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Modeling Knowledge Work for the Design of Knowledge Infrastructures

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Abstract: During the last years, a large number of information and communication technologies (ICT) have been proposed to be supportive of knowledge management (KM). Several KM instruments have been developed and implemented in many organizations that require support by ICT. Recently, many of these technologies are bundled in the form of comprehensive, enterprise-wide knowledge infrastructures. The implementation of both, instruments and infrastructures, requires adequate modeling techniques that consider the specifics of modeling context in knowledge work. The paper studies knowledge work, KM instruments and knowledge infrastructures. Modeling techniques are reviewed, especially for business process management and activity theory. The concept of knowledge stance is discussed in order to relate functions from process models to actions from activity theory, thus detailing the context relevant for knowledge work.

Keywords: activity theory, business process management, knowledge infrastructure, knowledge management instrument, knowledge stance, knowledge work, modeling, process
Category: H.1

1 Introduction

Information and communication technologies (ICT) to support the handling of knowledge in organizations have been discussed for quite a long time. Artificial intelligence systems have had a powerful impact on the conceptualization of knowledge. Both, academics and practitioners alike have spent considerable efforts to establish ICT support for the handling of knowledge, an idea that is almost as old as the field of computer science. Not surprisingly, the solution is still not there and many businesses trying to implement these technologies have been frustrated by the fact that the technologies certainly could not live up to the overly high expectations. However, there are still numerous projects in organizations that try to tackle the fundamental challenge of how to increase *productivity of knowledge work*.

In the 90s, after a period of high attention to the increase of efficiency of business processes, organizations were faced with the transformation of society into a knowledge society and its challenges to significantly increase the speed of innovation and improve the way organizations handle (distributed) knowledge. Concepts of knowledge management (KM) were suggested to meet these challenges. In its short history, KM has absorbed a wide array of research questions which made it interesting and attractive for a large community as diverse as its authors with backgrounds in psychology, organization science, management science or computer science. At the same time, the field of KM struggles with a large number of terms that are used differently, approaches that are incommensurable and lack applicability in a business context. More recently, however, a number of *knowledge management instruments* have emerged as state-of-the-art to support knowledge work.

Central hypothesis of this paper is that the implementation of KM technology in organizations has entered a new stage. In the last years, many vendors jumped on the bandwagon and insisted that their products had “knowledge management technology inside”. Recently, it seems that many technologies provided by the avantgarde systems have been weaved into information and communication infrastructures implemented in many organizations. Organizations should strive for improving their information and communication infrastructures, so that they are able to handle semantic descriptions of integrated, semi-structured data and offer advanced knowledge services on top of them. This is called *knowledge infrastructure*.

Therefore, KM research should head for concepts that help to implement *knowledge management instruments* fostered by *knowledge infrastructures* targeted at improving *productivity of knowledge work*. Process-oriented KM is a promising way for this [Maier04]. Business process modeling has been established in many organizations as a key task in order to analyze, understand and improve business processes and to support design, implementation and management of process-oriented ICT systems.

However, these modeling approaches lack concepts to support knowledge work which is often unstructured, creative, learning- and communication-intensive. Activity theory has been proposed to provide means to analyze knowledge work [e.g., Blackler95], but has not yet been integrated with business process modeling. Section 2 studies the concepts of knowledge work, knowledge management instrument and knowledge infrastructure. Section 3 outlines perspectives for modeling in KM. It gives an overview of extensions of process modeling approaches, describes activity modeling and compares concepts of business process modeling and concepts of activity modeling with respect to knowledge work. Section 4 studies the concept of knowledge stance to relate business processes and activities. Section 5 concludes the paper and section 6 gives an outlook to future developments.

2 Knowledge Work and Knowledge Infrastructure

This section first reviews the concept of knowledge work in order to study the changed requirements for ICT supporting this type of work. The systematic design of KM-oriented interventions targeted at improving knowledge work needs clearly defined instruments: KM instruments. Finally, basic characteristics defining comprehensive knowledge infrastructures are discussed which can guide the investigation of modeling methods suited for their design.

2.1 Knowledge Work

The concept of knowledge work was coined in order to stress changes in work processes, practices and places in the knowledge economy and thus stress differences to traditional (often manual) work. Knowledge work is characterized as follows:

- *target*: solves weakly structured problems with a high degree of variety and exceptions,
- *content*: is creative work, requires creation, acquisition, application and distribution of knowledge and bases inputs and outputs primarily on data and information,
- *mode of work*: consists of a number of specific practices, such as expressing or extracting experiences, monitoring what can be learned from happenings, translating knowledge to other domains, interpreting and absorbing knowledge and networking with other people,
- *personal skills and abilities*: uses intellectual abilities and specialized knowledge rather than physical abilities and requires a high level of education, training and experiences resulting in skills and expertise,
- *organization*: is often organized decentrally using new organizational metaphors, such as communities of specialized knowledge workers, has strong communication, coordination and cooperation needs and is highly mobile, flexible and distributed,
- *ICT*: requires a strong yet flexible personalized support by information and communication technologies.

When compared to traditional work, knowledge work can be characterized by stronger communication needs, weakly structured and less foreseeable processes, assignment of multiple roles to one person rather than a single job position per person and increasing importance of teamwork in the form of project teams, networks and communities in addition to work groups and departments. These changes are reflected by a decentral organizational design that strengthens the position of decentral units.

The boundaries of an organization are blurry and knowledge workers are engaged in a large number of communication, coordination and cooperation processes and practices that cross the organizational boundaries. Alliances, joint ventures, (virtual) networks and professional communities are some examples for types of institutional settings that have been developed to organize these exchanges.

From an ICT perspective, the main changes in the requirements occur due to considerably higher complexity of data and the focus on organization-wide and inter-organizational communication and mobility of employees engaged in knowledge work. Storage and handling of semi-structured data require additional ICT systems, e.g., document, content and competence management systems or experience data bases. Coordination in traditional office work is provided by workflow management systems that implement operative business processes. The lesser structured knowledge work can be coordinated by collaboration technologies. Consequently, modeling used to focus largely on data (entity relationship modeling), objects and classes (object-oriented modeling) and business processes (business process modeling). Knowledge work requires content-, user- and communication oriented modeling techniques that define meta-data and provide ontologies, user profiles, communication diagrams, knowledge maps and diagrams that show what objects, persons, instruments, roles, communities, rules and outcomes are involved in the main knowledge-related activities. Finally, the increased mobility of knowledge workers requires multiple, virtual workspaces that can be personalized according to the demands and practices of their users.

