The Wheel of Collaboration Tools: A Typology for Analysis within a Holistic Framework

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ABSTRACT

We present a holistic framework for analyzing and specifying collaboration solutions, developed by an oil and gas company in response to practical needs in supporting integrated collaboration and information management. A typology of collaboration tool capabilities, termed the Wheel of Collaboration Tools (WCT), is described. We assess its contributions, and discuss areas of application and potential further development. Our intent is to stimulate discussion and research related to this type of collaboration modeling.

Categories and Subject Descriptors

H.4.1 [**Information Systems Applications**]: Office Automation – *groupware*; K.4.3 **[Computers and Society]**: Organizational Impacts – *computer-supported cooperative work*.

General Terms

Management, Human Factors, Standardization, Theory.

Keywords

Collaboration framework, Collaboration processes, Collaboration tools, CSCW, E-collaboration, Groupware, Typology

1. INTRODUCTION

Collaboration technologies comprise an increasingly important part of the information and communications technology (ICT) infrastructure in organizations, related to key areas such as knowledge management, process improvement, teamwork, and supply chain management. The term e-collaboration is increasingly being used in industry to denote collaboration activities supported by some form of ICT [19]. The product market of collaboration technologies is growing fast, with an estimated number of around 1000 vendors offering products with some form of collaboration functionality [6]. This includes the entire range from specialized, small-scale collaboration tools to collaboration functionality embedded in large enterprise systems, creating a vast array of potential solutions for collaboration support. A major challenge for an organization in search of technology support for collaboration is thus to navigate in this jungle of options. What is the map to be used for analyzing the organization's total needs for collaboration support, and how do the available collaboration technologies fit together to form an integrated portfolio supporting these needs? Few guidelines exist in this process, making organizations an easy target for consultants with varying philosophies and product preferences.

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The classification of collaboration tools and technologies has been an important focus of the CSCW and groupware research area since its inception [16, 18, 37]. Early classification schemes such as the time-space taxonomy [9, 18] and functional classifications [11, 16] have proved useful structuring frameworks for distinguishing between major categories of technologies and applications. However, the usability of these frameworks is challenged by the increasing integration of functionality in collaboration products, supporting both asynchronous and synchronous collaboration [28].

Several theories and frameworks have been influential for classifying collaboration tasks, processes, and related technology support, such as the group task circumplex [23], task technology fit theory [8, 36], media richness theory [7], and coordination theory [21]. Although these different theories and frameworks provide an important basis for our understanding of the characteristics of collaboration tasks, processes and technology, they offer limited practical guidance for an organization in the process of developing a strategy for e-collaboration. We argue that there is a lack of a practical, holistic framework that may guide organizations in their efforts to specify, evaluate and acquire collaborative tools that can support their e-collaboration needs. From this perspective, the aforementioned models and frameworks are either too general in nature, not offering sufficient granularity for a detailed requirements analysis and evaluation of alternative solutions, or focus only on parts of the "big picture".

This article presents a holistic framework that attempts to address these shortcomings. The framework is based on a set of key concepts, including collaboration environment, collaboration process and collaboration support. The collaboration process consists of sub-processes, which again are detailed further into collaboration functions. The main emphasis in this article is on the part of the framework that defines the range of collaboration tools needed for an integrated e-collaboration solution.

A collaboration tool is defined here as a specific combination of a collaboration interface, collaboration functions, and content management and process integration functions. A typology of collaboration tools is presented using a wheel metaphor, referred to as the Wheel of Collaboration Tools (WCT).

The framework is developed by Statoil, a Norwegian based oil and gas company, in response to their need for establishing an integrated portfolio of collaboration tools that provides for the company's need for collaboration support. Gradually developed and refined through several projects, the framework has proved an important basis for Statoil in the development and implementation of their e-collaboration strategy and the new e-collaboration and information management solution introduced in 2005. This includes needs analysis, strategy development, feasibility studies, requirements specification and product evaluation. Thus we argue that this framework fills an important void in the research and practice on e-collaboration and CSCW, by bringing together key concepts from former theories and frameworks into a practical, holistic framework for specification, analysis and evaluation of e-collaboration tools.

