visualized and communicated. This is not limited to proving the generation of financial values, but can include qualitative improvements, time savings, spread of best-practices, etc. This last issue is one of the main motivations of this book. In the end, a software tool is developed, which supports the generation of transparency in a company and the communication of value generation or progress by visualizing the networking of people and their communicative work.

Practical examples for approaches towards a successful integration and for the development towards an actual feedback circle of Organizational Learning can be found in the community concepts of Siemens and Shell. Similar to the Hypertext Organization of Nonaka and Takeuchi (1997), the community organization has been integrated with business operations and competence centers in a feedback circle. Starting with the business processes, people work in either projects or processes and acquire practical experiences in their team work. Here, they generate knowledge. When these practical experts simultaneously participate in communities, they connect to related subject-matter experts and ask for special business problems or related issues and thereby validate their insights, transfer their solutions to others and conjointly produce an integrated and disseminated best practice approach. Special members of the communities are working for corporate competence centers. They try to elicit these emerging approaches and use them to create guidelines for new projects and processes. These guides and documents get formalized and are fed back into the business operations as rules and methods for improving business results. The circle of Organizational Learning is complete (cf. Figure 19).

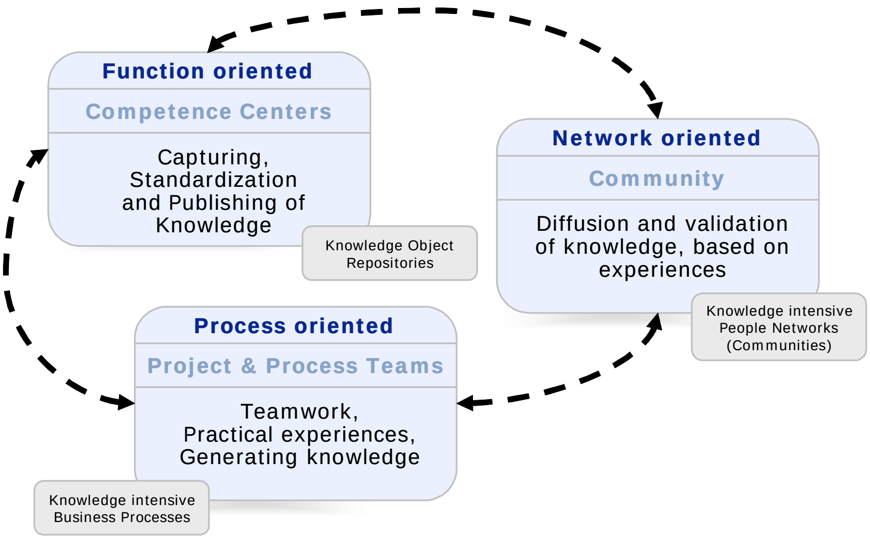


Figure 19: A practical Instantiation of an Organizational Learning Cycle.

This example utilizes the theoretical concepts of situated and social learning (cf. Lave and Wenger, 1991) as a prerequisite for an organizational learning approach. It recognizes that learning and knowledge creation happen in relationships between interacting people. Communities of Practice are thus a catalyst for the exchange of experiences gained in process and project activities - they provide a mechanism which supports organizational learning.

5.2 Practical Examples for CoPs in Organizations

In enterprises, Communities of Practice play an important role as a complement to existing organizational structures. They are (a) forming an important part of an organization’s strategy, (b) creating new lines of business through innovations, (c) solving problems rapidly, (d) transferring best practices, (e) developing professional skills, and (f) helping companies recruit and retain talent. (cf. Allee, 2000).

This section will outline some practical examples to give an impression of how communities are employed and embedded in a company.

As a first case study and extension of the organizational learning cycle introduced in the previous section, Siemens's approach to KM emphasizes the central role of communities for practical KM. Centric to all other elements of their Knowledge Management System (KMS), they chose Knowledge Communities as their primary focus. This is a very innovate and insightful decision, which led them to employ 'Communities of Excellence' (Enkel et al., 2002). There, virtual groups focus on functions, like process-engineering teams in the production or software engineers in the development division. The groups have members of the respective topical areas, processes, and projects. An IT-platform is utilized, containing discussion boards, 'urgent request' facilities, member directories, chat features, a search functionality, news pages, and link collections. Official coordinators have been established and are responsible for tracking the flow of contributions to develop their subject area. Next to this individual contribution of various practical insights, members have bi-annual meetings and special community projects. In this way, the Virtual Community is enriched and backed by personal contact.

Unlike Siemens, many other companies have (or would have) selected the knowledge marketplace or in other terms Knowledge Management via IT-portals as the central building block and primary project perspective. This often yielded in unsuccessful post-project results of the KM system (also compare for chapter 2.2.2).

As a result, Siemens connects 1200 software engineers in the R&D department in a topic-centric group. In their consulting branch called SBS (Siemens Business Services) they integrate 2000 consultants. The most impressive community comes hand in hand with the Sharenet application and includes 8000 sales people in more than 50 countries. The right hand side of Figure 20 shows the 'content' or output of these communities. It is divided into three groups. First, implicitly, CoPs contain relationships, experts, communities and contexts. Then, experiences and impressions are created and finally methods, structures and process models are formally produced. Implicitly these three subsequent types of content demonstrate the value chain of knowledge development in a community.

Business process	Knowledge Community	Content
R & D	1200 software engineers, industry automation groups	Implicit Relationships, experts, communities, context, …
Consulting	2000 SAP, management and service consultants	
Manufacturing	1500 process technology engineers	Emerging Impressions, experiences, … (Lessons Learnt)
Sales	8000 sales people in 50 countries for customized solutions (ShareNet)	
Procurement & Logistics	50..200 community members of Corporate Procurement and Logistics	Formalized Methods, structures, process models,.. (Best Practices)
Training	2500 in Belgium/Luxembourg Siemens Learning Valley	

Figure 20: Overview about Communities at Siemens. Source: Heinold (2000)

A further example for a major company that built Communities of Practice is DaimlerChrysler's Tech Club Concept. Here, product families like trucks, large cars, etc. are linked to the engineering areas like chassis, electronics, etc. This allows for topic oriented collaboration of engineers, working for different product families at distant locations (cf. Figure 21).

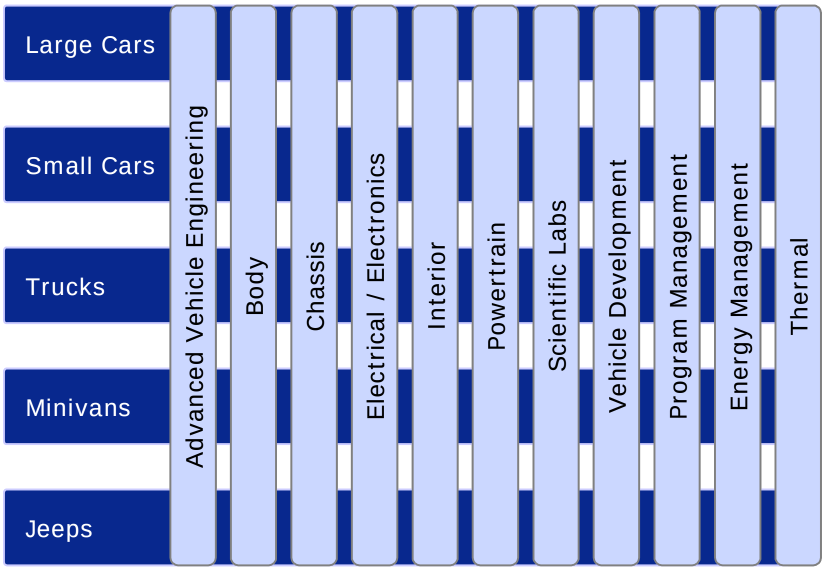


Figure 21: The Architecture of the Tech Club Concept.

Similarly, Shell owns many small groups, which were mostly informal in origin, with hardly any structure or facilitation (cf. Shell, 2001). In 1999, the small groups were combined into global networks called Communities of Practice. These groups are now quite large and have a formal position in the organizational structure. Example communities are sub-surface, surface and wells. Each CoP has 1500 to 2000 members. Additionally, smaller communities are dealing with issues of knowledge sharing, of competitive intelligence and with Human Resource Management. The communities have so-called 'hub-coordinators' for facilitation. They meet with other coordinators once in three to four months. They are responsible for the coordination of all activities within the various communities. The raised questions and discussions mainly deal with applying a colleague's expertise to exceptional situations in the business processes, for example drilling methods. A special department is analyzing all the semi-formal contributions and utilizes the insights contained to produce new process standards for the whole enterprise. Later, Shell augmented this communication oriented approach by a Learning Center, which trains best practices to about 3,500 senior and technical staff every year for an average 10 days of courses. Moreover, it set up Action Learning whose focus is on encouraging engineers to share ideas following a process of learning by doing, through extensive use of videoconferencing in order to connect to recognized experts throughout the organization.

In the IT sector, IBM is a further example of a sophisticated community approach. They host about 20000 participants in 60 IBM communities (cf. Gongla and Rizzuto, 2001). The groups are dealing with core competencies, like enterprise systems management, application development, testing methods, and organization change, industry sector competencies (automotive, chemistry, distribution, finance, health) or they are discussing market competencies, including e-business, package integration, total systems management, mergers and acquisitions, and finally KM. IBM intends to assign a certain degree of independence to the groups. This results in different characteristics in their range, scope, adoption of a concrete taxonomy versus rather general categories, or structured review versus loose workflows.

Among the internal tasks are managing the community's intellectual capital, sharing tacit knowledge, communications, socialization, membership management, and content management. IBM further set up external processes, which include incentive recognition, business strategy development and execution, and competency development. Finally, they developed measurement processes, which span both, the internally and externally oriented community processes.

In their CoP approach, IBM established a small set of roles, including a community leader, a core team with a router, who first reviews new submissions and assigns another member for their evaluation, and category owners, which are subject matter experts in the different sub-areas who are responsible for topic and content development.

Further organizations which consider Communities of Practice as a core element of an organization's KM approach are American Management Systems (AMS) and the World Bank. They utilize these groups to generate ideas during electronic discussions, which are then developed towards new products. Further, they use

CoPs to effectively solve problems: using the expertise of communities, the World Bank is able to quickly respond on requests from clients from various countries including issues like how to carry out reforms in different sectors, or asking for assistance in technical areas. The groups quickly identify best practices from different countries. Similarly, Buckman Labs has been able to reduce response time drastically through effective knowledge sharing.

Many more corporate examples illustrate the successful application of this special instrument of Knowledge Management, e.g. ChevronTexaco Corp., BP p.l.c., IBM Corp., or Unilever p.l.c. (cf. Allee, 2000).

5.3 Benefits for Organizations

Although some benefits already have been implied by the introduction, definition, and practical examples, a thorough review of the main corporate benefits will be discussed in this chapter. Their recognition helps in deriving appropriate management interventions to maximize benefits and control costs[35]. The benefits introduced in this section include the short term benefits identified in the literature like improved learning or transfer of tacit knowledge and the rather complex benefit of supporting the establishment of Social Capital and trust.

5.3.1 Short term Benefits of Communities of Practice

There are various short term benefits, which the organization can achieve by employing a Community of Practice (cf. Wenger et al., 2002). It can be an arena for problem solving and provides quick answers to questions. Hence, it allows for quicker and cheaper information search because one can easily identify and contact topic matter experts. By having discussed topics more informed decisions can be made with a higher quality. This also enables people to approach new problems more efficiently. The community is not just providing benefits to the organization but also to its members. It helps them with their challenges and gives them easier access to expertise. They can contribute their valuable insights to other topics and can easier become visible and recognizable with their specific experience. The connected expertise gives more confidence and backing in the tackling of business problems. But also, it is motivating to talk to colleagues about topics of interest in an institutionalized and legitimized way. It provides people with a sense of belonging to a group that together can work on innovations in a topic field. By this exchange, people's professional identities are being emphasized and reputation can be built.

[35] These will subsequently constitute a foundation for generating a measurement system in chapter 7.2.

Members create a shared understanding of a topic domain, which is supporting the transfer of knowledge. Knowledge Communities are more suitable to keep knowledge in use (“alive”) as databases or manuals. The tacit elements of knowledge are maintained and shared or are adjusted to local necessities. This makes communities a suitable means for introducing new members into an organization. They develop competencies and carry new developments into the company. They are often quicker and less inert as business units.

The impression of participating in the progress of a cutting edge development motivates members. Communities provide a ‘home’ and identity in turbulent times, where business units, projects, teams and affiliations are continuously changing. Further, in flat hierarchies Knowledge Communities constitute learning fields to share and discuss new ideas between employees.

Lesser and Storck (2001) examined the link between Communities of Practice and organizational performance. They identified four areas of organizational performance, which are determined by CoPs. These include a decreased learning curve for new employees, a more rapid response to customer needs and inquiries, reduced rework and ‘reinvention’, and the spawning of new ideas for products and services. Further “communities play a significant role in the development of Social Capital, which in turn influences organizational outcomes”. This beneficial property of developing an abstract and qualitative capital or value for the company will now be analyzed to improve the understanding of employing CoPs in an organizational context.

5.3.2 Social Capital

Significant attention is being paid to the development of ‘human capital’, that is the education, skills and expertise of productive employees. “However, sociologists such as James Coleman, Ron Burt and Mark Granovetter argue that there is much more to explaining the differences in individual success than individual characteristics alone” (Lesser and Prusak, 1999). This is consistent with the findings of chapter 3. What the authors identify is the complex corporate success factor Social Capital.

Here, Barney (1991) notes, that the Social Capital of an organization is a distinctive collective property, mediated by individuals. The underlying idea is that information is not spread evenly across all actions. The access to resources or information depends on the social contacts (Coleman et al., 1966; Granovetter, 1985). The connections of a person do thus imply a value, as this person is potentially capable to access the connected resources (e.g. other’s problem-solving approaches). This value is especially implied as individuals have to invest substantial time and energy in developing these relations (Burt, 1992). Once established, people also tend to keep with their current social relations in order to minimize transaction costs (Ben Porath, 1980). This cost perspective is also responsible for relationship maintenance. If a new contact only yields a marginal increase in benefits, it is likely to be abandoned over time to leave more resources and time for the remaining links (e.g. cf. Granovetter, 1974). In this context, Social Capital can simply be understood as the value derived from productive social relations, which appears in the form of improved information routing, resource exchange, emotional support, and public goods production and mobilization. This implies a reorientation "away from immediate ability of people to complete tasks, toward the longer term effects on their ability to act collectively" (cf. Resnick, 2002).

Social Capital complements financial and human capital (Barney, 1991) and can be regarded as an integral part of an organization's intangible assets (Pennings and Lee, 1998). The relation-specific assets, knowledge sharing routines, and effective relational governance mechanisms help firms to leverage their relational resources for knowledge acquisition and exploitation. The network-based view on organizations thus extends the resource-based view and suggests that dyadic and network relationships provide competitive advantage for a company (Lane and Lubatkin, 1998). They suffice the criteria of a corporate resource for sustained competitive advantage, as it is valuable, rare, hard to imitate, and imperfectly substitutable (Pennings and Lee, 1998).

To closer examine Social Capital and its relation to corporate performance, Tsai and Ghoshal (1998) conducted an empirical study, which proved that Social Capital had significant effects on the levels of knowledge exchange and combination within an organization and hence improved product innovation.

The underlying construct of Social Capital was proposed by Nahapiet and Goshal. They define this construct as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit" (Nahapiet and Ghoshal, 1998:243).

The authors further identify social capital as having three interrelated dimensions: structural, relational and cognitive (Nahapiet and Ghoshal, 1998:251).

Together these three elements foster the creation and sharing of Social Capital by improving the access to parties for combining and sharing intellectual capital, the anticipation of the value of this exchange, the motivation for exchange, and the ability of the organization to adapt to the emerging needs.

The structural factor requires the formation and actual existence of informal networks between persons in order to enable them to identify people with required resources.

The relational requirement is supporting the exchange between the individuals. It addresses issues like trust, shared norms and values, obligation, expectation and identification. Trust is the most complex element, and emerges in regular, honest, and cooperative behavior. "Social Capital is the capability that arises from the prevalence of trust in a society or in certain parts of it" (Fukuyama, 1995:26).

The cognitive aspect of Social Capital finally includes issues like common context and vocabulary, which is supported by the use of common artifacts and stories.

Lesser and Prusak (1999) link this model of Social Capital to the concept of Communities of Practice in order to show, how CoPs are beneficial for the development of Social Capital of an organization. Looking at the structural dimension, the employees set up and maintain informal personal relationship networks with others having similar or complementary interests. Experienced colleagues can be accessed and included in the problem solving. The knowledge of employees can be easier evaluated and people from the outside (like new employees) can be better connected to the network.

CoPs foster interpersonal interactions and over time build a sense of trust and obligation critical for Social Capital development. They can test the trustworthiness and commitment of others. The community develops its own ‘informal currency’, common norms and values or conditions of payments (notion of obligation). As people are organized around a common topic, they provide the required shared vocabulary. Further, the CoP generates knowledge objects or artifacts and stories which allow newer members to pick up social cues and develop commitment (Lesser and Prusak, 1999).

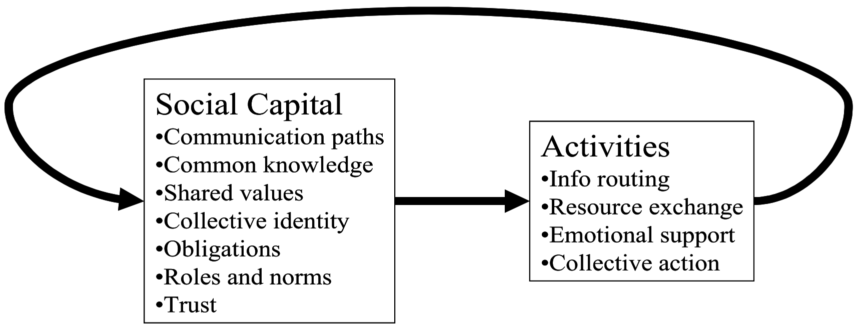


Figure 22: A positive Feedback Loop between Social Capital and the underlying and resulting Activities. Source: Resnick (2002)

Resnick (2002) identifies seven productive resources which are produced in a social network over time: communication paths, common knowledge, shared values, collective identity, roles and norms, obligations, and trust (also cf. Figure 22). As Lesser and Cothrel (2001) note, “these resources address the challenges of our three critical social capital dimensions. The first, communications paths, is structural, the next four mainly cognitive, and obligations and trust clearly relational”.

Summarizing, Social Capital is a value created in a social network over time and leads to the increase in partially measurable resources. This notion of resources also directs the attention towards evaluating the actual extend of the utilization of such values, or in other words: the measurement of the community. This idea will be extended later in chapter 7, where among other dimensions Social Capital in

Social Networks is being embedded in a comprehensive measurement framework, which subsequently is being implemented in a concept for IT-based support for evaluating Virtual Communities in chapter 8.

5.3.3 Trust

Related to the concept of Social Capital is the concept of trust and its benefits for sharing knowledge in an organization: “Social capital is the capability that arises from the prevalence of trust in a society or in certain parts of it.” (Fukuyama, 1995:26).

Fukuyama further defines the concept of trust as “the expectation that arrives within a community of regular, honest and cooperative behavior, based on commonly shared norms on the part of other members of that community”.

In the literature, trust is identified as one of the most important and fundamental success factors for people networks. It fuels sociability of the network as trustworthy relations produce information benefits for the linked actors (Burt, 1992).

Here Powell states (Powell, 1996:226), that trust can come from shared socio-cultural norms and traditions (‘characteristic-based trust’), institutions (‘institutionally based trust’), and positive experiences with the cooperation (‘process-based trust’; also cf. Zucker, 1986).

In the context of network oriented organizational structures (cf. chapter 3.2), Powell (1996) asserts, that networks require trust, as it enables them to handle complex issues faster and more efficient as authority or negotiation. However, it has to be noted, that the importance of mutual trust between employees is often only recognizable, when common procedures have to be abandoned in times of change or breakdown (Thomas et al., 2001). Then mutual trust supports collaborative effort to proceed towards organizational as opposed to individualistic goals. Trust enables people to build a more complex model of others as a basis for action in novel situations. Thus, it helps to solve collective problems as it is reducing complex realities much more efficient than projection, authority and negotiation and is implying that all participants restrain from free-rider behavior in the network and bring in their share to conjointly generate benefits. Zucker (1986) and Lane and Bachmann (1996) identified three main factors, which support trust in a network:

- characteristic-based trust, which emerges from shared socio-cultural norms and values,
- institutionally based trust, which emerges from a shared institutionalized environment, and
- process-based trust, which results from positive cooperation experiences.

By fostering the development of higher levels of trust between employees by continuous contact and expressive informal communication, communities are eventually also providing a benefit to the whole organization, e.g. in the form of Social Capital. Mutual trust is positively affecting the longelivety of organizations (De Geus, 1997).

5.3.4 Understanding Costs to evaluate Benefits

If the benefits of a community are under concern, a thorough understanding of their costs is a complementing prerequisite to arrive with a complete picture of the contributions of Communities of Practice in an organization. Often, only the costs of running Information Technology are taken into account as a cost estimate. This leaves out various other cost factors like the costs of participation. According to a recent empirical study by (Miller et al., 2002) on average, this factor contributes 52 percent of total costs. This share is mainly the sum of payments for members with community related roles. Another 32 percent of total costs are caused by face-to-face meetings. Usually this includes travel expenses and events but also costs for online conferencing. Only 10 percent of total costs are actually attributable to the provision and maintenance of IT. This can be explained with the fact, that most companies do own the required hardware anyway and community software is usually running on simple internet browsers (see chapter 6.2 on IT applications for CoPs). An average 6 percent are caused by the content management system and promotion activities, like publishing contributions, maintenance of databases or creating community newsletters (Miller et al., 2002:4).[36]

In summary, the previous sections showed that – offsetting occurring costs – Communities of Practice provide a wide range of benefits for a networked organization and are thus an appropriate instrument for network oriented Knowledge Management. The next chapter thus analyzes their elementary properties to identify, how their organizational structure works and how they can be set up and influenced in order to provide a value for the company.

5.4 Structural Properties of CoPs

A community's organization can be analyzed in terms of its structural elements, the established role model and the executed processes of the people (cf. Figure 23). These three domains of community structures will be described in the next chapters. This section will start with the introduction of relevant structural elements.

Of course, identifying or defining a CoP structure requires a minimum amount of formalism, which usually appears as a consequence of reaching a certain size of

[36] The percentages where derived from a study of the IBM Institute for Knowledge-Based Organizations, which analyzed 9 communities in 8 enterprises in the sectors financial services, pharma, software, chemistry, telecommunication and tool manufacturing.

membership. Building on the extensive work of Schoen (2000:94) about the employment, and organization of Communities of Practice in a corporation, these structural constituents can be differentiated into rules and properties. Whereas rules can be set and changed by the manager or coordinator of the community, characteristic properties are emerging over time (more or less influenced by the predefined rules).

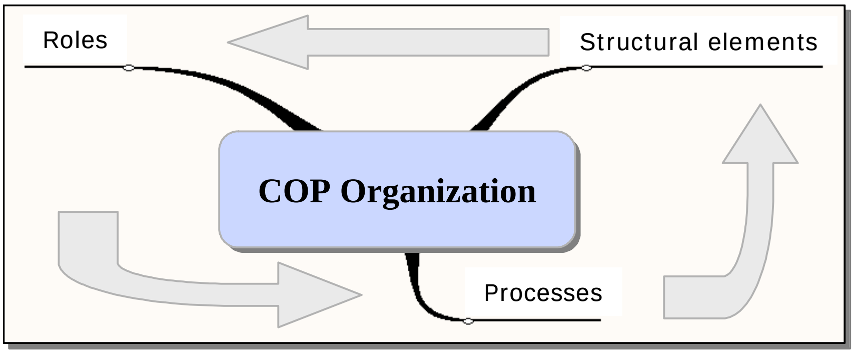


Figure 23: Elements to characterize a Community Organization.

Structural properties are either emerging or are defined by the core group of the community. They can be employed to influence the characteristics of the group. First, the size and the members of the core group have to be defined. Schoen (2000:95) suggests an optimal group size of five to six persons and proposes an absolute maximum of 25 persons. Next to the core group, the overall group size can be defined. Alternatively the group is left open to allow for unlimited members. In the beginning, there can be a pre-selection of sub-groups or hierarchies (Schoen, 2000:120). The membership duration, the continuity of their participation, their fluctuation and the actual growth of the group are related properties, which can be measured. The overall duration of the group and the lifecycle stage are the next indicator for CoP characteristics (also see section 5.6). This is followed by the definition of the geographical spread and coverage of the target group. Next, the type of the platform is determined together with its offered channels of communication (Schoen, 2000:96). Here, the mix of channels can be selected and defined to fit the culture and context of the community. For this property, there are various alternatives, which require individual processes: There are channels which support one to one communication with a high degree of privacy. Alternatively, there are the modes of one to many, many to many or few to few communication (Schoen, 2000:123). The distribution of connected or affected organizational working processes and organizational hierarchies can be regarded as a further constituting structural parameter. The community can be linked to external units (like organizational divisions or other CoPs). The qualitative and quantitative relationship structure itself is another defining property (Schoen, 2000:102). For the perspective of this work, this last element is very important during the active life of a community. The network-organization and the network oriented

Knowledge Management introduced in the previous sections are both concepts which imply that the actual structure of (network) relations is the fundamental and dynamic property of a Knowledge Community. This outstanding importance will be discussed in chapter 7 and is subsequently a major influence for the supporting technical approaches introduced in chapter 8.

A final and somewhat more abstract underlying property is the actual rigidity of these structures (or rather their dynamic behavior). This can also be measured, evaluated and even be purposefully influenced by coordinators of the community (Schoen, 2000:120).

The second category of structural properties consists of **rules**. These rules can be actively defined and manipulated to change the properties above. Among them are the rules of participation, the definition of the employed language(s), the intended utilization of the outputs, the design of internal knowledge processes (e.g. exchanges, editing and documentation, review cycles), and the purposefully staffing of certain community roles.

In a corporate setting, these rules can include the design of the incentive system (i.e. the evaluation, who gets rewarded or disregarded for what actions), the setup of the community strategy together with its system of business objectives and monitoring. Finally it can be decided whether the community receives budgets and in turn commits itself to pursuing external interests.

Figure 24 summarizes the structural elements of Communities of Practice.

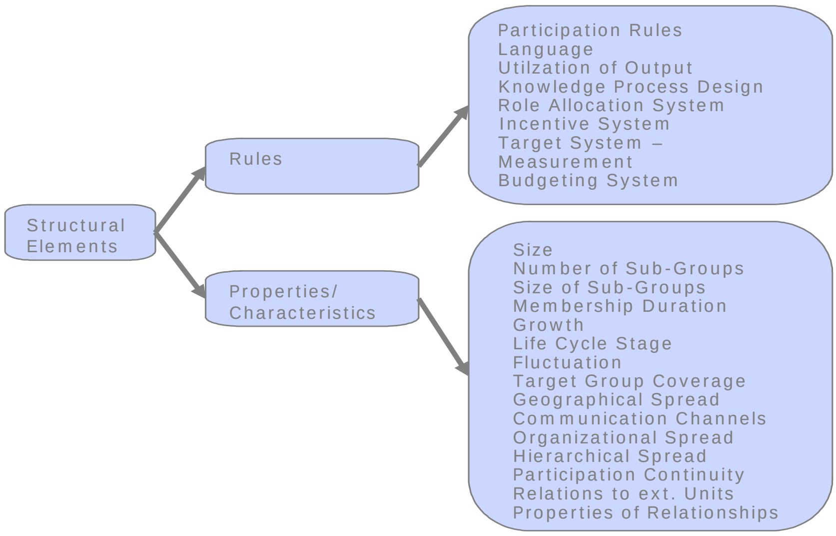


Figure 24: Structural Elements of a Community of Practice.

5.5 Roles in a Community of Practice

Next to properties and rules, another important aspect of understanding CoPs is, that the members of a community take diverse roles, which interact and conjointly produce the network organizational structure called Community of Practice (compare for example Schoen, 2000:117). The role model is usually constituted of a core group of the **most active members** of the CoP. They often have a similar function as a senior board, e.g. directing the community and making decisions. Further, there are active members and usually a majority of mainly passive members (Schoen, 2000:95). Here it should be noted, that despite their being inactive, they are very valuable for the organization as they read contributions and learn from the discussions of the topic matter experts. This is often not taken into account, when the active persons are measured against the passive members. The members can also be differentiated into internal and external members. Here, the latter are being affiliated to a separate division or organization (Schoen, 2000:95). Further the duration of the membership or the experience can aid in separating newcomers and experts. External to the community, there are potential members to be acquired.

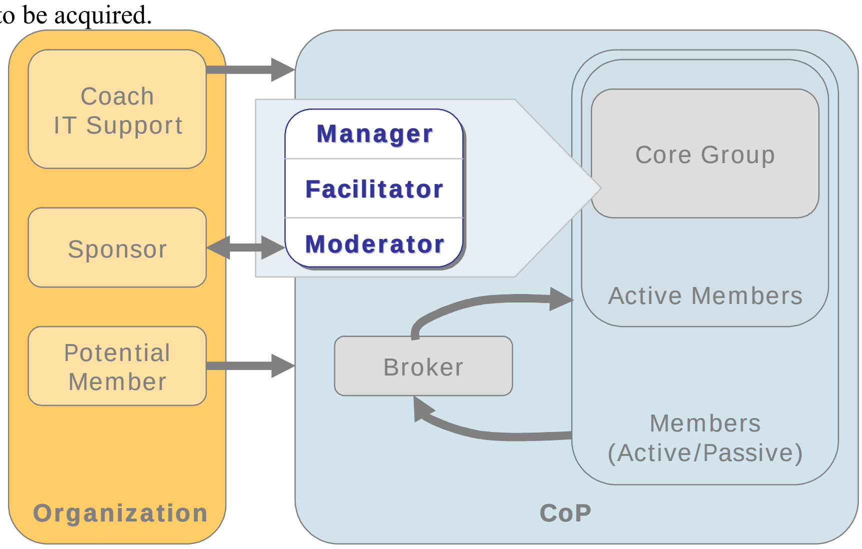


Figure 25: Overview about Community Roles.

Another role is the **broker** that connects similar people, who have not yet discovered each other and their complementary background themselves. The manager (also moderator or facilitator) is mostly one person in a coordinating position. The actual name for this role should be carefully selected in practice in order to express the special intention of employing such a coordinator. The manager is the most arguable, yet most powerful and authoritarian name for this job, whereas the term facilitators emphasizes the aspect of servicing the group. Next to the manager, there can be **sponsors** who want to achieve some business outcome of the community work and therefore provide financial incentives in exchange for a usable output or hint in a specific topic. Last but not least, there are coaches coming from central KM divisions and employees responsible for IT-Support as a service role.

The role model itself only comprises the structure of the community. However, much more relevant are the **activities** of the members. For example, people share tips like how to prepare a project offer for a certain technological solution. They discuss their approaches in discussion boards, work conjointly on generic documents (like for example a generic prognostic instrument for estimating a type of project risk), they maintain personal profiles and websites or work on think tools to tackle specific business problems or topic issues, like for example a KM audit. Some of these activities can even be structured and designed in order to allow for a smooth and unified execution. In that way, a CoP even shows some simple internal business processes. An overview about typical such activities of members is given in Figure 26.

- explain their work
- discuss their needs
- discuss their aspirations
- share information
- share hints & tips
- share advices
- share insights
- help each other
- consult each other
- discuss their approaches
- discuss their expectations

- solve problems
- explore common issues
- create tools
- create standards
- create generic designs
- create generic documents
- organize documents
- maintain a Web site
- develop trust, understanding
- develop (negotiate) common
- perspectives, approaches,
- practices

Figure 26: Typical Activities of Community Members.

For the network oriented KM approach, which is based on Communities of Practice, the manager role is very important for the progress of the group as it is responsible for all coordinative tasks. Hence, it strongly relates to the task of Knowledge Management as the person is overlooking the work of the experts and intervening into the activities of the members. Given this important position the CoP manager has to be supported in a systematical way. However, in previous chapters of this book, the tremendous difficulty of formalizing or even steering networks of people has been discussed. The question is, whether management is a constructive or a destructive activity in the domain of community work. This importance and huge potential which resides in a concept for management together with the specific difficulties to actually realize the potential benefits in practical applications is a main reason, why this role needs to be analyzed in more detail. Therefore it is now selected and discussed in order to identify concrete potential for conceptual and technical support.

5.6 Management of Community Structures - Pro and Cons

The examples of Siemens, DaimlerChrysler, or Shell illustrated professional applications of communities in enterprises. In such a commercial approach, often a coordinating role is established as an organizing and steering contact person to account for the increased responsibility of the group.

A primary intention for the employment of such a management role in a Community of Practice can be seen in the legitimization of the group in the organization. Here, Wenger (1998) introduces a maturity model, which shows different degrees of legitimization. In the beginning, the community is not recognizable for its members (level unrecognized), subsequently it becomes an entity for a central core of people (level bootlegged), in the third level the CoP is finally recognized as an institution in the organization (level legitimized).

Degree of Formalization	Description
Unrecognized	Invisible for the organization and to some extend also for the CoP itself
Bootlegged	Only informally visible to a limited amount of people in the immediate environment
Legitimized	Officially accepted as a valuable unit
Strategic	Widely recognized as having a central role for corporate success
Transforming	Able to influence and redefine its corporate environment and the whole orientation of the organization

Figure 27: Maturity Stages of a Community of Practice. Source: Wenger (1998)

To deal with the competition for time and resources with the project or line organization, or for improving the development of competences, the CoP Manager can employ outbound oriented tasks like the active communication of the existence and the results of his community. This role hence needs to steer the group towards a synergy (i.e. resonance) with the organization's objectives. This implies to select and pursue topics, which are of relevance to the enterprise. Further, the management can employ sponsored resources and meet the controlling needs of the respective sponsors (North et al., 2000).

The most important property with consequences for the feasibility of a management role and the subsequent design of coordination measures is the degree of voluntarism and bottom-up orientation of CoP-members. Many community mechanisms and platform activities can be traced back to internal group dynamics and social mechanisms. Therefore, the flexible and self-organizing communities are rather autonomous and difficult to manipulate and control by external persons (Stamp, 1997). Some authors even strictly neglect external exertion of influence (Por, 1997).

However, there is a scientific group which – despite accepting the difficulties – shares the opinion that communities can be supported and hence also be controlled by new means of work, despite the voluntary work of their members (Wenger, 1998; McDermott, 2000; Gongla Rizzuto, 2001). For example North states, that the contexts for living Knowledge Communities can be purposefully designed and created (North et al., 2000).

The proponents of this view highlight the personal leadership qualities, which are necessary for successfully establishing working communities (Henschel, 2000). A special aspect is the acknowledgement of the leader, which has to be rooted in his work within the community, e.g. by his expertise or organizational engagement, but not by any disciplinary definition (Wenger, 1998).

Figure 28 summarizes the main arguments for and against a management of communities. On the one hand, the management has to define certain selection criteria and rules for their members although communities are based on voluntarism. Further, communities need shared and lively events and meetings to keep up the continuity and motivation as well as to strengthen the trust despite the advantages of applying virtual interaction platforms. The CoP shall discuss topics relevant for the company, but still the members need to establish a high degree of involvement and personal interest. A community is being formed by certain situational needs and should be able to adapt to changing environments (e.g. size, members). Nevertheless, it also requires a certain amount of continuity. Handling and utilizing these major trade-offs is simultaneously the major challenge for management.

On the one hand...	But on the other...
participation is based on voluntarism and personal interest and engagement of the individual member	the management has to define certain selection criteria and rules for their members
communities can communicate using cheap virtual interaction platforms like intranet or mailing lists	communities need shared and lively events and meetings to keep up the continuity and motivation and strengthen trust
the community shall create a high involvement and emotional binding of the members	the CoP shall discuss topics relevant for the company
the community has to provide for a certain continuity to create the necessary trust between members and to form a common knowledge base.	a community is being formed by certain situational needs and should be able to adapt to changing environments (e.g. size, members)

Figure 28: Management of Communities: Pro's and Con's.

The following argument further describes this seemingly contradictory situation:

> "Communities of Practice do not usually require heavy institutional infrastructures, but their members do need time and space to collaborate. They do not require much management, but they can use Leadership. They self-organize, but they flourish when their learning fits with their organizational environment. The art is to help such communities find resources and connections without overwhelming them with organizational meddling. This need for balance reflects the following paradox: No community can fully design the learning of another; but conversely no community can fully design its own learning." (Wenger, 1998a).

The special challenge of a moderating or managing role is also widely discussed and characterized in the literature. Examples are McDermott's community leader (McDermott, 1999) or Fontaine's concept of a facilitator (Fontaine, 2001). By analyzing existing communities and their success factors on a more detailed level, Kim develops a seven role model including the three roles host, event coordinator, and greeter (Kim, 2000). A similar concept is found by Wenger (Wenger, 1998) who even identifies seven leadership roles. Among them, there is an institutional leader who is the link to the organization, an interpersonal leader who supports tight social networks between group members, and a day-to-day leader, organizing activities. In the end, all these roles can also be interpreted as special organizing tasks, which can be attributed to a more general organizing role, referred to as 'Community Manager'. This person takes the responsibility for the coordinative tasks and represents the community at its external interface to the surrounding formal organizational structure. While in some groups this role is very defined and visible, in other groups the leader does not appear explicitly or its tasks and responsibilities are dispersed across various persons.

Although the name of the role implies that communities are directly manageable, this task is very special because of the principle of voluntarism in such networks. There is no hierarchical power, which could be employed by a community manager. Members dislike to be instructed and rather feel like a group of volunteers who contribute their insights to a topic only, if they need to do it. This renders management more a facilitating context management, which enables members to work on their ideas (Fontaine, 2001). It is not focused at the distribution and completion of work tasks but on social interaction, learning, and knowledge exchange, which subsequently and indirectly foster the development of solution and the work on assignments. The generation of a strong identity and the emphasis on relationship networks is next to content-related work a very important factor for managing such a CoP. The manager has thus to indirectly and very carefully utilize the mechanisms of a voluntary expert group. This has to be reflected in the tasks of community management, which are discussed in the next section. Johnson (2001) attributes this effect to the various constructivist properties of Communities of Practice. They involve ill-structured problems, learning in a context of real-world-problems, shared goals, and the use of cognitive tools to organize knowledge. Ill-structured problems cannot be solved by any individual alone and hence the instructor is changing towards a facilitating coach for guiding the learning and helping the team to develop. This moves the control away from the instructors to the group and a network of people emerges.

According to this special situation, CoP managers are often emerging from the group and are equipped with strong expert legitimation to strategically and tactically be able to influence the community development.

Finally, a theoretical argument for why the management of people networks is actually vital draws back to System Sciences and to its proponent Luhmann (1984:46). He describes a group of elements as complex, if, due to immanent capacity restrictions in the ability to connect, not every element can be connected to every other. This immanent restriction also implies that the system (e.g. a network between people) can not fully access and observe the internal complexity of the system's elements (similar to information hiding in object oriented software architectures). In other words, because of the condition that these elements have to be complex to allow for their utilization for complex system's tasks, the elements (or their interfaces) are so specific, that their ability to connect to every other element is reduced. Complexity of elements hence creates the necessity for selection. Every complex task requires careful selection of relations between a system's elements. Thus, it is neither possible nor efficient to connect all elements or people in a network as the people are specialized and complex themselves. Rather, it is necessary to have the system or acting units like a manager select and direct the development and establishment of the network's relationship structure.

Summarizing, although the management of Communities of Practice is unlike conventional management, it can be utilized as a means of coordination. However, the management role has to consider completely new aspects, as it can not easily apply hierarchical authority. To some extend, CoP managers are thus pioneers for modern management approaches which can cope with increased autonomy of employees in working teams which utilize multiple and non-deterministic means of communication. The next chapter clarifies these specific options and according methods for managerial intervention into a network of experts.

5.7 What and How to manage

After having substantiated the benefits but also the key challenges of managing Knowledge Communities, further questions arise. For example: What should the manager actually consider and where are his concrete levers for intervention to be found. The research on Communities of Practice is proposing a wide variety of design and configuration concepts. One approach is to configure the rules and observe the changes in the properties of CoPs. This strategy has already been discussed in chapter 5.4. Another opportunity to identify domains of intervention is a systematization of general success factors and their translation into a conceptual management approach. As an example, the approach of North et al. (2000) will now be briefly introduced to prepare for the next chapter, which is moving from soft and generic domains to a more operational level of actual tasks for members, moderators, and the other roles.

The approach of North et al. (2000) discusses four important domains of intervention and configuration for a Community of Practice. The first element includes the persons, who are members of the Knowledge Community. They contribute several factors which are simultaneously domains for affecting a CoPs configuration. Such people oriented factors are their motivation, their organizational affiliation, their level of expertise, and their diversity in terms of knowledge. A further domain is the interaction of these persons. Here, factors like communication forms and intensity, the general atmosphere and the identity of a community are allocated. The third domain is the resulting knowledge transformation from tacit to explicit knowledge. Finally, the domain of organizational integration can be influenced by changing the degree of formalization, the community borders and the time horizon of the community.