This calls for (1) the systematic, flexible handling of context, (2) intelligent functions to handle the vast amounts of substantially extended types of contents, i.e. semi-structured data in the organizational "knowledge base", and (3) extended functionality for collaboration. These functions have to be realized in or seamlessly integrated with the knowledge workers' personal workspaces.

Correspondingly, management focus has shifted from a mere periodical financial focus with its past orientation to a flexible and balanced set of criteria that show the current status of the organization's resources, processes, innovation and performance. Metrics are required not simply for reporting the production statistics of goods and services, but to manage the innovation process(es) in the organization.

Substantially changed work practices of knowledge workers, together with recent innovations in ICT infrastructure, demand concepts and modeling techniques that extend business process modeling to cover aspects of knowledge work. So far, investigations into ICT support for work practices primarily focus structured, routine work e.g., by workflow management systems. It is only recently that authors are interested in the analysis of the specifics of knowledge work. Schulze identifies three informing practices in knowledge work through an ethnographic study of knowledge workers in a large Fortune 500 manufacturing firm [Schulze00b]:

- Ex-pressing is the practice of self-reflexive converting of individual knowledge and subjective insights into informational objects that are independent of the knowledge worker. Therefore, the knowledge worker "splits himself" into an experiencing and a writing self, continuously moving between the realm of doing and the realm of documenting. Knowledge workers have to suspend their subjectivity in order to become an objective observer. A typical example is the work of administrators documenting their thoughts and actions.
- Monitoring describes the continuous non-focused scanning of the environment and the gathering of useful "just in case"-information. Monitoring identifies important events and keeps the knowledge workers up to date in the area of interest and has to be done in an unobtrusive and objective way because of the danger to "contaminate" the information by the knowledge workers' interests or subjectivity. The practice is typical for the work of corporate competitive intelligence analysts with the mission of "objective, accurate, and reliable reporting".
- Translating involves the creation of information by ferrying it across multiple realms and different contexts until a coherent meaning emerges. Established frameworks, concepts, and theories are necessary to balance subjective induction with objective deduction. An example is the search strategy of corporate librarians, who iteratively try to coherently combine the interpretation of their customers' questions with answers resulting from their search.
- Moreover, networking could be an informing practice, too [see Schulze03 who refers to Knights93]. It describes the building and the role of relationships with people inside and outside the company that knowledge workers rely on.

To sum up, knowledge work is creative work solving unstructured problems that require exploration or creation of knowledge and can be categorized with the help of informing practices. These practices are the result of a certain research focus and thus further informing practices may exist but have not yet been identified.

2.2 Knowledge Management Instrument

Knowledge management is defined as the management function responsible for regular selection, implementation and evaluation of knowledge strategies that aim at creating an environment to support work with knowledge internal and external to the organization in order to improve organizational performance. The implementation of knowledge strategies comprises all person-oriented, product-oriented, organizational and technological instruments suitable to improve the organization-wide level of competencies, education and ability to learn and thus improve the productivity of knowledge work [Maier04].

Supporting knowledge work thus requires systematic interventions with the help of instruments. Even though the terms KM instrument, KM project, KM initiative and KM measure are widely used, there is hardly any concrete definition of any of these terms. A large number of measures has been proposed as part of case studies on KM which also comprise more traditional person-oriented measures, e.g., programs for personnel development, content-oriented measures that revolve around the use of (simple) metadata, organizational measures, e.g., job rotation, job enrichment or ICT measures, e.g., the use of data bases, email or Groupware.

KM instruments target different goals and consist of several measures that have to be aligned and supplement each other. The term KM instrument can be defined as being part of an ICT-supported intervention into an organizational knowledge base and consist of a collection of organizational, human resources and ICT measures that are aligned, clearly defined, can be deployed purposefully in order to achieve knowledge-related goals, target contextualized information as object of intervention and are independent of a particular knowledge domain.

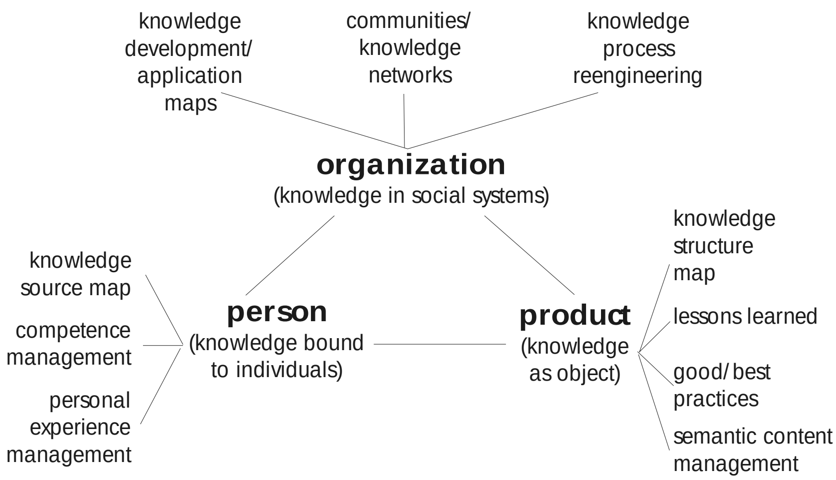

Figure 1: Classification of knowledge management instruments

Figure 1 gives an overview of a number of KM instruments well-described in the literature [for a detailed analysis of the term and descriptions of KM instruments see Peinl04, Maier05].

Even though KM instruments were defined as comprising person-oriented, product-oriented, organizational and ICT measures, actual KM instruments usually target one of the media of knowledge. All KM instruments can be supported by ICT. Basically, KM instruments thus are distinguished according to the main medium of knowledge into person-oriented, product-oriented and organizational instruments.