The authors have had different roles in the development of the framework presented in this article. Two of the authors represent the industry perspective and have been part of the conceptual development and gradual detailing of the framework, as well as different forms of application of the framework in Statoil. The two other authors represent an academic perspective, contributing to analyzing and evaluating the framework related to former research within CSCW and e-collaboration. These different perspectives have proved a valuable basis for discussion on potential further develop of the framework.

The next section briefly presents the background and origin of the collaboration framework. Section 3 provides an overview of the collaboration framework, constituting the foundation for the WCT typology presented in Section 4. In section 5, examples and experiences from using the WCT typology are presented. This is followed by a discussion of the contributions of the framework in its present form, and suggested areas for its further development. The final section provides conclusions and implications.

2. ORIGINS OF THE FRAMEWORK

After being early adopters of Lotus Notes and other collaboration technologies through the 1990s, by the end of the decade Statoil had a comprehensive but not very well integrated portifolio of collaboration tools. In broad terms, the portfolio was characterized by numerous independent IT tools for communication and information sharing, together with office support tools for individual work. Further, the users were left to themselves to figure out what to use the tools for and how they might change and improve their collaboration processes. Statoil thus acknowledged the need for a framework that could guide their construct of an integrated portfolio of tools, and also provide support for improved collaboration processes in its business.

In 1999, after first "freezing" their portfolio of office support and collaboration tools as well as infrastructure and PCs for the next two years, Statoil started the work to substitute this with a new and improved solution. The motivation for the "freeze" was both to save money and to ensure better planned renewals, implying taking more significant technology steps. For a major company with activities spanning several value chains and with a global reach, renewing the whole portfolio of collaboration tools was a major challenge, requiring a more integrative and holistic perspective. The goal for the implementation project was to provide the business with the tools needed and to ensure utilization of the potential for improving collaboration processes. Another major objective for the project was to provide considerably improved support for collaboration with external business partners, to meet present and future business needs.

At the time the most commonly used conception for distinguishing different collaboration tools was the time-space matrix [9]. For Statoil this was not useful since one of the chief objectives was to provide tools capable of supporting collaboration anytime/anyplace, preferably using the same solution. Further, this type of taxonomy did not give any guidance for how to apply the tools and improve collaboration processes. The conclusion became to develop a concept for the project that could assist in reviewing the existing portfolio, analyze the products offered by the vendors, and prepare a basis for a strategy to meet the company's need for collaboration support. This work was inspired by models developed by Statoil's research group for coordination and collaboration technology, and current academic partners at MIT Center for Coordination Science and Program for Applied Coordination Technology (PAKT) at the Norwegian University of Science and Technology.

A major challenge in the discussion with the vendors was to understand which parts of the collaboration functions complex their products supported. Even though the framework was in its early developmental stages it proved to be effective for this purpose. When analyzing the existing Statoil portfolio it became evident that several of the tools provided the same functions, leaving it for the users to figure out which tool to select when in need of a function. In the discussions with the vendors collaborating with Statoil in the project's feasibility study in 2000, it became evident that their range of products represented the same problem. The products had considerable overlap of functions, major functional areas were left out, and the support for workflow among the functions was poor. The products and functions were not coherent and complete. This problem was also acknowledged by the vendors, who regarded the framework as an interesting basis for further improvement of their products. This project was the first occasion for using the framework, and it was used to analyze the existing portfolio and the products from the vendors. In the following years the initial typology was applied to manage several challenges in meeting the objective of providing improved collaboration support. Experiences from different applications of the typology are presented in section 5, after first introducing the framework and its concepts.

3. THE COLLABORATION FRAMEWORK

Collaboration takes place when two or more people communicate and interact to reach a goal. This is done frequently in most business operations and is increasingly the basic modus operandi of the modern business world. To increase value creation and goal achievement it becomes crucial to understand and improve the way people collaborate.

As a basis for analyzing e-collaboration we define a framework consisting of collaboration environment, process and support. The collaboration process is performed in the context of a

collaboration environment. The environment consists of the nature of the task and the organizational setting such as line of business, markets, actors, competencies, organizational structure, corporate information and cultural beliefs. Adopting a structuration theory perspective [14], the collaboration process is constrained by the pre-existing environment but the relationship evolves over time and appropriations will be made both to the environment and the process [20]. Collaboration support consists of organizational measures, services and tools. The collaboration process is also constrained by the support and this relationship too will evolve over time and appropriations will be made both to the support and the process. The three elements of collaboration and the structuration process make up the collaboration framework as illustrated in Figure 1.