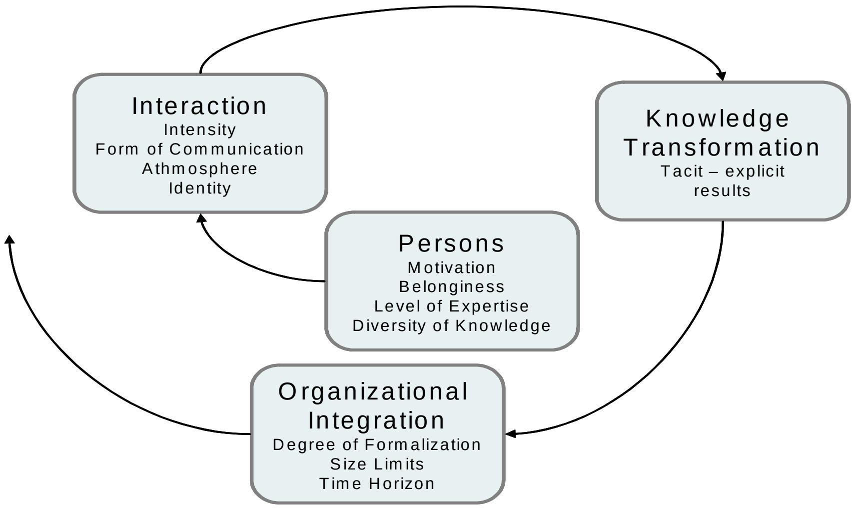


Figure 29: Four Dimensions for designing and influencing Knowledge Communities. Source: North et al. (2000)

If these domains are analyzed, it becomes obvious again, that the management of communities has special challenges. It is focusing on communication, motivation, knowledge development, and even such abstract concepts as identity. Together with the discussion about the special challenge of managing a heterarchic people network without legitimized hierarchical authority and the section on organizational benefits, it can be concluded that there must be a substantial dominance of social motives of a community moderator. In fact, the literature about the question of how to successfully running communities suggests a multitude of leadership tasks. They are summarized in the following incomplete yet comprehensive list (cf. Lave and Wenger, 1991; Nahapiet and Goshal, 1998; Hildreth et al., 1999; Wenger, 1998; Schoen, 2000; Wenger et al., 2002; Thomas et al., 2002; Hemphill and Westie, 1950):

- foster and maintain participation with valuable feedback ,
- balance solution exchange and solution development (in the form of content generation and integration),
- create group identity,
- create a setting of mutual obligation,
- integrate isolated participants,
- observe role formation,
- improve inefficient parts of the network,
- monitor quality of interactions,

- refine and share best practices (i.e. via contents and communication),
- understand existing informal CoP structure,
- increase informal learning activities,
- foster innovations,
- create familiarity between persons,
- communication of purpose, objectives, progress,
- balance group autonomy vs. openness,
- increase importance for participants,
- create relationship networks with tight connections and transparent visibility of members within the network,
- analyze specialization and roles of individuals to form role architecture to increase group stability, because over time group work is improving,
- create mutual trust,
- foster and communicate homogeneity and similarity in groups,
- weaken detrimental factors like concurrence and unsupportive personal profiling,
- create and environment of obligation and mutual commitment,
- analyze interaction and interactivity,
- create group stability, and
- influence orientation and objectives (polarization/diversity).

These management issues are very consistent with the literature on the role of community managers. Next to the actual creation, integration, refinement, exchange, and maintenance of contents (as knowledge assets), the creation of people networks appears as an important objective, again highlighting the difference between codification and personalization (cf. Hansen et al., 1999). It can be noted, that they do not include the usual means of conventional management: the delegation of tasks and control of results. It is more a context management, where the person in charge of developing the whole group has the complex challenge of socially intervening into a big group. The conflict between acting as a manager which needs to achieve objectives and acting as a catalyzing moderator, which has to remain 'invisible', is characterizing the necessary care when using the term management (cf. the 'facilitator' of Fontaine, 2001). The complex (and to a large extent systemic) environment of a community moderator and his soft tasks and challenges play an important role in this book's approach for managing network oriented Knowledge Communities and the subsequent software for supporting virtual expert networks.

Finally, it has to be mentioned, that a definite list or characterization of leadership roles in the context of community structures is still an issue under research. It can not be developed by applying conventional management theories and approaches, as community coordination fundamentally differs from other groups, like e.g. project teams. However, the issues discussed in this chapter provide a first orientation for the difficult question, where the moderators can be supported in their managerial tasks. Especially the strong sociological emphasis in such network oriented organizations affects the complex issues of measurement, analysis, and evaluation of the current state of the community, which is a major concern for CoP facilitators.

5.8 Tasks and Processes during the Community Lifecycle

The previous sections outlined the importance of managing groups of people when managing CoPs. This also relates to the issue of dynamic network evolvement. Here, the formation of a Community of Practice is essentially a bottom-up phenomenon. It starts with various small cells of maybe two or three people that interact to solve business issues. They do not know which relationships the other person has in the back. So the network is only partially known and it is very decentralized. These cells slowly grow in size, more people are incorporated, and the whole extent of the network gets more transparent. People learn to whom their colleagues address their questions. By this process, the network gets identified completely, yet it is still decentralized and communication from one point to the most distant opposite point of the network is difficult, time consuming and unlikely. Sometimes, the network gets centralized in a next step, using a platform. Now everybody reaches everybody via a central (often IT-supported) platform. Here, the character of the network fundamentally changes, a thing that every community coordinator has to consider. Often the close and exclusive social ties to some important contacts lose in value as other people now can also easily access this person. So, obviously there are disadvantages and advantages to consider.

To analyze the coordinator's influence on his community more systematically, a lifecycle concept can be established. Similar to Wenger's maturity model, a lifecycle perspective emphasizes the increasing development of the informal network and models general development stages. It renders it possible to derive the necessary demand for a successful cultivation of the underlying social network. By this, the general tasks of the previous section can be applied to influence the evolvement and progress of an actual 'object'.

In the literature several such lifecycle models are proposed (e.g. Wenger, 1998; McDermott, 2000; Gongla Rizzuto, 2001). Two of them will be very briefly reviewed before an integrated and simplified life cycle approach is presented[37]. It helps to allocate the multiple tasks for members, managers and other roles on a time scale of evolutionary steps. These tasks can again help to increase the understanding of what sequences of behaviors do happen in a community in order to shed more light on the question, how a suitable support should be designed for the participants of such expert groups. However, as the people integrating tasks are eminent throughout the lifecycle, these stages are also focusing on content-related tasks.

5.8.1 Wenger's Community Lifecycle

Wenger (1998) proposes a lifecycle model which is progressing through five stages: potential, coalescing, active, dispersed, and memorable. First, people face a similar situation without a shared practice and they start to find each other. They initiate discussions about shared topics of interests to utilize each others practical experiences. A decisive criterion for the emergence of a community is the intensity of the mutual interaction depending on the necessity of collaboration. This results in the establishment of informal relationships.

In the coalescing stage, the employees come together and start to recognize their potential. They have several meetings or other joint interaction and communication. They use these instances to explore their similarities and to define shared objectives. This leads to an engagement in conjointly developing a practice. It is not completely established; rather the community is negotiating it. Every member takes the position, that the engagement should also benefit its own objectives.

After having established a shared practice, a period of increased working activity starts. New knowledge is getting generated and exchanged between participants. Artifacts like documents or stories emerge. New topics move from the periphery to the center. Relationships develop between CoP participants. Novel topics may eventually lead to the development of sub-communities or even completely distinct groups.

However, over time the intensity of engagement declines, still the community is the center of knowledge-related activities. Some people meet from time to time to discuss current problems or look for mutual support. However, the importance decreases for members, and persons which do not belong to the active core even completely stop their participation. This makes the community less attractive for members and there are no newcomers. This chain reaction increases the decline until the group enters the memorable stage, where the community loses its central role, but its meaning for people's identities remains persistent. Important artifacts

[37] McDermott's model strongly resembles Wenger's model.

are sometimes taken for a subsequent community, so that individual parts of the CoP survive.

A similar lifecycle sequence has been identified by McDermott (2000). It consists of the stages plan, start-up, grow, sustain, and close.

5.8.2 IBM Lifecycle

A further lifecycle concept, which is actually more a maturity stage model, has been identified by Gongla and Rizzuto (2001) in their observation of IBM's Communities of Practice. In the 'Potential' stage, a community is forming around a nucleus. This core is consisting of individuals with a common work interest. However, the group has not completely discovered what their commonality is. Connections are the fundamental issue of this stage. People must be able to locate each other, communicate and form relationships.

In the following 'Building' stage, the community defines itself and formalizes its operating principles. Here, the members declare its existence. The core group starts to create structures and processes for the community's operations. Context creation and memory are fundamental functions. Members start a shared history by conjointly creating things, which later become utilized. This also fuels the common understanding of the notion of membership. The core starts to reach out to others who should join.

During the 'Engaged' stage, the community executes and improves its processes. It operates with a common purpose and grows in size and complexity. Access between community members is a key function to leverage explicit and tacit knowledge. The community learns about itself as an ongoing entity, e.g. how it adjusts and improves.

Phase	Definition
Potential	A CoP is forming.
Building	The CoP defines itself and formalizes its operating principles.
Engaged	The CoP executes and improves its processes.
Active	The CoP understands and demonstrates benefits from KM and the collective work of the community.
Adaptive	The CoP and its supporting organization(s) are using knowledge for competitive advantage.

Figure 30: Community Life Cycle Model of Gongla and Rizzuto.
Source: Gongla and Rizzuto (2001)

In the subsequent 'Active' stage, the community reflects, understands, and demonstrates benefits from knowledge management and the collective work of the community. It solves business problems and exploits business opportunities, which over time increases the CoPs role for pooling knowledge. Further, it extends its membership and builds relationships to external groups.

Finally "Adaptive", the community and its supporting organization(s) are using knowledge for competitive advantage. It reacts to external conditions, innovates and generates new business objects, like solutions, offerings, methods, processes, and even new groups or trends in its area of expertise. Figure 30 summarizes the lifecycle model of Gongla and Rizzuto (2001).

5.8.3 Integrated Lifecycle

Figure 31 integrates the three introduced approaches into a simple life cycle model with four phases. Before communities get implemented, it is advisable to identify preparatory steps in the context of the preparation phase (compare for McDermotts Planning Stage). Afterwards, the actual identification and formation of the community follows in the build-time-phase. Subsequently using the measures introduced in the next section, in the iterative and feedback-like run-time-phase the maturity and performance of the CoP can be increased (for example by the introduction of IT platforms). The objective is to postpone the final completion phase (Wenger, 1998).

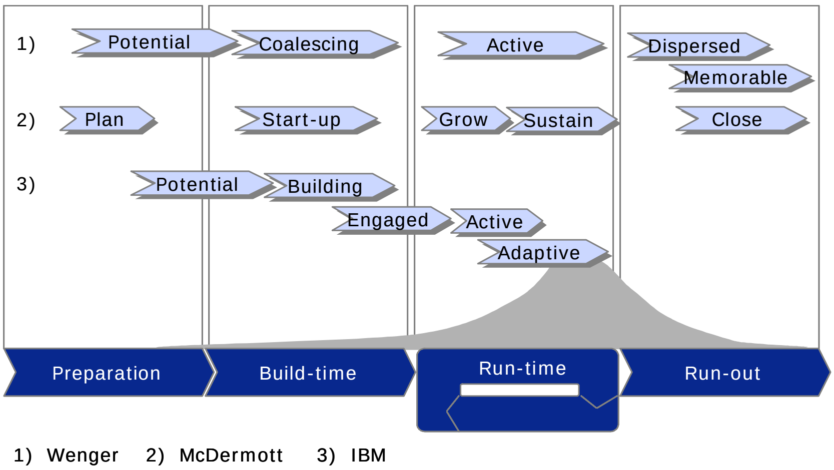


Figure 31: Four Phase-Model of a Community Lifecycle. Source: Trier (2002)

This general concept is now utilized to allocate the tasks and processes of community coordinators to the four stages. This gives a good picture of what actually happens inside an expert group, which in turn enables to better understand, how such groups can be supported by methods or even IT-applications.

However, it is difficult to find a clear separation between members' and managerial tasks in a community. Often, more than one leader emerges (e.g. compare the seven leadership types of Wenger, 1998), which acted as a regular member and might return to that level.

Next to the separation into lifecycle stages, another distinction can be drawn to systematize the tasks. The manager's position at the border between the community and the formal organizational structure, the tasks of the CoP-coordinator have two directions: there are inbound oriented and outbound oriented tasks. Inward oriented tasks are primarily directed towards the creation and communication of a group's identity. This can be developed by a bottom-up approach, by which the roles and working tasks are integrated and formalized. These tasks can also include the decision of organizational questions and the support of other coordinative roles, like for example, moderators, knowledge stewards or editors, brokers, or event organizer etc. (Trier, 2002). Outbound oriented tasks are focused at the environment of the community, i.e. communication the progress and value generation to the external stakeholders.

During the stages of the community lifecycle different issues arise. They are now discussed in the next chapters

5.8.3.1 Preparation Stage

For a successful implementation of communities a preparation stage should be considered. Here, the necessary prerequisites are examined, evaluated and created. Barriers for successfully running communities are primarily in the domain of social relationships and the corporate culture. A cultural assessment and an as-is-analysis of the current informal processes can avoid the problem of many KM initiatives that in the end the necessary acceptance of the solution may not be achieved. This can happen, if it has not been invested enough upfront in order to create a satisfactory understanding for the existing working processes and modes of the employees (Allee, 2000). In the underlying social networks the fundamental principle is trust (also see section 7.1.3 for more). Trust is especially important, if in large Virtual Communities employees meet new colleagues to create exchange relationships. Next to the management of organizational conditions, further preparatory steps are advisable, like for example the identification of the individual benefits of the community under consideration and its suitable topic areas or a community development strategy (Wenger, 1998).

According to Wenger, this strategy determines the subsequent requirements for the various organizational divisions. Line managers need to provide the necessary time and resources to ensure, that the persons can participate in suitable and beneficial communities in order to utilize the gained insights for their line projects. The corporate strategists have to create a bi-directional channel between strategy formation and community management. Finally the work environment must be designed accordingly.

5.8.3.2 Build-time Stage

During the build-time stage, a core of individuals with shared interests engages repeatedly in informal and problem oriented interaction. They start to learn about each other and get familiar (Gongla and Rizzuto, 2001). In this critical process, the options for management intervention are restricted to the identification of the existing tightly connected core and its extension with further suitable and complementary persons. For this activity, especially the informal interaction between employees needs to be studied[38]. It can also be necessary to start with uncovering and exploring the similarities of a group of related persons (Wenger, 1998).

For that, the usually inherent desire of emergent communities to grow (Nickols, 2000) should be supported with an appropriate organizational service, which can e.g. organize meetings or supply necessary resources. Schoen (2000:143) suggests conducting a preparatory kickoff-workshop. It is usually participated by a core group. Such workshops clarify the demand for an output and the required competencies. Further, the group explores its identity as well as methods and instruments for their community work. At this point, Wenger suggests the conception of an enterprise-wide community awareness campaign (Wenger, 1998) which is an outbound directed task to inform the organization about the existence of the CoP and about the likely values it will generate.

In sponsored CoPs (i.e. initiated by management), business benefits are derived from the organization's objectives and persons with the appropriate profile get contacted. This scenario is strongly related to team structures with dynamic patterns of interactivity but without a fixed set of members or fixed tasks.

In the next step, the community starts to form an own identity. The members generate defined processes and start to create structures. Typical roles are formed, like the enthusiastic champion, the integrating facilitator, or the competent expert (Nickols, 2000). The members create first artifacts and the history of the group starts, which slowly forms the actual purpose of the group over time. With this, the desire starts to contact and recruit new external members. The management activities of this stage include the provision of help to find a group's identity as well as the facilitation of the decision to become a visible and recognized community. Further, management can help with the planning of necessary processes and structures, like roles or codes of conduct, help with the identification of new members and finally it can deal with the capturing and documentation of knowledge flows and the integration of problem solving strategies.

After the structure and the institution of membership have emerged, the designed processes are executed in practice. The size of the community increases, it becomes self-sustaining and it learns about its own existence and characteristics.

[38] This investigation can also be supported with the tool developed and introduced in the final chapters of this book,

First learning processes appear and are implemented as improvements in the line divisions. The members share their experience and support each other in their business processes which are external to the community. The manager supports the integration of generated artifacts into a structured knowledge base (Knowledge Management System), the socialization of members, the establishment of feed-back structures and processes as well as means of introducing, motivating, and monitoring a result oriented community work (cf. Jarvenpaa and Leidner, 1998).

At this point in time, the migration to an IT-supported platform is especially for emergent Communities of Practice a very fundamental intervention, which also has consequences on the subsequent management of the group. Important decision criteria are the culture of the participants and the expected number of members as well as their expected geographical dispersion. This topic is introduced in more detail in chapter 6.

IT-platforms first start to affect the necessary condition of (ideally personal) social and not only professional connections between employees and therefore can cause a high risk in certain community cultures. Despite this risk, it is usually very beneficial to employ IT-platforms to guarantee the efficiency of the group with growing group size. Additionally, the community is given a (virtual) center, where almost all information can be seen and accessed. This is the first time, that all interaction can be observed explicitly, which improves the recognition of the individual identity. From a management perspective, this visualization and communication of the joint identity is a critical success factor. Coordinators should thus conduct trust-forming activities like the reduction of uncertainty about the employed technology and processes, they should ensure expectable communication, e.g. by notifying absences or introducing numbering systems.

5.8.3.3 Run-time Stage

Between the build-time and the run-time stage there is a continuous transition. The content-related work is slowly replacing the formation of structure. People conduct main and related activities to generate the CoP's output (Schoen, 2000:116; also cf. Figure 32). Main activities are documentation, discussion processes, utilization of the storage systems, cooperation on problem-solving processes or even just-in-time support for other's business problems, evaluation of contents, mediating and sharing contacts etc. External knowledge is acquired and the group looks for potentials and benchmarks. Moreover the definition and management of handled topics is being conducted (Schoen, 2000:140). Related activities of this stage are maintaining contents, or identity-improving activities.

For every problem, dynamically a cluster of experienced and interested persons emerges. They support each other and apply the shared knowledge in concrete tasks outside the community. Reflexive feedback about the actual learning processes of those who applied the advices for solving their problem fuels the knowledge and experience of the whole group. The manager can support this establishment of a feedback circle, which enables the adoption and improvement of the existing interaction patterns and working processes of the group according to the new insights gained. Thus, with increasing maturity, the groups become adaptive in their structure (Gongla and Rizzuto, 2001) and can start to autonomously incorporate changing requirements into their problem solving approaches. In this context, a further important task of the facilitator is to bring together the capabilities of the group's members with relevant business problems of the enterprise. For this, a main issue is to systematically nurture the communication. The latter is vital for knowledge processes and thus the management of communication channels, behavior, and networks are a crucial part of the manager's tasks. Knowledge Management hence boils down to communication management. This assumption plays a major role in the final solution proposed in this book. Finally, the facilitating coordinator has to communicate results and success stories like improved processes or new solutions to the whole group and to external persons. This requires the communication of value generation, the transfer of edited work results into public documents and into knowledge bases, reporting processes directed to sponsors and the alignment between the community's and the corporate strategy.

Generally, the manager has to ensure, that the organizational interests are relevant for the community's work and has to avoid, that CoP members do engage too much in work without significance for the enterprise (North et al., 2001). He has to observe if barriers hinder knowledge exchange or participation and he has to identify if the group is eventually approaching a decline stage.

An alternative approach for classifying the tasks of the run-time stage is a differentiation into different knowledge related processes. This shows again the good applicability of Communities of Practice for Knowledge Management. The complete cycle of building blocks as proposed by Probst et al. (1997) ensures a complete knowledge process. In community work, members document experiences, identify demand for new knowledge, classify and sort new contents, edit and evaluate the contents. Further they compress information and distribute it to suitable locations and persons. These knowledge processes are augmented by the management tasks of the moderator, who is usually influencing the objectives and observes activities and results.

These knowledge-related tasks of the manager differ according to the primary type of the community's interaction: This can be tending towards a personal face-to-face group or comprising a primarily IT-supported virtual group. The first type is usually found in a small group and the tasks of management are those of a team leader with only indirect orientation towards the accomplishment of results. In the usually larger Virtual Communities, the tasks of management are less bound to personal contact and a rather content-related work area emerges[39]. This can gener-

[39] Although the large group should additionally be treated as consisting of smaller groups.

ally be differentiated into three segments with a set of tasks for each (compare for example Participate, 2001):

- Transformation of unstructured information, for example via tracking of interactions to early discover and identify emerging information and content, establishing connections to qualification planning of the human resource division and to structured knowledge bases (Content Management Systems, Document Management Systems, Knowledge Management Systems).
- Diffusion of community knowledge, e.g. via newsletter or e-mail notification, supply with relevant external content, ensuring ergonomic platform functionality, adapt and improve the interaction and problem solving processes, edit contents for multiple reuse and wide application.
- Socialization (integration) of community members, using membership programs, measurement of interaction and identification of established social relationships ('strong ties') and key experts, connecting complementary persons and groups, creation of suitable incentives, organization of events like off-site meetings of new members with CoP-champions or membership management.

The measurable output created in the run-time of the community is primarily content-related or is represented in measurable improvements of the enterprise's value production. Examples for such innovations are:

- faster knowledge intensive process for setting up projects,
- more revenue per time period,
- widely available consulting expertise and best-practice approaches, or
- quicker achievement of full effectivity for new employees.

Internal Evaluations and measures can be utilized for an internal controlling and an external reporting. The latter communicates the successes to sponsors, to CoP-members, but also to potential knowledge carriers (experts) in the organization.

5.8.3.4 Decline Stage

In the final decline stage, a closing workshop to elicit and reflect and document implicit insights and to prepare reusable output artifacts should be conducted. The outputs are then handed over to the former members or to the enterprise. Sometimes the community transitions into a formal business unit.

The following Figure 32 summarizes the necessary tasks during the lifecycle.

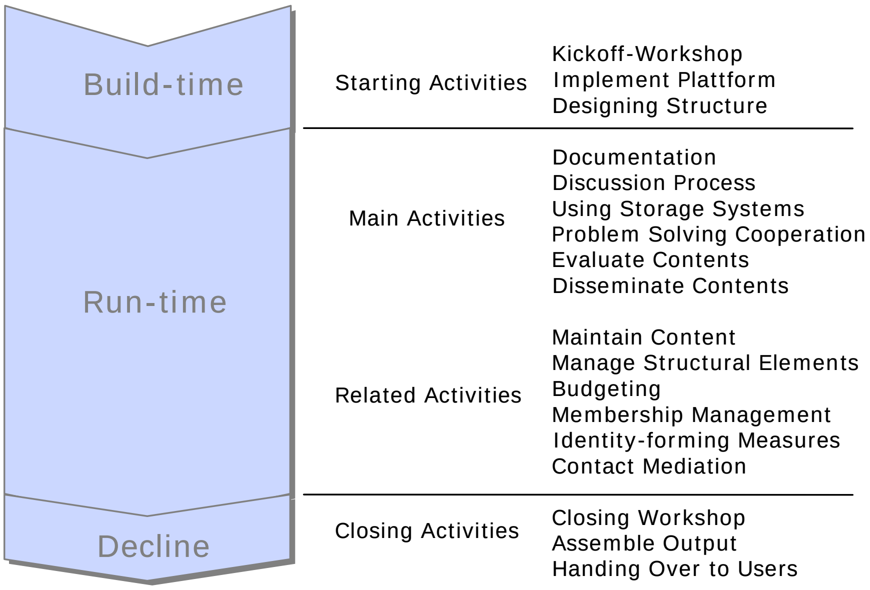
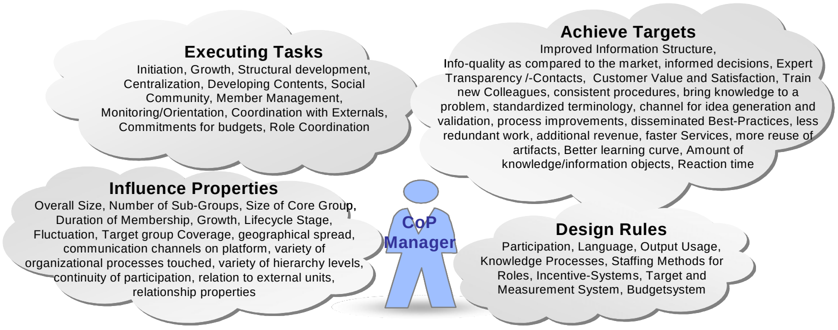


Figure 32: Overview about the main Activities in a CoP's Lifecycle.

Figure 33 shows an overview about the introduced tasks of a community moderator: In summary, the type of management processes is not only content oriented but is primarily dealing with structural issues, which precede the content or knowledge creation, e.g. the social structures and mechanisms of the group. The role's activities includes moderating processes (Schoen, 2000:140), initiation, external communication and connection to other groups, content maintenance, the creation of transparency, the measurement and management of structural elements, topic management, and competence (and progress) assessment.

The table at the bottom of Figure 33 summarizes the predominant work domains. Internally the moderator has to create value in three dimensions: People, Content, and Network. He has to build expertise and qualification in the people domain, identify useful contents and develop documents in the content domain, and foster a working network of employee relationships. Then he has to communicate this value to external stakeholders, including competence profiles, consulting topics, documented knowledge, standards, stories or Best Practices, or communicate his improvements in Social Capital.

Finally, from the multitude of activities shown in Figure 33, it can be implied, that the management or coordination of a community is no easy venture. The manager has to conduct various management tasks and has to influence the properties of the community correctly. Further, he has to define the rules and to achieve external and internal objectives.



Inward-bound: Create value	**Outward bound:** Communicate value
People: Build expertise and qualification	Competence profiles, consulting, training
Content: Content Identification and Development of Documents, Dissemination	Content, secured and documented knowledge > guidelines, Best Parctices, Stories
Network: Social Relationship Network	Social Capital > measurable results

Figure 33: Final overview about the tasks of a Community Manager.

In such a complex situation, conventional management is usually supported by employing a generic management feedback loop consisting of a planning stage, the subsequent execution of the plan, the measurement of the achieved results, and the interpretation of the measures in regard to the last stage: adaptation of the plan (e.g. cf. Hahn, 1996:41). This again emphasizes the important aspect of being able to derive measures or find other means to evaluate the existing situation. Only then, interpretation of this analysis can lead to improved interventions. The necessity of such a measurement aspect is even more important, if the large size and the limited transparency of expert groups with up to 1000 members are considered. The aspect of measuring community structures, processes, and progress (evolution) as well as their impact on managerial tasks is the focus of the next chapter.

5.9 Role of Measurement for Managerial Community Tasks

The American Productivity and Quality Center APQC analyzed communities in large companies. Here, systematic monitoring of effectivity and assessing the ‘health’ of the community has been identified as being a very important factor for Knowledge Management in an enterprise. Next to the incorporation of the organization’s general strategic objectives and the leadership qualifications of the moderating persons, the community structure is an important element of management. This institution demands, that CoPs need to set up objectives and measure the actual performance using monitoring and controlling instruments (APQC, 2001).

For this, a manager has to be capable of systematically observe and evaluate his group. As already introduced at the end of the previous chapter, ideally, he establishes a feedback loop of planning, assessment and evaluation. A central prerequisite is the perceptibility of effects, which is usually n outcome of a measurement system (as a 'sensor system' for a community). A further motivation to apply such instruments is the need to report the community's progress to the external organization, as described in section 5.6.

Next to APQC's general demand for CoP measurement, other authors at least emphasize the need. A recognized thought leader in the field of Communities of Practice, Richard McDermott, emphasizes the role of measurement for integrating communities into the organization.

> "For communities to become integrated into the business, they, like other organizational units, need to "play the game of business" and be judged against measures of efficiency and effectiveness, like other organizational activities. So measuring value is critical to fit into other organizational elements. The people who argue that Communities of Practice are too organic, too democratic, or too informal to be measured, do more harm than good in trying to make Communities of Practice a recognized part of organizations." (Cachel and McDermott, 2001)

McDermott further notes, that all measures have stakeholders. A community leader has different needs as a sponsoring business unit manager:

> "A community leader, for example, needs to know what events and activities regularly draw the most interest. So counting participation in meetings or hits to websites can provide important information to them. But business unit managers typically have little interest in this sort of information. They need to know if their investment of people and resources are worth it. So they need measures of the value of the community. Organizational leaders may also be interests in ROI information. But they may also take a broader view, interested in how communities create or develop organization wide capabilities or position them better in the market." (Cachel and McDermott, 2001).

As these examples imply, the issue of measurement is a very important aspect of community management. It helps responsibles to maximize the life-cycle duration and the value generation of their expert groups. However, so far, there are almost no profound approaches available. Although some authors propose preliminary measurement systems (e.g. Cothrel, 2000), most of them only propose to count clicks and documents in a software application. Usually, there is no systematic consideration of the special social structures of such CoPs integrated and if it is, then again no real measures are proposed. In this difficult situation, this book wants to extend the current approaches in order to advance the discipline and to improve the application of communities in enterprises. The special approach is to analyze the communication of a group of experts. The underlying communication contents and patterns are then employed to identify special social structures and processes. These structural insights are translated into measures, which subsequently assist community moderators and managers in their design decisions. The described approach takes into account the results of the discussion about network organizations and the related requirements of Knowledge Management (compare chapter 3.6). There, it has been identified, that network oriented KM primarily needs to focus on (the support of) expert communication in a network of people. Analyzing this communication to improve its support is thus a promising strategy.

With this approach in mind, looking for possible inroads for organizational but also technical methods for community evaluation and analysis prerequisites a closer examination of the role of IT and of community software in expert groups. During the previous chapters, related issues like the special form of a Virtual Community have already been touched. This aspect of IT-support together with its implications for community management will now be discussed in more detail in chapter 6. To anticipate the findings of the next chapters, IT plays a very important role for the support of large groups of experts. This enables the establishment of a technical approach to measuring communities in chapter 7, which is utilizing the available electronic traces of communication for deriving suitable models of the community infrastructure. The resulting approach is implemented as a software (cf. chapter 8), which can help managers to increase the necessary transparency of their group. Some case studies illustrate this benefit in chapter 9. But first, the important role of IT is compared to the actual offerings of community software support.

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 identifiying and communicating benefits, or the aspect of life-cycle stages and dynamic evolvement. 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 like mail centers, public folders, discussion boards, an integrated document storage facility, and yellow pages (McLure-Wasko and Faraj, 2000).

The necessity of a central place for communication has also been substantiated theoretically by Nonaka and Teece (2001). They established the concept of Ba, stating that knowledge transfer always requires a place like in this setting the platform in order to work. “Ba” is the Japanese word for place and represents the context in which knowledge is created, shared, systemized, and exercised.

In order to utilize all these advantages of software infrastructures, the manager needs to successfully migrate the very informal and invisible initial relationships of his group of experts to this platform. However, the adoption and movement to a platform has to be in line with the life cycle stage of the community (cf. Trier, 2002). The expert group originally emerges from informal relationships between people, who start to develop a network without the application of information technology. Over time, the growth in group size and the geographical distribution of members directs the attention to the issue of technical support for these groups and the application of a central community software platform together with related service processes.

The main difficulty in employing software support is the change in network structure. A formerly decentralized network with many social elements is becoming centralized on a platform. Persons with very exclusive relationships (sometimes established over years) could be afraid of losing their special network position. Moreover, the social character of the relationships is likely to be reduced, because IT can only support social interactions between the members of a community, but technology can rarely completely replace personal contact (Stamp, 1997) and its important contexts necessary for establishing strong social relationships.

These adverse effects have to be compensated by the manager by means like face-to-face meetings or the establishment of a strong and visible group identity.

CoP platforms are especially helpful for areas, in which **tacit knowledge** of experts can directly be applied to a related business problem (Brown and Duguid, 1998; Wenger, 1998; Wenger and Snyder, 2000). The people requesting help do not need to tediously analyze documents and protocols of similar scenarios to find and interpret a case with an appropriate fit to their problem. Instead, they can directly enter their request into a platform. A suitable subject matter expert can then apply his existing knowledge to this special context and does not need to explicate his experience into a broad and generic problem solution first. By answering questions of others and receiving the appropriate feedback about the practical implementation of their advice, experts are also frequently updated and reassess or even extend their experience in new concrete application scenarios. For the initiator of the request, this method is a better way to learn by applying other’s experiences.

Next to this ad-hoc mode of problem solving, community software provides the community with a means to discuss, develop, and integrate distributed partial approaches from projects or business processes to best practice standards. Communities of Practice are living longer than projects, which last only for a limited period of time. This long-term perspective of topic oriented people networks helps the organization to maintain important competencies achieved in various related projects even after they have been completed (Wenger, 1998). Experts generate their insights in projects and can nurture and develop their knowledge in communities. They can recognizably establish themselves as subject matter experts in a relevant topic field. Additionally, a valuable archive of the members' contributions is being created.

6.2 IT Applications for Communities

On a technical level, communities in an enterprise mainly develop by following one out of three migration paths (Trier, 2003; cf. Figure 34). In the first scenario, the community platform develops from the initial application of groupware to support teams in various corporate projects. These tools are becoming modified to host defined topics and support the new user group of CoP-members. Afterwards they are offered to emerging CoPs as an internal service. In the second scenario, the organization decides to officially align the existing expert networks and targets at connecting relevant employees without introducing a central document-centered system. When the company follows this strategy, it either develops typical CoP-functionality for internal communication and networking or it implements targeted software from a platform vendor.

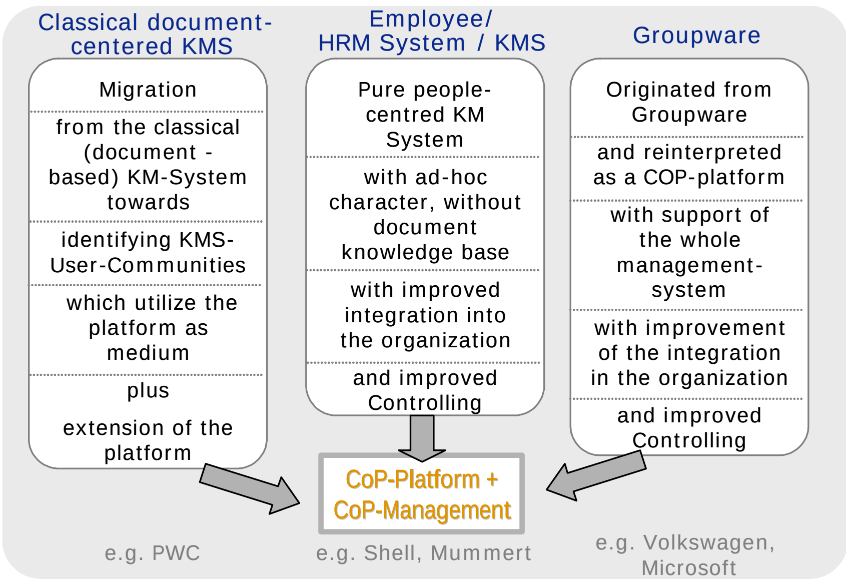


Figure 34: Three Migration Paths towards CoP development. Source: Trier (2003)

In the third scenario, the enterprise already adopted the codification strategy (Hansen et al., 1999) and runs a conventional primarily document-based knowledge management system (KMS). This system is being utilized by various informal groups of users. Although initially, the grouping of users is not directly intended, they form invisible communities because of their identical interests and the establishment of various relationships over time. Often companies broaden their approach towards the personification strategy (Hansen et al., 1999) to directly connect their employees and reduce the problems arising from maintaining large volumes of documents, often referred to as knowledge objects. To identify and actively support the existing groups, corporate KMS's are becoming enriched by special community features for direct communication between the experts.

These multiple paths leading to IT support for expert groups already imply the heterogeneity and dynamic development of this software segment. From various related fields of applications, vendors are extending their product towards improved community support. Examples for such moving market segments are document-based knowledge bases and knowledge exchange systems, project spaces and groupware, conventional discussion boards, tools for synchronous interaction and internet-community software.

The different software segments and their development towards the support of Communities of Practice are summarized in the following figure.

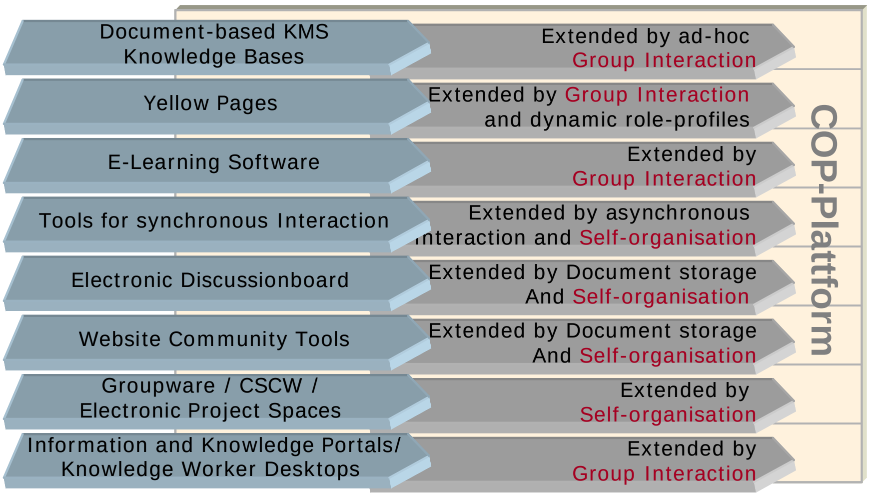


Figure 35: Software Segments integrate towards CoP Platforms. Source: Trier (2003)

This development towards an integrated product segment increases the risk of putting too much functionality into one platform. This can result in detrimental complexity effects affecting usage, e.g. training processes are taking longer, or researching information takes more effort. Moreover, information exchange can get inefficiently distributed over various communication channels (i.e. e-mail, discussion group, instant messaging, and telephone). This segregates the expert groups into sub-groups working on the same topic but missing each other because of a preference for different communication channels. Hence, it should be considered to prefer a simple solution with only some essential features and support for few electronic communication channels according to the intended strategy for supporting the employees. This strategy should be rooted in the communication culture of the organization.

The software to support Communities of Practice is no defined field, rather the various features can also stem from different applications. But often enough, the features are integrated into a special platform to be accessed by community members. Features include discussion groups, calendar features, socializing gimmicks, notification systems, blackboards, buddy lists etc. They do very much resemble groupware applications and that is no surprise, as communities are similar groups of people, working on a special problem. So it can be concluded, that not the provision of a unified tool is the innovation but the vitalization of the group in the intranet.

The architecture for a community application is on an abstract level not very complicated. It consists of a data layer, an application layer, and a communication layer (cf. Figure 36). The application layer hosts all the various modules, like discussion boards or publishing tools. It can link to external modules and data sources by using API's (Application Programming Interfaces). The importance for supporting the communication of the members is emphasized by the special communication layer. There are many channels available for communication. Unless all these channels are integrated, they have the tendency to divide communication instead of making it ubiquitous. Examples for channels are e-mail, sms, facsimile, pdf, browsers, wap-browsers or whatever their situation and location allows.

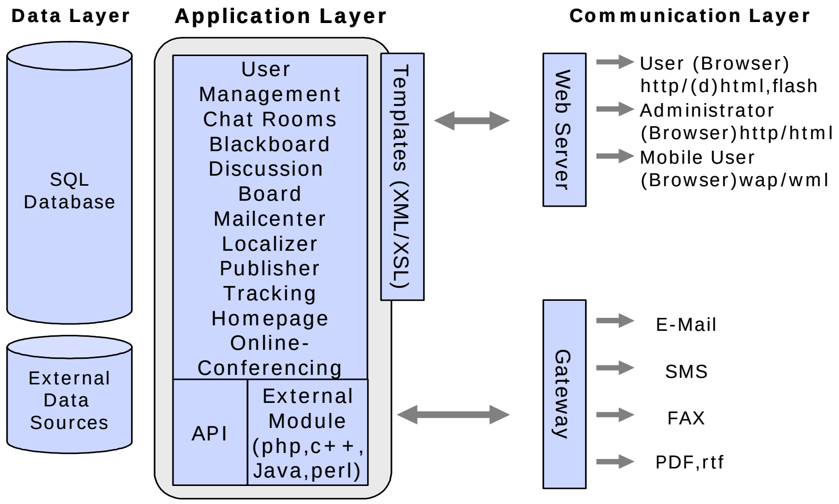


Figure 36: Generic architectural Model for a CoP Platform.

A sample architecture of a very renowned community software provider (Cassiopeia) is shown in the following Figure 37. It contains all the elements of the generic architecture. It illustrates the connection to databases using the Java database connectivity interface. They connect to user profiles using LDAP (light weight directory access protocol). Further, the various backoffice-modules are shown, including a data access manager, a user manager, a workspace manager and so on. The front-office modules discussion, mailcenter, etc. are accessing these administrative programs.

Cassiopeia offers features like a discussion board, conferencing with synchronous communication, expert requests, the creation of personal homepages without knowledge about HTML by using master forms, publishing personalized pages, data collections about the profiles of users, a mailcenter to send and receive messages, smart workflows for managing simple sequences of tasks, and toplists, which rank contents using an evaluation and point-System (e.g. for contributions to discussion boards).

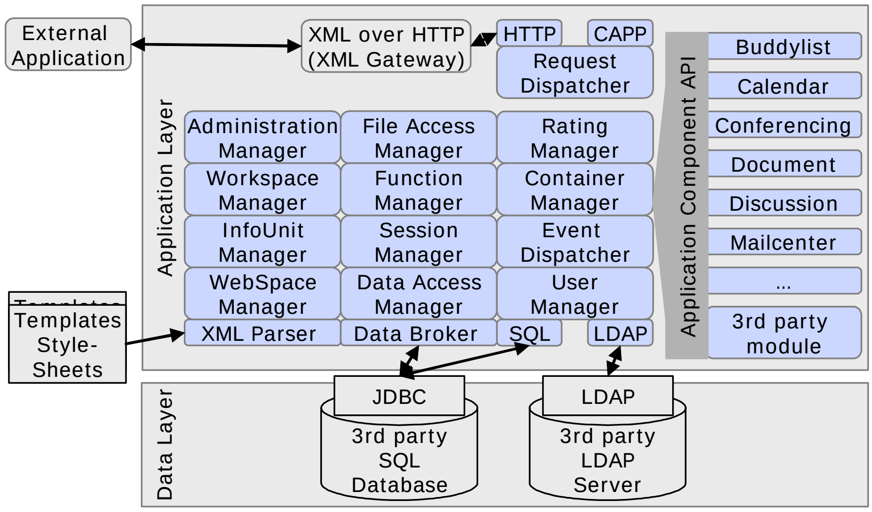


Figure 37: Sample Architecture of Cassiopeia.