Person-oriented KM instruments primarily aim at knowledge that is directly bound to individuals, e.g., personal experiences, ideas, proposals etc. These are knowledge mapping, competence management and personal experience management.

Central goal in *knowledge mapping* is the creation of corporate knowledge directories which visualize existing knowledge in organizations and support a more efficient access to and handling of knowledge. The main objects of mapping are experts, project teams, networks, white papers or articles, patents, lessons learned, meeting protocols or generally document stores. Different types of knowledge maps are suggested, e.g., knowledge source maps, knowledge development and application maps or knowledge structure maps.

Competence management supports systematic analysis, visualization, evaluation, improvement and usage of competences held by individuals in organizations. Competence management comprises expertise locators, yellow and blue pages as well as skill management systems, also called people-finder systems. A central skill ontology has to be defined for existing, required and wanted skills. Skill management systems are often not limited to information about skills, their holders and their skill levels, but also contain information about job positions, projects and training measures in which employees learned, used and improved their skills. Yellow and blue pages are directories of organization-internal and -external experts respectively.

The implementation of systems for *personal experience management* eases documentation, sharing and application of personal experiences in organizations. Several approaches exist that support capturing of experiences, e.g., Information mapping, learning histories or microarticles that help employees to document and structure experiences. Organizational measures are required that provide time tolerances and keep the effort as low as possible. Simultaneously, sufficient context of the experience has to be provided. ICT solutions help to automatically detect context.

Organizational KM instruments target knowledge that resides in social systems. Social systems in organizations are described with the help of the formal organization design, especially business and knowledge processes supported by knowledge process reengineering and process warehouses, projects and work groups supported by knowledge application and development maps as well as the informal organization, reflected by communities and knowledge networks.

Community management targets creation and fostering of *communities or knowledge networks*. Communities differ from knowledge networks with respect to who initiated their foundation. Communities are founded by like-minded people (bottom-up) and can at most be fostered by the organization. Knowledge networks are established and legitimated by management (top-down). Organizational and ICT measures to foster communities are the same as the ones used to support knowledge networks. Organizations can provide employees with time and space (e.g., meeting rooms) to share thoughts, establish IT tools (e.g., community builder or home spaces, blackboards or wikis) that support exchange of thoughts and create new roles like community managers that help keeping discussions going and look for important topics that should gain management attention.

Knowledge process reengineering (KPR) aims at redesigning business processes from a knowledge perspective. The term references the field of business process reengineering (BPR) that aims at fundamental (process innovation) or evolutionary (process redesign) changes of business processes. Business processes are modeled with the help of modeling techniques. The models are stored in model bases. The model base can be expanded so that it handles not only knowledge about the process, but also knowledge created and applied in the process. This is termed process warehouse. Examples for contents in process warehouses are exceptional cases, case-based experiences, reasons for decisions, checklists, hints, frequently asked questions and answers, potential cooperation partners or suggestions for improvements.

Product-oriented instruments target documented knowledge that certainly is of primary interest with respect to the design of knowledge infrastructures. Documented knowledge can be spread across multiple sources and require integration which is supported by ontologies or knowledge structure maps. Ontologies also aid the management of semantic content. While these two instruments target (electronically available) content as potential knowledge sources throughout the organization, there are two instruments that specifically establish the systematic handling of inter-subjective knowledge with commitment, e.g., lessons learned, good or best practices.

Lessons learned are the essence of experiences jointly made and systematically documented in e.g., projects or learning experiments. In a process of self-reflection, e.g., at the end of a project milestone the project members jointly review and document critical experiences made in this project. Lessons learned should aid individual self-reflection about one’s own experiences, joint reflection that explicates know-how gathered in a team and learning from the experiences of others. This process can be moderated by a lessons learned coach. Templates can be created that support structured documentation and including context information. An information system can aid this process, store and provide access to lessons learned.

Sharing of *(good or) best practice*s is an approach to capture, create and share experiences in a process-oriented form as e.g., procedures or workflows. This term in a wide meaning denotes “any practice, knowledge, know-how or experience that has proven to be valuable or effective within one organization that may have applicability to other organizations” [O'Dell98]. As managers might argue about what exactly is “best” in a practice, several organizations use different levels of best practice, e.g., (1) good (unproven) idea, (2) good practice, (3) local best practice, (4) company best practice, (5) industry best practice. Best practice teams provide guidelines about what constitutes good or best practices and support identification, transfer, implementation, evaluation and improvement of practices.

Semantic content management refers to managing meaningfully organized content, i.e. documented knowledge embedded in a context. Content is well-described with the help of meta-data, descriptions are machine-interpretable and can be used for inferencing. The instrument is tightly related to an IT solution, but there have to be rules that guide definition and use of semantics, monitoring external knowledge sources for interesting content that should be integrated, developing an appropriate content structure as well as publishing of semantically enriched contents.

Knowledge infrastructures foster the implementation of knowledge strategies with the help of a defined set of KM instruments.

2.3 Knowledge Infrastructure

Generally, there are a number of approaches to define ICT that supports knowledge work. This is reflected by a large number of different terms in use, such as knowledge infrastructure, knowledge management system, knowledge-based information system, knowledge management software, suite or support system, knowledge-oriented software, knowledge warehouse or organizational memory (information) system. Furthermore, e-learning suite, learning management platform, portal, suite or system define software systems that not only support presentation, administration and organization of teaching material, but also interaction between and among teachers and students. Knowledge management systems with roots in document management, collaboration or Groupware and learning management systems with roots in computer-based training already share a substantial portion of functionality and seem to converge or at least be integrated with each other.

In addition to these terms meaning a comprehensive platform in support of KM, many authors provide more or less extensive lists of individual KM tools or technologies that can be used to support KM initiatives as a whole or certain processes, life cycle phases or tasks thereof.

Knowledge infrastructures are organization-wide platforms that offer a joint workspace for collaboration, information, knowledge and learning to support knowledge work. In the following, the most important characteristics of knowledge infrastructures will be summarized (see Figure 2).