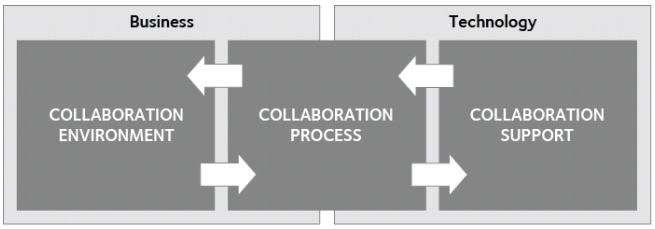

Figure 1. The collaboration framework

Successful collaboration requires appropriate management of all the three elements and the related structuration process. Still, the center of the framework, the collaboration process, is the arena for balancing the business perspective and the technology perspective, i.e. what to do and how to do it. For that reason we should make the collaboration process the outset for making priorities on how to collaborate and designing appropriate support. We will now explore each element of the collaboration framework.

3.1 Collaboration Environment

The collaboration environment comprises the organizational setting and the nature of the collaborative tasks conducted. Depending on the environmental characteristics the kind of collaboration processes and support needed will vary, and they will also develop over time. We highlight the importance of this conception for efficient collaboration through an illustration from the business of Statoil. Statoil is a Norwegian oil and gas company with a total revenue exceeding US$ 61 billion, placing it as the 13th largest petroleum company and number 70 of all companies in the Fortune global 500 list. Statoil has business in 33 countries and about 25600 employees.

Statoil is divided into five areas of business based on a mix of markets and functions. This creates interdependencies among the five business areas and they need to collaborate to achieve their targets, e.g. there are two business areas producing natural gas (from Norwegian fields and international fields) and a third area distributing the gas to the market. In additon to collaboration across internal organizational boundaries, Statoil is heavily reliant on collaboration across external organizational boundaries. At least 50% and at most 95% of Statoil's different activities are actually performed by other companies.

When developing a new oil or gas field the host country government usually gives the license to operate to a group of companies constituting a partnership. This kind of project includes numerous external and internal factors that influence the collaboration environment, such as: government involvement (e.g., national oil companies and government officials); peer oil and gas companies in the license partnership; external contractors and hired professionals; and internal business units doing specific tasks in the overall workflow. In addition, the nature of the project like the type of field (e.g., onshore or offshore), type of installation (e.g., rig or ship above the surface or sub surface installations), and whether it is oil or gas streams, adds elements to the environmental characteristics. Issues as these form the collaboration environment for a development project and influence the kinds of collaboration processes and support that will be efficient.

3.2 Collaboration Process

We have defined collaboration as acting together to reach a common goal. We further conceptualize this process to consist of three fundamental and interrelated sub-processes through which collaboration takes place: *coordination*, *production* and *decision-making*.

This conception is partly based on the work of Malone and Crowston at the MIT Center for Coordination Science during the years of 1990-94. They suggested a framework for coordination with four *coordination processes* and added *group decision-making* and *communication* [21]. Another influence was a tutorial on workflow management given by Schäl and Zeller at the ECSCW conference in Milano in 1993, where they outlined three types of cooperative work: *coordination*, *collaboration* and *co-decision* [31]. However, we found these frameworks to lack sufficient precision for our purposes. Malone and Crowston's description of "communication" is more about the actual tasks to be performed (e.g. collaborative authoring) rather than making sure they are coordinated. Schäl and Zeller's definition of "collaboration" as a type of cooperative work is somewhat tautological. Their explanation says "work together in the execution of a certain action," which, as with Malone and Crowston's "communication", focuses on the task execution. We have re-conceptualized these two terms into one distinctive sub-process of collaboration named *production*, meaning performing the core tasks. By drawing on these two models in a conceptually logical manner we achieved a more comprehensive conceptualization with three distinct sub-processes; *coordination* to make sure interdependent sub-tasks are aligned, *production* to perform the tasks, and *decision-making* to make choices on task related issues.

As stated above, these processes are interrelated and are often performed concurrently during a work sequence. Each of the three sub-processes is further elaborated below.