Another solution for community support, which will be briefly introduced, is offered by Livelink. Although it also includes discussions, it rather concentrates on attention management, which is the management of different views on relevant information sources, project management with online project rooms, project status reports, milestones, team management (e.g. add members and access control), task management (task segmentation, task allocation, planning and monitoring), a data base for project documents, and version control for shared documents. Further there are embedded search mechanisms like fulltext- und index-based search to provide access to complex organizational information- and knowledge object bases. Only recently, Livelink has added a target set of features in its community component for Livelink.

The applications Cassiopeia and LiveLink are being compared in the following Figure 38 (Cassiopeia is on the left hand side, LiveLink is right hand side). The grey bars represent functions employed by both applications. The boxes show special areas, where the different approach of both applications become recognizable. Light text represents unavailable features. This comparison shows that there are only few standard features, which are provided by both applications. Hence, although sold for the support of Communities of Practice, the tools are very different. This comparison substantiates, that there is no standard tool for supporting CoPs available, however some standard features slowly emerge (like e.g. discussions).

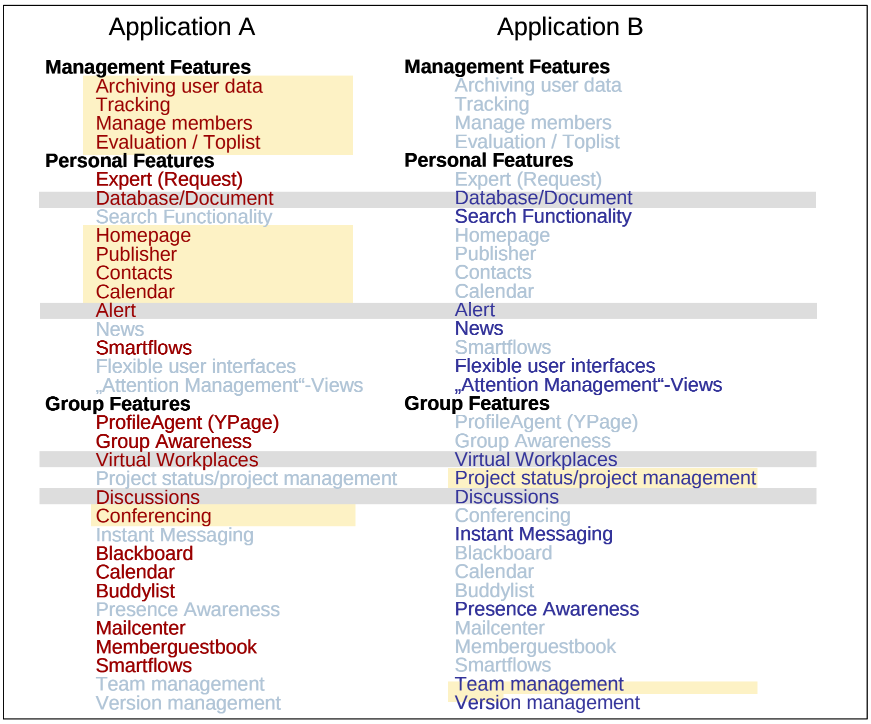
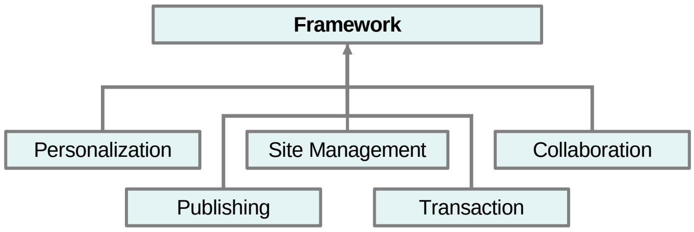


Figure 38: Comparing the features of Cassiopeia (left) and Livelink (right) as of 2003.

A third example is Communispace. Its features resemble groupware functionality, including traditional features like discussion, chat, calendar, organizing documents, or personal profiles. But additionally, Communispace provides facilities for specific content related activities such as framing issues, brainstorming, making decisions, or analyzing the “community climate”. A brainstorming facility helps to take the group through the various phases of brainstorming: generating ideas, discussing them, ranking them, etc. Communispace supports the reflection on the quality of the community in terms of relationships, levels of trust and participation, nature of conversations, etc. Its discussion facility requests contributors to categorize their contribution according to a taxonomy of ten different “speech acts” including question, answer, request, offer, assent, dissent, etc. On the other hand, the ability to handle documents is still underdeveloped and the search uses keyword indexes only.

The open source system ‘ArsDigita Community Systems’ (ACS) includes five domains: Personalization, Site Management, Collaboration, Publishing, and Transaction. Every set contains a series of modules, which realize specific functions. For example, the collaboration feature provides bulletin boards, discussions, web-based intragroup e-mail, calendars, chat rooms or address books. Together, the five modules represent their model or framework of an ‘Online Community’. The framework is shown in Figure 39.



Toolsatz	Modules
Site Management	Directory, Statistics, Search, Protocols, User Requests
Transaction	E-commerce-functions: „Recommendation Tracking“, Classification, Auctions, Security, „Auditing“ and online Reporting.
Collaboration	Access to information of various web-browsers, Bulletin Boards/ Discussions, Chat Rooms, Web-based E-Mails, Calendar, Bookmarks, Adressbooks, File Storage, Presentations.
Personalization	Membership Registration, Activity Tracking, Personalized Contents and Navigation, User Profiles, personal Portals and Sub-groups, access control, etc.
Publishing	Structuring via an authoring system, Editing, Templates, Content Filtering, Publishing Systems, etc.

Figure 39: Framework of the ArsDigita Community Application.

After having had a look on vendor products, the following Figure 40 shows a screenshot of a developed system used by Infineon (a semiconductor manufacturer). It is obviously based on the Lotus Notes platform and contains features like people, teams, events, activities, information, and discussions. In the main window, we can see a terminology taxonomy which is to support the search for topics, discussion threads etc. It includes a mindmap of the whole division under consideration, including process modules, document types, tasks, processes, technologies etc.

All previous examples show, that different vendors and individual corporate developments claim to support communities but pursue a very different approach. However, on an abstract level, community software applications have the following core set of elements:

- CoP-Portal,
- communication-interaction-collaboration asynchronous: Discussion Boards,
- communication-interaction-collaboration synchronous: work rooms, chats,
- Yellow Pages: participants- and experts directories,
- CoP-Management-Tools: membership- and document management, monitoring elements,

- forum for internals and externals to ask the community,
- document repository,
- search engine: find explicated knowledge in the documents and comments or tacit knowledge by identifying relevant members and experts, and
- a wide series of optional further tools: e.g. to create sub-communities.

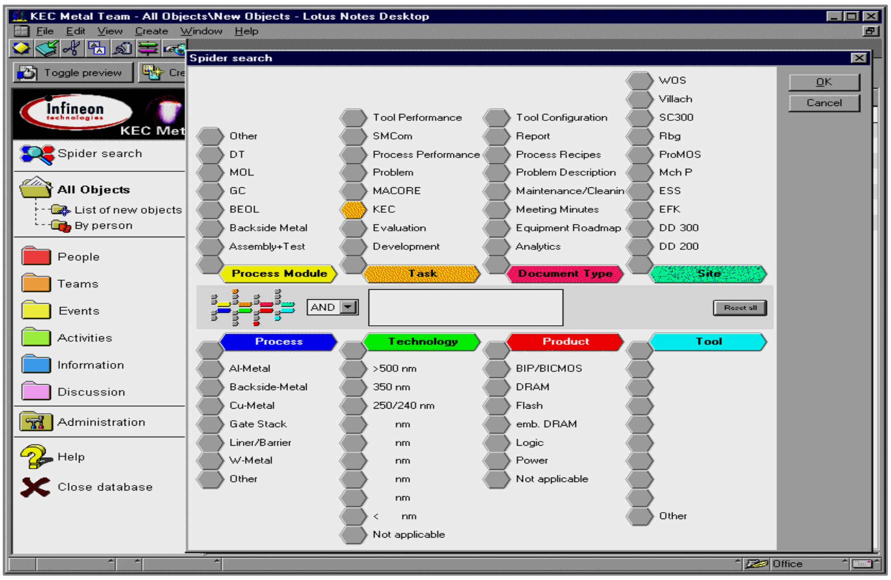


Figure 40: User Interface of a corporate Community application.

To summarize the analysis of community software, it can be concluded that most current features of community software focus on supporting search and retrieval of contents and the communication between members. Next to such member oriented features, the user group under research in this book, namely the coordinating roles, like moderators, brokers or facilitators are still insufficiently recognized. They do not only employ content oriented features, but need to observe, understand, and communicate the development of their social CoP networks by means of monitoring and analysis. Although some vendors already offer simple logging facilities, current software is not recognizing the network oriented mode of Knowledge Work and the impetus of social network theories for modern monitoring software features. Hence an important potential can be assumed by extending the existing functionality in this direction, as it enables the communication of CoP development to different stakeholders. On an abstract level, Figure 41 shows the main features of management oriented software facilities. They include the monitoring of (social) group structures and activities, topic management, and report generation.

Next to the support of community moderators these extensions would also benefit the members, which get a better impression of their otherwise invisible group. This fuels the community's identity. A tertiary interest group is comprised of network researchers and analysts, who frequently apply similar features provided by statistical expert software to conduct studies of Virtual Communities.

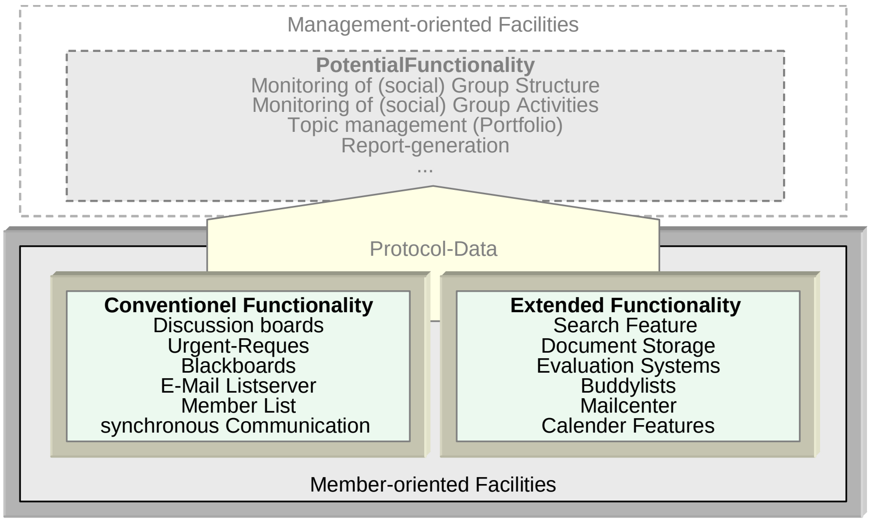


Figure 41: Extending current Community Software with management oriented Functionality. Source: Trier (2003)

6.3 Computer-mediated Communication in Virtual Communities

The last chapter illustrated, that the employment of IT actually leads to an abundance of new means of communication. However, this abundance also implies a dispersion of meaningful dialog, learning, and knowledge across these channels. Thus, the discussion of IT applications for the support of communities has to consider the aspect that most Communities of Practice start to employ **more than one communication channel** and that IT is not able to support all of them in one transparent and integrated approach. Examples for such channels, which are not integrated, are face-to-face communication or phone calls. So, every attempt to systematically conduct network oriented Knowledge Management with communities involves this **heterogeneous aspect** of communication and the potential loss of parts of the ongoing knowledge exchange.

To arrive with a more systematic picture of this multi-channel issue, a first distinction can be drawn by the differentiation between offline and online channels of communication, where the latter are employing IT as a carrier for their communication. The channels of a knowledge network can further be differentiated into decentralized versus central networks. A decentralized network has no perceptible central hub, like a central network. Such a hub could for instance be a web-portal, where all communication is centered and visible to all. Usually decentralized networks include more decentralized communication between two or more people in the network, without the option, that others can easily participate. These two dimensions result in four different types of communication channels:

- decentralized offline networks (e.g. talks between two employees, which can not be accessed by others),
- central offline networks (e.g. a meeting of all participants at one location, to which all persons need to travel to),
- decentralized online networks (e.g. e-mail communication, which is again only visible to the directly participating persons), and
- central online networks (e.g. discussion boards using a software platform).

These four areas differ in their network properties. For example, a decentralized network like an e-mail network has a different visibility of its member's contributions as a discussion board hosted on a central portal. Figure 42 assembles the different types of channels in a matrix.

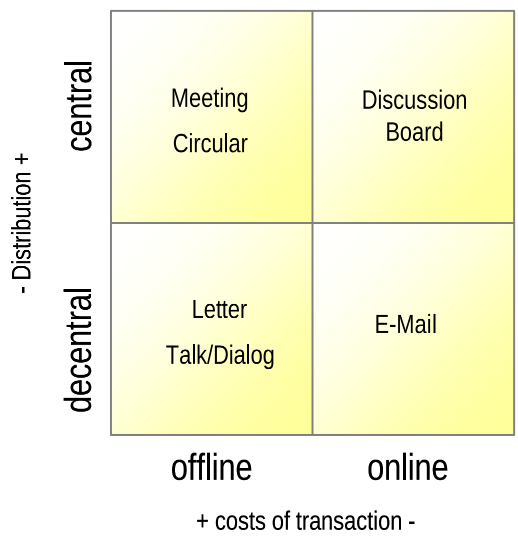


Figure 42: Box Model of Communication Channels for CoPs.

The properties of the two different categories offline versus online communication and their implication for communication and community is being analyzed by academia using the term Computer-mediated Communication, or simply CMC (e.g. Sproull and Kiesler, 1986; Riva and Galimberti, 1997). The underlying research discipline approaches to compare advantages versus disadvantages to substantiate and identify the role and the fields of application for the new means of communication.

The advantages of computer-mediated communication and their application for group work are illustrated in Figure 43.

Teams are not limited to meet at specified days but can establish permanent expert groups which work on different topics. The members do not have to work co-located but can be geographically dispersed. This is especially important for inter-departmental lateral communication in companies. Further, it is very unlikely, that all experts exist at one place. Another advantage is that members can asynchronously discuss their problems exactly at the time, they need the solution. They do not have to wait until the next meeting. Whereas physical meetings often show random or unsystematic discussions or a series of inflexible presentations, discussion in a CMC environment can be systematized in threads, which allows parallel meaningful dialog in topic areas. This enables larger groups, as sub-networks can dynamically be created. Larger groups in turn improve the access to expertise as the likelihood is far bigger to meet relevant experts as in a group of twenty. The communication is protocolled automatically and remains persistent and accessible in communication archives, together with relevant related working documents. Finally, multiple persons literally can speak simultaneously. The written form of discourse allows for following more comments as in an oral setting in a physical meeting. Even in a chat, the reader can scroll back to read the parts of recent contributions, which are of interest.

Generally, CMC supports the establishment of lateral communication among employees of the same rank. This eventually is also leading to a more personal type of communication. The examples in chapter 5.2 show, that many multinational companies primarily base their communities on such CMC channels in order to utilize these benefits.

Physical group work		Computer-mediated group
▪ Teams which meet once in a while	→	▪ **Permanent** expert groups which work on topics
▪ Co-located, time-dependent, not on-demand	→	▪ Geographically spreaded, **asynchronous, on-demand**
▪ Random discussions or inflexible presentations	→	▪ Threaded and systematical dialog in **topic areas**
▪ Clear size limits to ensure effectivity	→	▪ Groups can be much **larger – (sub-)networks** emerge
▪ Manual protocols or inaccessible dialogues, circling documents	→	▪ **Persistent** and **accessible** communication archives with central related documents
▪ Sequence of talkers, others listen, or 1-to-1 exchange	→	▪ **Multiple persons** can speak at once or read
▪ Moderation, Management of Knowledge Work, Organizational Integration	→	▪ **Moderation**, Management of virtual Knowledge Work, Organizational Integration

Figure 43: Advantages of Computer-mediated Group Work.

However, CMC research is also concerned about the richness and sociability of electronic media. As current research on CMC is primarily motivated by social sciences, it concentrates on analyzing the effects of CMC on social relationships and collaboration in organizations (Riva and Galimberti, 1997). The main approach is comparing groups which rely on face-to-face communication with groups employing CMC. Here, researchers added a further differentiation between synchronous and asynchronous CMC and found that especially in asynchronous CMC, two typical features of face-to-face conversation are absent (Mantovani, 1996): the collaborative commitment of participants and the co-formulation of the message and the feedback which allows the social meaning of the message to be processed immediately. This raises the general question, if CMC lacks necessary relational features (social cues) which are needed by persons to correctly interpret their social setting (Sproull and Kiesler, 1986). This social vacuum negatively affects the personal identities of subjects (Sproull and Kiesler, 1991). Obviously, the missing non-verbal feedback in CMC renders social processes more important than in a face-to-face situation. Lea and Spears (1991) therefore demand social reference norms to regulate behavior.

From this difficulty to socialize another difference emerges: CMC shows more of a task orientation than face-to-face meetings, as it requires a larger effort to socialize over CMC (Walther and Burgoon, 1992:62). This aspect is offset by negative effects in finding consensus in a group. This happens, because there are no social cues to adhere to and leaders cannot take charge of the discussion without disturbing the system of voluntarism. Further, the increased degree of anonymity reduces sub-ordinance in the group, so that more people will maintain and communicate their own opinions (Walther and Burgoon, 1992:52). The decisions that are made can thus show a tendency to be less compromising (Spears and Lea, 1994:448).

Discussing the issue of CMC and its effects, Knowledge Work in people networks also directs the attention to a special type of community which has not yet been mentioned in chapter 4.2 on the typologies of CoPs. In the past years, the increasing application of CoPs in global enterprises together with the event of sophisticated means of global Computer-mediated Communication has facilitated the development of CoPs whose members are not co-located (Lesser and Storck, 2001). Such a community is referred to as 'Virtual Community', if people primarily utilize a large array of traditional media like phone, teleconference, or fax, and electronics media like e-mail, videoconferencing, newsgroups, or intranets to support its members' interactions.

The term ‚Virtual Community' has first been used in 1993 by Howard Rheingold. His positive experiences from the internet-based portal 'The well' in the 1980s and 1990s influenced his sociological conception of the Internet as an utopist world which is existing in contrast to the local communities in the real world. He thus defined virtual groups as democratic and equal coalitions of individuals, which effectively cooperate in a joint venture (Rheingold, 1993). A virtual Community of Practice is often also called distributed (Wenger et al., 2002), computer-mediated (Etzioni & Etzioni, 1999), on-line (Cothrel & Williams, 1999), or electronic (McLure-Wasko & Faraj, 2000). However, it has been mentioned, that often CoPs employ a mix of communication channels. Thus a Virtual Community can also meet physically in face-to-face meetings. Conducted on a regular basis, they have been shown to be important for building relationships and trust among otherwise geographically distributed participants of Virtual Communities (Storck & Hill, 2000). Still, factors such as geographical dispersion and busy schedules make virtual (and also asynchronous) communicating through IT more efficient.

Summarizing, the research on CMC and on Virtual Community is showing both, promoters and skeptics, so that no clear answer can be given to the question, if a Virtual Community is a proper environment of effective Knowledge Work in a (social) people network. However, an empirical study of virtual groups (cf. Berge and Collins, 2000) supports the promotion of Virtual Communities in enterprises. According to the survey, 72.9 percent of its moderators considered their group as a community. Further, 70.6 of the moderators believed that their members feel themselves as part of a community. More than 70 percent where also noting, that they actively promote the sense of being a community.

These results are also relevant for the approach followed in this book. Here, it has to be recognized, that for the research objective of conceptualizing support for the methodical analysis and evaluation of Communities of Practice, the two offline sectors are very difficult to include. They would require time consuming manual interviews or surveys with the community members, a field for a conventional social network researcher. Although such analysis is sometimes done in practice, it would be difficult to apply it for a continuous and near real-time monitoring and management approach. Quite contrary, the two sectors of online communication channels are lending themselves more to automated analysis and evaluation. As this book is written from a business informatics perspective with the objective of identifying new application fields for Information Technology in a corporate environment, the research focus and scope will now be narrowed down to focus the two areas of online communication. However, the underlying assumption is that these two channels are to some extend representative for the community activities. This in turn depends on their weighting in the overall mix of communication media. Here, according to an analyst prediction, by 2007 the individual's time spent interacting with others in the virtual world will exceed physical interactions by a factor of 10 to 1 (McWilliam, 2000).

6.4 Focusing Discussion Groups

The last chapter highlighted the importance and benefits of Computer-mediated Communication and its application to Virtual Communities. The large share of such electronic discourse especially in the application of CoPs in large enterprises with multiple sites raises the question, which of these channels are the most important ones. For the conceptualization of a support for moderators and managers of CoPs (more precisely of CoPs with a large extend of virtual communication), the abundance of communication channels needs to be broken down into a very restricted sample of CMC means. To aid this decision, Figure 44 shows the results of a survey, which identified the most frequented CMC-channels in communities. On the top three positions, there are Discussion Boards, E-Mail, and Instant Messaging.

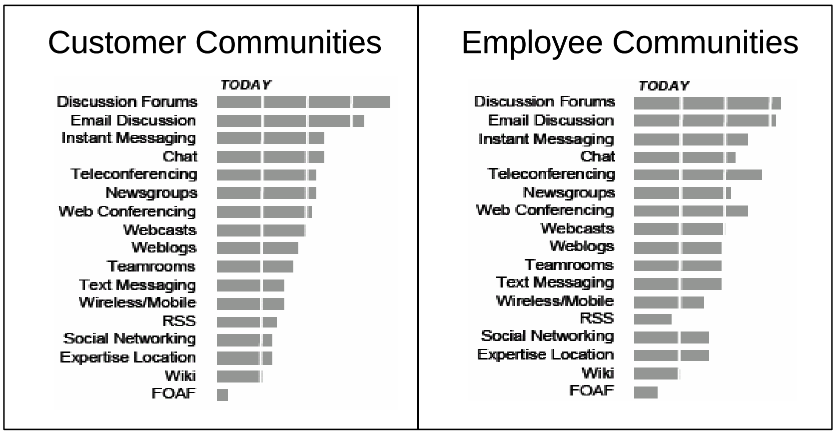


Figure 44: Ranking of utilized Communication Channels in two types of Communities. Source: Ambrozek and Cothrel (2004)

These three top channels will comprise the focus of the subsequent concepts. However, while including both, central and decentralized online communication (cf. Section 6.3), the subsequent discussion and design of a prototypical solution for an improved IT-support will adopt the domain of **central online communication** as its primary perspective[40]. A focus on central online communication is simultaneously putting the most frequented communication tool into the center of analysis: the discussion group (also called bulletin board, discussion group, or newsgroup). Communication via **discussion groups** is considered a research challenge because it is still insufficiently examined and the current interface is merely text-based. This form allows for a central and topic oriented storage of messages between experts.

Compared to this means of information exchange, currently much research is done with e-mail networks. It produced first applicable approaches for an automated visualization (but not yet true evaluation) of e-mail networks. They capture communication networks between senders and receivers in order to allow for structural analysis. For example, HP Research has identified 66 communities by capturing the e-mail communication of its 367 research affiliates. The groups have an average size of 8 people. Moreover community leaders can be identified (cf. Tyler et al., 2003).However, these networks have the disadvantage of being a decentralized peer-to-peer communication concept, where it is very likely to not oversee the overall content within the network. Quite contrary, discussion groups provide a consistent and complete access to the insights stored in it. The content is organized in topic threads. This makes discussion groups a suitable tool for targeted conversation generating conclusions or integrated perspectives. Examples are the development of an XML-extension to a web-based programming language, the development of an integrated design of a new business process, or the management of product problems. In all these scenarios, there are requests for expert advice in sub-domains within a larger topic area. The moderator is responsible for giving orientation and maintaining momentum within the discussing group.

On the other hand, current discussion boards are not very ergonomic. They provide features like the generation of threads. One member initiates a posting and others can reply to it. Over time a tree-like structure of comments forms around an initial question in a topic area. In larger boards, there can be thousands of semi-structured text elements posted by many hundreds of people. This makes it quite difficult to quickly work into the group's structure or to identify the most important areas and most important experts. In large groups, like the general discussions dealing with the Microsoft Operating System, the size is causing redundant contri-

[40] Including both means, that while presenting the subsequent approaches using electronic discussions as the primary perspective, the architecture of the software solution also allows for analyzing decentralized networks. The main underlying technical concept is the connector and its translation of decentralized communication archives into the generic database, described in chapter 8.3.3.

butions, so that constant analysis of the board has been implemented to identify large overlaps and cross-postings (e.g. Smith and Fiore, 2001). The main reason for such inefficiencies can be seen in the user interface, which has not much changed since the first introduction of discussion board technology. Another inefficiency has been discussed by Chang et al. (2002):

> "Threading and cross-indexing are useful for organizing newsgroup articles, but are not so helpful in identifying mutual interactions among the authors. Often a newsgroup user is looking for meaningful dialogs among the participants. Threading articles is not good enough as not necessarily all articles in a thread contribute meaningfully to the discussion: There certainly exist 'me too' articles and advertisement. Cross-indexing the articles by author names or subject keywords does not help much either in finding mutual interaction, as it loses the temporal dimension in group discussions." Chang et al. (2002:751)

Obviously, looking at online discussions, the notion of visual components (which will be discussed in the context of the concept of social translucence in the next chapter) can also be applied to improve the experts' communication network: Oliver et al. (1998) find that interactive materials are essential in a virtual environment, as opposed to pure text-based scaffolding. Further, Johnson frames the question: Can Communities of Practice in their true definition be set up, maintained, and supported using current web-based applications, which are mainly text-based environments (Johnson, 2001)?

Following this research direction, this contribution now examines how the value creation in electronic discussions of communities can be analyzed by automatically extracting and visualizing useful and already existing data about the community structure, consisting of the entities employees, topics, and documents as well as their many relationships.

In this context, another advantage is, that the analysis of discussion groups does not cause a privacy problem like with e-mail networks, because the information contained in it is meant to be public to the members of the group. This public visibility of contributions also causes less 'noise' in the messages. This means, that in a professional application, there are almost no unrelated messages, distorting the overall conversation.

All these issues render discussion groups a focal communication channel for further examination, analysis and visualization of the exchange of knowledge in expert communities. The main objective is to make online discussions more transparent and hence easier manageable. Only then, the previously introduced requirement of regularly observing and monitoring the work of a Community of Practice becomes feasible. However, a subsequent future research challenge in analyzing communities will be the question, how to accommodate and re-integrate the spread of communication over various channels in the analysis of people networks.

6.5 Current Gaps and required Concepts

The increased practical employment of virtual communication in expert groups poses new challenges for community managers and moderators. The abundance of communication channels, the very large group size, and the underlying voluntary participation with the resulting absence of the ability to execute hierarchical authority results in a complex area of management activities. Especially the role of measurement has been identified as being important for enabling successful intervention into people networks. The section on current IT applications also shows that current software offerings primarily target the user group of members and do not supply sophisticated functionality which supports management. Further, the applications tend to concentrate on content oriented features. The very important social domain and also underlying processes of management are, despite some exceptions, largely ignored.

The results of this situation can be illustrated with a recent study of Ambrozek and Cothrel (2004). Although 79 percent of moderators and members of CoPs agree, that technologies for online communities are continuing to improve and participation in online communities is growing (82 percent), most organizations can't measure return on investment (72 percent agree). To a large extend, this is attributable to the fact, that the discipline of creating and managing communities is poorly defined (59 percent agree). This results in a situation, where less than half of the respondents feel, that executives understand the value of online communities. Here, a systematical approach for capturing, measuring, evaluating and visualizing existing electronic expert networks can be a suitable method to improve current management approaches. The high value of according IT applications for such a monitoring of communities has not yet been discovered - neither by software vendors nor in industry applications of CoPs. Rather, companies are currently often only conducting survey-based audits to assess their communities, foregoing the rich data they could derive from their software and ignoring network metrics and models to improve the effectiveness of the knowledge network. Using questionnaires, the current conditions and outputs of the groups are estimated (Heinold, 1999). The available data about the virtual communication is not used and integrated into this measurement approach. Figure 45 illustrates current manual approaches. On the top left, the survey procedure is illustrated, including workshops, the problems of low return rate, report generation and an executive summary. The actual survey is depicted at the bottom-left side. It mainly includes issues of satisfaction, which do not really convey structural properties. However, the bottom-right side shows the achieved evaluation. The example identifies, that negative experiences dominate: Next to dissatisfaction with the reputation of the group and problems with its integration into daily work, as a special problem has been stated, that moderation and facilitation failed.

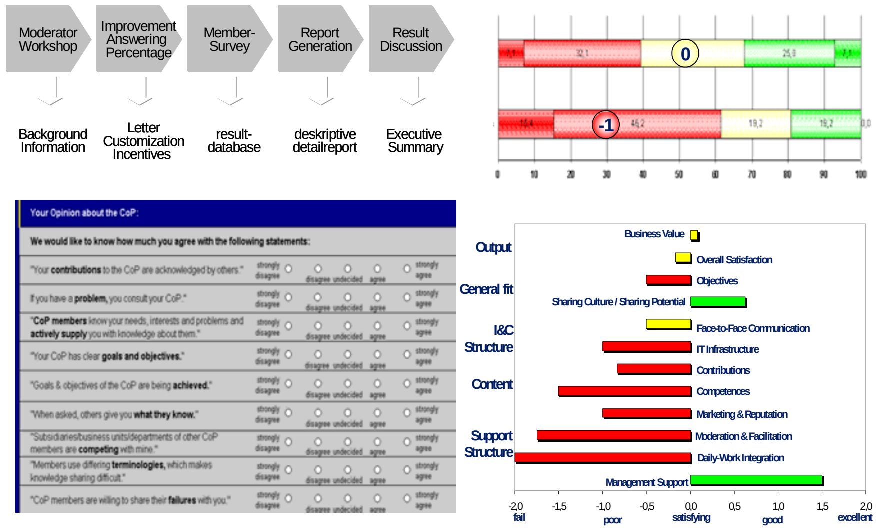


Figure 45: Current manual Approaches of evaluating CoPs.

Summarizing, a demand for augmenting community software with features for automated monitoring of community activities, social structures and outputs can be recognized. The main underlying question is how to generate necessary transparency, which in turn relates to the issues of measurement and evaluation. The next chapter will thus develop an appropriate measurement concept. Its advantage is that it derives its primary measures from sociological research in order to recognize the predominant role of a complex (social) communication network between people. The subsequent chapter will then derive the appropriate extension of IT-support and further presents several case studies to illustrate the added value.

7 Towards CoP Transparency, Measurement and Evaluation

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.

These factors provide the 'strategic' background, for which then, on an operational level, concrete measures have to be assembled.

Research on success factors is generally aiming at formulating guidelines, that can be influenced by persons and which leads them to an (intervention) strategy that is likely to be successful (Trommsdorff, 1990). The resulting concepts are usually not fully explaining all the correlations between the factors, but still they can help to intervene more effectively into a system (Leihmeister et al., 2004:2).

Following this approach, in this section, the contributions of Vestal (2003), McDermott (2000), Schoen (2000), Leihmeister et al. (2004), and Roberts (1998) are introduced. All these authors analyze necessary factors to create successful Communities of Practice. Their findings provides the basis for the main domains of measurement and a first set of concrete related factors for the objective of utilizing electronically available data to better manage Knowledge Communities. They are assembled to guide the selection of useful measurement domains and individual measures, which in the end are synthesized into a special measurement system for virtual Communities of Practice. It has to be noted, though, that not all success factors are lending themselves to help with the creation of a measurement system. For example, some of them simply relate to special managerial interventions by management or the establishment of an appropriate IT infrastructure.

A first selection of rather broad factors to be considered in order to move towards a successful Community of Practice has been proposed by Vestal (2003). His ten traits for creating a successful community are shown in Figure 46. Although this list is too general to be directly applicable for deriving concrete measures for some measurement system, it highlights several broad issues, which substantiate the importance of increased transparency and evaluation. For example, trait 3 suggests transparency about the core content by providing a knowledge map. This directly relates to the analysis of subject matters. Trait 4 directs the attention to the notion of eliciting, measuring, and presenting knowledge sharing processes. Trait 8 demands the provision of a measurement system, which is capable of providing insights about the community's progress to achieve business results (without actually discussing the factors that should be included, though). A further very general requirement is put forward in trait 9: it should be possible to recognize the member's expertise. Related to the last aspect is a factor discussed one year later by Lesser and Cothrel (2001). They emphasize the development of connections to people with relevant expertise as the biggest challenge in an online community.

1. A compelling, clear business value proposition for all involved
- What value does belonging and participating in the CoP have for an individual?
- What value does it bring my department if one of my staff takes time to participate?

2. A dedicated, skilled leader
- Does the CoP leader have the skills to facilitate an organic, outside-of-line responsibility group?
- Does the leader have a vision for moving the CoP forward?

3. A coherent, comprehensive knowledge map for the core content of the CoP
- Does the group call on frequently used common content, topics or knowledge that should be pulled into one shared space?
- Do all members of the CoP understand who the sources and recipients of knowledge are within the community?

4. An outlined, easy-to-follow knowledge sharing process
- Do people know how, what, and when to share?
- Are community members able to easily access and reuse knowledge from others or a shared space?

5. A technology medium that facilitates knowledge exchange, retrieval and collaboration
- Does it include a repository of community content and knowledge?
- Is the technology supported by the organization's IT group?
- Does the technology meet user group needs? Did they have input into the look, feel, and content?

6. Communication and training plans for those outside of the CoP
- Do community members (and prospective members) understand why they should participate?
- Is there a self-training or short program that shows individuals how to share and find knowledge from each other?

7. An updated, dynamic roster of CoP members
- Are CoP members able to access others with their interests quickly and easily?
- Do members have tools that assist with rapid, one-to-many communication?

8. Several key metrics of success to show business results
- Does the CoP have a documented measurement system to show how it's meeting its business value proposition?
- Is there a plan for collecting, reviewing, sharing and validating measures of success?

9. A recognition plan for participants
- Can participants recognize what's in it for them?
- Is the recognition scheme built into the HR process and is it part of the development or evaluation process?

10. An agenda of topics to cover for the first three to six months of existence
- Do your CoP leaders and members have hot problems to solve early in the lifecycle?
- Are there sufficient face-to-face or voice-to-voice meetings for members within six months of the group's launch?
- Are there enough actions and activities for this group to become accustomed to working together to solve problems?

Figure 46: Ten Traits for a successful Community of Practice. Source: Vestal (2003)

A further general overview about community success factors has been published by McDermott (2000). He divides factors into four groups: a management challenge, a community challenge, a technical challenge, and a personal challenge (cf. Figure 47). Among the relevant issues for a measurement approach are the **topic focus** of the CoP, the encouragement to participate, the notion of **thought leadership**, personal relationships among community members, the activity of the **core**

group, the relation between knowledge development („thinking together“) and knowledge exchange („sharing information“).

Management Challenge
1. Focus on topics important to the business and community members.
2. Find a well-respected community member to coordinate the community.
3. Make sure people have time and encouragement to participate.
4. Build on the core values of the organization.

Community Challenge
5. Get key thought leaders involved.
6. Build personal relationships among community members.
7. Develop an active passionate core group.
8. Create forums for thinking together as well as systems for sharing information.

Technical Challenge
9. Make it easy to contribute and access the community‘s knowledge and practices.

Personal Challenge
10. Create real dialogue about cutting edge issues.

Figure 47: Critical Success Factors in Building Community. Source: McDermott (2000)

Next to these two American approaches, there are two European perspectives on the required set of success factors. First, Schoen (2000:220) proposes a very comprehensive and detailed list of nine success factors, each including a set of detailed aspects:

1. knowledge carriers (experts),
2. behavior, culture, and management support,
3. vision, expectations, objectives, and strategy,
4. external networks of the community,
5. IT-infrastructure and tools,
6. CoP organization and structures,
7. CoP processes and activities,
8. contents and context, as well as
9. results and satisfaction.

Again, not all these factors include items which help to utilize available electronic data to derive useful measures for evaluating CoPs. Still, various important measurement domains can be identified. Taking the perspective of this book’s approach to look in more detail at the first factor: knowledge carriers, aspects like the **subject fields** (knowledge) of the experts, the internal network structure of knowledge carriers with their interests, their similarities and network roles, sub-groups, or the **network's size** and **dynamics** are of interest. Factor 2 contains aspects like **quality**, **trust** in the network, constructive **feedback** culture, experimental knowledge development, or **participation activity**. Factor 3 subsumes issues like identity or progress towards objectives. This is also substantiated by Lave and Wenger (1991) who highlight that it is vital to communicate the community's objective and progress. Factor 4 emphasizes the visibility of the CoP to the outside. Other factors which can help to determine measures are Factor 7 proposing to measure time of participation, activity level, **interaction frequency**, or Factor 8, which is among other things directing attention to the quality of the contributions, the amount of contents, and the age or recency of a contribution. These factors can help to give orientation for setting up an own measurement system as described in section 7.1.5.

A further approach to systematizing elements which influence the success of a Community of Practice has been proposed by Leihmeister et al. (2004). The strength of this approach is its empirical foundation. The authors observed 160 communities and collected 745 datasets.[41] The success factors have been ranked and are shown in Figure 48. Elements, which are relevant for the developed measurement approach are (in decreasing order of importance) **reaction times**, the quality of the contents, recency of contributions, controlling the satisfaction of CoP members, encouraging interactions among members, the **relationships between old and new members**, a continuous evolution of the community which reflects the interests of the members, trust among members, controlling the **growth** of the community's membership, and controlling the **frequency** of visits.

A final analysis of important success factors which shall be recognized for the establishment of the CoP measurement system has been suggested by Roberts (1998). She found, that the sense of community in a virtual group does not primarily depend on synchronous interaction facilities but on the richness of asynchronous participation opportunities. They can be determined by factors like **cohesion, effectiveness, help, relationships, language, and self regulation**. Especially interesting is the factor **cohesion**, which looks at the **relation between long time members and new users** as a proxy for stability, which is directly indicating the sense of community in a virtual group.

Analyzing the multiple approaches to establish influential success factors for Communities of Practice can help to provide a broader segregation of the relevant domains for developing a measurement system as described in section 7.1.5. The following general key domains can be defined:

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[41] Unfortunately the sample includes various types of commercial communities like gaming communities, lifestyle communities, etc. which more belong to the type of Community of Interest. However, insufficient research is available to conclude that this leads to inapplicable results for the field of knowledge communities.

- knowledge (in terms of quality contents and according topics), which is stored within the network together with the according processes to develop and share it, as well as the ability to recognize and access the appropriate experts,
- the participation activities of the members which are necessary to create dense networks between experts together with the underlying requirement of high degrees of trust, and
- a continuous evolution, progress and growth of the community, which has to be visible to the outside.

Success factor	Overall ranking	Overall mean	Mean non-com.	Ranking non-com.	Mean commercial	Ranking commercial
Handling member data sensitively	1	1.328767123	1.33333333	1	1.32352941	1
Stability of the website	2	1.534246575	1.51282051	2	1.55882353	2
Short reaction time of the website	3	1.561643836	1.56410256	3	1.55882353	3
Offering up-to-date content	4	1.638024076	1.69230769	5	1.57575758	4
Establishing codes of behavior (netiquette/guidelines) to contain conflict potential	6	1.733914487	1.87179487	9	1.57575758	5
Evolution of the community according to the ideas of its members	10	1.856164384	1.94871795	10	1.75000000	6
Continuous community-controlling with regard to the satisfaction of its members	5	1.72384807	1.69444444	6	1.75757576	7
Assistance for new members by experienced members	8	1.750103778	1.74358974	8	1.75757576	8
Encouraging interaction between members	9	1.760612615	1.73684211	7	1.78787879	9
Intuitive user guidance / usability	11	1.900878463	1.97297297	11	1.81818182	10
Offering high-quality content	7	1.749143836	1.66666667	4	1.84375000	11
Building trust among members	12	2.054794521	2.15384615	13	1.94117647	12
Sustaining neutrality when presenting and selecting offers	15	2.219983884	2.41176471	17	2.00000000	13
Continuous community-controlling with regard to growth of the number of members	14	2.166755619	2.28571429	14	2.03030303	14
Continuous community-controlling with regard to the frequency of visits	16	2.251556663	2.44444444	19	2.03030303	15
Constant extension of offerings	13	2.1327759	2.14285714	12	2.12121212	16
Building a strong trademark	17	2.266915733	2.39393939	15	2.12121212	17
Price efficiency of offered products and services	20	2.471200261	2.67857143	22	2.23333333	18
Personalised product and service offers for members	22	2,550452544	2,78125000	24	2,28571429	19
High number of members within a short term	18	2.347873107	2.39473684	16	2.29411765	20
Arranging regular events	19	2.416355334	2.43589744	18	2.39393939	21
Supporting the community by regular real-world meetings	23	2.563129492	2.68421053	23	2.42424242	22
Focusing on one target audience	21	2.508509755	2.55555556	20	2.45454545	23
Appreciation of contributions of members by the operator	25	2.743046907	2.88888889	26	2.57575758	24
Offering privileges or bonus programs to members	28	2.876551168	3.11764706	30	2.60000000	25
Integration of members into the administration of the community	24	2.648972603	2.61538462	21	2.68750000	26
Special treatment for loyal members	29	2.880045452	3.02857143	29	2.70967742	27
Defining sources of revenue as starting condition when building a virtual community	30	2.957685099	3.16129032	31	2.72413793	28
Personalised page design of the community site according to the preferences of its members	26	2.774562496	2.81578947	25	2.72727273	29
Establishing and supporting sub-groups within the community	27	2.873194818	2.89473684	27	2.84848485	30
Increasing market transparency for members	31	3.041016981	2.96428571	28	3.12903226	31
Existence of an offline customer club as starting advantage	32	3.540554955	3.29032258	32	3.82758621	32

Figure 48: Success factors of Virtual Communities. Source: Leihmeister et al. (2004)

Next to these three domains, the issue of group identity is an important dimension. However, it can not be very well measured using the electronic data available. Rather, it is implicitly affected by measurement and visualization and hence is included as an indirect and qualitative domain complementing the measurement system.