Goals. The use of this kind of systems aims at increased levels of effectiveness for the organization. The primary goal of knowledge infrastructures thus is to increase organizational effectiveness by a systematic management of knowledge. Thus, knowledge infrastructures are the ICT environment for effective knowledge work, the technological part of a KM initiative that also comprises person-oriented and organizational instruments targeted at improving productivity of knowledge work. The type of initiative determines the type of infrastructure for its support.

Processes. Knowledge infrastructures are installed to support and enhance knowledge-intensive processes, tasks or projects of e.g., knowledge creation, organization, storage, retrieval, transfer, refinement and packaging, (re-)use, revision and feedback, also called the knowledge life cycle, ultimately to support knowledge work. In this view, knowledge infrastructures provide a seamless pipeline for the flow of explicit knowledge through a refinement process, or a thinking forum containing interpretations, half-formed judgements, ideas and other perishable insights that aims at sparking collaborative thinking.

Comprehensive platform. Whereas the focus on processes can be seen as a user-centric approach, an IT-centric approach provides a base system to capture and distribute knowledge. This platform is then used throughout the organization. In this view, knowledge infrastructures are not application systems targeted at single KM initiatives, but platforms that can either be used as-is to support knowledge processes or that is used as the integrating base system and repository on which specific KM application systems are built. Comprehensive means that the platform offers extensive functionality for user administration, messaging, conferencing and sharing of (documented) knowledge, i.e. publication, search, retrieval and presentation.

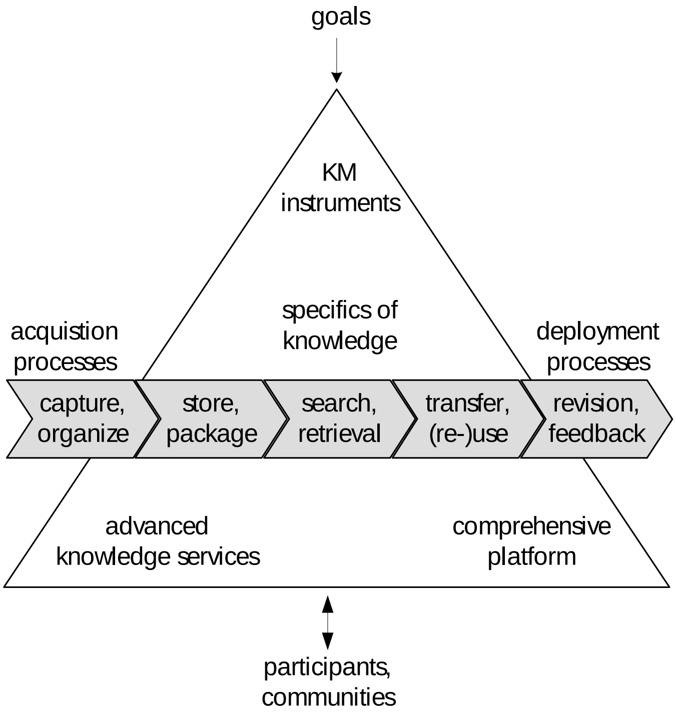

Figure 2: Characteristics of knowledge infrastructures

Advanced knowledge services. Knowledge infrastructures are described as ICT platforms on which a number of integrated services are built. The processes that have to be supported give a first indication of the types of services that are needed. Examples are rather basic services, e.g., for collaboration, workflow management, document and content management, visualization, search and retrieval or more advanced services, e.g., profiling, personalization, text analysis, clustering and categorization to increase the relevance of retrieved and pushed information, advanced graphical techniques for navigation, awareness services, shared workspaces, (distributed) learning services as well as integration of and reasoning about various (document) sources on the basis of a shared ontology.

KM instruments. Knowledge infrastructures are applied in a large number of application areas, e.g., in product development, process improvement, project management, post-merger integration or human resource management. More specifically, knowledge infrastructures support KM instruments, e.g., (1) the capture, creation and sharing of best practices, (2) the implementation of experience management systems, (3) the creation of corporate knowledge directories, taxonomies or ontologies, (4) expertise locators, yellow and blue pages as well as skill management systems, also called people-finder systems, (5) collaborative filtering and handling of interests used to connect people, (6) the creation and fostering of communities or knowledge networks, (7) the facilitation of intelligent problem solving. Knowledge infrastructures in this case offer a targeted combination and integration of knowledge services that together foster selected KM instrument(s).

Specifics of knowledge. Knowledge infrastructures are applied to managing knowledge which is personalized information related to facts, procedures, concepts, interpretations, ideas, observations, and judgements. Here, knowledge means information that is meaningfully organized, accumulated and embedded in a context of creation and application. Knowledge infrastructures primarily leverage codified knowledge, but also aid communication or inference used to interpret situations and to generate activities, behavior and solutions. Thus, on the one hand knowledge infrastructures might not appear radically different from existing IS, but help to assimilate contextualized information. On the other hand, the role of ICT is to provide access to sources of knowledge and, with the help of shared context, to increase the breadth of knowledge sharing between persons rather than storing knowledge itself.

Participants. The internal context of knowledge describes the circumstances of its creation, e.g., the author(s), creation date and circumstances, assumptions or purpose of creation. The external context relates to retrieval and application of knowledge. It categorizes knowledge, relates it to other knowledge, describes access rights, usage restrictions and circumstances as well as feedback from its re-use. Contextualization is one of the key characteristics of knowledge infrastructures which provide a semantic link between explicit, codified knowledge and the persons that hold or seek knowledge in certain subject areas. Context enhances the simple "container" metaphor of organizational knowledge by a network of artefacts and people, of memory and of processing. Communities or networks of knowledge workers that “own the knowledge” and decide what and how to share can provide important context. Meta-knowledge, also sometimes in the form of a set of expert profiles or the content of a skill management system, is sometimes as important as the original knowledge itself. Therefore, users play the roles of active, involved participants in knowledge networks fostered by knowledge infrastructures.

Summing up, the term knowledge infrastructure can be defined as follows: (1) a comprehensive ICT platform (2) for collaboration and knowledge sharing (3) with advanced knowledge services built on top that are (4) contextualized, integrated on the basis of a shared ontology and (5) personalized for participants networked in communities (6) that fosters the implementation of KM instruments (7) in support of knowledge processes (8) targeted at increasing productivity of knowledge work.