3.2.1 Coordination

Coordination is to manage dependencies among activities [33]. There are two fundamental issues to all organized activity: the division of labor into different tasks to be performed, and the coordination of these tasks to accomplish the overall activity [25]. At the moment labor becomes divided into tasks, dependency relations are created among the tasks and their performers. People become dependent on each other to accomplish their respective tasks. Such dependencies need to be dealt with and that is

coordination – managing the dependencies. Relationships characterized by dependency have a substantial value potential but demand appropriate coordination [35].

According to March and Simon [22], coordination is either done by plan or by feedback. *Planning* is to decide up front how to coordinate a specific situation. It is a kind of programming of action. Feedback is *mutual adjustment* based on new information. The coordination is done during the task performance and takes the course of events into account. The more unpredictable and shifting the business environment, the more the organization needs to use coordination by feedback [op. cit.]. Thompson [33] adds *standardization* as a third type of coordination, as a variation of planning. Standardization is to make something uniform i.e. consider different occurrences as equal because they share some main characteristics, and then apply the same kind of handling to all of them.

3.2.2 Production

In our framework, production covers the tasks related to creation and sharing of information and knowledge. This includes capturing and authoring information in shared information spaces [16], as well as distribution of information through asynchronous or synchronous communication channels. Publishing of information and mechanisms for effective search and retrieval are also key elements in this sub-process.

3.2.3 Decision-making

Decision-making involves analyzing and evaluating alternatives and making a choice. Choice-making comprises both an intellective task and a judgment task, where the aim is to bring relevant information about the question at hand together so the work group can arrive at a conclusion on the most appropriate choice [24]. The conceptualization of the decision-making process in our framework can be seen to build on the classic decision models of Simon [32] and Mintzberg et al. [26], outlining main phases in the decision process (e.g., intelligence, design, choice, and review) and key sub-processes in these phases (e.g., information query, reporting, evaluation and analysis). Although this conceptualization mainly represents a rational perspective on decision-making, we also acknowledge the influence from non-rational and political elements in this process [5].

3.2.4 Content Management and Process Integration

In addition to the three basic collaboration sub-processes described above there is the challenge of managing the information dealt with during the sub-processes, and integrating the sub-processes effectively. The need for *content management* runs from the very start of a collaboration process and beyond its end, i.e. throughout the content life cycle. Information management is necessary, both for the sake of the process and for the purpose of documentation and content re-creation and reuse. To make the overall collaboration process effective an integration of the sub-processes is needed. *Process integration* is the transition and flow of process results and context information within and between coordination, production and decision processes. This includes workflow support.

3.3 Collaboration Support

The challenges related to establishing collaboration practices that work are extensively documented in the research literature [e.g., 20, 27]. Organizations must take action and make it possible for people to collaborate in effective ways. Collaboration support consists of *organizational measures*, *services* and *tools*. These are three main types of means to enable effective work practices and collaboration. Organizations need to make available an adequate portfolio of tools, build an appropriate selection of services and make organizational adaptations to foster desired collaboration practices.

Organizational measures are means to enhance the organization's encouragement of effective collaboration. Each individual is responsible for developing and adapting to effective collaboration practices. A service provider must be established to offer professional collaboration services to support the lines of businesses according to their specific collaboration needs. The overall organization by its centers of excellence and line managers is responsible for developing collaboration practices within each respective area.

Services must ensure support to the organization by enabling productive collaboration processes and practices. Advisory services identify appropriate collaboration practices and tools and demonstrate the value of applying them. Training services offer basic knowledge and skills in collaboration methods and tool usage relevant for work situations. Facilitation services enhance collaboration processes by assisting the participants on method and tool applications as they perform their tasks.

Tools are used to improve the way people collaborate and utilize the potential of digital technologies. A tool represents a combination of collaboration interface, collaboration functions, content management and process integration, and should support the preferred methods and communication styles for the collaboration process. A *method* defines the steps to be taken to carry out a collaboration process or sub-process. Methods say something about how the work should be conducted, and often give detailed process descriptions. Examples of production method types are brainstorming methods and authoring methods. An example of a decision support method type is voting, and an example of a method type related to content management is content classification methods, which include e.g. semantic analysis and linguistic analysis.

A *communication style* represents the circumstances by which the collaboration process takes place, regarding:

- Timing of participation – same or different time
- Location of participants – same or different place
- Media type used – e.g. text or rich media
- Identification of participants – anonymous or identified.