In summary, the conceptualizations of success factors, which have been introduced so far, already suggested various concrete measurement factors for a measurement system:

- (number of) general relationships among community members,
- relation between knowledge development and knowledge transfer,
- activity of the core group (in terms of volume and frequency of participation),
- important subject fields,
- network size,
- network dynamics,
- reaction times (as indicator of feedback culture),
- (number of) relationships between old and new members (cohesion),
- network growth, and
- frequency of interaction or participation.

Next to the introduction of general success oriented management factors for running CoPs, an analysis of related research topics is now being introduced. In principle, these fields can be derived by taking the above lists of success factors and the manager's tasks discussed in section 5.7 as an orientation. After looking at Cothrel's (2000) approach of measuring community structures, the emphasis will be on general group research, empirical social factors, measures proposed by the field of Social Network Analysis, and finally the field of Social Capital in an organization. As the next sections will show, together these four fields motivate various measures, which can be derived from data of electronic communication and which can then be used to support management interventions into CoPs. Because of these qualifying aspects they are incorporated into the integrated measurement system for evaluating Communities of Practice introduced in section 7.1.5.

7.1.1 Measures from logging Community Activity

A first potential source for useful CoP measures is the work of Cothrel (2000). He describes a framework consisting of three dimensions: activity, topic, and economic measurement. Activity measures describe the health, topic measures show insight, and economic measures indicate the Return on Investment (ROI).

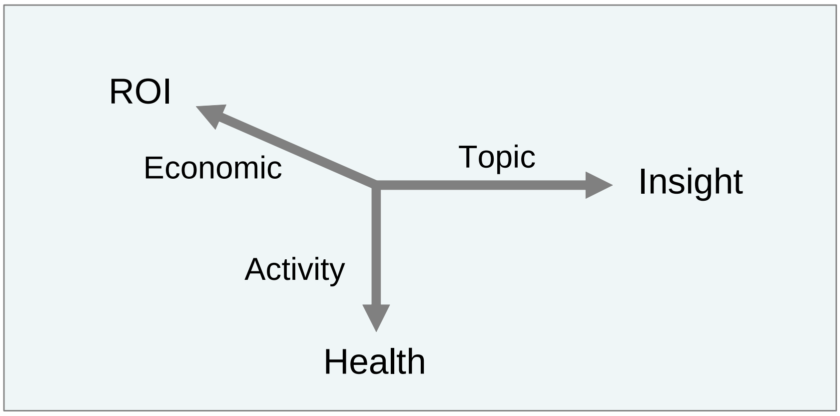

Figure 49: Cothrel's three Dimensions of Community Measurement.
Source: Cothrel (2000)

Cothrel's most elaborated domain is the Activity measurement. He suggests a (somewhat arbitrary) set of 'common measures' for an online community (also compare Figure 50). They include unique visitors, page views, session time, community click-through (what percentage of visitors to the home page click through to a community program), registered members, postings per day/week/month (in member-to-member interaction programs), read-to-post ratio (in member-to-member interaction programs), page additions (in member-generated content programs), page revisions (in member-generated content programs), peak number of concurrent users (in live events), total number of users (in live events), audience penetration (if the total size of the target population is known), repeat visits, and frequent visitors.

Unique Visitors	Page views	Session time	Community click-through	Registered members	Postings per day/week/ month	Read-to-post ratio
Page additions	Page revisions	Peak Number of concurrent users	Total number of users online	Audience pene-tration	Repeat visits	Frequent visi-tors

Figure 50: Common measures for measuring the success of an e-community.
Source: Cothrel (2000)

The second domain is topic measurement. Here, Cothrel remains very general and simply states that topic measures are difficult to define and that they require content analysis. He indicates issues like the identification and analysis of heavily trafficked community areas, discussion threads and the most commonly discussed subjects. Further, he mentions the analysis of the concentration of interest, describing how member activity is distributed across the most commonly discussed subjects. Another factor is the percentage of total community traffic that flows to the ten most heavily trafficked topic areas and the spread of community interest across the top ten subjects. Finally there is the share of the top subject in terms of overall communication volume. Although Cothrel is not giving clear and operative examples of how to derive these figures, these issues can later be utilized to derive measures.

The final set of required CoP measures suggested by Cothrel is evaluating ROI. He understands this community-related ROI as follows:

> "Contrary to popular belief, community ROI is not about `monetizing' community members or performing other unnatural-sounding acts. […] [I]t is about putting a process in place for recognizing the value that online community members create." (Cothrel, 2000:19)

This domain is even less detailed than the very general topic measurement domain. Cothrel notes, that this domain requires data not only from the community, but also from transactions systems in order to allow for a comparison of community member activities versus the activities of other site visitors. He is only very general about the 'how' of measuring ROI. Cothrel suggests metrics like visits, return visits, purchases, frequency of purchase, transaction size, and referrals. Here, Cothrel's focus on commercial communities has fundamental differences to the approach of this book. He assumes that the conversion of community members to paying customers generates the ROI for the community. However, this is not the case in Knowledge Communities. Here the generated value is less a consumptive one but more an increase in overall efficiency. Obviously, the applicability of Cothrel's suggestions for the economic domain is limited to commercial customer (B2C) communities, showing again the importance of determining and defining the appropriate types of the community under consideration (compare section 4.2).

Summarizing, Cothrel's topic domain is not systematized and needs to be transformed into a clearly defined set of measures. He does not discuss the underlying motivations and relations of his measures (e.g. to more general structures of CoPs). The suggested ROI measures can not be applied for the scope of this book's measurement system. However, Cothrel's collection of activity measures can be of help for establishing a basic quantitative impression. Among the important 'common measures' are:

- read-to-post ratio,
- peak number of concurrent users,
- registered members, and
- postings per day/week/month.

Unfortunately, the main focus lies on listing the typical logging measures for tracking the usage of web-based communication applications. Nevertheless, this is an important domain for measuring the activity of a Virtual Community although it has to be noted, that is insufficient if not augmented by other measurement domains. This aspect is indicated in the following quote:

> „Using hits and page views to judge a site's success is like evaluating a musical performance by its volume." (Forrester Research, 1999)

Hence, for the purpose of deriving meaningful measures, pure statistical activity numbers like e.g. total number of users online are not providing useful insights. They need to be connected to an interpretational framework. The parallel users could for instance be interpreted as an indicator of co-presence which in turn improves the feeling to participate in a living group. To closer examine this interpretational framework, more abstract research areas, which are related to the community's structure and processes need to be analyzed.

7.1.2 Measures from Group Theory Research

As Communities of Practice can be regarded as a social group, an important contribution to the research question of how Communities of Practice should be structured, run, improved, and supported can be found by reviewing general group theory. This can then help to derive the factors to be measured in order to manage the community as suggested by these theories.

Although this field is far too broad to be extensively discussed within the scope of this book, the factors which are relevant for analyzing and supporting Communities of Practice are introduced now.

As a first approach to define the term group using its basic properties, Wiese (1924), identifies **duration** and **continuity**, **role structure**, and **emerging traditions**. This rough set of group properties constitutes a first concrete set of general factors which can be analyzed in order to be able to assess if group properties are existing as a part of evaluating qualitative properties of a community. Especially the group's duration can be analyzed although it has to be added, that there is no concrete point in time defined for a set of persons to become a group. However, in the other direction, if some stability and duration can be observed it is a positive indicator of a Community of Practice (although it should be enriched by analyzing other factors like activity).

Schaefers (1980:20) demands, that a successful group requires a system of **shared norms** and a **role structure**. The shared norms emerge during interaction which is affected by social sanctions for not behaving according to the established norms. If feedback signals successful communication behavior, than this behavior is repeated and manifested. Others may eventually imitate these patterns. The role structure hence emerges from these patterns and from the activities of members. For example, if a person often organizes, delegates, and speaks, it is likely to take a leading role. If it is a specialist in a special subject field, it will be asked on that topic and develop it further.

A further general factor for the persistence of a group is **interaction**, although its type and intensity can vary between groups. Only by interaction - which in a community setting is meaning communication - norms, structures, and identity can emerge. Festiger (1950) describes four causal factors for communication in a group:

- communicating opinions and values,
- achieving objectives of the group,
- changing or forming roles and status, and
- conveying emotions and perceptions.

Communication can also be analyzed according to its **contents** (cf. chapter 8.4.3 on content coding) and according to its **directions**. The latter is independent of the content and conveys information about the factor 'role structures'. Direction is recognizable, when the most active persons are asked often. Further, when lower positions direct their requests to individual persons and not to the whole group, or if the overall communication flows from lower to higher ranks in the network.

The **communication structure** can also be related to the performance (i.e. success) of a group. For example, tasks are solved best in a star-pattern of communication. Lines and circles are usually slower and more apt to mistakes.

Lerner and Becker (1962) have analyzed the impact of similarity or **homogeneity** between members. They conclude, that in competitive situations complementary persons collaborate, whereas in situations where shared activities are executed, homogeneous persons build groups. Homogeneity as such ascertains each participant in its own behaviors and values and increases stability in a group. In a Community of Practice, where the transfer and conjoint generation of new knowledge is the primary objective, homogeneity between members is hence an important factor. However, it should also be noted, that if people are too similar in their knowledge and values, it is very likely that their similar perspectives will decrease their ability to innovate (in terms of integrating different domains and perspectives). A greater variety of members creates a better pool of resources, which leads to higher performance (also compare the section on Social Capital).

Summarizing, the main factors which can be applied for generating an interpretational framework for evaluating statistical measures in a virtual CoP are:

- duration,
- continuity,
- role structure,
- emerging traditions / shared norms,
- interaction (in a certain frequency about contents in several direction),
- communication structure, and
- homogeneity.

7.1.3 Measures from Social Network Analysis

Social Network Analysis (SNA) is defined as a framework for the analysis of structured social relationships (Wasserman & Faust, 1994), which in the organizational context can reflect role-based authority relationships of formal organizational structures, informal structures based on communication, information exchange, or affection (Tichy et al., 1979).

The main hypothesis of this field of research is that human behavior is influenced by structural properties (e.g. restrictions) and less by direct characteristics of the actors (e.g. norms). This shifts the focus away from classifying actors using their properties towards observing relationships between actors and the actor's embeddedness in a complex relationship network. This relationship network and the individual relationships have influential structural conditions. Hence SNA is generating and applying approaches and instruments to describe and evaluate the relationships between actors. This focus is very suitable for the analysis of Knowledge Communities, which consist of networks of people which communicate with each other. Here, according to Wellman (1997), social networks are virtually present whenever a group of people interacts electronically. Thus, assuming such communities are resting on an underlying social network enables the systematic examination of such computer-networked communities (Wellman et al., 1996). The relationships between them are of value for the community and the organization. For this object of analysis, the rapid and regular advance in social networks research provides a vast body of measurements and methodologies (Wasserman & Faust, 1994), which can also be applied to increase the transparency of people networks in Communities of Practice and to evaluate their properties. It further provides a concrete set of measurements which can be used to indicate and clarify the broad factors proposed in group theory.

In theory, a social network is a social relational system with the elements actors and relations (relational ties). Actors can also be analyzed on different group levels, like dyads (pairs of actors in two states, adjacent or not adjacent), triads (three nodes subgraph with four states: 0,1,2,3 connections), subgroups, groups, or the overall network (Wassermann and Faust, 1994).

There are two general and related types of networks. An ego-centric network consists of a focal actor, termed ego, a set of alters who have ties with ego, and the measurement on the ties among ego and these alters. This data is also referred to as personal network data. Ego networks are used frequently to study the social support of persons (Wasserman & Faust, 1994). Each alter in an ego network has an own personal network again, so that finally all ego networks interlock to form a complete social network of a group.

Measurements within the domain of SNA can either include composition variables, i.e. the properties of actors, or structural variables, i.e. the properties of relationships. These relationships can be directed or undirected. In the first case, the direction of communication is unidirectional, e.g. A supports B. Undirected relationships represent connections without a specific direction, e.g. A and B communicate. However, this relationship still can be **asymmetrical** (e.g. B writes more than A). Further, **relationships** in a network can differ in their **strength**. Usually a person has few strong relationships and various weak relationships to peers, although there is no specific definition of what is weak and what is strong. Generally, this property is relative to the general constellation in a social network (Marsden and Campbell, 1984). It has been found, that pairs who maintain strong ties are more likely to share the resources they have (Wellman and Wortley, 1990). Another important finding for the analysis of expert networks in the context of Knowledge Management has been provided by Hansen (1999). He found, that strong ties are important for sharing tacit knowledge. Further, an electronic tie combined with an organizational tie is sufficient to allow the flow of information between people who may never have met face-to-face (Garton et al., 1997).

The applied sociological approach of sociomatrices derives various network properties from a very simple set of data about the network stored in a matrix. The rows and columns each belong to a person. The value in the cell, where row A meets column B represents the strength of relationship between both persons A and B. This relationship could for example be the amount of communication exchanged between two employees.

The simplest measure is to actually count the **number of members** or actors in a network. It is a proxy for the network size. Larger social networks tend to have more **heterogeneity** in their social characteristics and more complexity in their structure (Wellman and Potter, 1997). Large heterogeneous networks (such as those often found online) are good for obtaining new resources whereas small homogeneous networks are good for conserving existing resources (Garton et al., 1997).

A further indicator for network size is called **diameter**. It is the longest distance between two nodes in a network or in other words, the longest path. A small line-shaped network of 6 people (longest path or diameter = 5) is thus larger as a dense network with several hundreds of people around one central node (here the diameter is only 2). It is a proxy for the likelihood that information passes through the net. The larger the diameter, the less likely is this information flow.

Further, the actually-occurring relationships between the actors in a network can be counted. They can be compared to the number of possible ties. This is calculated by multiplying the size of the network's population (n authors) by (n-1) and dividing this by 2 if the tie is undirected. A network of 6 people can hence have (6x5/2=) 15 ties if undirected relationships have been under consideration. The network measure **density** is now the ratio between existing ties and the maximum possible ties. A density of 1 means all possible ties exist. Hence density indicates if a network is tightly or very sparsely connected.

> "*Densely-knit networks* (i.e., groups) have considerable direct communication among all members […] few members of *sparsely-knit networks* communicate directly and frequently with each other. As in the Internet, sparsely-knit networks provide people with considerable room to act autonomously and to switch between relationships." (Garton et al., 1997)

The density can be applied together with relationship strength to discover clusters or **groups** in a network. They usually are highly interconnected sets of actors (thus employing a high density). Further they have strong ties within the group. Such evaluation of subgroups or epicenters of communication can help to identify structural patterns of the overall network. All measures can also be applied to compare and characterize the subgroups. Such network groups can be connected to other network groups by actors with membership in both groups.

Another basic property of an actor is his nodal **degree**. This is the number of lines that are incident with it, which is equivalently the number of adjacent nodes. It is a measure of the activity and connectedness, assuming that connections need activities to maintain. A network can be characterized by its average nodal degree, which shows the average number of connections of each actor. If an actor has a degree of zero, i.e. no direct relationships, he is called an isolate.

In people networks with directed relationships, it can be differentiated between indegree (e.g. A has received support) and outdegree (e.g. A provided support). Applying these two indicators to Communities of Practice can show, who is very active (i.e. sending messages or having a large outdegree) and who has much attention or prominence in the network (i.e. large indegree by receiving messages from others). Outdegree is hence a measure of expansiveness whereas indegree is a proxy for receptiveness and popularity (Wasserman and Faust, 1994:126). Comparing the **indegree and outdegree** of two actors in a relation gives an insight about their relationship's symmetry, which can also be named **reciprocity** (see next chapter for its interpretation in the social domain). If an actor has an indegree of zero and an outdegree larger than zero, it is called transmitter, the opposite constellation is named receiver. If both types of degrees are above zero it is called a carrier (Wasserman and Faust, 1994:128). In the context of the measure degree, there are also the network positions **hub** and **pulsetaker**. A hub is a person with many direct ties. It is very likely to simultaneously be a broker. Such a broker is connecting large subsets, which would otherwise not be connected. A pulsetaker is having only few direct links to the network, which makes his position very comfortable as every link requires effort to be maintained. Still, he has very effective links, for example to a hub, meaning that while only having few direct links he can draw resources from the network through a multitude of indirect links, which originate in his connected actors.

Related to the nodal degree is the measure of **centrality**. It is an important property of a network as a very centralized network is dominated by few or even just one central node. If such critical nodes are removed, the network fragments into unconnected sub-networks. Networks with low centrality have no single point of failure.

One subtype of centrality is **degree centrality**, which is simply indicating, how involved the actor is in ties (i.e. having a high degree; Wasserman and Faust, 1994:178). A second subtype is **closeness centrality**, which measures how close an actor is to all other actors in the network. If he is close to all, he can quickly interact with them without needing to rely on many other people (Wasserman and Faust, 1994:183). A third type of centrality is called **betweenness centrality**. It assumes that an actor, which is required to be passed if two other actors want to connect, is 'between' these two actors. The more instances of being 'between' two actors exist, the higher is the 'betweenness' of the actor under consideration. It is in other words simply the number of paths that pass through a node and indicates how often a given node is required by others to reach any node via the shortest path. Actors with a high betweenness are central in the network as they are undergoing a certain 'stress' during the activity of the network. The measure betweenness can be normalized by dividing it by its maximum value.

The notion of betweenness also relates to the network role of a broker. Such a broker occupies an important network position. It sits on an exclusive path between many other actors. They hence require this person to connect to many of their related actors. Such a **broker** between two subnets can also be called a cut-node. If this node is removed, many connections between other actors disappear. A related name for this network position is gatekeeper, as in a diffusion process, this node can control the flow of information (Garton et al., 1997).

In conclusion, this section briefly introduced the perspective of Social Network Analysis together with its most important measures. These can help to establish useful insights into the structure of a virtual Knowledge Community network between experts, which mainly consists of communication acts between the members. The most important factors for evaluation with a measurement system are:

- network size,
- relationship strength,
- network roles (broker, gatekeeper, pulsetaker, hub, isolate, transmitter, receiver, carrier),
- degree (activity, prominence, symmetry or reciprocity),
- betweenness and centrality,
- density, and
- diameter.

7.1.4 Measures for Social Capital or Trust

Social Capital and trust have already been introduced as a major benefit and resource for a company (Chapter 5.3.2). Measurement and facilitation of community structures need to include this dimension. That is why this chapter is discussing the main factors which can be measured to indicate the extent of Social Capital and trust in a virtual Knowledge Community. It has to be noted that most of these measurements actually originate in the domain of Social Network Analysis. Social Capital can hence be regarded as a more abstract property emerging in social networks. The likelihood of receiving social support is less dependent on the personal characteristics of an actor, but more on the form and quality of his relationships.

In chapter 5.3.2 on Social Capital as an organizational benefit, the three interrelated structural, relational, and cognitive dimensions have been described (Nahapiet and Ghoshal, 1998). Together, they contribute to the formation of Social Capital. The structural factor requires the formation and actual existence of informal networks between persons in order to enable them to identify people with required resources. Here, the structure of people's relationship networks is of interest as it determines their access to social resources. Applying the Social Network Analysis methodology introduced in the previous section, this is further determined by the **relationship's strength**. In the context of Social Capital and trust, 'strong ties' and 'weak ties' both can be useful for different purposes. Whereas strong ties imply more trust and familiarity, weak ties were found to provide links to external sources or other clusters which are often a useful source for novel information or different perspectives of other knowledge domains (Granovetter, 1973). This leads to the conclusion that the pattern and the strength of relationships is also of interest for analyzing this domain of measurement.

The relational requirement of Nahapiet and Ghoshal is supporting the exchange between the individuals. It addresses issues like trust, shared norms and values, obligation, expectation and identification. The relational aspect of Social Capital requires, that people think their actions will be appropriately reciprocated (cf. Lesser and Prusak, 1999). This implies that mutual trust emerges from **mutual obligations** and the **reciprocity** of communication relationships. The absence of personal profiling and the support of altruistic and assisting behavior is another supportive group behavior to improve the relational aspect of Social Capital.

The cognitive aspect of Social Capital finally includes issues like common context and vocabulary, which is supported by the use of common artifacts and stories. This shows the importance of measuring similarity and **homogeneity** to enable familiarity between persons.

Further, social support is determined by emotional support or help in the past, by relatedness or familiarity, and to some extend by gender as women tend to provide emotional support more often than men (Wellman and Wortley, 1990).

Section 5.3.3 highlighted the importance of a frequent and positively attributed relationship to establish trust between communicating persons. Trust is a fundamental principle necessary to create Social Capital in a knowledge network. Its determinants are very similar to those of Social Capital, so that these two concepts can be treated as one interrelated domain.

One measurable proxy to determine the level of trust in a network is hence the **frequency of interaction** between authors and with this also the **relationship strength** as more frequent relationships will also have higher relationship strength.

A recent study showed that the level of trust which exists in virtual workgroups could be measurably improved by even a single face-to-face interaction at the beginning of the project (Rocco, 1998). However, this success factor is beyond the scope of what electronic communication can support. A detrimental environment which limits the building of trust and mutual obligation is a highly competitive, individualistic culture (Lesser and Cothrel, 2001). That is why factors like concurrency and personal profilation have to consider that for a group, the people who actually help others are the most helpful members. Hence, **altruism** should be rewarded.

Another factor which supports trust is **mutual obligation** (Nahapiet and Ghoshal, 1998). The underlying idea is that an actor is more likely to provide resources on request, if he has an obligation to do so. Such an obligation emerges, when he has received more resources from the requesting actor, than he has provided. This concept is thus analog to paying off a debt.

Jarvenpaa and Leidner (1998) analyze the forming of trust in global virtual groups. They identify several behaviors which influence trust. Positive early behaviors include **social communication**, conversation conveying **enthusiasm**, individual initiative, and conjointly coping with technical and task uncertainty. All these factors can be measured to some extend by conducting a manual or semi-automatic content coding (also compare section 8.4.2 on content analysis). This method classifies different types of communication and thus allows for analyzing the shares and networks of different such categories. Behaviors, which try to improve trust in more mature stages of the group, include predictable communication (e.g. warning of absences), **timely responses**, rotating leadership, and phlegmatic reaction to temporary crises.

In summary, the domain of Social Capital research obviously draws on measurements from Social Network Analysis. It serves as an abstract layer or an interpretational framework above the quantitative measures of SNA. This will later also be reflected in the hierarchical dependencies between different domains of measurement in the measurement concept. As a result, the most important factors which can be supportive for an integrated measurement system for Knowledge Communities are:

- homogeneity,
- reciprocity or mutual obligation,
- familiarity,
- relationship structure and strength,
- interaction frequency,
- altruism and assistance to others,
- degree of social communication, and
- response time.

7.1.5 Measures for Knowledge Processes

A final domain, which has no underlying theory, but can be derived from the other areas, is the measurement of knowledge processes. However, assuming, that the Community of Practice conducts Knowledge Work in a network of experts, this domain is implicitly evaluated by the other domains. Given, that the knowledge processes are contained in the actual communication, it has to be analyzed, to what extent the actual transfer of knowledge can be identified by communication analysis.

Main questions are the relation between questions and answers, or the time until responses are available. Another important related domain is the actual analysis of topics, which have been discussed. This can be done by extracting keywords or analyzing broad and related topics.

Summarizing, it has to be noted, that no theoretical frameworks exist so far for the evaluation of actual knowledge processes in expert communication. Although a set of measures will be developed to reflect this domain, more research is still to be done to be able to automatically evaluate knowledge transfer or knowledge development. The main factors so far are:

- relation between questions and answers,
- response time, and
- topic analysis, including similarities or dominating topics.

7.2 Deriving a Measurement Concept for Communities of Practice

After having analyzed the main tasks of management (section 5.7), the underlying success factors for running a Community of Practice (section 7.1), and factors in five related research areas, a large and substantiated selection of important measurement factors or indicators can be assembled. The objective remains to identify available electronic data in virtual Knowledge Communities which can be utilized to calculate the discussed measures and to integrate them into a systematic measurement system. This can then be used to direct the design of a supporting software tool for analyzing virtual communication networks (see the next part of this book on the development of the according software tool).

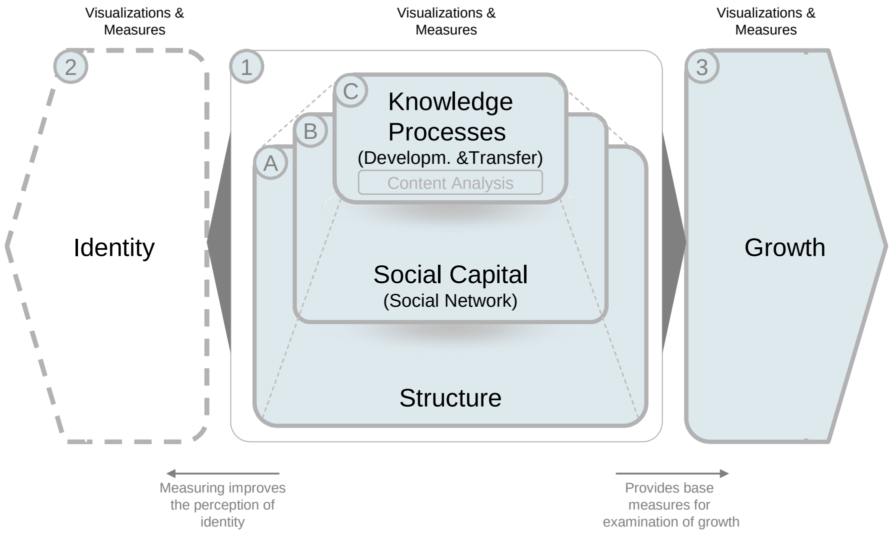

Figure 51: Measurement Concept for the Evaluation of virtual Knowledge Communities.

Figure 51 shows the conceptualized measurement approach for evaluating CoPs. The multiple measures identified in the previous sections can be systematically classified into three types:

1A) measures of structure (quantitative communication structure including basic logging data),

1B) measures of Social Capital (Social Network) (including group factors, social network factors, and more abstract extend of social capital and trust), and

1C) measures of knowledge processes (knowledge development and transfer).

These three domains constitute the core of the measurement system. The simplest layer is the actual quantitative structure. It can be evaluated by looking at measures like number of authors, volume of messages, average time between messages sent, network density, network diameter, etc. The structural measurements can also be calculated for each relation or for each author. A more general indicator of this domain is structural uniformity, which implies the evenness of the network. It detects steep peaks or very evenly distributed network activity.

Some structural properties also convey information about the social network within the communication network and by this also about the quality of Social Capital as the access to resources distributed in a people network. This section thus comprises a second layer on top of the quantitative structure. Examples are average strength of relationships, reciprocity of relations, number of direct and indirect contacts per author, etc. More complex soft indicators which can be evaluated with such measures are the level of trust and the degree of Social Capital.

Some of the structural properties additionally give insights about the level of knowledge exchange and its underlying knowledge processes. Useful measures are unanswered versus answered questions, average number of replies, or average message length per relation. This knowledge related set of measurable network properties also leads to content oriented analysis of the network structure. In the measurement concept, this is the point, where topic and keyword analysis are integrated into Social Network Analysis in order to align the idea of analyzing communication networks with the idea of Knowledge and Expertise Management[42]. Measures are e.g. the main keywords of a relation, an author, or the complete network as well as the similarity between authors based on their keyword overlap.

Next to these three core sets of measurement two related domains are included. Identity (domain 2) is the first important domain. Here, facilitation of virtual communication networks can be achieved by simply enriching the otherwise invisible group structures with useful visualizations. Examples are cues of who is similar to an ego, adjacent, or co-present. This phenomenon of Social Translucence has been discussed by Erickson and Kellogg (2000) and will be provided as a brief introduction in the next section.

Next to supporting group identity, the three structural properties finally provide the foundation form the basis for the final suggested measurement domain: growth and development (domain 3). It helps to understand not only the configuration of the network, but also its dynamic behavior including the group's velocity or deceleration, its declining sectors or the establishment of network roles over time.

To prepare for this novel domain of measurement and evaluation of dynamic behavior, a longitudinal visualization component has been developed. It allows for actually observing how new nodes and relations are added over time and how network properties are changing. In the future, this element provides much potential for further research as such analytical insights about longitudinal network measures are of interest for community moderation and management, especially if it is connected to topic analysis.

The complete set of individual measures for the four domains Structural Properties, Social Capital Properties, Knowledge Process Properties, and Growth Proper-

[42] More on this innovative yet very challenging endeavor can be found in chapter 8.4.4.

ties is shown in Figure 52. All measured elements are related to the overall network (marked with N), to individual authors (A) or to relations (R).

Together the table includes 55 individual measures for a Virtual Community. They can be differentiated into 13 structural properties, 18 Social Capital properties, 16 knowledge process properties, and 8 growth properties. The amount of measures already implies the focus on analyzing social elements and knowledge processes.

Some of these measures are now introduced in more detail to illustrate the general approach of deriving the evaluation indicators from the available electronic data.

Structural measure number 5 is called **ATBMS**. This is simply the abbreviated form for ‘average time between messages sent’, which is a proxy for the frequency of postings and also implies the speed of content additions or content related growth. It can be calculated for the network and for each author. For the network (notation: N [ATBMS]) it is simply the overall lifetime of captured data (last – first entry) divided by the sum of all messages (N [Duration] / N [#msg]).

Structural measure 11 is the **core group’s share** of the overall number of authors in the network (N [Coregroup share]). To determine this core group, the most active actors in an expert network are ranked. Then they are added to the core group until this group accounts for 80 percent of the network traffic. The share is then the size of the core group divided by the total number of available actors in the network (N [Coregroup size/ # A]). This measure shows, if the core group is either very small compared to the rest, showing that there is a ‘tall peak’ in the communication volume with only a small but very active nucleus, or if the network is more evenly distributed. It is thus similar to a market share or monopoly measure in economical theories.

Social Capital measure 14 indicates an **author’s obligation** in an individual relationship (A [Obligation in R]). It indicates how many an author ‘gives to’ or ‘takes from’ a contact. Obligation occurs, when the author has generated a ‘debt’ in terms of support, meaning that he received more from his peer than he provided. It has been shown in section 7.1.4, that this increases the probability, that he provides support at the next request of his contact person. The measure simply relates the received messages to the sent messages and normalizes this number to arrive at a range of -100 to +100 percent of obligation (A [1-((#sent M - #rec M)/ (rec M + #sent M))-100]). Reaching the maximum 100 percent means that the author has a very high obligation to provide resources at the next request of B.

Social Capital measure 18 is the **similarity of author properties** and requires author coding for its actual implementation (R [Property Similarity of A's]). This means that it is necessary to analyze a wide range of information about the author’s properties. The measure basically calculates a similarity measure by counting similar properties (R [#pairs of property entries/# properties*100]). This could for example be organization, division, hierarchy, job role, years of experience, prior projects, industry sector, education, etc. The theoretical idea is that a high similarity between authors (in terms of backgrounds) positively affects the levels of trust and subsequently also the access to other employees' resources.

An example of a network role analysis is Social Capital measure number 24, the **pulsetaker**. The measure compares a person's indirect contacts with its direct contacts and computes the relation between these two factors (A [#indir contacts / #direct contacts]) in order to identify how many indirect contacts the actor has per direct contact. This helps to identify pulsetakers, which have to put very little effort into the maintenance of their direct contacts and still have access to many indirect sources of information.

Measure 28 is a very easy to compute yet very powerful indicator for the network's probability of providing social support: the average **strength of the relationships** of the network (N [avg strength of R]). It is calculated by counting and averaging the numbers of messages for each relationship between two authors (N [avg R [#msg)]). The stronger the relation in the network, the higher is the probability to access other member's resources.

A further interesting example is measure 31, the number of **mutual contacts** in a relationship between two authors (R [# mutual contacts]). The underlying argument is that the probability for a good relationship (and hence for access to resources in the network) increases when the two persons share some contacts (R [# paired contacts of A and A2]).

Measure 32 looks at the amount of relations between **old and new members** of an expert network (N [#R [old and new]]). It is calculated by looking at the overall maturity (time period) of the expert network and counts relations which connect two authors, whose days of first appearance in the network are very distant to each other - at least half the age of the overall network (N [# R [where ((days since A appeared - days since A2 appeared)/days of discourse data) > def50). This is a very interesting proxy for the likelihood of new members to connect and draw on resources of experts.

Measure 35 is an example for a measure for evaluating knowledge processes. It is comparing **answered versus unanswered postings** in a virtual discussion (N [answered/unanswered msg]). This can technically be done by looking for messages which reference another message. These are then regarded as answers (N [#initial M with reference / #initial M without being referenced by others]). It is a proxy of how likely it is to receive answers for requests or in other words to receive support from experts.

			Description/Name	Calculation	Implies
1	1	Structural Property	N [Message Volume]	N [#msg]	Size of the network in terms of content
2	2		N [Author Volume]	N [#A]	Size of the network in terms of participants
3	3		N [Relations Volume]	N [#R]	Amount of relations in the network
4	4		N [Diameter]	N [longest path]	Size of the network in terms of distances
5	5		N [ATBMS]	N [N [Duration] / N [#msg]]	Frequency of activity, speed of added contents,avg time between mess sent
6	6		N [#Transmitters]	N [# A[no received M]	Only sent messages, similar to minus 100 of A [Obligation]
7	7		N [#Receivers]	N [# A[no sent M]	Only received messages, similar to plus 100 of A [Obligation]
8	8		N [Variance of #contacts]	N [Variance of #contacts]	Structural differences in the network (steep)
10	10		N [Variance of Relstrength]	N [Variance of Relstrength]	Structural differences in the network (steep)
11	11		N [Coregroup size]	N [# A[coregroup=y]	Size of active nucleus
12	12		N [Coregroup share]	N [Coregroup size/ # A]	Share of active nucleus in overall activity
13	13		A [elapsed time since last ac	A [days since last message sent or received]	How long has the author been idle/inactive?
14	1	Social Capital Property	A [Obligation in R]	A [1-((#sent M - #rec M)/(rec M + #sent M))-100]	(-100% to +100%) How many authors gives or takes to a contact
15	2		R [Reciprocity]	R [(1-((abs(#rec M - #sent M))/#(rec M + #sent M)))*100]	approaches 100% when symmetric relationship
16	3		N [avg Reciprocity]	N [sum reciprocity / # R]	shows how even the relationships are
17	4		A [avg Obligation]	A [sum A[Obligation in R] / #R]	how much obligation has an author to others, negative for accessing network ressources
18	5		R [Property Similarity of A's	R [#pairs of property entries/# properties*100]	[0..100] - same background (like hierarchy), more similarity more trust and access
19	6		N [Density]	N [R (existing) / R max * 100]	Connectedness in the network, = access to all ressources
20	7		N [# Isolates]	N [# A with 0 R]	no established or historical access to network ressources
21	8		N [Density of Coregroup]	N [R (existing) / R max * 100 for all R between A[coregroup]]	how well connected is the nucleus
22	9		A [# core group contacts]	A [R where A2 [# core group = y]]	how many active and central access persons
23	10		A [direct contacts]	A [#R]	how many access persons
24	11		A [Pulsetaker]	A [#indir contacts / #direct contacts]	how many indirect contacts per direct contact (multiplier of indirect information access)
25	12		A [Broker]	A [# R [where A is neccesary path-element of R[A2,A3]]]	how many pathes between other authors in the net do require A as their element, bottlene
26	13		N [#Brokers or Cutpoints]	N [#A where A [# R [where A is neccesary path-element of R[A2,A3]]]	how many weak points are in the network structure
27	14		A [duration of membership]	A [(days since A appeared/days of discourse data)*100]	is it an established member or a recent
28	15		N [avg strength of R]	N [avg R[#msg)]	how strong are on average the messages in the network - good for access to ressources
29	16		A [avg strength of R / #R]	A [avg R[#msg)/#R]	how strong are the relationships of A on average
30	17		A [above average connectio	A [#dir contacts/ N[avg A[#dir contacts]	is an author extensively connected compared to the avg network
31	18		R [# mutual contacts]	R [# contacts of A appear in the contacts of A2]	Propability for a good relationship increases when same 'friends'
32	1	Knowledge Process Property	N[# R[old and new]]	N [# R[where ((days since A appeared - days since A2 appeared)/days of discourse data)	how many relationships between oldies and newbies exist
33	2		N [avg mess length in chars]	N [avg mess length in chars]	how likely is content being included in a message how comprehensive is it
34	3		N [Assistance]	N [#A with avg obligation <0] or N [# A [obligation <0)/#A *100]	how many authors assisted others more than they took
35	4		N [answered/unanswered m	N [#initial M with reference / #initial M without being referenced by others]	only hierarchical discourses! How well get questions answered
36	5		N [avg #answers/request]	N [avg #referencing M for #initial M]	only hierarchical discourses! How well get questions answered
37	6		N [avg answer time]	N [avg time between M and referencing M (not only initial msg]	only hierarchical discourses! How well get questions answered
38	7		A [avg answer time]	N [avg time between M and A's referencing M (not only initial msg]	only hierarchical discourses! How well get questions answered
39	8		A [Rating]	A [avg rating by others]	requires property: Rating, quality measure
40	9		R [Keyword Similarity of A's]	R [#pairs of keywords/# keyowrds * 100]	[0..100] - same background (topic-related) - Content Analysis based similarity measure
41	10		N [keyword list]	N [20 most frequent keywords identified - together with their neighboar words]	Content Analysis - shows content of the network
42	11		A [keyword list]	A [20 most frequent keywords identified - together with their neighboar words]	Content Analysis - shows content of the authors contributions
43	12		R [keyword list]	R [20 most frequent keywords identified - together with their neighboar words]	Content Analysis - shows content of the relation
44	13		A [keyword variance]	A [#M containing 1 out of 20 most frequent keywords/#M]	Content Analysis - How many of A's messages are covered by his 20 keywords - polarizati
45	14		N [keyword variance]	N [#M containing 1 out of 20 most frequent keywords/#M]	Content Analysis - How many messages are covered by 20 keywords - polarization
46	15		A [topic leaders]	A [most occurences of the networks keywords]	Content Analysis - who speaks most about the keywords
47	16		A [Network keyword overlap	A [how many overlapping keywords with N[keyword list]	Content Analysis - similarity between the author and the overal network
48	1	Growth Property	N [Density Trend]	N [Density change over time]	how improves the connectedness between authors
49	2		N [Sliding Density Trend]	N [Density of relations idle for < 20% of the discourses period - change over time]	how improves the recent connectedness between authors
50	3		N [Diameter Trend]	N [Diameter change over time]	how improves the size of the network over time in terms of distance
51	4		N [ATBMS Trend]	N [N [Duration] / N [#msg] - change over time]	how increases the speed of message volume addition in the network
52	5		A [ATBMS Trend]	A [A [Duration] / N [#msg] - change over time]	how increases the speed of message volume addition of the author
53	6		N [Keyword Variance over ti	N [#M containing 1 out of 20 most frequent keywords/#M - change over time]	how changed the polarization of the network over time
54	7		N [Hot Topics]	N [Keywords, whose occurances increased most over time]	which keywords spread across the network over time
55	8		A [Hot Topics]	A [Keywords, whose occurances increased most over time]	which keywords determined A's contributions over time

Figure 52: Four Domains Model of Network Evaluation
(Structure, Social Capital, Knowledge Processes, and Growth).

Another knowledge process evaluation is provided by measure 40 – a **keyword similarity** measure between two authors (R [Keyword Similarity of A's]). It is simply looking for the amount of keywords, which two selected authors have in common to derive an insight about their shared topics of expertise. This is then being normalized to arrive at a percentage which represents the amount of overlap of the author's backgrounds (R [#pairs of keywords/# keywords * 100]).

In the domain of growth measures, measure 48 is the **trend** of the network's density. **Density** has been defined as the actually occurring relationships in a network divided by the maximum possible relationships. A trend indicator now shows how the network's connections do increase or decay over time (N [Density Trend]; also compare section 7.1.3). Increased density indicates that authors establish more direct connections to each other, thus increasing their own connectedness to others, which in turn makes a smooth flow of information more likely. Further, it benefits the social structure as more relationships imply that more paths for social support are emerging. This growth measure is hence also related to the Social Capital and the knowledge process domain.

A final measure, which shall be introduced, is measure 54: the identification of '**hot topics**' in the overall network (N [Hot Topics]). It is actually an enumeration of topics and not an ordinal or cardinal measure. However, it is of high interest for moderators in the field. It helps them to actually see, which topics are growing. It is a growth measure as it is looking at the keywords and their occurrences over time. The keywords, which increased in their occurrence have spread most across the network over time and are hence of high interest (N [Keywords, whose occurrences increased most over time]).