3 Modeling Knowledge Work

Models are representations of a selected portion of the perceived reality of an individual or a group of observers. Modeling is one of the key tasks that helps on the one hand to understand, analyze and improve knowledge work and on the other hand guides design and implementation of KM instruments and knowledge infrastructures. This section first presents a framework for analyzing and relating concepts used to model knowledge work. It then turns to (extended) process modeling and activity modeling. These two comprehensive approaches are compared to each other considering their attempt to capture a substantial portion of the environment of knowledge work.

3.1 Perspectives for Modeling in KM

The design of KM initiatives requires joint consideration of important KM modeling concepts: (1) KM instruments, (2) organizational design, i.e. knowledge tasks and processes, roles and responsibilities, (3) people, i.e. skills, communication and cooperation in networks and communities, (4) knowledge topics and structures, i.e. type of knowledge, ontologies and meta-data and (5) ICT tools and systems, i.e. functions, architecture, structure and interaction of knowledge infrastructures (see Figure 3).

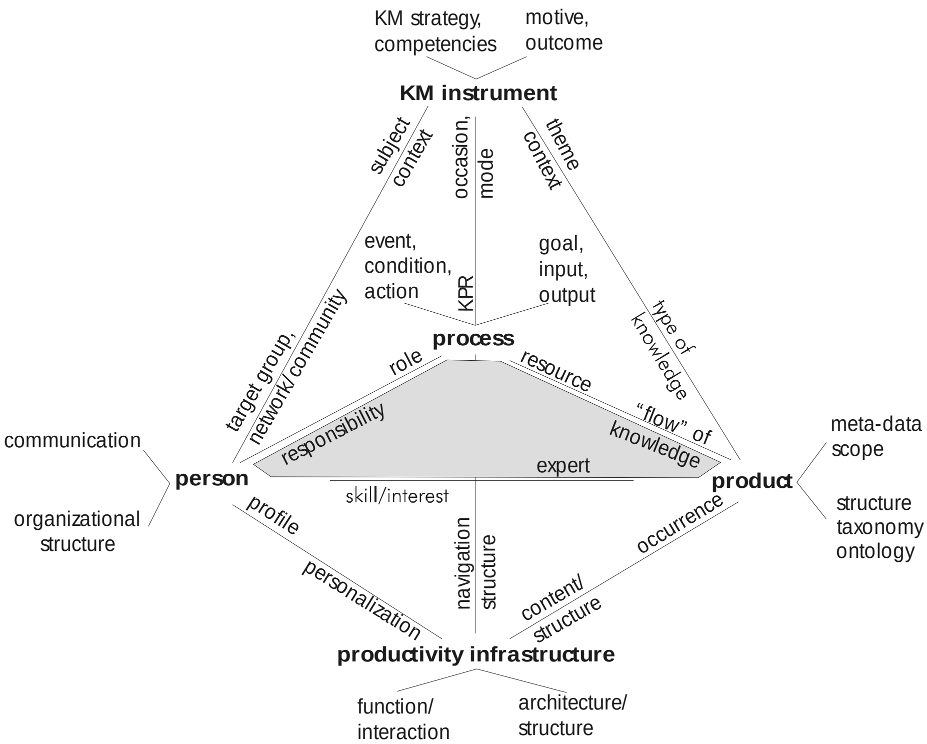

Figure 3: Perspectives for modeling in knowledge management

The five main perspectives KM instruments, person, process, topic and productivity infrastructures in the sense of knowledge infrastructures aiming at increasing productivity of knowledge work, are connected by a number of concepts. Persons are involved in processes by responsibilities for activities and roles that are assigned to actions. Processes, especially activities and actions, are supported by knowledge infrastructures in order to improve organizational performance. Also, processes can be used to aid navigation in infrastructures. Topics are mapped to occurrences, e.g., documents or other resources. Structures, taxonomies and ontologies can be used as the primary structure of contents stored in infrastructures. Persons hold skills that are structured as topics. Persons and networks have interest in topics. Experts take care of certain topics in organizations, e.g., subject matter specialists. Processes and topics are connected by knowledge resources, e.g., in the form of skills and in the form of documents that are required in activities and actions and by the so-called “flow” of knowledge. This “flow” refers to an analysis of the knowledge lifecycle, i.e. in which actions or activities knowledge is created, distributed and applied. Identity management, i.e. profiles and personalization techniques, are used to support access of contents and services in knowledge infrastructures. Finally, KM instruments link the context of persons, topics and infrastructures to certain steps in processes which provide occasions for knowledge-oriented tasks.

A large number of modeling approaches, methods and techniques have been developed in the literature. Examples are business process modeling, communication modeling, data modeling, data flow modeling, knowledge modeling or object-oriented modeling [e.g., Balzert01]. Each of these approaches predominantly focuses one of these dimensions.

3.2 Process Modeling

In the last years, many organizations have applied concepts of business process reengineering [e.g., Davenport93; Hammer93] and a number of methods and techniques to support business process modeling have been proposed in the literature. As process modeling is a complex task that requires computer support in order to be an economically feasible approach, most methods are applied with the help of a corresponding tool. Examples are ADONIS [Junginger00], architecture of integrated information systems - ARIS [Scheer98; Scheer01], integrated enterprise modeling - IEM [Spur96; Heisig02], multi-perspective enterprise modeling - MEMO [Frank02], PROMET for process development (PROMET BPR) and for process-oriented introduction of standard software (PROMET SSW, [Österle95]), semantic object modeling - SOM [Ferstl94; Ferstl95] or business process modeling methods on the basis of the unified modeling language UML [Oestereich03]. Moreover, there is a number of frameworks and reference models for the definition of workflows that implement business processes [see e.g., Kumar99; WfMC01]. The methods differ in formality, semantic richness and understandability.