Methods and communication styles define *how* the collaboration process is performed. A function in a collaboration tool will comprise or support one or more methods and communication styles for one or more collaboration sub-processes. The following section further details the collaboration tool concept, presenting the Wheel of Collaboration Tools. The other collaboration support elements (organizational measures and services) are not elaborated further in this article.

4. WHEEL OF COLLABORATION TOOLS

The Wheel of Collaboration Tools (WCT) is a typology of the capabilities of collaboration tools. The typology consists of three main layers, metaphorically comparable to the main parts of a wheel as illustrated in Figure 2. The mid layer represents a generic decomposition of the functions needed to support the three collaboration sub-processes of coordination, production and decision-making. The core layer is the functions for content management and process integration. The outer layer represents the interface to the collaboration functions, consisting of devices, portals and the physical workspace. Together this encompasses the attributes of computer based tools for collaboration. Metaphorically, the collaboration interface represents the tire, the collaboration functions are the spokes, and content management and process integration is the hub of the Wheel of Collaboration Tools (WCT).

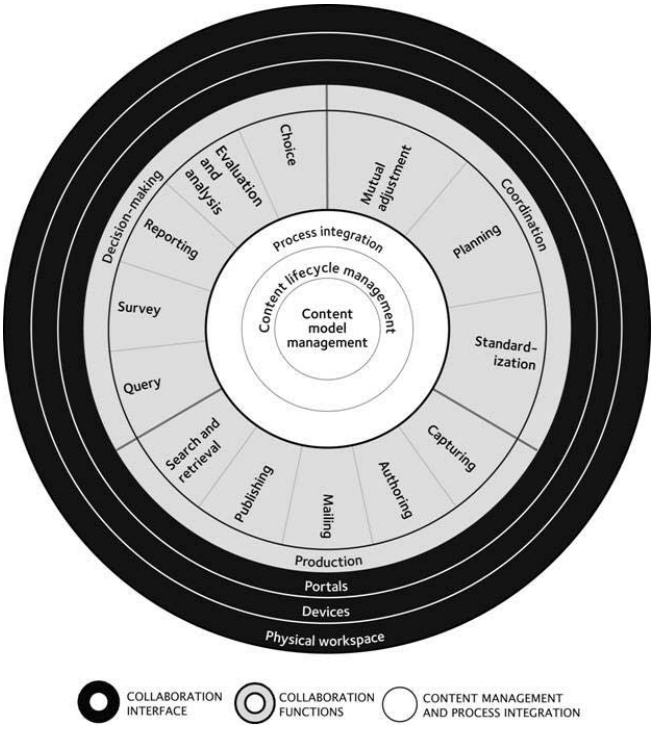

Figure 2. The Wheel of Collaboration Tools

4.1 Collaboration Interface

The tire of the wheel represents the interface to the collaboration functions. It consists of three sub-layers. The outer layer is the *physical workspac*e used for collaboration, e.g., an office or meeting room. The mid layer is the computer *device* used, e.g., a PC, phone or videoconferencing system. The *portal* layer represents the main view to the representation of the collaboration functions and information shared in the collaboration process. The origins of this layer are partly derived from the growing diversity of computers on the market, including Smartphones and tablet PCs. Another market trend is the introduction of portals as an answer to information overflow and the lack of easy access to personalized application support. In addition, work is increasingly carried out in a great variety of physical settings, such as airplanes, team rooms, and offices.

4.2 Collaboration Functions

The collaboration functions comprise methods and communication styles for the collaboration sub-processes described in section 3.2. For each sub-process a set of main functional areas are defined. The definitions of functional areas and examples of further decomposition into sub-functions are given in Table 1.

The set of functional areas and examples of sub-functions is derived from the body of knowledge about collaboration processes and analysis of the software offered by the vendors. Much of the motivation for creating the WCT typology came from experiences with trying to systematically analyze functions offered in the software market. During cooperation with major vendors in 2000 and 2002 it became clear that the collaboration market was not well defined and that a more rigorous approach had to be applied. Based on the conceptual understanding of the needs for collaboration support, Statoil was able to point to shortcomings in the vendors' solutions regarding functional coverage and integration. This critique was acknowledged by the vendor representatives, and in some cases also used as the basis for product improvements.