These dozen measures, which have been introduced in more detail, show the motivation and the method for deriving a set of concrete indicators by using the available electronic data. In a subsequent step, such a measurement system can also be supported with useful visualizations of the results. In the domain of virtual group visualization, this supports the final domain of identity, which is heavily relying on mutual awareness of the group and its properties.

7.3 Social Translucence - adding Visualization to Measurement

Next to mere measurement of statistical factors, the visual access and interpretation of such factors is a major issue. It is a very beneficial aspect of a software supported measurement system and increases manageability by providing cockpit-like features to moderators and members. This is why visualizations of expert networks are a key element of the evaluation and analysis approach of this book. Sometimes these visualizations yield more insights than mere numbers as they directly and user-friendly represent structures, clusters, dead areas, important experts, dense relationships, etc. However, they need to be connected to measures in order to allow for comparisons between different communities. A further benefit of including visualizations in the evaluation of Knowledge Communities is the very positive effect on the member's impression of identity. In the measurement system indicated in Figure 52 (page 169), this role is reflected by adding a complete domain 'identity' which basically hosts visualizations and is a result from increased transparency through measures.

In this context, visualization can be defined as the use of computer supported, interactive, visual representations of abstract data to amplify cognition (Card et al., 1999:1).

In the literature, the importance of visualizations for the identity of a group has been analyzed under the name **Social Translucence**. This concept has been suggested by Erickson and Kellogg (2000) to express the necessity of providing visible clues based on perceptual information of the social situation (presence and activities of users) to the members of a virtual group to create social resources that help to structure the online interactions. By such visual information, people become aware of each other and social conventions and dynamics are enriched. The mutual awareness increases the accountability of the member's actions. Behavior is more visible and persistent, the history and thus also the character of users is getting conveyed. This creates more coherent, productive, and fluid online interactions. Users can imitate and observe others, peer pressure emerges. Erickson and Kellogg see Social Translucence as a fundamental requirement for supporting most types of communication and collaboration in digital spaces.

The general underlying benefits of visualization have also been discussed by Card et al. (1999:16). The authors propose six mayor ways by which an Information Visualization can amplify cognition:

- **Increasing memory resources available to the user:** This can be done by either directly using the resources of the visual system or help cognition by reducing working memory requirements for doing a task by allowing to store certain information externally and visually. For example when doing a subtraction by hand, working memory requirements can be reduced by using a pen and paper and writing down the overlap of the subtraction of two digits under the next pair.
- **Reduced search:** Search time can be reduced by visually grouping related data. Larger amounts of data can be represented in a small area. For example in a map height of locations is often color coded. If the data would be printed out for each location it would be probably illegible.
- **Enhanced recognition of patterns:** Recognizing information is often easier then recalling the information. Information can be simplified and organized by grouping certain information, abstracting the information in an informative way and selectively omitting certain details. UML diagrams are used in programming to visualize the structure of objects in a

program. They put the different objects in relation to each other through grouping and thus reduce the complexity of the code by only displaying an abstraction of its functionality.

- **Perceptional inference:** Visualization can help people to make a large amount of graphical inferences which else would be very hard to derive. It can also enable humans to make specialized graphical computations, like using diagrams to generate hypotheses about data.
- **Perceptional monitoring:** By organizing a display, a large number of potential events can be monitored. This is used in cockpits of airplanes.
- **Manipulable medium:** A configurable medium allows the user to explore the parameter space and the data. For example, math programs allow the user to plot data and then to zoom into sub areas. The user can change parameters and directly see the changes in the graphical output.

These general advantages show how beneficial the addition of useful visualizations is for interpreting a complex set of measures. In an approach that builds on modeling and analyzing a community to subsequently apply a measurement system with a large set of measures, the addition of various illustrating visualizations is very synergetic. It helps to increase the social translucence of the system for its members and gives them a better impression of identity. Further, for the target group of moderators, the visualizations are especially helpful to aid the understanding of the moderator or manager about the complex structure of his network. The developed visualization environment should hence amplify cognition in many different ways. It should be a **configurable medium** and allow the user to zoom the data to different levels of detail. The medium should allow exploring the data by filtering using different criteria. It should **reduce search** for data by plotting many authors and their relations in a structured way in a small area. The application should **enhance recognition of patterns.** This can be done with a structured display of the data by making the relation dependencies as clear as possible. The user should be assisted to make **perceptional inferences** by visually encoding relevant information into the visualization.

In summary, this section derived a concrete measurement system with 55 measures in four domains from a selection of success factors. These main domains are structural quantitative measures, measures indicating the social structure and Social Capital, measures for analyzing knowledge processes, and measures indicating growth and evolvement. Further, the importance of adding visualizations to the measurement system has been emphasized. These visualizations often achieve more benefits in terms of user acceptance and insights as pure statistical evaluation. This is why a major decision for the development of the prototypical software has been the predominance of visualization over measurement and evaluation. Whereas visualization enables understanding, measurement enables comparison. (“Visualization comes first, measures are the extension.”). In the next section, the developed technical software approach to implement the introduced measurement and visualization approach for monitoring virtual communities is described in detail.

8 A Tool 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 make Virtual Communities more transparent and which thus also helps to better employ this organizational structure of experts for a network oriented Knowledge Management.

This chapter will now specify the requirements for a tool which provides such functionality for visualization and evaluation of otherwise invisible expert networks. Afterwards, the engineering approaches and decisions of the according software project are introduced and discussed to finally present the developed solution: a monitoring support for existing software applications for Virtual Communities.

The design stage was guided by a general procedure. Its four main elements are 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 53). The main principle in the development of the 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 53), 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).

The general requirements of a (knowledge) community manager have already been discussed to a great extend in the previous chapters. Similarly, the measurement system has been conceptually developed in chapter 7.2. Remaining is thus the examination of the available data sources and their general structures and the development of a suitable visualization interface, which presents the measures in a suitable format to achieve insights for the community manager. The latter component can be called ‘cockpit’ as it allows a steering person to access and read the main parameters of a system (just like in a car or plane). This aspect is an ongoing field of research as no visual access to virtual people networks yet exists. After briefly reviewing related technical software approaches and prototypes, the development project for this book's approach will be presented.

The key research areas for the following development of the software for analyzing and visualizing virtual Knowledge Communities are a modeling notation (using Graph theory and SNA), the depiction of information about network properties (enriching information by property mapping), the challenge of accessing multiple channels of communication (and the resulting integration of different storing paradigms), the actual implementation of the measures for evaluation, the integration of topics and keyword analysis, and finally longitudinal visualizations, animations and measures to evaluate evolution and growth.

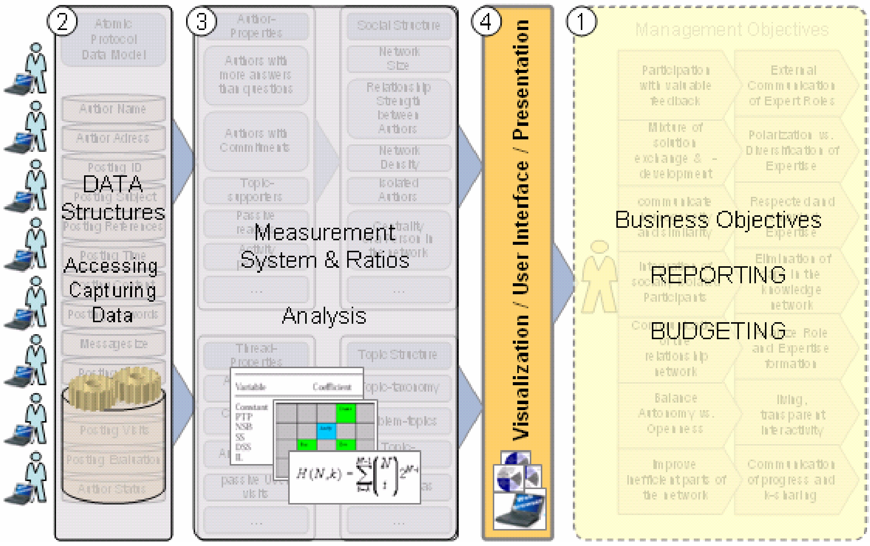

Figure 53: Overview about the general Procedure to develop a Tool for Visualization and Evaluation of Communities of Practice.

8.1 Current Visualization Approaches

During the past years, research on Information Visualization proposed some experimental instruments which employ various visualization techniques, which help to create a foundation for a management cockpit for social relationship monitoring. Still, they have not yet been combined and applied for the purpose of stakeholder communication. In order to give an impression about the current state of the art in related approaches, this section is reviewing the most important prototypes of the field. They usually primarily increase the identity of a virtual group by adding insightful visualizations of group structures and processes. Most developments obviously assumed, that the structural patterns are best communicated by using visual proxies of quantitative community patterns. However, the measurement domain is always inseparably connected to such visualizations as it provides the basis for generating the individual visualizations. The main strands of measurement and visualization is user logging and its map-like representation on a display. Only few approaches actually focus on the emerging relationship network of people in Communities of Practice.

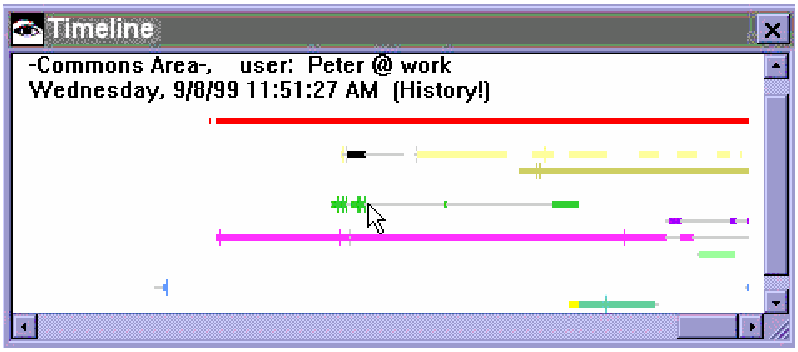

Figure 54: Visualizing Discussion history with the 'Babble' Time-line.
Source: Erickson and Laff (2001)

A first example to be introduced is the Babble-Timeline developed by the IBM T.J. Watson Research Center in order to visualize discussion histories (see Figure 54). This graph is connected to the management domain of social processes. Horizontal lines refer to users, gray parts indicate a user who is logged in but not viewing the current discussion, gaps represent periods, where the user was logged out. Colored parts imply that the user looked at the discussion currently examined. Vertical marks indicate the user's postings, gray marks stand for postings in other discussions, and colored marks are contributions to the actual discussion.

A second example is the interface of Coterie, created at the MIT Media Labs (Figure 55). It is representing users as ovals, their color brightens if they are active, they form clusters around topics, active conversants are centered, and inactive listeners (called 'lurkers' are located at the sidelines. Despite providing insights in the current movements, the solution lacks a statistical perspective for ex-post analysis of social processes or structures.

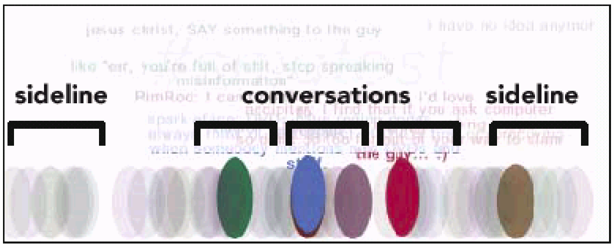

Figure 55: Display of a Chat Conversation with Coterie. Source: Spiegel (2001)

In 1999, Xiong and Donath created a visualization called Peoplegarden. It represents users in a message board as petals of a flower-like structure. The height of the 'flower' is related to the time the user is active in the board. There are two colors for the flowers' petals: magenta and blue. Magenta represents postings, blue replies. This shows if users only answer others' request or if they ask more than they answer. Further the petals start to fade out over time. Thus a discussion group with bright flowers indicates recent posts. It can be observed if a discussion board is dominated by one person or if conversations are more evenly distributed. Optionally, the number of responses is represented as small circles at the end of the posting pattern. Despite the very ergonomic proxy this visualization is not showing the connections between people, so that there are no real networks emerging.

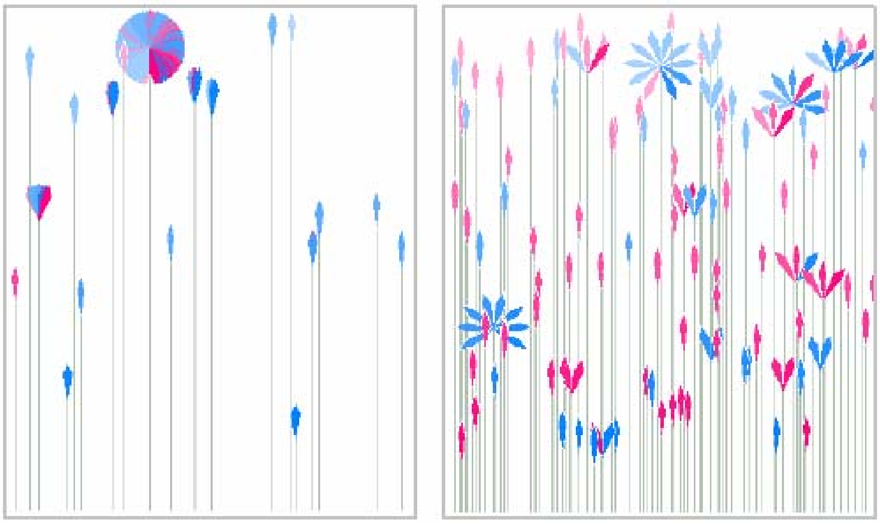

Figure 56: Visualization of Discussion Boards as a Peoplegarden.
Source: Xiong and Donath (1999)

Donath et al. (1999) developed a further visualization which represents postings over time. It is called Conversation Landscape. Vertical lines show the period of activity for each participant; horizontal lines are postings. Highlighting shows, who was within hearing range of the selected participant at any given time. This hearing range is requiring the user to locate himself nearby a discussion in order to be able to follow its content. If his position is too far away, the user can only see activities, but can not read the text. The user can interact with the representation, e.g. by selecting a horizontal bar shows the text of the according posting. The wider this line, the longer is the related posting. Again, the actual interaction and knowledge exchange between users is not represented.

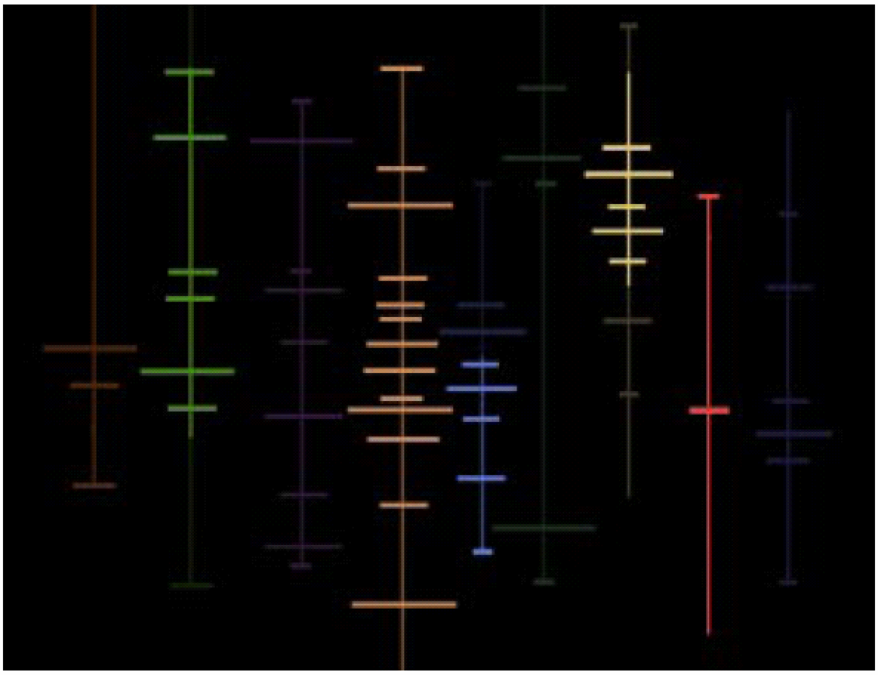

Figure 57: Visualizing Author Timelines with Conversation Landscape.
Source: Donath et al. (1999)

Figure 58 shows a completely different approach. Here, the Netscan hierarchy display (Smith and Fiore, 2001) visualizes the entire Usenet. Newsgroups are represented by rectangular regions. Boxes are nested within other boxes, indicating hierarchies. Their size represents each group's cumulative numbers of posts. In the interactive version, pointing the mouse at a box brings up a text label identifying the newsgroup or hierarchy. The size can also be set to show the number of posters, the ratio of posts to posters, the average message length, or the percentage change in message traffic from the previous week to the current one. In a later version of this box plot, color coding has been added to indicate shrinking groups with red colors and growing groups in green.

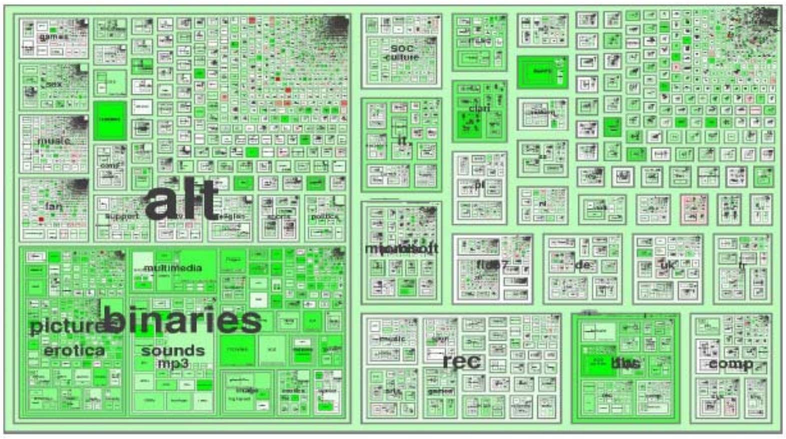

Figure 58: Boxplotting the size of different Newsgroups with the Netscan Hierarchy Display. Source: Smith and Fiore (2001)

Another representation of the Netscan approach shows the actual thread and how it evolves and differentiates over time (cf. Figure 59). In this view, boxes represent messages. Lines between messages show replies between messages. Various signs give more information. Small people-shaped figures at the left hand side represent the users, which posted on that day. The box with the red dot indicates the originator of that thread. Thus, it can be observed if this person ever revisited his request. The half-shaded box finally indicates the most prolific author's activities.

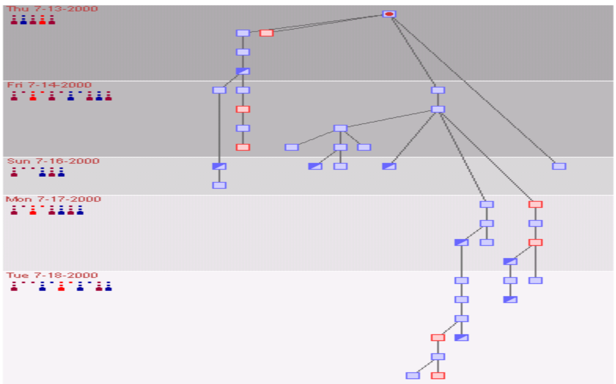

Figure 59: Netscan Thread Tree. Source: Smith and Fiore (2001)

A somewhat more intuitive display of thread structure and 'health' has been developed with the application eTree (see Figure 60). It is using an 'ecosystem' as a proxy. Threads are mapped as branches with posts as leaves. Recent posts are colored in a lighter green, eventually turning darker over time. Hot topics are highlighted as yellow 'flowers'. Participants are located around the tree (color represents affiliation). The more active a poster is, the closer he moves to the center.

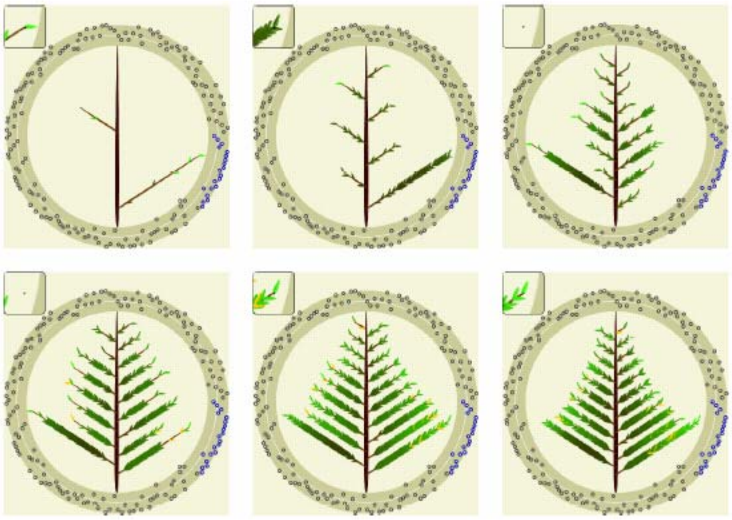

Figure 60: Visualizing thread 'Health' and Development with eTree.
Source: Girgensohn et al. (2003)

While threaded views on communication like that of Netscan or eTree are useful for indicating newsgroup action, they are not very helpful to identify mutual interaction and the resulting relationships between authors. Thus, meaningful dialogs between authors are harder to follow (Chang et al. 2002:2). A different approach, which is more focusing on such relations between clusters of a social network is the Social Network Browser of Chang et al. (2002) shown in Figure 61.

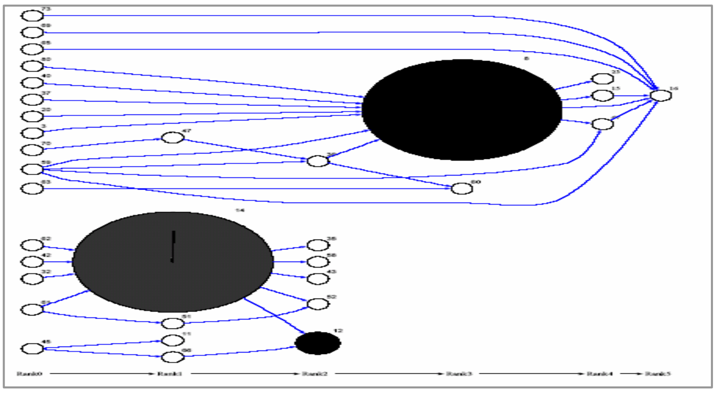

Figure 61 Browsing Newsgroups with a Social Network Analyzer.
Source: Chang et al. (2002)

The number of articles of an author determines the nodesize. The prestige degree (i.e. received messages) is represented by the shade of the node (the darker the more prestigious). Correspondences between authors are mapped to the edge. This means that all direct paths (messages) between two authors become one edge with the according weighting. When there are clusters, where any author has a connection to all other authors, they are called strongly connected component (SCC) and are indicated by a box around this cluster.

The tools introduced so far target the user of a virtual communication network. However, a further target group consists of social network researchers and analysts. There are software applications offered for this group, which are concentrating on a very sophisticated set of statistical functionality. Figure 62 shows the application Pajek, which is dominating in terms of spread and complexity. Despite the multitude of available statistical manipulations, their meaning is often very difficult to understand without appropriate statistical knowledge. Further, the application requires a very specific data format which is not recognizing any special attributes of virtual communication data as Pajek is a generic network analysis tool.

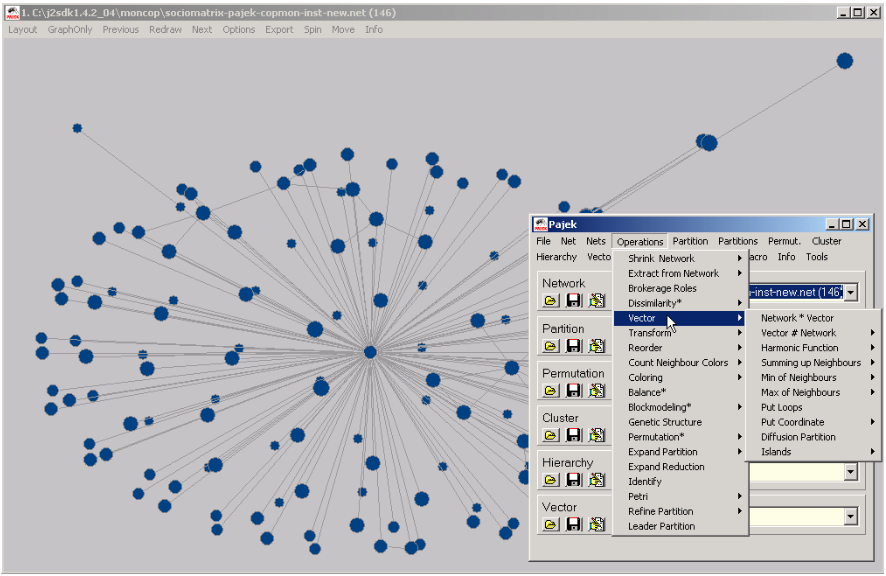

Figure 62: The user interface of Pajek.[43]

Summarizing, there are various interesting visualization approaches available. They reach from simple add-ons to existing community websites to very complex statistical tools for professional network researchers. The view on social networks in a Virtual Community environment is still very rare. Rather, visualizations

[43] Available as download at: http://vlado.fmf.uni-lj.si/pub/networks/pajek/

simply illustrate the flow of events, like for example in thread structures. Some approaches find metaphors which allow the user to intuitively understand the development and 'health' of the electronic group. Unfortunately, most of the applications are bound to a specific communication application (or project web site) and are hence not applicable for arbitrary sets of data. The alternative sector of statistical tools relies on thoroughly prepared matrices and datasets, which they import as a special format. Their generic approaches do not allow to incorporate community-specific information, like author affiliation, or message evaluation. The requirements of a professional corporate application and hence the requirements of a moderator of such a group and his need to communicate progress are not specifically met by current tools.

Despite the partial approaches to provide more insights into social structures and interaction patterns of communities, there has not yet been a focus on the requirements of corporate application.

Hence, even after reviewing a software market with various related tools, it can be recognized, that there is still a need for developing an application, which overcomes these shortcomings by allowing to connect to various data sources of virtual communication, which is representing the existing relationships between people, and which allows to visualize, manipulate and evaluate the resulting networks of communicating experts.

8.2 The Tool's underlying Graphical Visualization Method

The previous examples of visualization approaches emphasized, how measures of structural community patterns can be enriched by visual proxies. In chapter 7, the measurement domains of social networks (Social Capital) and knowledge processes where identified as contributing most to the evaluation of Knowledge Community structures and processes. For these two areas, useful visualizations need to be developed. For the prototypical software engineering, the visualization of social networks has been selected as the primary view.[44] It best represents networks of experts and their interactions resulting in strong relationships. The perspective furthermore elicits meaningful dialogs between experts and is rendering visible the Knowledge Work which is to be supported by a network oriented Knowledge Management (also compare for the KM entity model in section 2.2.3). This view also provides the most sophisticated theory of measurement. To incorporate knowledge processes into such a view, content and keyword analysis will be linked to the SNA perspective, so that in subsequent stages of development the network oriented view can also be extended to represent relationships between topics or relationships between authors and topics. This novel approach of integrating topic mapping and social network visualization is described in more detail

[44] Similar to the approach of Chang et al. (2002), introduced in the previous section.

in chapter 8.4.2 and 8.4.4. In this section, a brief introduction of the underlying domain of social network visualization is presented in order to understand the main elements of the resulting network graphs. These graphs are produced from the communication data and get laid out using a spatial layout algorithm as developed in chapter 8.4.1, which also introduces the related technical solutions in greater detail.

As an extension of the social network analysis using sociomatrices (compare section 7.1.3), the related analytical approaches concentrating on network graphs enable a more visual analysis of large people networks. This visualization approach actually originates in the works of Moreno in 1932. He introduced points which represent actors and edges which indicate the link between actors. The sociomatrix can be transformed into a graph by taking the matrix and deriving the number of authors (which equals the number of rows or columns). The graph has the same number of nodes. In every cell of the sociomatrix, there is a value, which is either zero or above zero. If the cell has a value larger than zero, the author of that row is having a relationship with the author of that column. This relationship is added to the graph by drawing a line from author A's node to author B's node. A network drawing emerges and authors who have many relationships appear well connected. Figure 63 shows one of the earliest examples of a social network graph. It has been rendered by Moreno in 1934 and maps friendship choices among fourth graders. After the invention of these graphs in the 1930s, there where several stages of development reflecting the respective state of the art in information technology, like the introduction of computational procedures in the 1950's (e.g. Bock and Husain, 1952; Proctor, 1953), first screen oriented graphs in the 1970's (Lesniak et al., 1977) or the event of social network analysis tools in the 1990's (Krackhardt et al., 1995). A comprehensive overview about this development is given by Freeman (2000).

The actual graph has not changed since that, still it was possible to automatically draw very big networks very fast on a screen, to manipulate them according to the analyst's needs, and to enter more information into the resulting view. As an example, the last section introduced the tool Pajek which can be applied for this task.

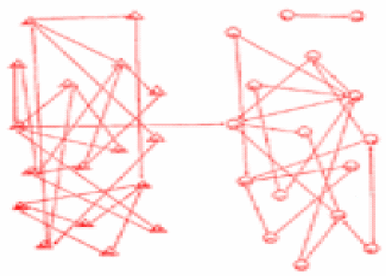

Figure 63: Original Drawing of Friendship choices among fourth graders.
Source: Moreno (1934:38), cit. in. Freemann (2000:3)

8.3 Software Engineering Process and Software Framework

With the final determination of the main visualization method in the previous section (social network visualization) the software engineering process can be planned and initiated. The main objectives of the development of an application for visualization and measurement of virtual Knowledge Communities are:

- the connection to various offline and online information sources of virtual communication software (Community Software),
- the provision of a generic and standardized database structure which is storing different discourses in one structure (e.g. allowing for integration),
- the development of sophisticated visualizations of networks of experts in Virtual Communities, and
- the development of a comprehensive measurement system ("visualization comes first") to enable the comparison and evaluation of community structures.

The overall project procedure is shown in Figure 64. Altogether thirteen separate steps were defined, which form a sequence. However, this sequence is also an iterative process as at any time the project can step back, e.g. to include new insights about measurements into the requirement catalogs.

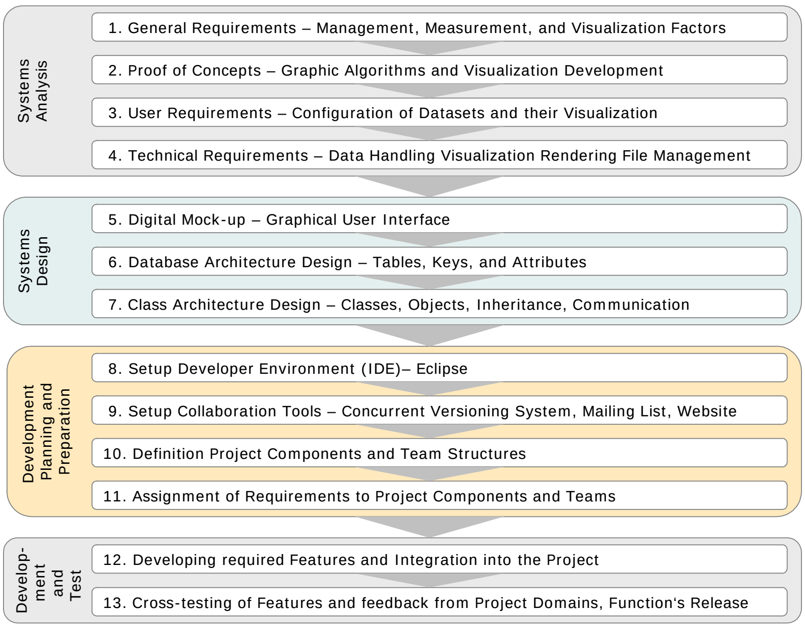

Figure 64: Software Engineering Approach for the Prototype.

Prior to the actual development work (stage 4: Software development and test), various preoperational tasks were conducted. First, requirement lists and catalogs were assembled to reflect general management and measurement, user, and technical requirements. To check if the electronic communication data actually results in meaningful networks, various ‘proofs of concepts’ have very early been programmed in the simpler language PHP[45]. In stage two, the systems design, a digital mock-up of the graphical user interface has been generated to discuss user ergonomics and the necessary sliders, buttons, panels, etc., using the actual visual appearance of the tool. Starting from initial circle graphs of social networks, this process has shown useful for testing the planned computer graphics algorithms. Architectural graphs of the intended class and communication architecture as well as the applied database structure have been developed. In the next stage of systems development planning and preparation, the project time plan has been generated, the integrated development environment (IDE) has been selected and installed, a set of collaboration tools has been adopted, the teams were determined and were assigned to groups of requirements from the requirement catalog. Finally, the development stage could start. The required functionality has been generated and after a testing review and feedback from other teams, it has been released.

8.3.1 Requirements Profile

In stage one of the software engineering project, the main requirements were assembled. These included general requirements for community management and the according measurement or visualization factors, user requirements of configuration and manipulation of the dataset to achieve an individual visualization, and the resulting technical requirements for data handling, visualization rendering and file management.

Among other things, the user should be able to connect to virtually any electronic communication network, like NNTP[46]-based standard Newsgroups, Slashdot based HTML[47] Discussions, MBOX[48]-based Unix E-Mail Archives and Listservers, Outlook E-Mail Archives, Lotus Discussion Databases etc. This necessitated the development of a component based individual connector structure. All data should be incorporated into one single database. This requires a feature for updating existing discourse imports with new data. The application needs to be able to extract keywords from discourses and calculate network analysis measures. When the utilized data set needs to be extended with user-specific background data (like author affiliation or evaluation), the addition of editable author and relationship properties needs to be provided. All data should be transformed into a

45 Pre-Hypertext Processor
46 Network News Transfer Protocol, also see chapter 8.3.3
47 Hypertext Markup Language
48 Mailbox Mail Standard for Unix Operating System

meaningful visualization graph. This requires renderers for 2D and 3D networks of communication. Visual manipulation should include rotating and zooming the resulting network graphs. A feature for time-based observation of growth of the network has been listed to later enable longitudinal measures and visualizations which where found to be very useful for network evaluation. The application should be able to store screenshots and optionally videos from the networks and their evolvement. Picking of authors needs to be supported in order observe their individual behavior, development, and author properties. Intelligent features to reduce the network size are required to increase transparency in big people networks, e.g. the limiting of visible authors enables to generate egonets and partial networks of his immediate environment and contacts.

A sample part of the catalog with the main requirements is given in the following Figure 65.

Nr	Bereich	Nutzungsanforderungen, Der Nutzer muss	abgeleitete Technikanforderungen, die Software muss	Priorität	Bearbeitungsstand
1	Quellenimport	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	im Pull-Down Menu 'Import' die unterstützten Konnektoren identifizieren (welche existieren) und als Menupunkte anzeigen		
2	Quellenimport	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	für lange Quelle>MySQL Transfers eine Fortschrittsanzeige in Prozent anzeigen		
3	Quellenimport	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	der gewählte Konnektor identifiziert und aufgerufen werden		
4	Quellenimport	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	der entsprechende Konnektor die Auswahl erhalten		
5	Analysedurchführung	Nach Abschluss der MySQL Aufbereitung wird der Nutzer gefragt ob die Analyse sofort starten soll oder später	eine Dialogbox zur Auslösung oder zum Abbruch der Analyse anzeigen		
6	Analysedurchführung - Log	die Analyse verfolgen können	während der Analyse einen Fortschrittsbalken anzeigen		
7	Analysedurchführung - Log	die Analyse verfolgen können	während der Analyse logtexte in einem Fenster anzeigen		
8	Analysedurchführung - Log	die Analyse verfolgen können	das Analyselog in ein lokales logfile ablegen		
9	Analysedurchführung - Log	die Analyse verfolgen können	die möglichen Visualisierungsformen auf Basis der erhältlichen Daten eingrenzen (2D-Cluster, 3D-Cluster (evtl. über Pajek VRML Exportdatei einlesen und in Webfenster anzeigen), Circle Diagramm, Spring Diagramm, Egonetwork, Dendrogram, Charts, Measurement-Log,		
10	Analysedurchführung - Log	die Analyse verfolgen können	die nicht möglichen Visualisierungsformen im Menupunkt Visualisation auf disable stellen		
11	Analysedurchführung - Matrix	die Analyse verfolgen können	im Hintegrund die Matrix bilden und in einem Array vorhalten		
12	Analysedurchführung -Visual.	die Analyse verfolgen können	im Hintergrund die Visualisierungsformen erstellen und auf Grafikpanes zu Anzeige vorhalten		
13	Analysedurchführung -I-Menu	die Analyse verfolgen können	im Hintergrund die zu den Visualisierungen gehörenden Interaktionsmenues erstellen und vorhalten		
14	Analysedurchführung -I-Menu	die Analyse verfolgen können	im Interaktionsmenu die Reiter Graph, Log und Report anlegen		
15	Analysedurchführung -I-Menu	die Analyse verfolgen können	im Reiter Graph die Möglichkeiten zur Manipulation der Visualisierungsdarstellung anzeigen (Nodesize>Activity, Hide Isolates, Labels: Names, Numbers, Locations, Desymmetrize Matrix, Size +/-, Fixpoints, Search for terms,…		
16	Analysedurchführung -I-Menu	die Analyse verfolgen können	im Reiter Log die Möglichkeiten zum textuellen Anzeigen der Netzwerkinhalte aufzeigen (Nutzername, Inhalte der Konversation, Initiativen, Antworten,…später ausbaubar in Eingriff in das Forum!)		
17	Analysedurchführung -I-Menu	die Analyse verfolgen können	im Reiter Report die Möglichkeiten zur Informationsspeicherung vorbereiten (Snapshot des Bildframes, Speichern des Snapshots, Eingabe von Kommentaren zur ggw. Visualisierung in ein Eingabefenster im Reiter, Anzeige der Reportstruktur in Dialogbox (Grafik, Autokommentar, Manuellkommentarfelder, Umordnen der Reportstruktur in Dialogbox, Export in PDF-Datei)…		
18	Analysedurchführung - fertig	die Analyse verfolgen können	die Fertigstellung der Analyse und Vorbereitungsphase in einem Dialogfenster anzeigen		
19	Visualisierung	eine gewünschte Visualisierung auswählen können	ein Pulldown Menu Visualisation mit den angebotenen und für das aktuelle Datenset möglichen (enabled) Visualisierungsformen anzeigen		
20	Visualisierung	eine gewünschte Visualisierung auswählen können	die Visualisierungspane und die entsprechenden Reiter werden angezeigt		
21	Visualisierung	einen gespeicherten Snapshot zur Anzeige bringen	im lokalen Log-Verzeichnis gespeicherte Grafiken einlesen und unabhängig vom ggw. Aktuellen Datenset anzeigen		
22	2D-Cluster	das 2D Cluster ansehen und manipulieren	der Abstand aller Nutzer wird über FR-Algorithmus aus deren Interaktionsdichte abgeleitet		
23	2D-Cluster	das 2D Cluster ansehen und manipulieren	Aktivere Nutzer werden mit einer größeren Nodesize kenntlich gemacht		
24	2D-Cluster	das 2D Cluster ansehen und manipulieren	Starke Beziehungen werden über dickere Kanten kenntlich gemacht		
25	2D-Cluster	das 2D Cluster ansehen und manipulieren	die Schwerpunkt der Interaktion wird über einen kleinen grauen Knoten auf der Kante repräsentiert (Ausgänge/Summe Ausgänge+Eingänge > der Knoten rutscht zum relativen Empfänger)		
26	2D-Cluster	das 2D Cluster ansehen und manipulieren	das eingestellte Standardlabel ist der Nutzername		
27	Export	eine bestehende Matrix abspeichern können	einen Menüpunkt 'Export' besitzen		
28	Export	eine bestehende Matrix abspeichern können	ein Dialogbox für ein lokales Dateiauswahlmenü besitzen		
29	Export	eine bestehende Matrix abspeichern können	das Pajek Flatfile Format Exportieren können		
30	Export	alle möglichen Automatischen Report Elemente automatisch als PDF exportieren können	das Menu Export muss einen Menupunkt für Export des automatischen Reports anzeigen		
31	Datenbank	Der Nutzer muss Kategorieinformationen in die Datenbank eingeben können	Die Datenbank muss eine Zusatzspalte bekommen, in der man Kategorien zu den Messages zuordnen kann	low	
32	Datenbank	Der Nutzer muss Kategorieinformationen in die Datenbank eingeben können	Die Datenbank muss eine Zusatztabelle bekommen, in der man Kategorien zu den Autoren zuordnen kann (z.B. Standort,Jobposition)	low	
33	Datenbank	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	Die Datenbank muss mindestens die Spalten MessID, From, To gefüllt haben		
34	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	die Konnektoren zu Newsgroup, PHP-MySQL Archiv DB, Lotus-Flatfile-Import, Microsoft Messenger aufweisen		
35	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	die Konnektoren müssen ein eigenes Dialogfenster anzeigen		
36	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	die Konnektoren müssen die Eingabe der Quelle erlauben		
37	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	ein HTTP/FTP basiertes Auswahlmenü für das Laden von remote-locations besitzen		
38	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	ein Eingabefeld für einen Zielnamen für die MySQL Datenbank Conversion anzeigen, dabei bestehende Datenbankeneinträge zur Ergänzung anbieten		
39	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	das Dialogfenster des entsprechenden Konnektors anzeigen		
40	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	der entsprechende Konnektor die vorgesehene Quelle finden und in dessen Daten in die MySQL Datenbank parsen		
41	Konnektoren	ein unterstütztes Daten-Format in die MySQL Datenbank importieren können	gewährleisten das ein älterer Stand eines Datensets erhalten bleibt und nur das neue in die Datenbank hinzugefügt wird, dabei evtl. einen kurzen Konsistenzcheck durchführen (ein Überlappungsbereich muss mit dem entpsrechenden bestehenden DB Inhalt übereinstimmen		

Figure 65: Parts of the original technical requirements catalog document (in German).