Recently, a number of authors have proposed extensions to business process modeling techniques that model (some of the) specifics of KM. Examples are extensions to ARIS [Allweyer98], the business knowledge management framework and the corresponding modeling method PROMET®I-NET [Bach00; Kaiser99], GPO-WM [Heisig02], KMDL [Gronau03], Knowledge MEMO [Schauer04] and PROMOTE [Hinkelmann02; Karagiannis03]. Main extensions are on the one hand additional object types, e.g., knowledge object, i.e. topics of interest, documented knowledge, individual employee, and skill, and on the other hand additional model types, e.g., knowledge structure diagram, communication diagram and knowledge map. Ideas for concepts that have to be modeled in order to capture more detailed aspects of knowledge-intensive tasks have been implemented in tools for flexible workflow management [Goesmann02]. Examples are Bramble [Blumenthal95], KnowMore [Abecker98], MILOS [Maurer98], WorkBrain [Wargitsch99], and Workware [Carlsen98].

Even though the added concepts describe a portion of the context of knowledge work, they are not suited to model the often unstructured and creative learning and knowledge practices in knowledge work and particularly their link to business processes. The various modeling approaches offer different support for the modeling perspectives person, process, product, KM instrument and productivity infrastructure. Some aim more at an organizational redesign and thus on persons and processes whereas others guide the implementation of software and thus are more inclined towards products and productivity infrastructures. None of the methods clearly focusses design of KM instruments.

Most modeling methods implicitly assume that knowledge is an object that can either be documented or possessed by an individual. Some of the introduced concepts are not limited to the level of object types, but describe instances of objects. Examples are individual employees and individual skills. The methods vary with respect to expression, i.e. the number of modeling elements, degree of formalization as well as primary modeling goals. They either aim at designing processes, networks, HRM tasks or knowledge infrastructures. In the latter case, methods can be classified according to whether they focus modeling at and for build time versus run time of knowledge infrastructures. Finally, as with all modeling methods, there is varying support by procedure models and tools that ease the burden of drawing models and translating them into reusable pieces of software or knowledge descriptions.

3.3 Activity Modeling

ICT systems have to fit with the users' situated work practices in order to model and support knowledge work [e.g. Greenbaum91; Sachs95; Schulze00a, also Hädrich04 for a previous version of this analysis]. Activity theory has been proposed to provide means to analyze knowledge work [e.g. Blackler95] and to guide the design of information systems, especially group support systems, but recently also knowledge infrastructures [see e.g., Sachs95; Kuuti97; Collins02; Clases02; Hasan03].

Acquisition of knowledge in modern learning theories is not a simple matter of taking in knowledge, but a complex cultural or social phenomenon. Thus, some authors suggest not to model knowledge as an object with its connotations of abstraction, progress, permanency and mentalism as proposed in the extensions to process modeling (see section 3.2), but as processes of knowing and doing which take place in (socially-distributed) activity systems [e.g., Blackler95].

Figure 4 shows the elements of activity systems. These systems provide a unit of analysis for the dynamic relationships among individuals (called agents or subjects), their communities and the conception(s) they have of their activities (called object; inner triangle in Figure 4). These relationships are mediated by instruments and concepts (e.g., language, technologies) used by the agents, implicit or explicit social rules linking them to their communities and the role system and division of labor adopted by their community (outer triangle in Figure 4; [Engeström87]).

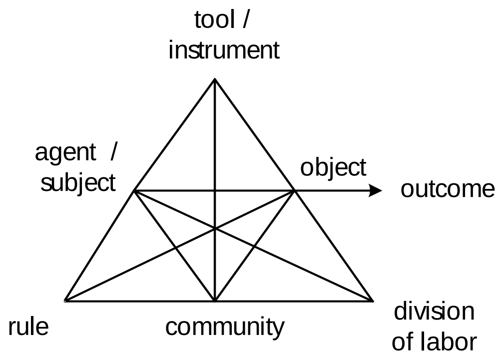

Figure 4: Model of the socially-distributed activity system[1]

Activities have a hierarchical structure (see Figure 5): They are driven by common motives which reflect collective needs [Engeström99]. They are accomplished by actions directed to goals coupled to the motives. There is a many-to-many relationship between activities and actions: an action could belong to multiple activities and the object of an activity could be reached by multiple alternative actions [Engeström99]. Actions in turn consist of orientation and execution phase. The first comprises planning for action, the latter execution of the action by a chain of operations [Kuuti97]. The better the model upon which planning is based fits the conditions, the more successful the action will be. Actions can collapse into operations, if the model is accurate enough, so that no planning is necessary. Operations are executed under certain conditions and are the most structured part that is easiest to automate.

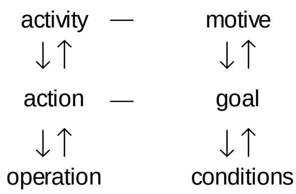

Figure 5: Hierarchical structure of an activity [Kuuti97]

An important feature of activity theory is the dynamic relationship between the three levels. Operations can again unfold into actions, e.g., if conditions change, as well as actions can become activities. Elements of higher levels collapse to constructs of lower levels if learning takes place. They unfold to higher levels if changes occur and learning is necessary.

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[1] Figure 4 is based on [Enge87], see also [Blac95], [Enge99].

3.4 Comparison of Process and Activity Modeling

Process modeling describes routine work solving structured problems that primarily aims at exploitation or application of knowledge. However, as stated in section 2.1, knowledge work does not fall into this category. Consequently, an alternative concept is needed to describe knowledge work. Still, processes describe the details of an organizational value chain that provides the main concept to ensure that activities in the organization are targeted towards creating customer value.

The concepts provided by activity theory are well suited to analyze the creative, unstructured and learning-oriented practices of knowledge work. Activities primarily operationalize exploration as strategic focus. They aim at the joint creation of knowledge that is then applied in business processes. However, although activity theory comprises motives and objects, they lack integration with the value chain. It is not ensured that activities are oriented towards creating customer value. Therefore, concepts of process and of activity modeling have to be combined in order to get a more comprehensive picture of knowledge work in a business context.

Nonaka's metaphor of the hypertext organization [Nonaka94] can be used to illustrate the relationship between process and activity modeling. It consists of the three layers (1) business system layer on which routine operations are performed by a formal, hierarchical, bureaucratic organization, (2) project system layer on which knowledge is developed within multiple self-organizing and loosely coupled projects and (3) knowledge base layer consisting of tacit and explicit knowledge. Employees can switch between these layers that provide the context of knowledge creation. The business system layer might be described by concepts of process modeling and the knowledge base layer might be described by concepts of activity modeling. The project system layer connects these two layers. Projects can be described by process models or activity models. It remains unclear how the relationship between these layers can be modeled. In a first step, Figure 6 maps business processes and activities on three levels and contrasts refinement in business process modeling and routinization in activity modeling [see Hädrich04].