8.3.2 Software Architecture

From the lists of requirements the actual architectural software approach needs to be derived. The resulting software framework for the Social Network Intelligence Tool is depicted in Figure 66. The main constituents are the frontend including the Graphical User Interface and the intelligent backend including the connectors to the original data sources. These two components are introduced in more detail in the next section. In general the connector accesses the original data source of electronic expert communication. This can either be a flatfile dump export of an archive, a database access, or an online HTML, FTP[49], or NNTP access. The data is transformed into a standardized format and stored in an integrated database. The data analysis and management is carried out by a backend component which for example starts the textual analysis. This backend also provides a very rich interface to the frontend which allows accessing the authors, their properties, the relationships, filtering results, or accessing the database etc. The frontend generates a sociomatrix (matrix) and a graph. Via dynamic filtering and visualization rendering the intended graph is computed and displayed on the screen in the selected visualization form. Via the graphical user interface (GUI) the user can manipulate the rendering and filtering of the network to configure his individual perspective on the community network.

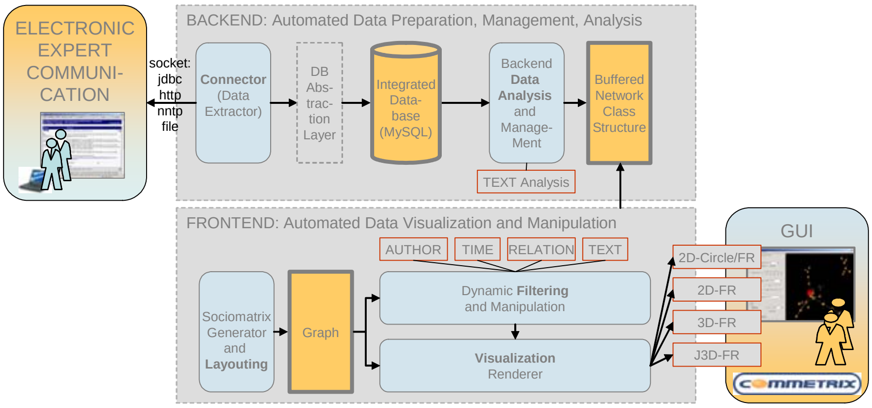

Figure 66: General Application Framework with Backend and Frontend. The communication data is elicited by Connectors and visualized by the Frontend.

This rather abstract architectural level can be broken down into the actual UML class diagram, which gives more insights about the various classes and how they interact to conjointly produce the desired graph and analysis. It includes data classes (like for buffering discourse or author data), data representation classes (like the complete graph), interface implementation classes (like the individual connectors or the 3D Renderer), interfaces to define the implementations, control

[49] File Transfer Protocol

classes which host the application logic, and user interface elements. Figure 67 summarizes this class structure.

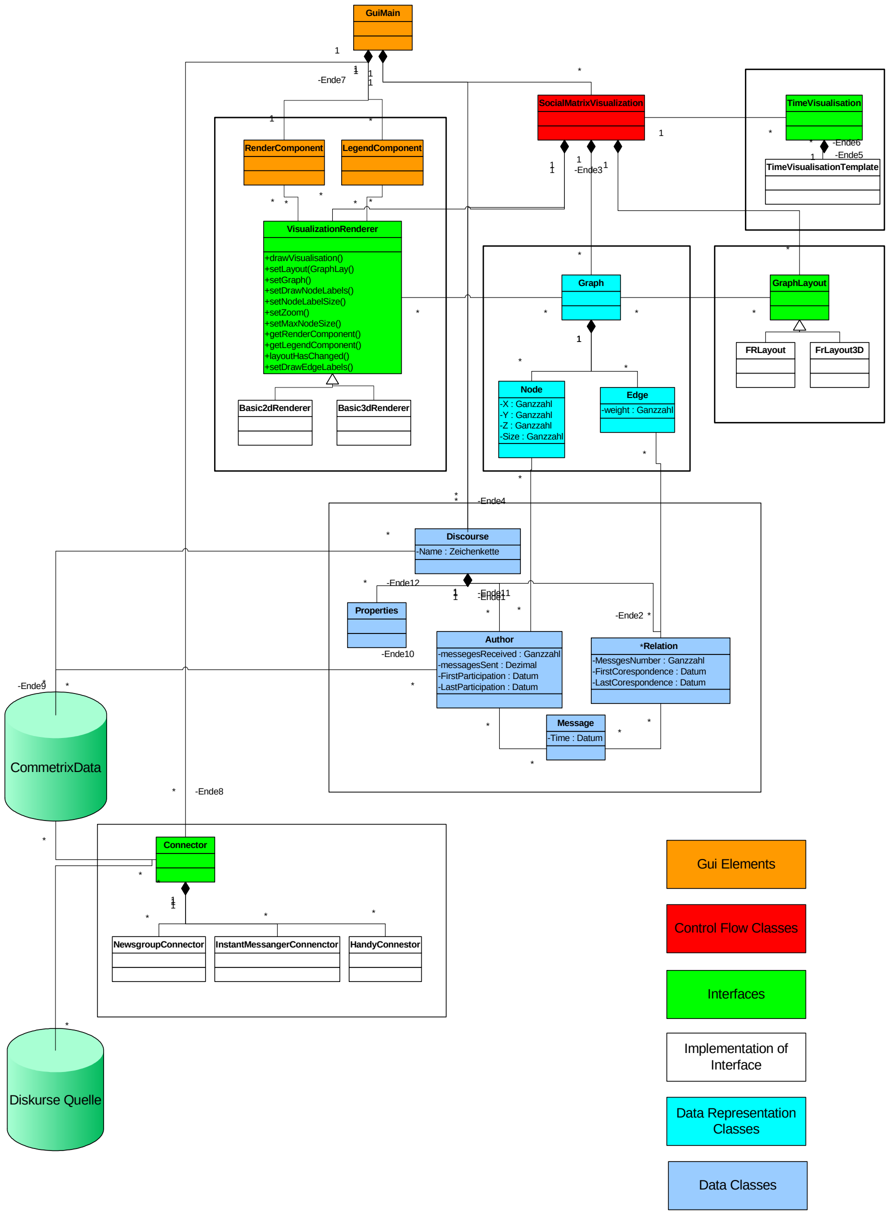

Figure 67: Class Structure of the Software for CoP Visualization and Measurement.

8.3.3 Data Sources and Data Architecture

In order to determine the data architecture, the structure and elements of the original data sources have to be analyzed. This has then to be mapped into a data structure, which is suitable for Social Network Analysis. As guidance, Scott (1991) describes three types of data in Social Network Analysis:

Relational Data: This is the representation of contacts, ties and connections between the members of a social network. These relations link one participant of the network to another.

Attribute data: Attributes describe the participants in a network. They may be collected by questionnaires. Attributes might be sex, age or rank in an organization.

Ideational data: Describes meanings motives, definitions and typologies of network members.

Looking back at the source data, a very widespread format to store virtual discussions is the Network News Transport Protocol (NNTP) standardized in RFC977 (Kantor and Lapsley, 1986). It is the foundation for internet-based newsgroups and has been employed in the project as the primary data source for establishing the data structure. However, later it has been extended to accommodate for more modern and comprehensive data attributes of other discussion board systems. The NNTP standard defines only very few elements for storing an expert communication network on the newsgroup server. They include a unique message identification string, the user name, the posting topic, and the posting body. Useful data items, but not captured are passive readers of a posting or topic keywords.

This NNTP format is now being introduced in order to discuss the typical appearance of a data source of a virtual communication network. Alternatives to this standard are lose HTML formats, XML[50] structures, or databases.

NNTP is no special software application, rather it is a standard which allows exchanging articles (i.e. distribution, inquiry, retrieval, posting) using an interactive internet connection. It is employing a reliable stream-based connection (usually TCP[51]) between a client in the network and a server residing on a host, which stores the postings. Various standardized commands enable the client to receive or to send articles. NNTP is text-based. Like with SMTP[52] for mail exchange, there are defined headers to coordinate the exchange and contents (or body elements), which belong to a header. This header structure is the standard, which determines the available data structure and hence subsequently also the design of the database. Therefore the main elements of NNTP structures will now be outlined.

[50] eXtensible Markup Language
[51] Transmission Control Protocol
[52] Simple Mail Transfer Protocol

Articles start with a series of required headers and can have optional headers. The latter should start with the letter X (e.g. X-Complains-To) for better recognition of its optional character. Among the required headers for analyzing expert networks are:

- **From:** The from header contains the e-mail address of the author. Its correctness is not verified. Usually the name of the author is also contained (in round brackets) in this segment, e.g. 'FROM: author1@mail.com (Author Name)'.
- **Newsgroups:** News can be published in the server's hierarchical list of groups. This publication target is given after the newsgroups header. Usually, only one target position is defined, as cross-postings ('xpost') are often not wanted. An example for such a destination is 'de.comp.lang.php.installation '.
- **Subject:** The subject header contains the title of the message. It should help a user to identify the contents of that message. If the message is a reply to another contribution, this fact should be signaled by inserting "Re:" at the beginning of the title.
- **Date:** The date header stores the time stamp of sending the message. It depends on the system clock of the client. An example is 'Date: Fri, 13 Feb 2004 01:29:35 +0100'.
- **Message-ID:** The first server which receives the message from the client assigns an internal unique identification code. Together with the complete name of the server, this results in a unique message-ID. Other servers can thus reference to this message. They are not allowed to change this identifier. An example is '4p4o20tiva8b1k6v7e@4ax.com'.

Next to the required headers, there are optional headers possible. The most important one of this group is the **references header.** Discussions in the Usenet are ordered in a hierarchy. There are initial requests, which get answered by subsequent contributions. These answers can get comments and so on. This hierarchical structure is derived from the references header. It simply contains all messages, to which the current posting is either the direct or indirect answer. Message-IDs are stored in the sequence of the discussion. For example: 'References: <c0em8k$ae4$1@news.cs.tu-berlin.de> 4p4o20tiva8b1k6v7d4b86@4ax.com'.

To elicit the actual people network from the postings, these references between postings are extracted and analyzed. They indicate answers or comments to a previous posting and hence a communication relation between two persons. These relations between authors are the fundamental information for creating an expert network from the data set. An example for such a hidden communication relation between two authors of a NNTP-based discussion group is shown in Figure 68.

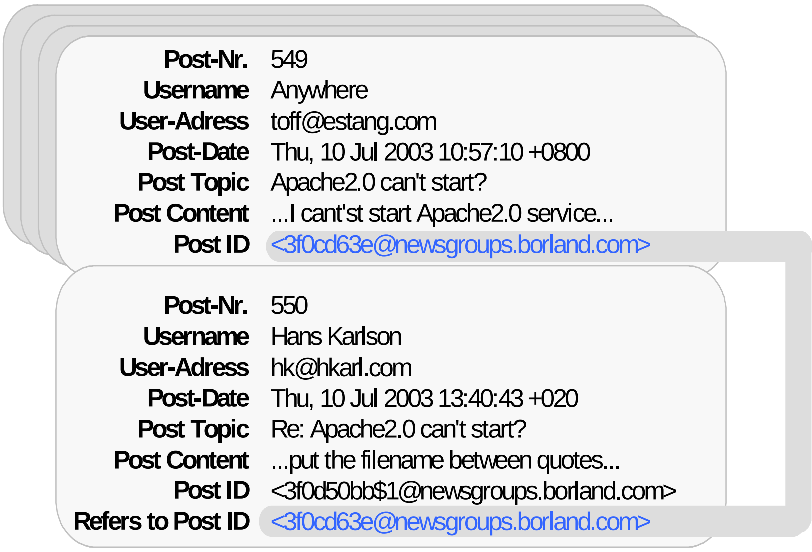

Figure 68: Relation between online Discussants in NNTP.

For accessing information about a discourse, a series of related standardized commands is available. They include:

HELP:	Lists all available commands
LIST:	Returns a list of all available newsgroups
NEWNEWS:	Returns a list of all new article-IDs
NEWGROUPS:	Returns a list of all new newsgroups
GROUP:	Specifies newsgroup for next commands
ARTICLE:	Return an article
BODY:	Return the text of a selected article
HEAD:	Return the headers of a selected article.

These commands can now be utilized to code a program which extracts the required messages, their authors, references, time stamps, contents etc. of a selected newsgroup from an available online news server. The resulting data can then be stored in a database. Figure 69 shows an example of how the extracted data looks like. The message-ID, author name, author e-mail, posting subject, bodytext, posting time, and referenced message-ID have been extracted.

Log von Server news.php.net, Group php.soap am 18.02.04 - 14-25 New Jersey, erzeugt mit nntp-to-mysql.php

mess_id	int_art	author_name	author_email	post_subject	bodytext	post_time	refers_to_mess_id
1058901716.1101.6.camel@lapper.ubtanet.com	870	Jared	jmashburn@ubtanet.com	Forcing int to String	Integer nusoap number using Hi passing Digit Tele...	22 Jul 2003 13:21:54 -0600	
01e801c35089$728a3e30$8c01a8c0@ENTROPY	871	Chris Boget	chris@wild.net	Re: [SOAP] Forcing int to String	string number Integer nusoap value phone PHP Tele...	Tue, 22 Jul 2003 14:42:55	
1058904265.1101.29.camel@lapper.ubtanet.com	872	Jared	jmashburn@ubtanet.com	Re: [SOAP] Forcing int to String	string number Digit numbers storing characters ph...	22 Jul 2003 14:04:24 -0600	01e801c35089$728a3e30$8c01a8c0@ENTROP
B5835E1CC5947D4F81BEAE6C6997398F63D331@etna.sim.um...	873	Gendron Bruno	b.gendron@umontreal.ca	Defining array of arbitrary type or sequence eleme...	E C type Canada DAE Content de en Montr FAA able ...	Tue, 22 Jul 2003 16:07:19	
1058904960.1102.34.camel@lapper.ubtanet.com	874	Jared	jmashburn@ubtanet.com	Re: [SOAP] Forcing int to String	string number value Integer PHP nusoap Chris phon...	22 Jul 2003 14:15:59 -0600	01e801c35089$728a3e30$8c01a8c0@ENTROP
8CAA2F1AC7B96C43974814DD3D95EF982EF356@sfomail-01....	875	rom: Gendron Bruno [mailto:b.gendro	Gendron Bruno [mailto:b.gendron@umontreal.c	[SOAP] Defining array of arbitrary type or sequenc...	D E array type SOAP TransferInformation http gran...	Tue, 22 Jul 2003 14:50:45	
20030724120435.48ac73ae.arnaud.limbourg@club-inter...	876	Arnaud Limbourg	arnaud.limbourg@club-internet.fr	Re: [SOAP] WSDL Server Persistant Session	x Server copy SOAP methods By default PHP makes c...	Thu, 24 Jul 2003 12:04:35	20030722165921.97634.qmail@pb1.pair.co
20030724120624.72f8cc6f.arnaud.limbourg@club-inter...	877	Arnaud Limbourg	arnaud.limbourg@club-internet.fr	Re: [SOAP] Forcing int to String	Http sourceforge net mailarchive message php msg ...	Thu, 24 Jul 2003 12:06:24	1058904960.1102.34.camel@lapper.ubtanet.co
20030724161331.41762.qmail@pb1.pair.com	879	=?Iso-8859-1?Q?S=F6ren_fuhrman	sf@golem.de	Re: [SOAP] WSDL Server Persistant Session	client SOAP x wsdl methods WSDL copy Server looks...	Thu, 24 Jul 2003 18:12:31	20030724120435.48ac73ae.arnaud.limbourg@club-inter...
20030724235138.2827a764.arnaud.limbourg@club-inter...	880	Arnaud Limbourg	arnaud.limbourg@club-internet.fr	Re: [SOAP] WSDL Server Persistant Session	CURL timeout function php talks http net show soa...	Thu, 24 Jul 2003 23:51:38	20030724161331.41762.qmail@pb1.pair.co
3F205602.2000302@caraveo.com	881	Shane Caraveo	shane@caraveo.com	Re: [SOAP] WSDL Server Persistant Session	soap function PECL Shane SOAP http talks php Pres...	Thu, 24 Jul 2003 14:56:18	20030724235138.2827a764.arnaud.limbourg@club-inter...
20030725010226.2fff55cc.arnaud.limbourg@club-inter...	882	Arnaud Limbourg	arnaud.limbourg@club-internet.fr	Re: [SOAP] WSDL Server Persistant Session	soap PECL PEAR SOAP exists It did never That slid...	Fri, 25 Jul 2003 01:02:26	3F205602.2000302@caraveo.co
20030725132418.88250.qmail@pb1.pair.com	883	=?Iso-8859-1?Q?S=F6ren_fuhrman	sf@golem.de	Re: [SOAP] WSDL Server Persistant Session	SOAP PECL soap Shane HTTP php function client set...	Fri, 25 Jul 2003 15:23:22	3F205602.2000302@caraveo.co
20030725183947.88999.qmail@pb1.pair.com	884	Davey	davey@php.net	FWD: [PRE-Proposal] XML_Encrypt and Crypt_PGP	XML Encryption use Key Management SOAP PGP Crypt ...	Fri, 25 Jul 2003 19:39:49	
20030729031752.86765.qmail@pb1.pair.com	885	Sek-Mun Wong	sekmun@connectingspace.com	nusoap vs PEAR::SOAP	nusoap use run between someone PEAR SOAP implemen.	Tue, 29 Jul 2003 13:17:51	
20030729081115.60802.qmail@pb1.pair.com	886	Michele Manzato	Michele.Manzato@verona.miz.it	dateTime in PEAR::SOAP	SOAP PEAR timestamp use Type dateTime way right c...	Tue, 29 Jul 2003 10:11:14	
20030729204439.41940.qmail@pb1.pair.com	887	Merlin	news.groups@web.de	xmlrpc to old?	xmlrpc seems first php Now worked webservice buil...	Tue, 29 Jul 2003 22:44:37	
20030730185733.38139.qmail@pb1.pair.com	888	Will Green	will@hotgazpacho.com	Re: [SOAP] Defining array of arbitrary type or seq...	SOAP array TransferInformation class type http fu...	Wed, 30 Jul 2003 14:57:18	8CAA2F1AC7B96C43974814DD3D95EF982EF356@sfomail-01....
20030730192515.61816.qmail@pb1.pair.com	889	Will Green	will@hotgazpacho.com	PEAR::SOAP server handling MIME attachemnts	client MIME server SOAP attachments handle give e...	Wed, 30 Jul 2003 15:25:00	
20030730225726.73830.qmail@pb1.pair.com	890	Rob Booth	rbooth@indyme.com	Data Size issue	string data HTTP Meg SOAP PEAR running message Se...	Wed, 30 Jul 2003 15:57:25	
20030730230530.79634.qmail@pb1.pair.com	891	Rob Booth	rbooth@indyme.com	Re: [SOAP] Re: PEAR::SOAP - Nested complex types -...	type SOAP array types complex urn match Coordinat...	Wed, 30 Jul 2003 16:05:29	
20030731003128.46831.qmail@pb1.pair.com	892	Will Green	will@hotgazpacho.com	Re: PEAR::SOAP server handling MIME attachemnts	attachments array server attachment client php si...	Wed, 30 Jul 2003 20:31:11	20030730192515.61816.qmail@pb1.pair.co
3F286A31.7090308@caraveo.com	893	Shane Caraveo	shane@caraveo.com	Re: [SOAP] Re: PEAR::SOAP server handling MIME att...	php server attachments array attachment SOAP clie...	Wed, 30 Jul 2003 18:00:33	20030731003128.46831.qmail@pb1.pair.co
20030731013633.88102.qmail@pb1.pair.com	894	Sek-Mun Wong	sekmun@connectingspace.com	nusoap	list using nusoap lsn	Thu, 31 Jul 2003 11:36:35	
20030731014213.91148.qmail@pb1.pair.com	895	Will Green	will@hotgazpacho.com	Re: [SOAP] Re: PEAR::SOAP server handling MIME att...	Content d php ee c fa Type ef text e server X L d...	Thu, 31 Jul 2003 01:27:12	3F286A31.7090308@caraveo.co

Figure 69: A Snapshot of Information extracted with a first Prototype of a Newsgroup Connector.

This table is not capable to satisfy all requirements (i.e. speed of massive queries) of the final tool. Therefore a more sophisticated data structure has been designed and implemented as a MySQL database. The main data elements are the discourse itself, the messages, and the authors. Added entities are keywords, which can be stored as additional information about messages, further subjects and a table for dynamic properties. This table illustrates the idea, that not all data to be extracted can be a-priori projected by the database designer. This renders it necessary to include a generic element, which stores discourse specific information about messages or authors. The database realizes this issue by offering a generic meta-data table for messages and authors (cf. MessageMetaDataTypes and AuthorMetaDataTypes in Figure 70). The designer of a specific connector for an individual discourse can create new properties and subsequently store the extracted data in the database. For this, the connector first creates a new meta-data type in a special table and then adds entries into the metadata table which reference this type followed by the actual instance of the data element. For example, if user location shall be included into the database, the connector would first need to instantiate the new type Location and then it simply adds new metadata entries, which contain the specific location (e.g. US, Poland, Germany, etc.). The following Figure 70 shows the final Entity-Relationship-Diagram (ERD) of the database design.

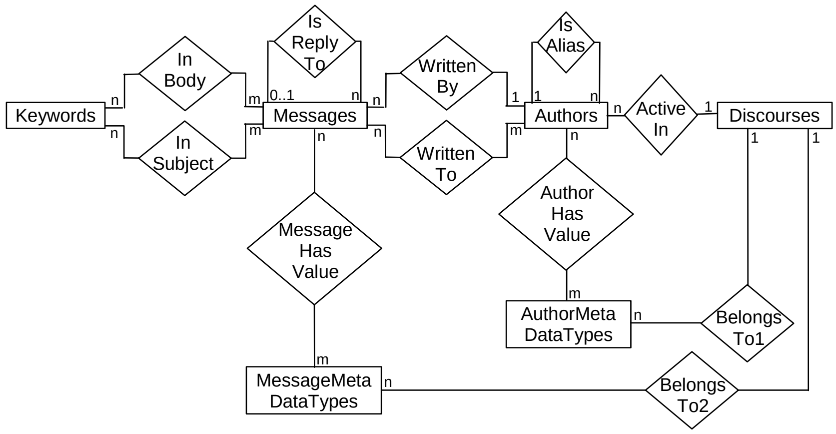

Figure 70: Entity-Relationship-Diagram of the Data Structure.

The final database architecture is shown in Figure 71. If a message has more than one author, the table MessageRecipients stores these relationships.

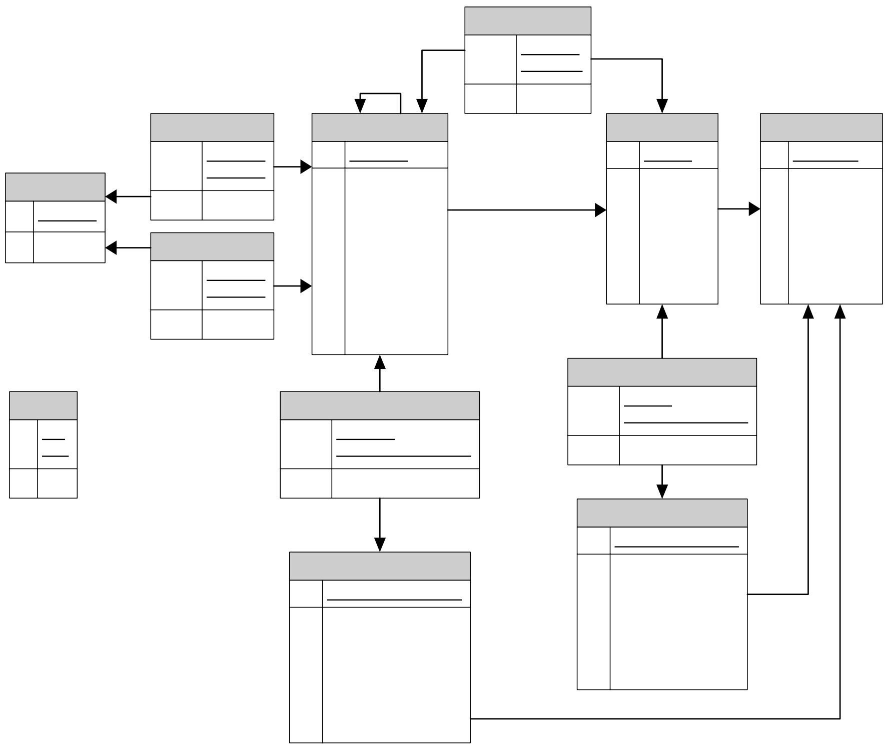

Figure 71: Final Database Architecture of the Tool.

8.3.4 Intelligent Backend and Connectors

After establishing the data structure for storing electronic discourse data sets, the actual software components which work with this data can be introduced (also cf. Figure 66). The first major cluster of classes constitutes the intelligent backend component. Its main elements are modules for source import via connectors, filtering, data base handling, data buffering, and the interface for the frontend's requests. One of its major tasks is to execute available connectors which can be selected by the user. The approach of using a set of connectors recognizes the requirement to enable the access to a wide variety of information sources. For this, a modular approach has been adopted, which allows for easily creating individual connectors for every new data source. Their objective is to elicit useful data about the information exchange between participants of some type of online discourse. Currently, the solution provides implementations of connectors for importing e-mail archives, instant messaging protocols, newsgroup archives, and Slashdot discussions. However, the idea is that new connectors can simply be added when needed. In order to minimize the effort for coding such new connectors a 'data base abstraction layer' has been introduced. The connector can work directly with an interface of Java objects and does not have to take care about details of the database. As introduced in the previous section, the database provides for generic ('dynamic') properties which can be created and filled according to the individual needs of the connector writer. This allows storing virtually any extractable data which might be of interest. Later, the frontend automatically identifies all properties and integrates them into selectable choices for color-coding, node-size-indicator, edge label, and node label. By this, the software offers individual analysis based on one integrated database structure and without any modifications of the Graphical User Interface. For example, in Slashdot archives, the user can select the author evaluation, which does not appear when a newsgroup discourse is analyzed.

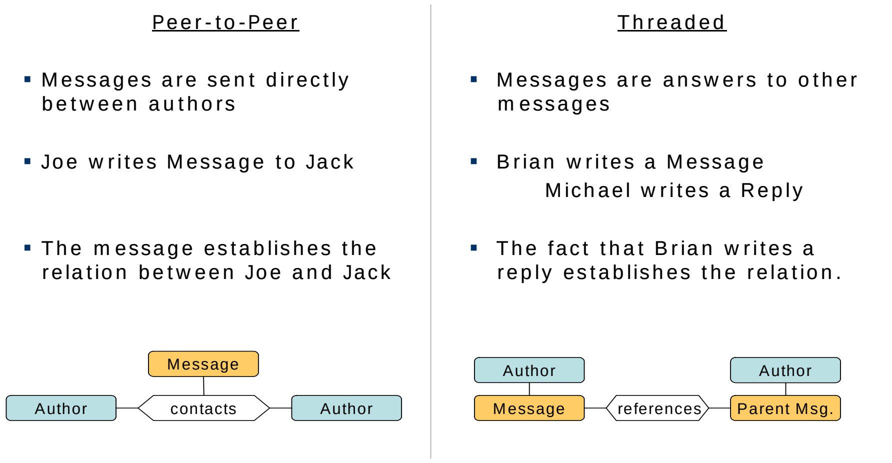

Figure 72: Integrating different Storing Paradigms in electronic Discourses.

In the process of connecting and importing data sources, another fundamental design issue is of importance. In electronic communication networks, there are two basic storage paradigms: peer oriented and hierarchical networks. Whereas instant messaging, e-mail, or chats belong to the first category, discussion groups include hierarchical information, as messages can refer to parent messages. Obviously the hierarchical paradigm comes along with the central mode of online communication, whereas decentralized online communication is stored in peer-to-peer paradigm (also compare section 6.3). In Figure 72, the different storage paradigms are visualized. In peer oriented archives like those of e-mail servers, author A is contacting author B directly via the message. However, in hierarchical archives like in discussion groups, author A is writing message 1 which references message 2, which has been written by author B. Basically, the latter procedure is comparable with author A sending a message to author B, however the references are stored differently. The hierarchical storage paradigm maintains the information which message is an answer and which is an initial request. This allows to virtually tracing back a thread or dialogue. Such referential information can not be automatically extracted from peer-to-peer storage, which therefore becomes more fragmented.

The connector recognizes these two different storage paradigms and transforms the data in a way that it can be stored in one single integrated data structure introduced above. An example is given in Figure 73. This procedure leaves room for a very important potential. By transforming multiple storage approaches into one structure, the tool is theoretically capable of integrating different channels of communication into one analysis. This concept meets the challenge of an integrated analysis of multi-channeled Communities of Practice, introduced in chapter 6.3.

Peer-to-Peer

Message	Author	Recipient
Msg1	John	Jack

Hierarchically threaded

Message	Author	ReplyTo
Msg2	Michael	
Msg3	Brian	Msg2

Message	Author	Recipient	ReplyTo
Msg1	John	Jack	
Msg2	Brian		
Msg3	Michael		Msg2

Figure 73: The Paradigm Transformation Approach.

Another element of the backend is comprised of a set of filtering classes. It is including filters for authors, keywords, relationships, and time-periods. They are accessible via a sophisticated backend interface. Filtering the datasets is often necessary to reduce the amount of elements in the visualized graph, because large communication networks can easily include many hundred authors and even more relationships. No transparent graph can be drawn for such a sample. This is why dynamic and static filters are included.

Among them, author filters allow for limiting the number of authors in the dataset. This can be utilized to explore the various ego-networks in a social network, i.e. to observe the direct environment of a single selected author. Further, filtering for authors can show, if two authors are directly connected.

Relationship filters set a threshold for the strength of the relationship, i.e. the number of messages between two persons. Relationships which are less intense than predefined by the user are not shown in the final graph. Thus, the network only contains edges for strong relationships and weak connections are invisible. This reduces the complexity of the overall network.

Time-period filters reduce the visible network by limiting the start and end of communication activity. This filter is also used as a moving window and thus supports longitudinal analysis of the network's evolution, which is described in more detail in section 8.4.2.

Finally, keyword filters can reduce the network size by only showing a subnet of the part of the communication, which is including a certain keyword or topic. This feature is closer examined in chapter 8.4.4.

The following Figure 74 gives a partial overview about the according backend interface responsible for time-period filtering. The processed requests of the frontend can include the definition of start and end dates of filtered discussions or the first and last date of stored data. Further commands of this interface are utilized to add messages at the end or at the beginning of the selected period, if they are in the filtered set or to remove them if they are not.

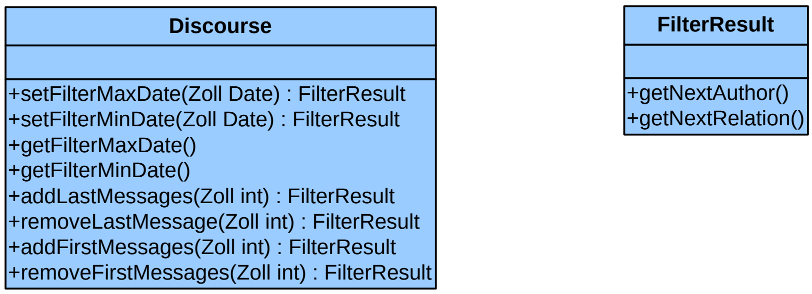

Figure 74: Time-period filtering Interface and Functions.

The architectural separation into a backend and a frontend component requires a comprehensive interface between the backend and the frontend. The different filtering requests discussed above already provided a first example of it. Generally, user manipulations (as GUI events) and requests are submitted to this interface and the backend returns the according information or executes the according commands. This modularization is useful for a later extension with a web-based client, which can then communicate with the original backend. Figure 75 now gives an overview about the remaining methods of the backend's interface to the frontend. For example, the user wants to know the number of relations of an author and the average strength. The frontend is accessing the interface to activate functions for counting the relations of the author or the number of messages in the relations. The backend returns the necessary information and the frontend shows them to the user. In order to improve the application's performance for database-related requests of the frontend, the database's data is buffered in buffer classes in the backend. This reduces the overall number of database accesses and connections, which results in much faster response and processing times.

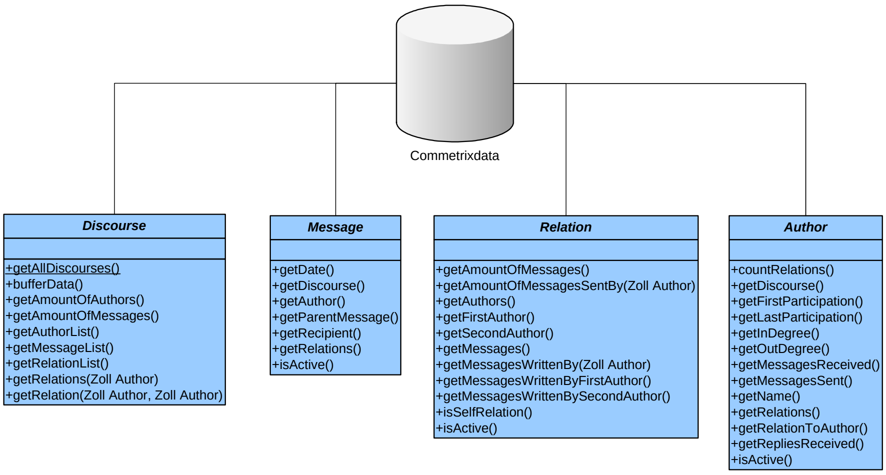

Figure 75: The Backend's Interface to the Frontend.

8.3.5 Frontend and User Interface

The frontend is responsible for generating visualizations using the data prepared and provided by the backend. Further, it presents these visualizations in an ergonomic Graphical User Interface (GUI). The user can manipulate the configuration of the visualization to represent individual information or reduce the visible size of the network. For these functions, the main necessary elements of the frontend are the Graph, the Layout, the Control, the Renderer, and the GUI component.

The Graph element is storing the data set for the visualization with the core elements node and edge. Much more complex is the Layout component. It is applying the Spring Embedder Algorithm introduced by Fruchterman and Reingold (1991) in order to create a meaningful graph from the information about the communication between the experts. The method is applied to present a (people) network as a structure with nodes and edges. Nodes represent actors and edges represent the relationships between them. Actors that are shown close together have stronger links than actors which are very distant. The abstract layout component can get instantiated to allow for individual layouts to present the information. This enables a later addition of completely different views. Currently, layouters are applied to generate two dimensional and three dimensional representations of the communication structure. The following Figure 76 shows an example. The illustrated network structure is a preliminary result of a 3D layout. It shows the authors as nodes and their relationships as edges. The details of the underlying algorithm are introduced in the next chapter about the applied technical frameworks methods.

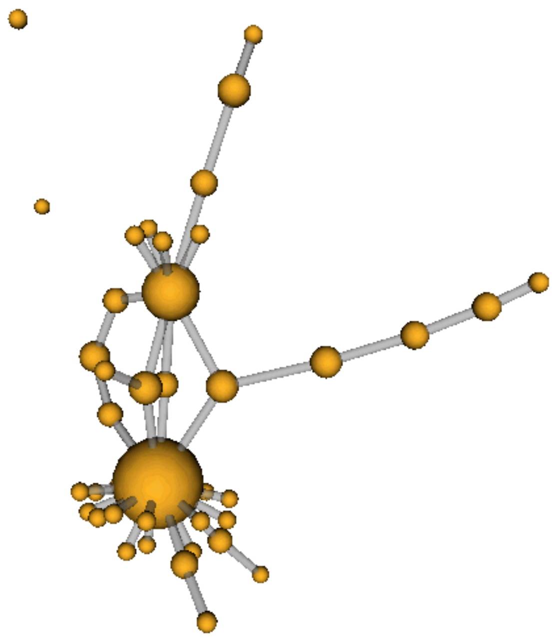

Figure 76: Spatial Layout of Nodes constituting a preliminary communigraph.

The data and flow control element for visualization management is the component, which actually activates the necessary computational tasks. It is thus a coordinating and steering class intervening between the other 'specialist' classes. The general process executed by it starts with the creation of a graph (class) according to the selected data. Then, it lets the layouter compute the spatial coordinates. Finally, the renderer is activated to present the nodes and edges on the screen. Every step does not necessarily need to be completed before the next can start. This allows for changing the data in the graph or its layout while simultaneously the user can follow the according changes. This results in animated movements of nodes which move to their new or final positions. The control element can further manipulate the graph according to the filters set by the user. They include a time filter to show only the nodes which are active in a given time period. This allows for longitudinal analysis and animation of the evolvement of the networks (also see chapter 8.4.2).

Last but not least, the application includes a set of renderers, which can be selected by the user to switch from 2D to 3D. However, not every renderer requires its own layouter. For example, to deal with complex networks which use up large amounts of memory and processing time, there are two modes of 3D visualization: a Java3D based rendering machine with light sourcing and a 'simple' or 'emulated' 3D visualization which in turn saves considerable amounts of memory and processing time and can be employed for larger networks, where the full 3D variant would be too slow. Both utilize the same 3D renderer to calculate the according coordinates.

The last important component is the graphical user interface. It is necessary to manipulate and configure the generated visualizations in order to create individual views which help the user to understand his network under observation. As most insights will not be generated by the initial graph layout, but by filtering, color-coding, labeling, or other means of configuration, a sophisticated interface is required which creates the impression that the user can actually play with his model to learn about the underlying structure. Figure 77 summarizes the GUI elements, which help the user to control the application. It also gives a first impression of the available functions of this book's software approach.

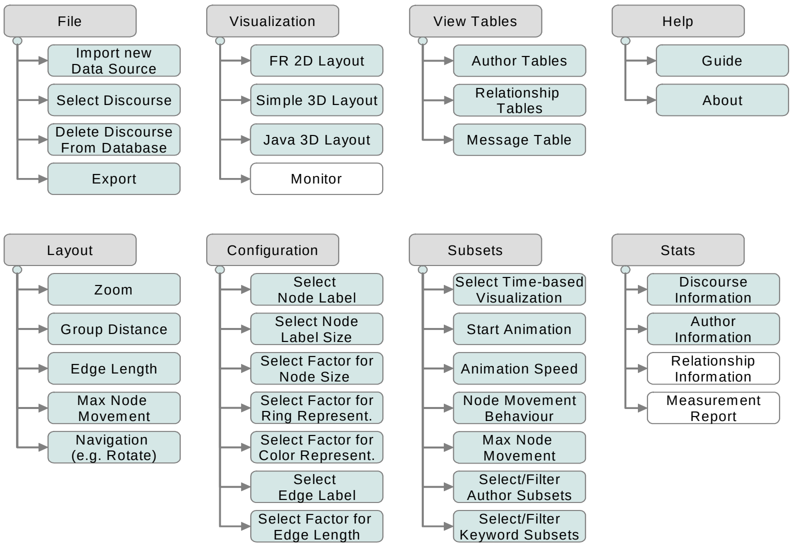

Figure 77: User Options for controlling the Application.

With these functions, the user starts with importing a new data source or selecting it from the database. He can select his preferred visualization form (e.g. 2D or 3D). Then he can change the layout by zooming or changing optimal distances or movement behaviors of nodes. The user can further configure the view by selecting the label of the nodes (e.g. index number, name, e-mail, or keywords), the property which is translated into a color code (e.g. blue for poor evaluation or orange for good evaluation), the property which is translated into circles surrounding the node (e.g. hierarchy levels, only in 2D), or the edge label (e.g. number of exchanged messages). To build subsets he can utilize time-based or ego-based filters. The latter allow filtering out a subset of authors. Further, the animation of the network evolution can be controlled. Finally, the user can access the measurements and analysis panel ('stats') which contains important information about the discourse, the author, the relationship and the measurement report according to the measurement system developed in chapter 7.2. In the table menu, the analyst can actually observe the original tabular data. This can be used to add more properties manually, like for example the department, the author belongs to, or a project. Such information could subsequently be used to color the nodes according to such affiliations.

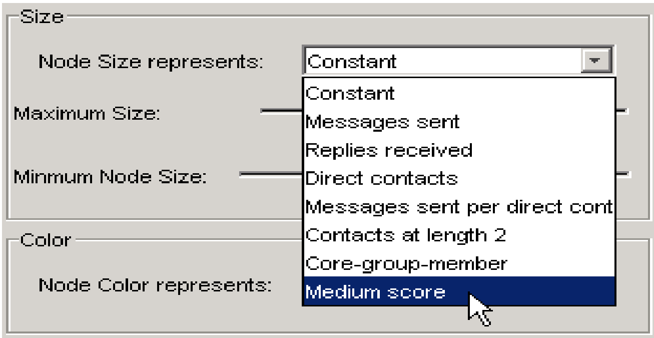

Figure 78: Inserting Properties from the Backend using a dynamical combobox Menu.

The dynamical aspect of the application can be illustrated with the handling of properties. Every individual application that hosts discussions stores different additional data, for example message evaluations, author evaluations, author profiles, or author login times. As introduced in chapter 8.3.4, the intelligent backend offers a means for storing such discourse, message, or author properties regardless of the individual data source. Now, the frontend automatically identifies such stored properties of the active discourse and offers various means for manipulating the produced graph. Nodes as well as edges can be labeled, sized, and colored to represent all meaningful information. It automatically detects, that e.g. the property 'author is member of core group' can only have the two states yes or now, or that the evaluation for a certain discourse reaches from -1 to +5. The mapping is dynamically being aligned with this information. This is done by retrieving certain property types: some are enumerations of strings which do not imply a scale, some convey ordinal scales, and some are Boolean, i.e. true or false. The frontend automatically enters qualifying properties into the according combo-box for the user to select it. This feature is shown in Figure 78. Using this dynamic property mapping, every individual property of a discourse can hence be maintained, analyzed and visualized. The complete user interface is illustrated in Figure 79.

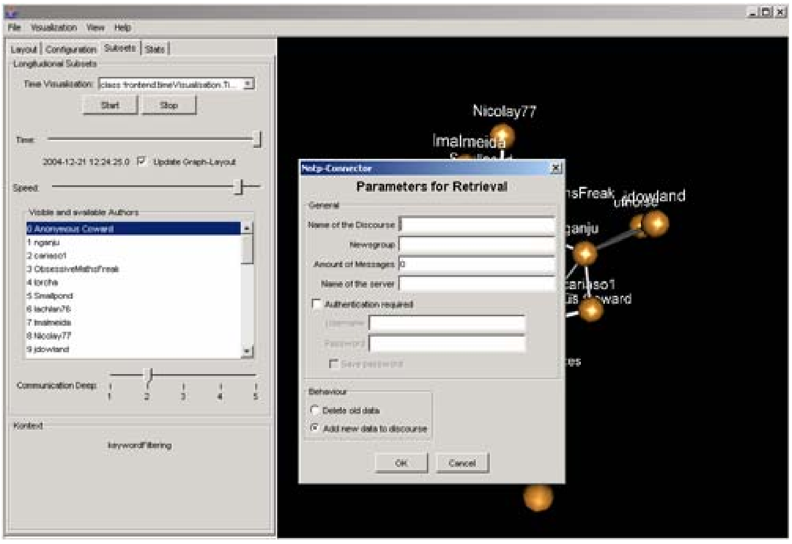

Figure 79: A Sample of a final User Dialog as presented by the Frontend.

8.4 Applied Technical Frameworks and Algorithms

The software components illustrated in the previous sections require underlying methods, technical approaches, algorithms, or available libraries. Key methods are graph theory and the related spatial layout algorithms to incorporate social network visualization and analysis. Key technical elements are 3D computer graphics as well as document and media export. To extend the core visualizations, further domains have been incorporated. Longitudinal network visualization offers the observation of time-related evolvement of the network clusters. Further, content coding is a technique to create more insights about the content of the discussions in the network. It has to be differentiated from automated keyword extraction as another approach to generate such insights: Whereas content coding gives insights about the intended purpose of communication (help, flaming, request, social, etc.), keywords are actually representing snippets of the contents, which can be helpful for searching the net or creating meaningful subsets. Finally, an initial part of the complex measurement system as introduced in chapter 7.2 has been developed towards a technical framework, which subsequently has been added to the software application.

8.4.1 Graph Theory and Information Visualization

A fundamental requirement of this work's approach is the issue of how to display a network of nodes and relations and how to include or visualize measurements in meaningful graphs. The required process to generate such visualizations from the data sources has been theoretically founded on the process proposed by Card et al. (1999:17). In their model, raw data is transferred into data tables which are a more accessible structure for visualization. Data tables must be mapped into a certain visual structure. This visual structure should make the data as easy and as efficient to interpret for the viewer as possible. The structure is later observed by the user via different views (cf. Figure 80). They allow understanding a complex system (of information) by watching it from different perspectives. All these steps can be augmented by human machine interaction to make the visualization as specific and as insightful as possible.

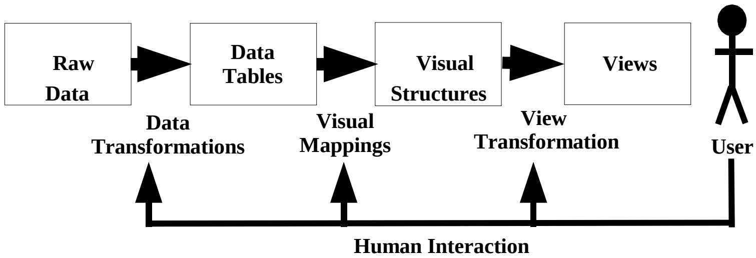

Figure 80: Diagram of Reference Model for creation of a Visualization.
Source: Card et al. (1999:17)

The graph which is to be generated via such a process can be theoretically derived from and described with the terminology of **graph theory**. According to Battista (1999:3), a Graph G = (N, E) consists of a finite set N of nodes and a finite set of edges that are constituted by pairs (u, v) of nodes. An edge with u = v is called a self loop. Edges that occur more than once are called multi edges. A Graph that has no self loops and multi-edges is called a simple graph. If there is a graph G' = (V', E') where V' ∈ V and E' ∈ E, then G' is a subgraph of G. A drawing of a graph is planar if no two edges cross each other. A graph G is planar if it permits a planar drawing. Planar graphs are important for displaying graphs because crossing edges decrease readability of graphs.

The last point directs the attention to the importance of ergonomic factors in graph drawing. Here, the theory of **Gestalt Laws** comprises a set of guidelines which can aid in the generation of insightful and user ergonomic graphs. These Gestalt Laws examine several rules that describe the way humans see patterns (if not quoted otherwise, mainly taken from Ware, 2000). First, things that are located close together will be grouped together as a perceptional unit. Second, elements with the same shape are grouped together. Slocum (1983) introduced the principle of spatial concentration in which people perceptually group regions of similar element density. A further aspect for the design of visualizations is that humans are more likely to see a smooth continuation as a better continuation of a form than an abrupt angular one. Palmer and Rock (1994) argue that connectedness of structures results in a stronger perception of relation to each other than size, color and shape. Symmetry of graphs plays an important role, as symmetrically arranged visual structures are much easier to recognize as a whole. Closed contours will be seen as one object. When seeing a closed contour, the viewer tends to divide the observed space into inside and outside of the contour. Smaller components in a pattern are recognized as objects. A figure is something object-like, perceived to be located in the foreground. Everything else is identified as background (ground) behind this figure.

A further issue related to Gestalt laws and user ergonomics of visualizations are drawing conventions, which define certain requirements for a graph to fulfill in order to belong to a specific type of representation (Battista, 1999:12). These graph drawing conventions include:

- polyline drawing, where edges are drawn in polygonal chain of lines,
- straight line drawing, where edges are drawn as straight lines,
- orthogonal drawing, where edges are drawn as chains of alternating connected horizontal and vertical lines,
- grid drawing, where nodes and edge bindings have integer values, and
- planar drawing, where there are no edges crossing.

For the graphical visualization of people networks, these graph drawing conventions can be examined to create one of these pre-defined classes of graphs. Examples for the resulting visual appearance are given in the following Figure 81.

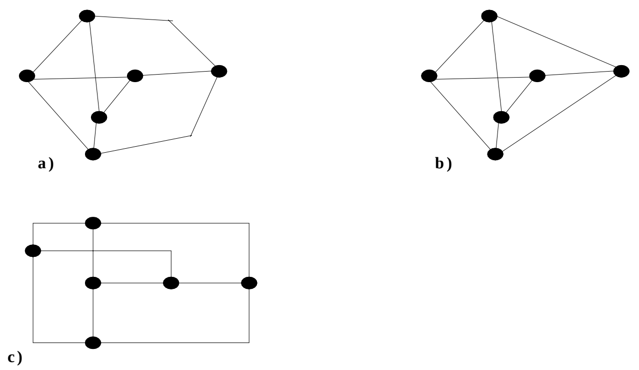

Figure 81: Example Graph Drawing Conventions for specified Types of a Graph:
a) polyline b) straight line c) orthogonal.
Source: Battista (1999:13)

Next to such types, aesthetical properties can support the generation of a readable graph. Among the basic applicable aesthetical criteria for graph drawing are (Battista, 1999:13):

- **Crossings:** Minimization of crossings in a graph. Ideally a graph drawing should be planar but this is not always possible.
- **Area:** Minimizing the area of drawing. This is only of meaning if the graph drawing cannot be scaled down.
- **Uniform edge length:** Minimization of the variance between edge lengths.
- **Angular resolution:** Maximization of the smallest angle between two edges incident to the same node.
- **Symmetry:** emphasize and display symmetry of a graph in its drawing.

For drawing graphs, it must be considered that aesthetical criteria are often conflicting each other. Thus tradeoffs are unavoidable. Further, it can be difficult to deal with all chosen aesthetics at once even if they don't conflict (Battista, 1999:17). Graph drawing algorithms therefore generate priorities between the applicable aesthetical rules.

Next to these basic rules or requirements for designing insightful graphs, visual variables which convey information have been researched and systematized by Bertin (1983:42). He identifies the following six items, which can augment a graph like the communigraph of this book's software approach in order to represent additional information:

- texture of an object,
- size of an object,
- color of an object.
- orientation of a pattern or an object from vertical to horizontal,
- color value of an object, which is the continued variation of color from black to white. It may also include shades of grey or of any other color,
- shape of an object, and
- plane or position of an object in a two dimensional planar space.

Summarizing, the theoretical process of graph drawing can aid in the generation of visualizations from raw data. Resulting graphs can be described theoretically using the terminology of graph theory. This allows for a systematical analysis of graphs in a subsequent step, as measures are founded on the theoretical structure of a graph. There are many further concepts which generally guide the design of a computational graph. Among them, there are Gestalt Laws, types of graphs, aesthetical criteria, and options for encoding additional information. These abstract theoretical concepts are now involved in the subsequent generation of an insightful graphical representation of data about people (or social) networks. After describing the specialization of graph theory in the field of social network visualization and analysis, the next chapters introduce the concrete graphical layout algorithm adopted to recognize the discussed theoretical requirements for an insightful graph, discussed in this chapter and the application of a technical environment which helps to actually draw and represent the resulting network graph on a computer.

8.4.1.1 Social Network Visualization and Analysis

Based on the concept of sociomatrices for network analysis as introduced in chapter 7.1.3, analytical approaches concentrating on social network graphs have been developed. They enable a visual analysis of large people networks. This social network visualization is a specialization of the more abstract graph theory. Scott (1991:70) describes some basics of graph theory in the domain of social networks by using very simple undirected binary graphs consisting of nodes and edges between them. In social network visualization, the nodes represent the authors (persons) and edges represent their relations. The term ‘undirected’ refers to the missing information about the direction of the edge, which does not point to a particular node but connects them. ‘Binary’ refers to the possible value of the edge: an edge either exists (1) or not (0). If two nodes are connected by an edge they are called ‘adjacent’ to one another. All nodes adjacent to a node comprise its neighborhood. The number of nodes in such a neighborhood is called the node’s ‘degree’. In other words, a node’s degree is a measure for the size of its neighborhood. In analogy to the sociometrical approaches described in 7.1.3, in directed graphs there is a difference between edges pointing towards the node (‘indegree’) and away from the node (‘outdegree’). Nodes can be directly connected by an edge or indirectly by a sequence of edges. Such a sequence is also referred to as a ‘path’. A path’s length is measured by the number of edges in it. The length between two nodes is the length of the shortest path that connects them.

Figure 82 illustrates how the concrete graph can actually be extracted from an existing discussion group. The procedure described is simultaneously following the process from raw data to views suggested by Card et al. (1999:17) and depicted in Figure 80. As chapter 8.3.3 described, discussion groups follow a hierarchical paradigm to store their communication. This means author 1 writes message A, which is referenced by the answering message B, written by author 2. Thus, a relation between authors 1 and 2 is implicitly existent if there is a relation between messages A and B (also compare the upper-right illustration of two newsgroup headers which are connected and thus also connect their authors in Figure 82).

On the left hand side of Figure 82, the hierarchal storage pattern of a discussion board is visualized. User 1 writes a message and user 2 answers it. This is also indicated by his subordinate position in the tree’s hierarchy. User 3 comments the answer and thus provides an answer to user 2. Then user 1 intervenes again and answers on the comment of user 3. User 4 posts another answer to user 2 (same hierarchical rank as user 3 but subordinate to user 2), user 5 posts his answer to the request of user 1, just as user 3 does. In such a structure, it can be differentiated between various types of relationships. Another person can either be directly referred by another person or directly reference that person's contribution. Further he can indirectly reference some person (like user 3 who is indirectly also posting a contribution to the initial request of user 1) or be referenced.

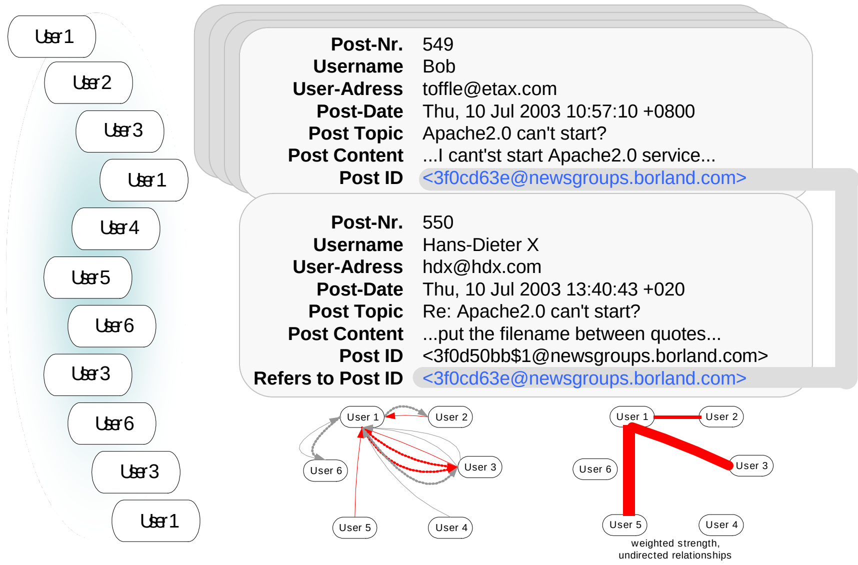

Figure 82: From Message Hierarchies to Relationship Networks.

The actual technical reference between communication acts is depicted in the upper right corner. Every posting is equipped with a header, which contains the reference to the related posting (i.e. posting 3f0d50bb$1 refers to posting 3f0cd63e).

If the relationships for person 1 as implied in the figure on the left hand side are translated into a network graph consisting of nodes and edges, the two graphs in the bottom-right corner of Figure 82 appear. The left network graph contains directed edges, where different edges mark indirect direct references. The design question is how to generate the overall relationship between two authors from the multitude of different message relationships. To increase transparency and reduce visualization complexity in the resulting computer generated graphs, it is advisable to create undirected relationships. This can be done by summarizing the set of directed relationships or by only counting sets of two subsequent messages in an opposite direction (or in other words a dialog). Indirect references can either be ignored or receive a small weight, which affects the strength of the overall relationship. The second network on the bottom-right corner is showing the weighted undirected relationships of person 1 if indirect references are ignored. A strong relationship to user 3 can be observed. It can also be verified in the discussion tree on the left: user 3 is answering one request, user 1 is giving feedback to user 3, and later user 1 is answering 1 request of user 3.

Based on the resulting network graph, which is simultaneously a social network visualization as specified by Scott (1991:70), all the available network measures developed by the research domain of Social Network Analysis are applicable. For example, the relationship strength is the value of the edge between two nodes in the graph. If user ergonomics shall be improved, this value can for instance be aligned with the thickness or the color of the line representing the edge. Reciprocity can be calculated by looking at the different in- and outdegrees of a certain node in a network. A final example is the network role of an author, which refers to a visual pattern in the network. For example, in a graph a broker should appear as a node between two clusters of nodes.

Following these approaches, the final model for this book's software visualization approach includes the main elements author and relation (as a quantity of messages). Authors are represented by a node (sphere). Each node has core attributes like name, e-mail, and index number. Moreover, the author (node) has several properties. These are different from core attributes, as they are conveying a qualitative or quantitative meaning, which can be grouped, compared or measured. These properties later allow for comparative analysis of the network's participants. Visually, this is supported by enabling the user to encode properties via node or edge label, node size, or node color.

Relations are an additive set of individual messages and are represented by edges. Each edge has an index number. Apart from that, it has measurable or comparable properties, like the number of messages, it represents, the average evaluation of its contents, or the main keywords.

8.4.1.2 Spring Embedder Algorithm

A very important visualization approach for representing social networks as graphs is the clustered 2D network graph using the Spring Embedder Algorithm as proposed by Fruchterman and Reingold (1991). It distributes nodes in a two-dimensional plane with meaningful separation, which is representing the (distance of the) original relationship between the nodes. This method has been selected because it provides a detailed insight into the communication structure of a virtual people network (e.g. in a discussion group) and suffices many aesthetical criteria. For example, the original Fruchterman Reingold Layout (FR-Layout) draws edges at even lengths, keeps the angles between vertices as big as possible, and minimizes edge crossings. Therefore the results have a very clear structure and are easy to read. The algorithm is very simple and therefore easy to modify. If the edge length is intended to represent meaningful information (like the relationship strength), then the aesthetical element of even edge lengths can be simply omitted in order to improve the overall utility of the resulting graph.

The underlying mechanism simulates a force system of virtual springs, attached between authors. Conceptually such force directed methods consist of two parts (Battista, 1999:304). First, a force system needs to define the physical model which determines the behavior of nodes and edges. The second element is an algorithm that finds the equilibrium state, which in turn defines when the graph is ready to be drawn.

To generate the first element - the force system - a matrix is computed, containing the optimal distance between any two members. This distance is derived from the strength of their connection. Authors who have a strong relationship are bound by a higher attractive force and hence should have a smaller distance than authors with a weak relationship. In the force system, this effect is created by modeling each node as a charged particle. This means, that repulsive forces are existing between all nodes to keep them at a distance and simultaneously edges between nodes invoke attractive forces, so that edges attract two nodes which they connect. The edge attraction is modeled by the formula

$$fa(d)=d^2/k$$

and the node repulsion by the formula

$$fr(d)=-k^2/d$$

where d is the distance between the two nodes connected by the edge and k is optimal node distance.

Attracting and repulsive forces sum up to a zero at a distance of k. Here, the connection is in equilibrium. In other words, two nodes connected by an edge would have this distance k if they are in a state of equilibrium and without outer influence. The developed layout component of the software application is able to let the user alter k (with the parameter ‘optimal edge length’). Visually, this results in a scaling effect. The network is laid out on a larger space.

The actual layout algorithm starts by randomly allocating nodes representing community members on a two-dimensional plane. This results in an initial state with a random actual distance and the according forces between nodes. Then, the complex system of springs is relaxed. The simulation compares the current with the optimal distance k. This actual distance can also be expressed as a force: attractive and repulsive forces are added to determine the current overall forces between each two nodes (as described above, they should add up to zero if the optimal distance k is reached). The computed values are stored in a force matrix. Each cell is indicating the attractive forces fa(d) that reduce a positive difference (i.e. where the actual difference is still higher than the optimal) or repulsive forces fr(d) that increase a difference between each pair of nodes in the graph. By adding one node’s directed forces towards or away from all other nodes, a final force vector can be calculated to move every node for a certain distance into the resulting direction. The amount of movement of the nodes is limited by an upper limit, which is called temperature. This temperature sinks during the iterations. At the beginning, the temperature is very high because the nodes will be far from their equilibrium. But while the layout proceeds the graph gets closer to a state of equilibrium and the steps of adjustment get finer and finer.

This process is repeated until the complete force system approaches an energy minimum. This implies that the sum of the differences between the actual and the optimal distances has been minimized with the current configuration of nodes and hence the spring system is in its most relaxed position. Visually, during multiple iterations, a clustered network graph is emerging, showing areas of strong relationships versus areas where there are no relationships.

The framework for the visualization tool has been designed modular which allows for subsequent addition of alternative algorithms. In order to understand the implicit characteristics of a graph, it might be very useful to switch between different algorithms which convey different aspects about the same graph. However, in this book's approach, for the beginning, the Fruchterman Reingold layout suffices all requirements. However, the FR-layout has been extended into a three dimensional FR-Layout (see for example Figure 76 for a basic layouting result). This is similar to the 2D approach but includes a third dimension and hence three dimensional distances and force vectors between nodes. This additional dimension provides one more degree of freedom for the nodes to find optimal positions and to minimize the overall tension (energy) in the network. This is caused by the fact, that there is more space on a sphere around a node than on a circle around a node for his adjacent actors to position themselves optimally. Further, there are less crossings between edges as there is more space for them to position and the three dimensional angle between edges in complex graphs are larger, making the graph more readable and ergonomic. Further, the resulting 3D graph allows for a better perception and comprehension of the original communication structure, which now more resembles an object, which can be zoomed or rotated to observe it from different perspectives, just like a complex molecule. However, there is also a downside. As there are multiple perspectives possible, it is difficult to have one optimal view on the graph, as almost always, some nodes are hidden behind others.

8.4.1.3 The application of Java 3D

After describing the underlying theoretical methods and algorithms, the derived technical implementation needs to be introduced. In the software application, two different technical approaches to present 3D models have been incorporated. There is a version called 'simple 3D' which is simulating the third dimension by mapping three dimensional edges on a two dimensional pane and by simply increasing the node size of nodes which appear closer to the user. This mode is available, when the network is very large and memory resources have to be saved. If the computer is sufficiently equipped or the network has a reasonable size (depending on the state of the art in memory technology and graphical hardware), a full 3D mode can be utilized. It is based on the special Application Programmer's Interface (API) for Java 3D (J3D), an optional addition to the standard Java implementation. Java3D provides 3D rendering for Java programs, but can simultaneously use OpenGL as the interface to the hardware. However, J3D does not require direct hardware device driver support. Conceptually, it is a hierarchy of Java classes for three-dimensional graphics rendering and includes many high-level constructs for creating and manipulating 3D geometric objects. All objects reside in a virtual universe. The classes offer a 3D canvas, which is an extension of a usual Java Abstract Windowing Toolkit canvas. Instances of special J3D objects can be created and placed into a 'scenegraph'. Such a scenegraph is a tree-shaped hierarchy that specifies all contents of a virtual universe and how it has to be rendered. It contains objects to define issues like geometry, lights, location, orientation, and visual appearance of objects. Each path in the scenegraph specifies all necessary information about the bottom element ('leaf' without a further child class) including location, transformation, or behavior. A sample path includes the creation of a Canvas3D object. A VirtualUniverse Object is attached to it. As its child class, a Locale object defines the original landmark, where further objects and properties are located. This Locale object links to a view branch, which contains all necessary information about the view on the rendered structure, including viewing controls and a 'movable' ViewPlatform on which the view 'sits' to observe the content. Further the Locale employs a content branch which contains the visual objects and their appearance. These two branches are rooted in a special Branchgroup object, which serves as the root object for scene graphs. Another special object is the TransformGroup, which is connected to a Transform3D object. It can be used to generate transformations like translation or rotation of objects (relative to the view of the observer). A final option is creating an Interpolator which controls behaviors of objects, like dynamic spinning (which is different from a static rotation, as the latter is only orienting the object in the universe without a movement).

Based on this conceptual architecture the scene graph in Figure 83 has been specified for the J3D renderer of the visualization tool for people networks. It starts with the instantiation of the VirtualUniverse object. The locale comprises the root and has a simple view branch, which owns a transformation object that zooms the view according to the user's commands. The content branch contains two general transformation nodes. The first is managing the interactive rotation and translation as requested by the user and the second manages centralization of the structure. Below these scene graph elements, the actual visual objects are defined, namely Node3D and Edge3D. The nodes own transformation elements in order to translate the nodes to the right positions, transform their sizes, once they are located at these positions, and finally to draw the visual shape, which is a sphere. Next to position of nodes, texts are located, repositioned and rotated using the billboard convenience class of J3D, which rotates the text in a way, that it always faces the view (i.e. the observing user). Finally, the actual text is instantiated. Similar to the nodes of the people network, the edges are drawn. Here, the problem arises, that the spatial orientation of the edge is depending on the position of the nodes. Finally, a cylinder shape is instantiated and the complete graph is drawn on the canvas.

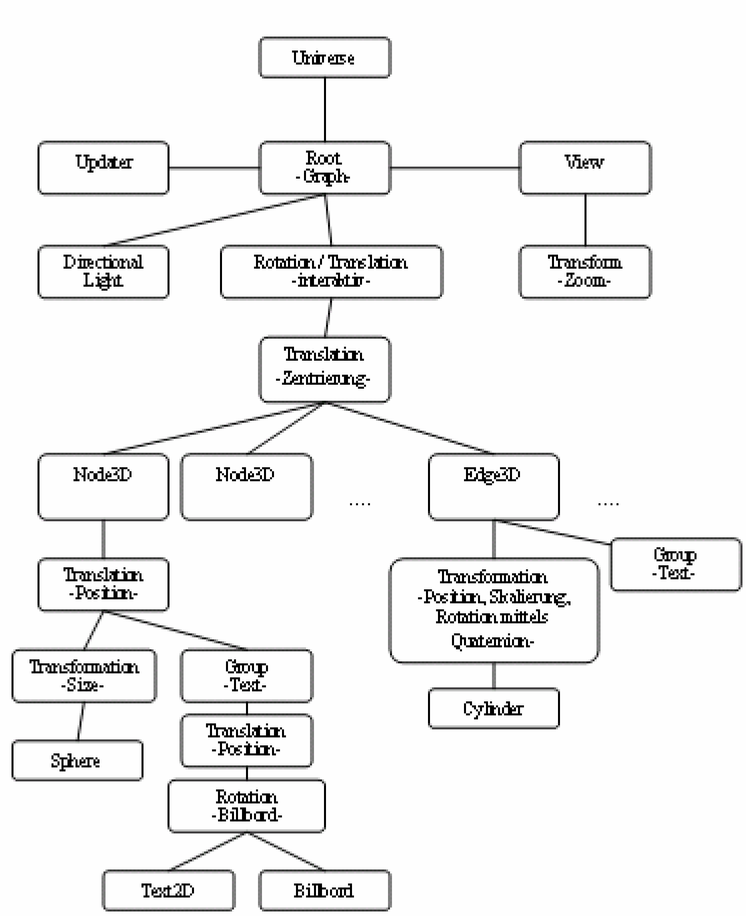

Figure 83: The conceptual Design Specification of the J3D Renderer.

A special issue for dynamically rendering the extracted data of the people network's communication is the restriction, that the structure can only be modified in predetermined ways, once it has been drawn on the canvas (status 'live'). For example, objects can not be added to the drawing shown on a canvas, but they always have to be defined a priori. This means they initially need to exist before the

3D structure is shown. The only option for modifications to existing objects is enabled by turning on capabilities. Sample capabilities are transformations, geometry coordinates, or shape colors. Another complication as compared to 2D graphics is the management of light sourcing, which has to be set up correctly in order to see the structure.

To handle these issues, the following solutions have been implemented. An elementary scene graph is generated only once (upfront). The required nodes and edges are created and cached in the beginning. Text labels are only generated when requested by the user in order to save processing time. A scene graph can be updated in dynamic intervals (using the Updater class). To rearrange the network structure according to the user's request, the geometrical vectors are not updated, but the transformations (of edge length or node size). The graph can be rotated and translated by using a local coordinate system. Zoom is implemented via manipulation of the view transformation. Using the billboard feature of J3D, the text labels are always facing the user. Further features are the automatic zoom on the graph and the automatic centralization in the user's 3D canvas. Further, objects can be picked, i.e. to view author properties. The problem of not being able to alter the scenegraph during the visualization is affecting the ability to simply draw new nodes into the graph as they appear. This is a very important element of time-based visualization, as the control component constantly adds new nodes which 'enter' the conversation. This shortcoming has been overcome by managing the visibility of scene graph objects.

Summarizing, the J3D renderer provides text labels for edges and nodes, frame based rendering, mouse-controlled navigation, changes in colors, texts, and visibility, dynamic alteration of edges and nodes, and auto-zoom to optimize the view on the graph, which is requiring the determination of the optical center of all nodes.

8.4.2 Animated Longitudinal Visualization and Analysis

Card et al. (1999:30) emphasize that changes over time can also be used to encode information. Following this idea, a special visualization feature has been developed: the time-related filter. It allows for observing, how the network actually evolves over time. The observer can see how clusters are emerging and connecting with other clusters, or who has been the initial nucleus of a cluster.

The underlying technique is the implementation of a time filter in the backend and the according addition of a time controller to the layout algorithm. The time filter allows for generating a set of authors, which are existing in a discourse in a specified time period.

The time-related animation can either be message driven or time driven. Message driven animation simply includes the next message in the graph and the layout component adds it to the visualization. The backend supports the fetching of the very next message in a discourse but also the fetching of a larger bundle of 'next' messages in order to allow for higher speeds of animation (also cf. Figure 74 in chapter 8.3.4). This is necessary, if for example an instant messaging discourse is visualized, where there are thousands of messages between a limited set of existing authors. True time driven animation on the other hand adds the next time frame (from hours to weeks, depending on the overall duration of the discourse and the speed selected by the user) and fetches the nodes and relations which have been added in that time period to add them to the graph.

In principle, both types of animation yield in the same result. However, message-related animation does not visually differentiate periods of large volume increases and periods of low growth, hence making it impossible to evaluate velocity. On the other hand, true time related visualization does often not show a meaningful addition of new messages as multiple messages are added in periods of fast volume increase.

A third alternative for time driven visualization is time-window-based animation. This type actually moves a window of a constant size through the sequence of messages. The result is a visualization of the changes in the network as old structures which fall out of the time-window again are either faded out or completely disappear. This helps to emphasize the actual current activity and the added content.

Technically, the backend's time filter receives the active time period from the frontend and retrieves the active nodes and relationships. Here, certain design issues have to be defined - for example, how to display a relation, where the answer is outside the active period. Here, either both participating authors can be set as inactive or the one which posted his message can be active and the reply does not exist or both are treated as active.

Another important design issue is the FR Layout algorithm. It needs to be adapted as the original algorithm of Fruchterman and Reingold does not take into account an addition of nodes during the calculation of positions. In the developed layout algorithm, new nodes come in at random positions and are instantly taken into consideration with their repulsive and attractive forces. Special attention has been put to the visual comprehension of the animation. For example, the position of singular objects should be less sticky then that of larger structures in the current network. This results in a physical impression of inert large molecules and rather active and quick new nodes.

Next, the rendering process needs to take into account the temporal addition of nodes and edges. The 2D renderer can handle this requirement very easily, but the J3D renderer generates the problem, that its scene graph structures can not be altered during the visualization of the graph. This is why all nodes need to be included in the layout, yet they are rendered invisible before they actually 'appear' in the discourse.

The resulting animation is illustrated in the Figure 84. It shows screenshots of the evolution of an electronic communication network of a corporate instant messaging discourse. From initially unconnected employees, two clusters and a stable connection between them emerge. In the presented animation, the unconnected nodes have their initial positions although they have not yet become a part of the structure. This means that the inactive nodes are not hidden.

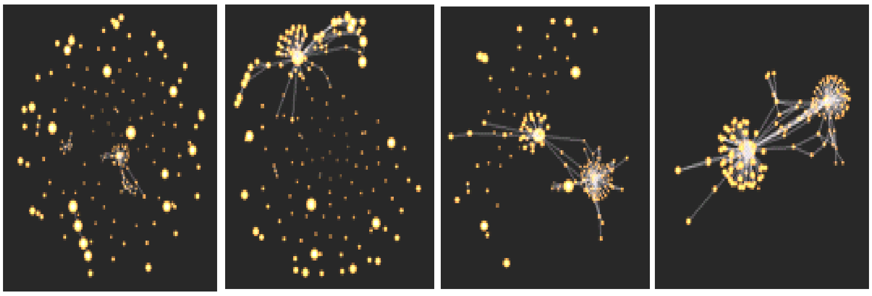

Figure 84: Screenshots of the Evolution of an electronic Communication Network.

8.4.3 Semi-manual Content Coding and Analysis

The domain of social network visualization and analysis is the observation and evaluation of structural patterns. However, in Communities of Practice, not only the neutral structural patterns are of importance but also the content which has been discussed in the network. One way to work closer towards a content oriented analysis is semi-manual content coding using certain coding schemes. This technique is frequently used by researchers to analyze the structure of communication. The analyst goes through the complete data set and assigns an according type out of a predefined set of alternative categories. For this process, the application allows for using a provided Java-based table to add property information. This can include information about authors' affiliation or hierarchical status, or also the application of a content coding scheme.

Although this semi-manual technique does in its original intention not allow for identifying hot topics[53], it yields in more insight about the actual culture and application of the discourse. A sample coding scheme is consisting of elements like quick answer, document transfer, or socializing communication. For example, if two persons have a private conversation about their hobbies, this could be regarded as a socializing communication. Figure 85 shows a typical scheme for a classification of contents of a virtual discourse as suggested by Muller et al. (2003) and Isaacs et al. (2002). It contains 17 categories of communication.

[53] This could be done by going through the messages and manually assign a limited and predefined set of ten to twenty keywords.

The information about communication purposes can subsequently be utilized by the application to indicate different types of contents with different colors, node sizes, or rings. Alternatively, only the subset of a communication network could be visualized, which contains the according content coding category. A sample study could show a subnet which shows only socializing relationships between employees and compare it with a subnet for document transfer. By this it could for instance be found out if socializing in networks is a barrier for efficient knowledge work or if it finally leads to other types of communication and hence supports the subsequent transfer of knowledge. If the two networks are involving the same authors, then obviously these authors first communicated to socialize before they started knowledge exchange.

Purposes	**Description**	**Domain related to**
Availability check	Asking whether the receiver of IM is available to start a conversation	Organization
Follow-up	Follow-up of previous IM conversations or email messages	Organization
Ftf meeting coordination	Arranging face-to-face formal meetings	Organization
Informal meeting coordination	Arranging face-to-face informal meetings	Organization
Leave memos	Leaving memos without checking conversation availability	Organization
Media switch	Switching communication medium in the middle of conversation	Organization
Third party call	Asking the phone number or availability of a third party whose presence the IM receiver can check	Organization
Announcement	Broadcasting to several IM receivers	Organization
Phone call arrangement	Arranging phone calls by checking the availability of the IM receiver	Organization
Information sharing	Sharing information related to task completion	Knowledge Work
Discussion	Discussing issues or problems to complete tasks	Knowledge Work
Document transfer	Sending and receiving documents	Knowledge Work
Quick Q/A	Asking a simple question and answering it	Knowledge Work
Simple request	Asking for a favor to do a simple thing	Knowledge Work
Problem solving	Discussing a problem in depth and find solutions	Knowledge Work
Socializing	Having a conversation about what is not related to work	Socializing
Others	Other categories which cannot be grouped into those described above	Other

Figure 85: A possible Classification of contents in a corporate electronic Instant Messaging Discourse. Source: cf. Muller et al. (2003) and Isaacs et al. (2002)

8.4.4 Automated Shallow Text Analysis

Next to assigning content types to messages, real topic analysis can be pursued. The software approach of this book started with shallow text analysis. However, in later stages more sophisticated procedures can be developed. According to the co-occurrence of terms in documents, a relation can be computed, indicating the relative vicinity of the two terms (or in other words the strength of the relation). Finally a neural net algorithm, like a Hopfield Network could be added to create a hierarchy of the concept relations.

The shallow text analysis approach applied for the software analyzes all messages and their subjects and reads in the full text. This text is then segregated into lists of words. Afterwards, a ‘stop word’ list is applied, which includes up to 1,000 common function (or non-semantic bearing) words, such as on, in, at, this, there, etc. and „pure" verbs (words which are verbs only), e.g., calculate, articulate, teach, listen, etc. This list helps to delete high-frequency words that are too general to be useful in representing document content. Then, a stemming algorithm can identify the word stem for each remaining word. Sample suffixes include: ive, ion, tion, en, ions, ications, ens, th, ieth, ly, ing, ings, ed, est, er, ers, s, es, ies, ness, iness, and 's. The resulting keywords are counted for each contribution and stored in decreasing number of occurrence. This procedure yields the most important words for each subject and each message. By summarizing all messages of an author, the most relevant terms for that author can thus be found.

A sample approach to utilize keyword analysis in a visualization is shown in Figure 86. The left-hand side shows the sample keywords, which have been extracted for the authors S, F, Y, and H (anonymized) in decreasing order of occurrence. For example, the message S sent to F dealt with the keywords ‘Socket_select’ (a PHP command), ‘crashes’, ‘http’, ‘net’, and ‘win’. If these keywords are occurring on both sides of a communication relation (i.e. also in the answer of F), then they are symmetrical and are placed at the center of the edge between S and F. Sometimes only one author uses a keyword (e.g. ‘id’ written by author F). Then this word is located near the author.

A subsequent feature which can be developed after the introduction of keyword analysis is a search functionality for the people network. All identified terms are shown in a list or a search term can be entered (like in Figure 86 at the top-right corner) and the found relations and nodes are marked using a color.

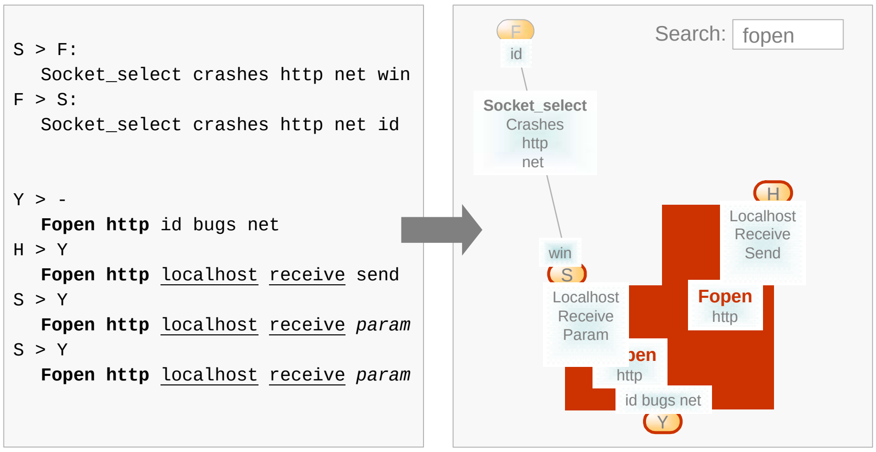

Figure 86: Approaches for Keyword Visualization and Analysis.

There are many interesting subsequent features based on keyword analysis possible. They are part of the measurement approach introduced in chapter 7.2. For example, a similarity between two authors can be calculated by looking for their keyword overlap. Furthermore, the variance of the keywords of the community can be measured to find out if the discussion limits its initially usually very general focus to more specific analyzes.

8.4.5 Implementing and extending Measurements

A final implemented framework is the measurement system developed in section 7.2. Here, in a first stage selected measurements are implemented into the software for demonstrating the value of such evaluation functionality (cf. Figure 87).

The actual measurement takes place in the backend. The discourse class is augmented with methods for measuring discourse metrics. These can then be accessed by the frontend. It has to be differentiated between dynamic properties and static (or non-dynamic) properties. They differ in the aspect, that dynamic properties are evaluated for every change in the network, for example when a time driven animation is played. Examples are messages sent by an author or the relationship strength. The calculation of static measures is either too resource intensive or the recalculation of the measure for each change in the visualization is not meaningful for the analysis. This type of property is thus only updated upon request and remains unchanged during animations. Examples are indirect contacts of an author or his membership in the core group.

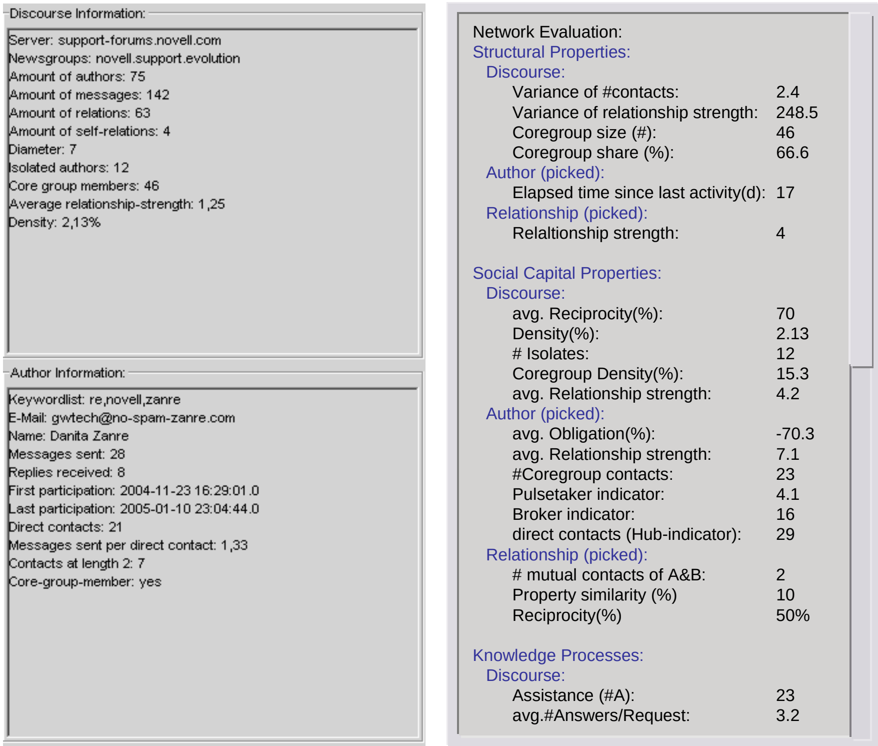

Figure 87: Two prototypical stages of the Measurement Concept implementation. Left: Measures are sorted by Entities, Discourse and Author. Right: The Measurement System Structure has been adopted (parts are invisible).

The implemented measurement system allows creating a first insight about the quantitative structures, the probability of employing Social Capital benefits, and knowledge processes. However, it has to be noted, that during the development, it became clear, that such a measurement system is a big research challenge which requires further development efforts (which were far beyond the initial scope of this book's software approach).