Refinement in process modeling can be characterized as an aggregation / specialization relationship consisting of the following three levels:

- *value chains*: are modeled by core and service processes relevant for an organization.
- *processes*: can be detailed as a sequence of events and functions, e.g., as event-driven process chains.
- *tasks*: each function can be modeled as a number of tasks that have to be fulfilled in order to accomplish a function's goals.

Hierarchization in activity modeling means routinization and consists of the following three levels:

- *activities*: are defined with respect to strategic core competencies identified in a process of strategy development.
- *actions*: what has been learned by a person or a group of persons can be used as a skill or competence in a (series of) actions within a business process.
- *operations*: further routinization of actions yields operations, i.e. detailed descriptions of how to fulfil a task that can be automated or at least heavily supported by ICT.

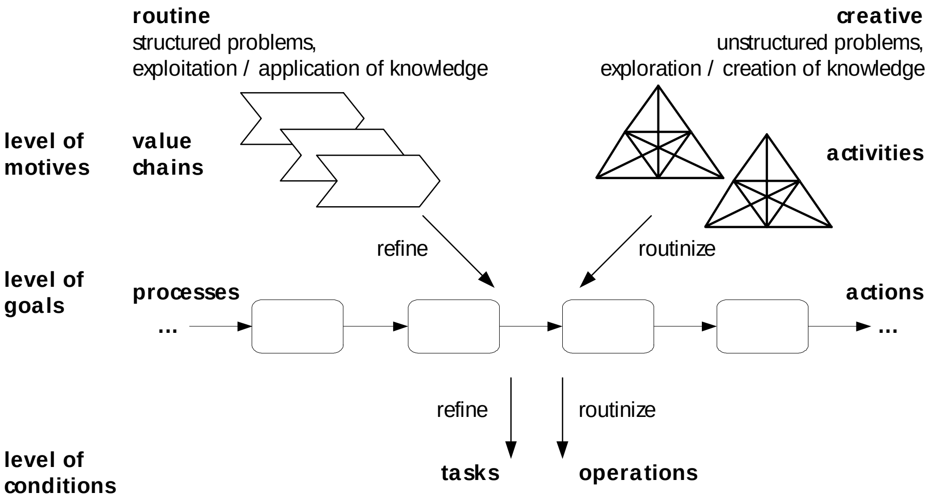

Figure 6: Process modeling and activity modeling compared [see Hädrich04]

The three levels contrasted here can be characterized as level of motives, goals and conditions. Motives specified in a business strategy lead to the definition of processes and activities in a process landscape and a set of activities respectively. Value chain orientation and activity orientation could be integrated on the level of goals. On this level, actions could be connected to event-driven process chains. Processes and actions are performed in order to achieve certain goals that are determined considering the motives during process design and analysis of activities. Finally, conditions trigger tasks and operations.

Consequently, concepts of process modeling and of activity theory provide two different perspectives on work practices in business organizations. The process-oriented perspective focuses implementation, exploitation, and accumulation of knowledge in the context of business processes. Some knowledge-related tasks may be described by knowledge processes and knowledge flows, i.e. by extended process modeling techniques. The activity-oriented perspective focuses creative, dynamic, and communication-intensive tasks, unstructured problems, membership in communities, self-organizing teams and demand for learning. A concept is needed that connects these two perspectives which is termed knowledge stance [Hädrich04, Maier04].

4 Knowledge Stance

Both perspectives and the concept of knowledge stance are shown in Figure 7. In a process-oriented perspective, an employee accomplishes functions on the level of goals that belong to business processes by fulfilling a sequence of tasks on the level of conditions. Simultaneously, she can be involved in one or more activities framing knowledge-oriented actions necessary to complete the functions.

An activity can be focused on the business process or a more general activity pursuing a motive not related to the business process, e.g., an effort to build competencies related to other topics or business processes. In contrast to the clearly defined sequence of events and functions, there is no predetermined flow of actions.

A *knowledge stance* is a recurring situation in knowledge work defined by a certain occasion, a context, and a mode resulting in knowledge-oriented actions. It describes a situation in which a knowledge worker can, should or must switch from a business-oriented function to a knowledge-oriented action.

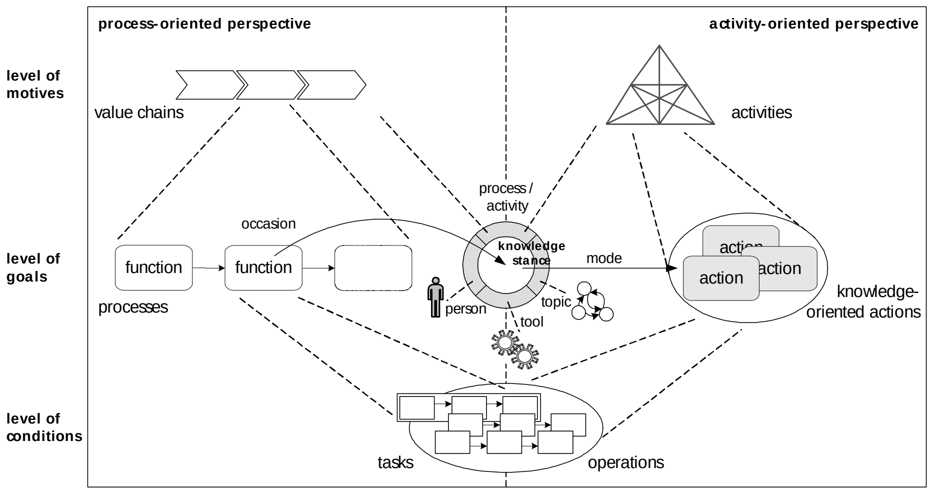

Figure 7: Concept of knowledge stance (based on [Hädrich04])

Context comprises all relevant dimensions suitable to describe the actual situation of the worker. Context is classified in process- and activity-oriented perspective on two levels of granularity, i.e. individual function/action or entire process/activity, as well as in type and instance level (based on [Goesmann01]). Instance level means in this case that context is restricted to the work order or action actually processed. Context on the type level refers to all work orders or actions of the same type.