After the implementation of the actual measures, further issues arise. Moderators need to export the generated evaluations and visualizations. Especially for the metrics, an export into useful formats like CSV (comma separated value) or even XML is necessary. Further, an important question is how to make several measurements comparable in order to identify trends. This could even lead to a second database, which systematically stores the analysis or to an external analysis component which is activated and then runs several analysis routines to prepare an extensive report.

A second interesting issue is the development of a measurement approach for dynamic properties. As just mentioned, the dynamics of a people network are highly interesting for moderators. They want to know, where new hot topics and active authors are emerging in their network. Although the introduced system proposes measures for evaluating network growth (i.e. density trend, hot topic, posting frequency trend), much more experiments need to be carried out in this segment of measurement in order to generate good insights about the longitudinal evolution.

Following the idea of combining visualization and measurement, the measures can be connected to visualizations. The property approach of the application partially implements this idea. However, ideally, most measures should be augmented by color-coding or node-size coding to give a more illustrative impression to the user. This can be combined with temporal evolvement to highlight growing areas with colored backgrounds or dying conversations by fading out colors.

If measurement and visualization are combined, then, next to allowing visual representation of the measures in the graph, this should consequently lead to a true cockpit with visual evaluations for allowing quick insights into the current situation of the network in order to support the management of Knowledge Communities. The introduction of a conceptual development for this issue will be reserved for the outlook in chapter 10.

Before that, the next chapter will illustrate the application of the software approach using several case studies.

9 Case Studies for IT-supported Community Visualization and Analysis

After the developed technical approaches have been introduced and discussed, the resulting software needs to be tested 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. This work will first analyze a non-commercial newsgroup called Slashdot.org which informally discusses latest news. A further example, which will be briefly introduced (anonymized) is an Asian manufacturing company, which used instant messaging to coordinate their knowledge workers. Finally, a Java Developers and Help Forum are examined. These cases will be utilized to illustrate the main features of the software and to emphasize the insights achieved when communities are visualized and evaluated. Finally, a first emerging procedure for IT-supported community analysis is assembled and documented in chapter 9.4.

9.1 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 88 is being generated. As described in section 8.4.1.2, the distance between authors gets smaller, the stronger their communication relation is, i.e. the more they communicate with each other.

From the multitude of Slashdot-based discussions, a group is selected, which discusses the maintainability of Open Source software. It can serve to illustrate the ability of including information in the social network visualization. From this discussion only a small sample was taken to illustrate the analysis using various visualizations. It includes 57 authors, which exchanged 103 messages in 6 days. They formed 77 relations. The low duration of the sampled discussion is represented by the resulting low average relationship strength of 1.29. The diameter (longest path) of the network is 7, which implies that a central author would need to pass about three persons until he reaches the periphery of the network. There are no isolated authors, whose questions where not commented. 36 persons or almost two thirds of the available members are necessary to create 80 percent of the board's volume. This shows the large structural uniformity with an especially active (epi-) center or a small core group. Given, that this discussion is employing a hierarchical discussion paradigm, the density is comparatively high with 4.5 percent (i.e. every 20^{th} possible relation is actually occurring).

In the network's visualization (Figure 88), the node size has been set to represent the activity of the authors in terms of sent messages. The node labels show the author names, the edge labels show the amount of communication between two nodes. As this is only a small sample of a short period, there has not been much communication between any two authors and the relationship strength is mostly one. This implies that there is not much probability for utilizing Social Capital in this network, as there are no strong relationships. Considering the fact, that this is rather an ad-hoc network, it is thus obviously not yet a 'social' network.

The node color has been set to represent the authors' evaluations. This yields in the next insight. The most active authors[54] do not need to be the ones with the best evaluation. In fact, the node representing the anonymous author is actually decreasing the overall evaluation of the network, as its evaluation is particularly low despite its activity. This pattern also shows that authors usually did not appear to be highly active in this sample. Rather they comment once and then only read.

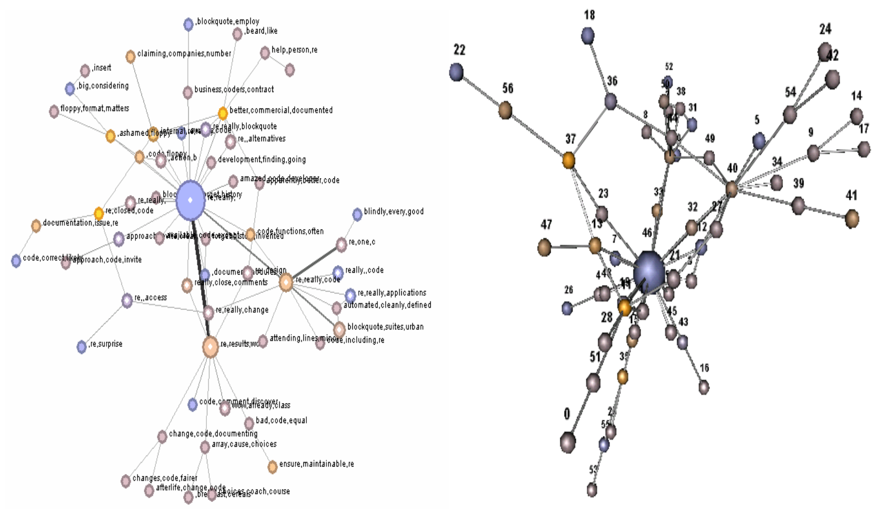

Figure 88: Viewing a Slashdot Discussion Group.

[54] Which in this sample is a category called Anonymous author, which multiple authors can employ for posting anonymous contributions.

The node size could also have been set to represent the average amount of communication with any of the author's contacts, or in other words the average depth of his relationships. This uncovers, if the author maintains many weak relationships or rather only few but strong relationships. Generally, this network contains about four strong relationships. Alternatively, setting the node size to decode messages received would yield in insights about the prominence of authors. The nodes who received the most attention in terms of communication are bigger in size.

This network can now also be analyzed for important topics. Figure 89 shows the result of filtering the keywords read, readable, readability, understandable, and understand. These terms refer to the readability OpenSource source code and its role for OpenSource Maintenance. Using the same filtering approach, the topic 'documentation' has been found to comprise a large subnet in the overall discussion. Such analysis can help to quickly identify special topics and their subnetworks in the discussion. It further leads to observing the evolvement of such topics over time.

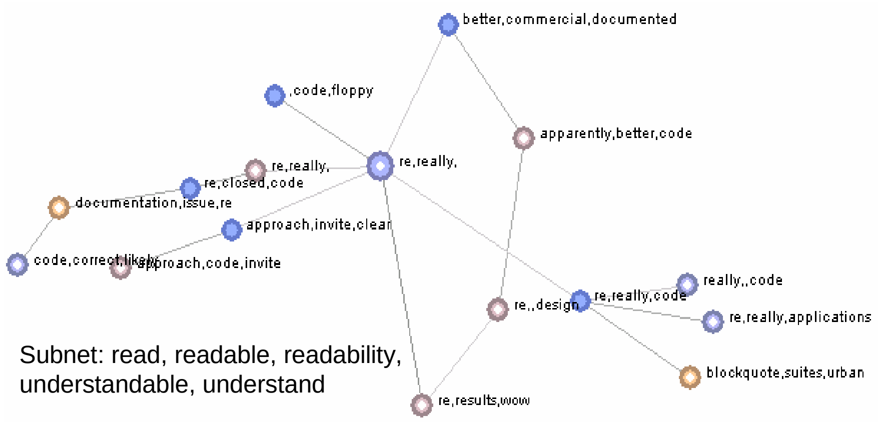

Figure 89: The Subnet with the Topic 'Readability' of OpenSource Code.

9.2 Case Instant Messaging in a Manufacturing Company

The software application has been applied to study the communication in a manufacturing company (initially described in Cho et al., 2005). The observed communication channel has been instant messaging (IM). The IM transcripts of two people A and B have been analyzed in depth. A is at level 1 (out of 5) in the corporate hierarchy. He analyzes market trends, positions the company in the market based on the analysis of market trends, analyzes the profitability of the company based on sales records, and develops the Knowledge Management website for the company. B is at level 2 in the organizational hierarchy and takes the responsibility for managing the ERP (Enterprise Resource Planning) system and for providing technical support to remote offices.

As the two individuals where the focus of the analysis, the method of ego-centric networks (or simply ego networks) has been applied for quantitative analysis and visualization. This case thus shows, how ego-networks can be analyzed using the software application introduced in the previous chapters. Such an ego-centric network consists of a focal actor, termed ego, a set of alters who have ties with ego, and the measurement on the ties among ego and these alters. This data is also referred to as personal network data. Ego networks are used frequently to study the social support of persons (Wasserman and Faust, 1994).

For the analysis, a special connection to MSN-Messenger has been developed to automatically scan, extract, and analyze the network structures in over 80,000 communication acts stored in the sampled electronic Instant Messaging archives of the company under consideration.

In 217 days, A sent 2574 (45 percent) and received 3185 (55 percent) messages. Comparing this inbound and outbound traffic, there is no clear evidence for A being either a passive and prominent collector or an active initiator of messages. The same applies for B. Comparing the traffic volume of both persons is indicating a clear difference. In 244 days, B sent 39595 and received 38217 messages. On average, this equals 162 sent messages per day, whereas A only sent 12 messages daily, illustrating B's heavy use of IM. With this large volume of messages, B maintains 139 contacts, which is more than three times as much as A's 45 contacts. The different scope of the two persons' networks can be visualized with an ego-centric social network visualization, rendered by the software application (see Figure 90). The star pattern, which has been produced by the layout algorithm, is typical for an ego-centric data set. The network of B intuitively appears much larger.

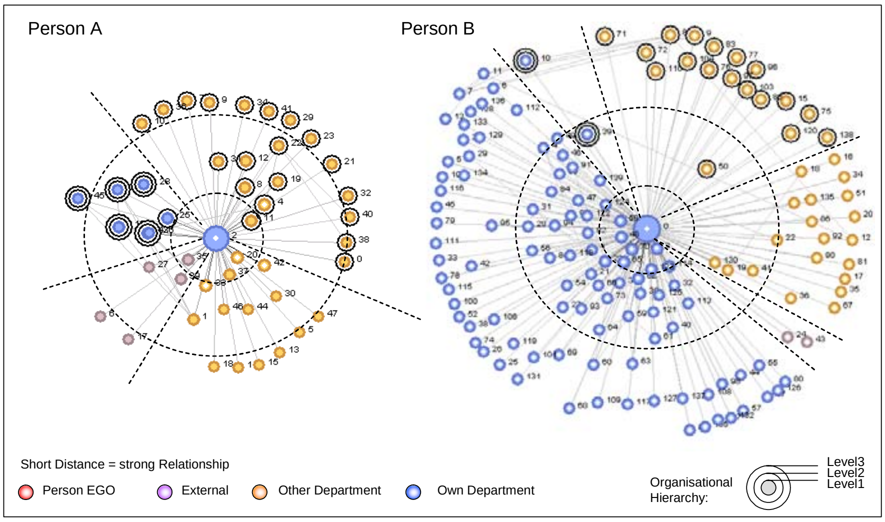

Figure 90: The ego-networks of Person A and B in two different Departments of a Manufacturing Company. Also cf. Cho et al. (2005)

In the visualization, property coding has been applied to store additional information about the hierarchical level and the location of the authors (also compare chapter 8.3.3). Looking at the network of person A, the majority of his 45 contacts are outside his department on the peer and subordinate level. There are no relationships to external superiors. In his own department, A has only six contacts. These contacts are almost only to superiors. However, it has to be recognized that A has no subordinates within the department. Finally, four external contacts are maintained. B has a completely different pattern. Of his 139 contacts, more than two thirds are subordinates which work in the same department. There are only two contacts to his superiors and no contacts to peers. B's contacts to other departments are at the peer and the subordinate levels. B maintains only two external contacts.

About two thirds of A's received message volume were received from persons of other departments. Analyzing this subset of external messages, one half was sent by 21 peers in other departments and the other half of the external messages was received from 14 external subordinate persons. On average, peers sent fewer messages per person (53) than subordinates (74). This shows that although comprising only about one third of A's external contacts, these subordinate members write messages more frequently to him.

Compared to A, only 9 percent of B's messages have been written by employees of other departments. From them, the biggest group is comprised of external subordinates, which account for 6 percent of the overall communication volume. Like with A, the subordinates wrote much more frequent than employees on peer level. Opposite to A, the external share is very small compared to more than 90 percent of messages received from B's own department. It has mainly been generated by his subordinates, who also wrote much more frequently than external peers and subordinates. B has received only one percent of his conversation from higher levels in his department. Both respondents have in common, that they have very few relationships to internal peers and external superiors.

The analysis of A's IM use in terms of message sending and reception gives some insight into his networking patterns. To internal superiors, A is a reactive collector and receiver with received messages outnumbering sent messages with a ratio of 1.6. This is an interesting result, as in his work relation A would be expected to be the active reporting person and his superior the receiver and collector of his information. However, given the tendency of IM conversation towards informal and spontaneous communications, the superiors of A would be more eligible to apply informal language to his subordinate A, than it would be in the other direction.

This tendency can also be observed in A's conversation with external people at lower levels in the organizational hierarchy. Person A received fewer messages than he sent (ratio 0.8). Hence, A is more an initiator of informal messages to this group, than a collector. Again, the superior position in the organizational hierarchy is the dominant sender of IM.

To complete the discussion of A's hierarchical exchange ratios, the conversation with external and internal colleagues at the same hierarchical level needs to be explored. Here, A is receiving nearly two times as many messages from external peers as he sends (1,115 vs. 598 messages; ratio: 1.8). Within his department, the opposite could be observed: he received 114 messages from his peers and sent 174 (ratio: 1.5).

Looking at person B, to internal superiors he is an active sender with a ratio of 1.8. This is opposite to person A which has been a receiver of IM messages from higher ranks. This is interesting when assessing the above assumption, that the informal character of IM communication would suggest that there is not much bottom-up communication with superiors as informal communication is not appropriate for this hierarchical relationship as found for A. However, having in mind, that B is a heavy user and applies IM less for socializing than A (compare Cho et al. 2005), this result could also confirm B's employment of IM as a means to increase efficiency in his work relations. Analyzing B's relations with lower levels in the hierarchy reveals that there is no dominant direction (B is a receiver with a very low ratio of 1.01). To external subordinates, B is even sending more than he received. These differences can be related to B's job profile: He is more supporting and less reporting than A. A is hence more a collector of information from others, B more a provider of information.

Using the ego-centric networks, the relationship patterns of A and B can also be analyzed in more detail by looking for strong ties. For this, a threshold can be defined, which separates strong from weak connections. A pragmatic approach is to set it at half the strength of the strongest relation (Rmax/2 with Rmax = strongest relation in the egonet), thus providing a relative view that eliminates the differences in usage intensities between A and B. Applying this method, A maintains 11 percent or five strong ties (threshold Rmax/2 = 218 interactions) which are responsible for 45 percent of the overall message volume. The remaining 89 percent (40 contacts) are weak ties of A. The tight connections include contacts at different hierarchical levels within and outside the department: one peer and two subordinates from external departments plus two internal superiors. B maintains 5 percent or seven strong relationships (threshold Rmax/2 = 1147 interactions). They generate only 30 percent of B's processed message volume. Still, comparing the average amount of interaction, B has considerably stronger communication ties with his contacts than A. If A's threshold for a strong tie would be applied to B, he would maintain 48 relationships at the level of A. The pattern also shows that B has only strong ties to internal subordinates. Generally, he has only very few dense relationships with external employees and none with his superiors.

To apply a time-based analysis to this case study, the development of hierarchical relationships overtime is now visualized and discussed. Figure 91 shows A's and B's egonets during 6 sampled months. Throughout the months, new contacts are added continuously. Close contacts with strong relationships move to the center.

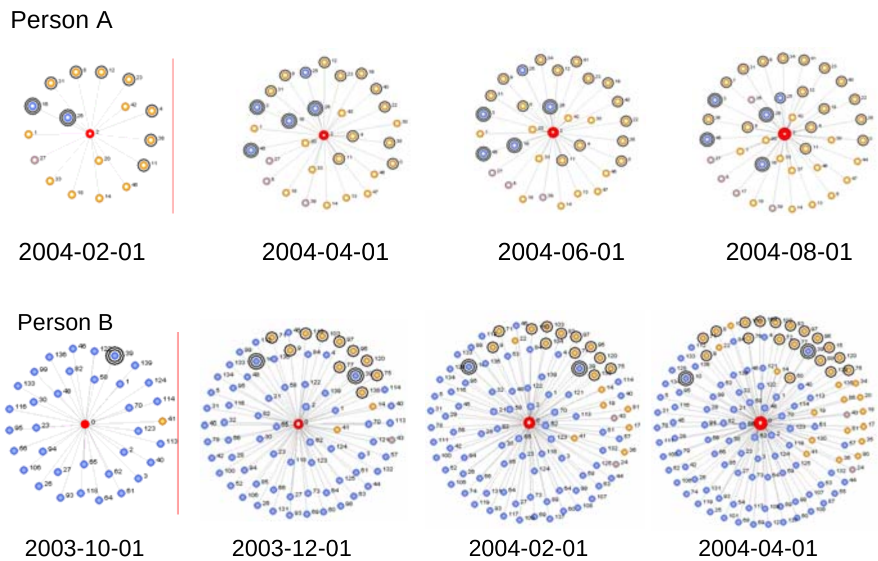

Figure 91: The Evolution of A's and B's ego-centered Network (ungrouped, two month between each instance of egonet).

Applying the hierarchical and locational categories, Figure 91 shows the development of both respondents' communication network. Within 6 months, A added 26 new contacts to his 17 existing contacts (250 percent growth): 4 external collaborators, 4 internal superior, 7 external peers and 11 external superiors. The colors also illustrate that A has developed from internal to external contacts and used IM for creating cross-departmental relationships to geographically separated locations. Looking at the job of A, which is to accumulate and analyze information, this behavior seems to support his work.

B initially started with 35 contacts, and added 1 internal superior, 48 internal subordinate, 15 external subordinate, 18 external peers, and 2 external collaborators. In sum, this accumulates to 84 new contacts which is more than 300 percent growth. However, his primary growth came from developing relationships to his internal colleagues on lower levels. As he is managing the ERP-system of the company, this could imply that he is organizing his group using Instant Messaging.

The continuous increase in relationship strength of A and B to colleagues across hierarchies and locations is depicted in Figure 92.

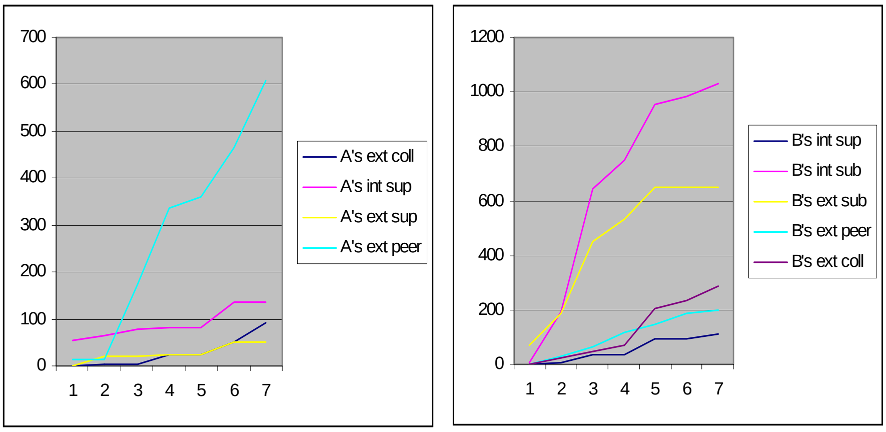

Figure 92: Development and Increase in Relationship Strength for Persons A and B over 6 Months.

The two ego-networks have also been examined using content analysis (compare for Cho et al., 2005). This gives many insights into the purpose of applying instant messaging and the role of Knowledge Work. The content coding scheme introduced in chapter 8.4.3 has been applied. Looking only at the broad domains knowledge work, socializing, and (self-) organization, it can be seen, that both in A's and B's electronic communication, messages related to Knowledge Work comprise the biggest share (50 percent for A and 67 percent for B). Socializing which can be interpreted as a means of maintaining and improving relationships to foster Knowledge Work is also a considerable part of the respondent's communication (33 percent for A, 8 percent for B). The different amount of socialization could be attributed to the fact, that A is more a 'Collector' who needs to establish good connections to draw resources from his network, whereas B is more a 'Provider', which does not require him to socialize in order to improve his relations. Looking at the socializing messages reveals that most socializing was actually to check the results of informal meetings, or send seasonal greetings. This application of content coding is looking only at broad types of communication. This could be enriched by a detailed keyword analysis. However, as most of the conversation of this case was not in English (Asian company), this was not possible with the current software solution.

9.3 Case Public Java Developer Forum

The next case includes a dataset of 10 days (02/04/2005 until 02/13/2005) of discussion activity in the Java developer forum comp.java.lang.help. During this period 161 authors where involved and exchanged 400 messages. Between the 161 authors 183 relations where formed. The longest path between two authors (Diameter) had a length of eleven edges. At the first sight, there are no separated clusters. In the group, 17 persons are isolates (ca. 10 percent). The coregroup includes 81 people, which means, that more than 50 percent of the network's authors are responsible for generating 80 percent of the message volume. This indicates that the network activity is very distributed across the group and there is no small epicenter of activity.

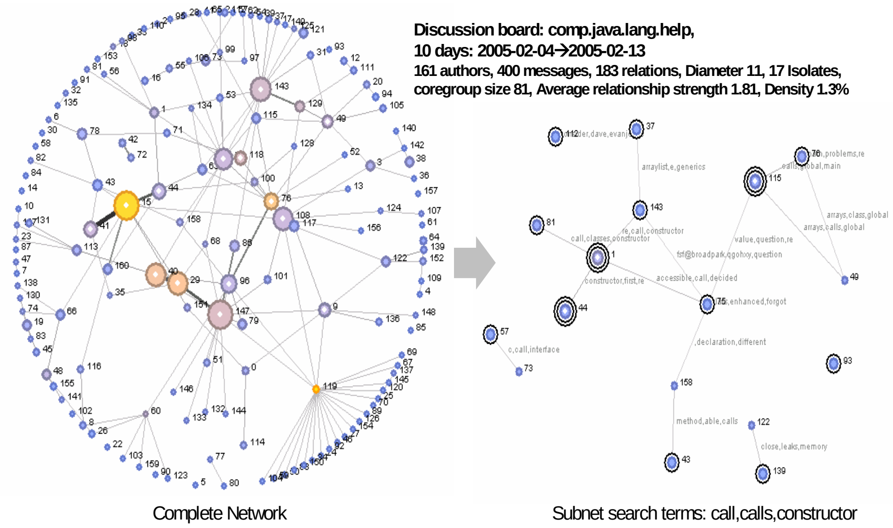

Figure 93: Complete Network (left) and filtered Sub-network where the terms Call, Calls, and Constructor occur.

This is obviously due to the fact, that the sampling period is too short to build a smaller set of core members. The same implication can be derived by looking at the average relationship strength of 1.81. Thus, only very few messages have been exchanged to form the relationships. However, the graph shows six strong relationships (e.g. between node 29 and 40 or between 15 and 41). The overall density is only 1.3 percent, which shows, that almost all of the possible connections between authors are not yet realized. This effect can be attributed to the hierarchical structure of a discussion board in contrast to a peer-to-peer based structure, where direct relationships are much more important for communication.

In the complete network, there are about seven to eight very active authors, which moved to the center of the graph. They participate in the strongest relationships in the sample. On the other hand, they are not very well connected to each other. This could indicate that they discuss about rather unrelated items and receive their answers not from each other, but from otherwise not active experts. The sending activity is indicated by the node size. Node 15 and node 147 were most active. For example, node 147 sent 17 messages to his 12 direct contacts and received 8 messages; node 15 has 10 contacts, sent 17 messages and received 19.

Author 119 shows an interesting pattern. He has eighteen connections to otherwise peripheral contacts. However, the person has sent only two messages. To illustrate what happened, the node color has been set to represent the received messages. Orange color shows that author 119 invoked a very impressive feedback (22 messages) given his low sending activity. Social Network Analysis interprets this position as ‚prominence' in the network, representing the attention an author has gained from others. The question must have been unrelated, as the answers came by new authors, which previously have not acted in the sampled network. If sending and receiving activity are added, node 15 was most active. The according person participates in the strongest relation, which has emerged between authors 15 and 41. Their dialog includes 15 messages (cf. Figure 94). As two initial requests, two messages directed to a third person, and one self-related message do not qualify for adding to the relationship strength, the overall communication relation has a strength of 10. This number thus represents the actual communication, where one person reacted on the other person's assertion – or in other words, where a real information exchange took place. The undirected relationship in the case does not directly show who is putting more effort into this relationship. Author 15 contributes 9 messages and author 41 6 messages. This looks like author 15 is the primary driver. However, in terms of strengthening the relationship, author 15 increases the strength by 4 and author 41 by 6 to arrive at the overall relationship strength of 10. This is due to the fact that an initial request is not adding to the relationship. Further two of the postings of author 15 are directed to third persons. This shows, although author 15 is writing more messages, the relationship is primary built by author 41. Thus, quantitatively, this relationship is not completely symmetrical. Rather author 15 is accumulating some commitment to help author 41 in the future. The notion of commitment becomes even clearer, if the contents are analyzed. User 15 is only describing problems and author 41 is providing solutions. Obviously user 41 is the expert in this relationship and user 15 the novice. Looking at the complete network, user 15 seems to be a person, who quickly asks and draws a lot of resources from the Virtual Community.

Discussion board: comp.java.lang.help, 10 days: 2005-02-04→2005-02-13					
Dialog Sequence between 41(Id: 1339) and 15 (Id: 1313) between 2005-02-07 and 02-12					
MessID	Sent_by AuthID	Answer to MsgID	Relationsh. Strength	Content Description	Content Type
111169	1313	---	Initial Request	Needs help for connecting to a database with tomcat	Problem Description
111216	1339	111169	1	Discusses issues to clarify the problem again	Problem Description, Solution
111390	1313	111216	2	shows a partial solution from others and thanks	Problem Description, Solution, Socializing
111249	1313	---	Initial Request	asks for the differentiation of instantiating, implementig and subclassing?	Problem Description
111389	1339	111249	3	reassurance of initial assumptions, adds to the definitions	Feedback, Problem Solution
111421	1313	111389	4	thanks and asks a related topic: implements 'implement' all methods?	Soclializing, new Problem Description
111482	1313	111421	self	clarifies mutual understanding about a detail of his request	Clarification
111461	1339	111421	5	Answers 'yes' and gives examples	Problem Solution
111476	1313	111461	6	comments and thanks	Socialization, Clarification
111192	1313	111175	directed to a 3rd person	Tried a JDBC-driver related solution from a third author - does not work	Solution Application, Feedback
111229	1339	111192	7	corrects the initial solution	Solution Correction, Feedback
111539	1313	111531	directed to a 3rd person	MySQL driver selection - solution feedback and request extension	Clarification
111551	1339	111539	8	gives possible way to solve the problem - bug fix	Feedback, Problem Solution
111553	1313	111551	9	Feedback and Thanks	Feedback, Socializing
111554	1339	111553	10	solution extension	Solution

Figure 94: The detailed Dialog of the strongest Relationship in the Sample (between Authors 41 and 15).

Another interesting feature for the analysis is the keyword filter. The right hand side of Figure 93 illustrates the result of searching the network for the terms call, calls, and constructor. A sub-network emerges, which comprises the authors and messages, where these keywords occurred. The rings illustrate the amount of sent messages. The authors which discussed about these terms can be found immediately. The five users 1, 44, 143, 115, and 75 can be identified. If the rings are set to represent the received messages, author 1 is highlighted. He obviously is the central figure around the search terms. Looking up this author's contributions yields in a series with postings with the subject: ‚calls to super must be first statement in constructor'. This shows how keyword search can help to quickly find sub-groups of people which discuss a special issue.

9.4 Conclusion

The previous cases applied the software solution for visualization of knowledge communities to the analysis of real-world communication networks. Eventually, the analyses of the cases followed a general procedure, which is influenced by the available features and emphasis of the software. It is summarized in Figure 95, which simultaneously suggests a first methodological approach towards a procedure for IT-supported analysis of electronic communication networks. It starts by interpreting the basic structural and social measures, like message volume or average relationship strength and density. Here, the general structural uniformity of the network can be analyzed by comparing the core group size to the size of the overall network to see how centralized the epicenter of activity actually is. After studying the numbers, the visualization of the network gets configured to achieve insights into the structural and social patterns. This is done by highlighting important structural patterns, active and prominent authors, individual properties (like author evaluations, hierarchical levels or organizational affiliations), or strong relations and their characteristics (symmetry and obligation). In the next stage, the contents and keywords are analyzed. This yields in insights about the keywords of authors, or keywords which are very important in the network.

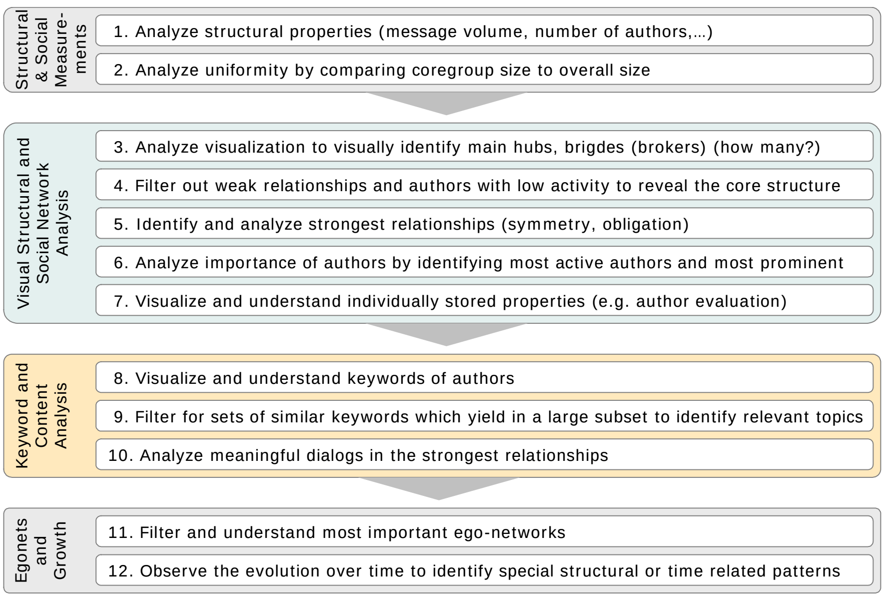

Figure 95: Towards a Procedure for IT-supported Analysis of Virtual Communication Networks.

The simple keyword study can be extended by observing the actual contents, e.g. by tracing some meaningful dialogs of strong relationships. Together with the previously analyzed properties of the relationships this can yield insights about knowledge processes. The final step takes a closer look at individual subnets of authors (ego-centric networks) and their properties. Finally, the growth and evolution of the network is studied using the longitudinal animation.

The four stages shown in Figure 95 are obviously related to the four measurement domains for the analysis of electronic communication networks, namely structural, social network, knowledge process and growth measures, as introduced in section 7.2. It has to be noted that more research is necessary for developing applicable measures (and related visualizations) for the observation and evaluation of knowledge processes and growth. Another important implication is that in large networks, the filtering approaches take a very central role to reduce the overall network to meaningful subnets which allow observation, measurement, and evaluation. This can include filtering for important authors, relations, time sequences, or topics.

Next to these future development needs, it is also necessary to note, that actual measurement is still difficult, especially if it is to prepare the qualitative evaluation of working versus poor structures. This is mainly due to some conflicting options for interpretation. It is simply hard to tell, whether a structure is poor. Here, some first list of objective criteria needs to be discovered.

For example, if over 6 months A sent fewer messages than he received, does this indicate his obligation to write more in the future or does this simply represent his normal network position as a collector of information? Further, interpretation of measures strongly corresponds to the type of network. For example, in a discussion board the necessary density is usually lower than in an e-mail network, as all communication is centrally visible, so that not every new person needs to get into contact with the expert and on average, the number of 'necessary' relations is therefore lower. Another example is the actual establishment of relationships. Although frequent communication forms this relationship, such frequent communication in a community with virtually unlimited members does rarely happen. There seems to be the primacy of topic-orientation. The users do not look for generating relationships but for helping others out if their topic of expertise is requested. However, the second case showing the actual long term corporate application proves that strong relationships are being built to a limited set of persons.

Finally, when looking at all the results of the cases, an indirect but important issue needs to be discussed. It is the immediate danger for privacy issues, which is sometimes causing criticism. Here it has to be checked, if legal rights of the studied individuals are affected. This is especially the case in peer-to-peer based networks (e.g. e-mail or instant messaging), where the individual person stores his messages and thus is interested in a high degree of privacy. In discussion boards, this issue is elevated to the group level. Every person contributing to the group agrees on the public character of his posting within that group. However, it has to be ensured, that the group as a unit enjoys a certain degree of privacy. This issue can be dealt with by only working with anonymized authors. However, in some corporate applications of this analysis, it might be the objective to identify a special expert person. Here, careful considerations have to be carried out to ensure a satisfactory protection of private data and to avoid a detrimental behavior of the group's members.

10 Outlook: 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 systematical 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.

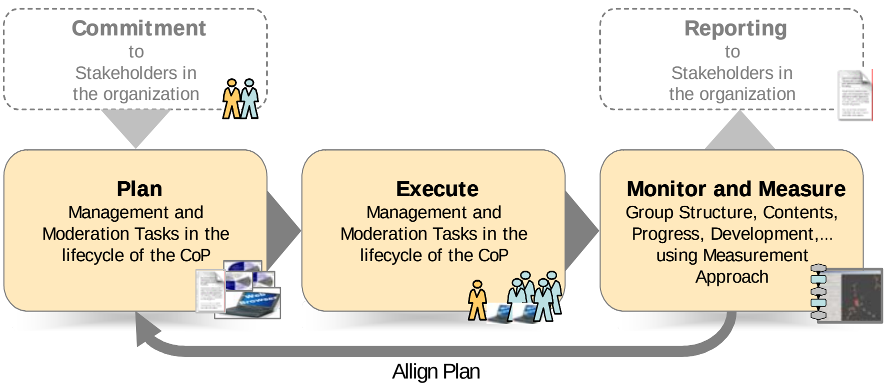

Figure 96: A concept for People Network Management in a Virtual Community using Social Network Intelligence Software.

The first necessary element of such a People Network Management is the planning of intended management and moderation tasks for a specific community. This can be influenced by commitments which the community has to sponsors, service departments, or Knowledge Management strategies. The plan is executed in the actual task of moderating or managing the group through the stages of the lifecycle as described in chapter 5.8. Throughout this work a systematical monitoring of the group's development can be employed. This activity utilizes the software application as introduced in chapter 8. The achieved insights can then be applied to configure the structural properties, described in chapter 5.4 or to adjust management activities again and the loop can start over (cf. Figure 96). Additionally, a report documentation can be created to communicate the progress and value to the members and to external stakeholders.

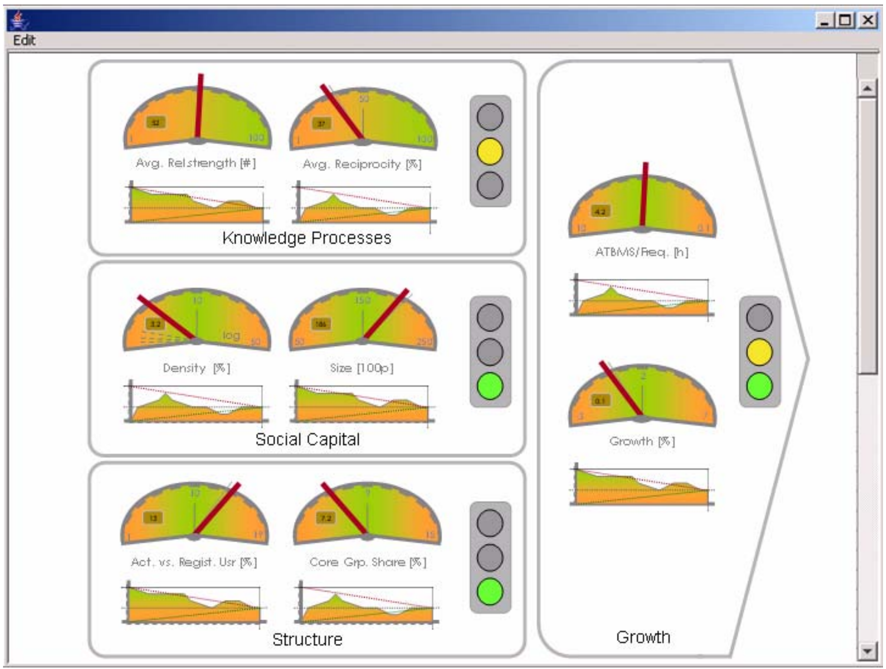

Figure 97: A Cockpit for IT-supported People Network Management.

The continuous observation of the group's structure, its social network evolution, and knowledge processes can eventually be supported by an actual monitoring cockpit. An illustration of how such a cockpit for IT-supported management of Virtual Communities could look like is given in Figure 97. For each of the measurement domains, two dashboard instruments have been selected. For example, in the structural domain, the manager observes the ratio of active versus registered users and the ratio of the core group versus all members to analyze participation and uniformity of the network. If the core group share gets to high, this implies a closed group in the center, which does not react satisfactorily to external requests.

By setting his generally expected ratios as normative benchmarks, the moderator can quickly see if activity decreases or centrality increases more than intended. Currently, the traffic light is green, meaning that every measure is in the tolerance zone. In the domain Social Capital formation, the manager observes density, which is logarithmically scaled and size over time. In the knowledge process domain, he has selected the indicators for average relationship strength and average reciprocity. Here the traffic light is yellow, implying that one of these measures approaches a threshold limit selected by the manager. The growth dimension displays a measure for the Average Time Between Messages Sent (ATBMS), which is a proxy for the frequency or speed of the posting activity. Further, there is a measure which represents growth. The traffic light implies that one of these factors is approaching the threshold for an alert.

The previous example of a Cockpit interface shows, what could eventually be developed using the methodology and the software approach introduced in this book. With such concepts, the moderation of communities could eventually be advanced towards a true (people network) management role. Still, it has to be emphasized again, what already has been discussed in chapter 5.6: the management of networks is very different to the conventional understanding of managing. It can not employ hierarchical authority and has to consider the network itself as an object for analysis and intervention. Primarily, the social aspects come first, which render the manager more a facilitator than a decider for the group. This is simultaneously a very modern approach to managing in a complex environment with autonomous knowledge workers which derive value from expert networks.

Finally, it can be concluded, that the further development of software applications which support virtual community monitoring is a rewarding research area. This coincides with the recent publication of Gartner Group (2004) about the future growth domains for Emerging Technologies: It defined ten software fields as ‘On the Rise’. Next to topics like RFID, Augmented Reality, Wikis, Information Extraction, or Truth Verification, software which supports Social Network Analysis is on this list. This promises much further development in this field during the next years.

11 Literature

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12 Appendices

12.1 CoPs in corporate KM Approaches – Overview

Overview about recent corporate approaches to CoPs and KM:

Organization	Target Value Proposition	Approach	Results
ChevronTexaco	Reduce operating costs, improve operational excellence, improve safety	CoPs, facilitate transfer of best practices, People Finder	Two billion dollar reduction in annual operating costs (1991 v. 1998); $670 million came from refining best practices. **Total investment of more than $2 million (total figure unknown)**
Dow Chemical	Provide faster access to information, improve information management, improve sales leads	Content management, communities of practice	Increased number of sales leads —Increase in new product sales Improved customer satisfaction scores **CM investment of over $3 million for start up, $8 million annually.**
GE Plastics	Decrease customer service costs	Customer portal, customer knowledge repository	Number of test chips created decreased from 4.2 to 2.7 Average reduction of 4.5 hours per color match Savings of $2.25 million per year **Total investment unknown**
Shell	Create a single, global company Reduce cycle time "Too fast to follow"	Global Networks (CoPs) New ways of working Letting the new guys into "Old Boy" networks Transfer of best practices	$200 million/yr cost savings Reduced number of wells Increased facility uptime Reduced design and planning errors **Total investment of approximately $4 million**
BP	***Know-how:*** A brand attribute; ability to innovate and execute faster and smarter than competitors	Networks, Peer Assist, AARs, Retrospects, Technology VP support, Operations Value Process	$260 million cost savings Drilling cost reduction for Schiehallion (West of Shetlands) Refinery turnarounds Retail site construction , **Total investment unknown**
Schlumberger	Knowledge in the hands of employees and customers	CoPs, InTouch KM system, intranet, extranet, content management	$200 million cost savings 95 percent reduction in time to resolve tech queries 75 percent reduction in updating modifications **Total investment of approximately $20 million**
Cap Gemini Ernst & Young	Faster revenue growth, lower costs	CoPs, central KM managers, content management	Ten-fold increase in revenue with only **five-fold increase** in employees
IBM Global Services	Revenue growth, industry leadership	COPs, knowledge managers, Intellectual Capital Management System	400 percent increase in service revenue Time savings of $24 million in 1997 **Approximately $750K to start up, $750K annually to maintain**
Best Buy	Bring creative new solutions to market faster, shorten the learning curve, lower costs	Portal (RetailZone), Employee Toolkit, Communities of Practice (Retail and Services)	1.5 percent increase in gross margin Sold 4.2 units/store/day more in pilot stores 3 percent drop in damage claims Paper reduction savings of $250K/year **Total investment of approximately $3.5 million**
Data gleaned from APQC's "Successfully Implementing KM" (1999), "Managing Content and Knowledge" (2001), and "Retaining Valuable Knowledge" (2002) benchmarking studies			

(cf.: http://www.providersedge.com/docs/km_articles/Measuring_KM.pdf)