Examples for relevant dimensions are elements of the related activity and the process, e.g., artifacts like software tools, diagrams, knowledge maps, other subjects involved, desired outcomes, relevant roles, rules, e.g., user rights, members of the community important for the user, e.g., with whom she communicates regularly, as well as other process steps connected by knowledge flows. The two dimensions location and time should also be included as they are important parts of the context.

In order to support knowledge stances with ICT, context should be derived automatically as much as possible by the knowledge infrastructure or the workspace in use on the basis of the usage history or information about the user. The best way to represent the context and the relations between the elements of the context seems to be an ontology. Thus, inferencing can be applied.

Mode can be described by the four informing practices expressing, monitoring, translating and networking (see section 2.1). Triggered by an occasion, the employee decides whether to monitor processes of knowledge generation by others, to translate knowledge to different contexts, to express knowledge or to network with relevant cooperation partners. Mode is the primary concept that frames the performed actions.

A business process offers several occasions to learn and to generate knowledge related to core competencies of the organization. *Occasions* trigger knowledge stances and are associated with the functions of which the business process is composed. Occasions offer the opportunity or create the need for knowledge-related actions. A knowledge stance is not limited to generation of knowledge, but may also include translation and application of knowledge created outside the knowledge stance which in turn offers the possibility to generate knowledge.

Context, mode and occasion are means to specify the set of available, allowed or required knowledge-oriented actions. A straightforward approach to support knowledge actions is to automate corresponding operations that accomplish the action. They are highly dependent on the stance and thus must obtain information from context variables as well as mode and occasion of the knowledge stance. This could be accomplished e.g., by offering workflows to automate actions or to guide the user by wizards known from office applications. Examples for actions improving the quality of documented knowledge elements are [Eppler03]:

- *integration actions*: visualize concepts, list sources, summarize, personalize, prioritize contents, highlight aspects, give an overview, elicit patterns,
- *validation actions*: evaluate source, indicate level of certitude/reliability, describe rationale, compare sources, examine hidden interests/background, check consistency,
- *contextualization actions*: link content, state target groups, show purpose, describe background, relate to prior information, add meta-information, state limitations,
- *activation actions*: notify and alert, demonstrate steps, ask questions, use mnemonics, metaphors and storytelling, stress consequences, provide examples, offer interaction.

From the perspective of a knowledge infrastructure, those knowledge stances are of primary interest that can be supported by ICT. Depending on occasion, context and mode, it can be decided which parts of the knowledge infrastructure, i.e. contents and services, are suited to support the selected knowledge-oriented action. With respect to the characteristics of knowledge infrastructures, knowledge stances represent situations in which a bundle of advanced knowledge services can be suggested to complete knowledge-oriented actions. In some cases, flexible knowledge processes can be offered. Due to activities framing the social system in which knowledge is handled, the specifics of knowledge are considered when designing a comprehensive platform for supporting occasions to explore or exploit knowledge in business processes. Knowledge stances also provide a concept to connect KM instruments to business processes. For example, in a certain knowledge stance, a knowledge infrastructure could suggest to document a personal experience or to start a lessons learned process depending on the activity context and the activities other members of the community are currently engaged in.

Context should be derived with as little user effort as possible. Currently opened documents on the desktop, emails in the mailbox or the history of the Web browser could be used to determine parts of context information. This could be enriched by data about the current function in the business process the user performs and data about actions that other users took in similar situations. Furthermore, awareness services could monitor current activities of other employees relevant in the knowledge stance and thus be helpful in analysing which cooperation partners are currently available or even engaged in similar business-oriented functions or knowledge-oriented actions respectively. Context elements and their relation can be represented by a standardized or shared ontology. Thus, inference techniques can be applied and context can be communicated to and translated for other applications built on the basis of the knowledge infrastructure.

5 Conclusion

The paper discussed characteristics of knowledge work, knowledge management instrument and knowledge infrastructure that have to be designed in order to support knowledge work. The paper gave an overview of the perspectives and approaches for modeling in the context of process-oriented KM. Activity theory was discussed as a means to include the dynamic, creative and often less structured aspects of knowledge work. The concept of knowledge stance was discussed to integrate the process-oriented and the activity-oriented perspective. The latter is necessary to extend modeling to knowledge activities and to the users' situated work practices. Knowledge stances are means for the design of knowledge management instruments fostered by knowledge infrastructures to support knowledge work. The suitability of this concept was briefly shown considering the characteristics of knowledge infrastructures.

6 Future Work

Many organizations have undergone substantial reorganization during the last ten years when they reengineered their business processes and exchanged proprietary, unintegrated solutions for standard ERP systems. Horizontal and vertical integration of structured data stored in relational data bases has substantially improved documentation of business transactions in organizations, increased data quality and flexibility of the organization's business processes and reporting system. Thus, ERP solutions are one important pillar of information and communication infrastructures in many business organizations. What is left, is the design of weakly structured processes as typical for knowledge work and the integration of semi-structured data and advanced knowledge services which are dispersed in numerous servers and applications, largely unintegrated and consequently hindering knowledge work.

The implementation of KM technology in organizations has entered a new stage. It is not anymore the quest for the best individual tool targeting a specific KM problem that organizations should engage in. Organizations should now systematically build a second pillar in their information and communication infrastructures. Knowledge infrastructures focus integration of valuable knowledge elements needed in weakly structured knowledge processes as much as ERP solutions targeted integration of business data needed in well-structured business processes.

The concept of knowledge stance together with concepts of activity theory seems to be an adequate extension of business process modeling to cover aspects of knowledge work. Further detailing of the elements of knowledge stances, i.e. context, occasion, mode and knowledge-oriented actions, is necessary. The concept of knowledge stance, its integration into a modeling method for KM and the subsequent design and implementation of KM instruments and knowledge infrastructures promises substantial increases in the productivity of knowledge work.

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