4.3 Content Management and Process Integration

The concern of information life cycle management has been developed into the concept of content management (CM), which makes up the hub of the wheel together with process integration. Content management is the management of content in the information storages used by the collaboration functions, through the entire content lifecycle. It consists of two main parts. *Content model management* comprises functions for the management of a common content model, and *content lifecycle management* constitutes functions for management of the content lifecycle in the collaboration tools. *Process integration* is the transition and flow of process results and context information within and between coordination, production, decision-making, and content management support functions. In this article we only present the main functional areas, with selected examples of definitions and sub-functions.

Content model management consists of the following functional areas: metadata management, taxonomy management, template management and role management. As an example, *Taxonomy management* is the management of a corporate content classification structure, to be used by content management functions, collaboration functions and the portal. This implies functions to develop, maintain, and apply the taxonomy.

Content life cycle management consists of the following functional areas: access and security, versioning, transformation, classification, distribution, retention and tracking. As an example, *Versioning* is the management of revisions, versions and editions of content objects and structures. This includes the functions of version control, version comparing, revision, rollback, content inheritance and reference content management.

Process integration includes the functions of workflow, content change notification and subscription.

Table 1. Collaboration functions – definitions and decompositions

FUNCTIONAL AREA		PROCESSES SUPPORTED	EXAMPLES OF SUB-FUNCTIONS
COORDINATION	**Mutual adjustment**	Coordination of production or decision-making process based on mutual adjustment between actors/activities	Actor presence monitoring, activity and information status monitoring, instant meetings and messaging
	Planning	Coordination of production or decision-making process based on planning and scheduling of activities	Planning using selected methods, scheduling, plan follow-up
	Standardization	Coordination of production or decision-making process based on standardized processes, results, competence, norms or values	Creation and use of standard content templates and process templates
PRODUCTION	**Capturing**	Making existing information object available for use	Content import, upload, scanning, image capturing, optical character recognition
	Authoring	Developing content of information object	Create, edit, review, finalize
	Mailing	Sending and receiving information object	Send, transport, receive
	Publishing	Making information object accessible for a target group	Select format and media, select target group, presentation
	Search and retrieval	Search and retrieval of information object	Search, retrieval
DECISION-MAKING	**Query**	Information exploration and retrieval in digitally represented resources, for reporting, evaluation and analysis	Query definition, query execution, query results presentation
	Survey	Questionnaire for information retrieval from human resources, for reporting, evaluation and analysis	Survey creation (incl. method selection), collection of answers, survey results presentation
	Reporting	Presentation of information for evaluation and analysis	Source selection, report content selection, report format selection, report generation
	Evaluation and analysis	Comparison and evaluation of information using evaluation methods. Discussion and analysis of production, query, survey, reporting and evaluation results	Content and method selection, perform evaluation and analysis in group, results presentation
	Choice	Making choice and building consensus	Define selection/ approval criteria, make choice based on criteria

The functions of content management and process integration are mainly derived from the work with CM solutions and their providers. Some academic knowledge is of course available, especially on information life cycles, but there has been a major increase of this software market segment the last few years [30]. This is partly due to people not finding the information they need within a reasonable time, and partly due to the requirements imposed as a consequence of new regulations such as the Sarbanes-Oxley Act.

5. EXPERIENCES FROM USING THE WCT TYPOLOGY

The WCT typology has been used in several activities related to the development of Statoil's e-collaboration solution during 1999-2005, mainly in the phases before new products were selected and acquired for the solution in 2000 and 2003. The application can be grouped in two main categories:

- **Evaluations and analyses**
  Evaluation of existing collaboration tools, feasibility studies, needs analyses, scenario analyses, product evaluation.
- **Plans and specifications**
  Strategy development, concept development, requirements specifications, process modeling.

In evaluations and analyses the typology has been used for defining and structuring the evaluation criteria. In plans and specifications the framework has been used as a structure for goals, objectives, measures and requirements. It has also been used as a basis for modeling collaboration and information management processes. In the phases after the products were selected, the use of the WCT typology has so far been limited.

The main contribution of using the typology has been to provide a holistic and consistent structure of the functional capabilities to be evaluated, analyzed or specified in the early stages of the implementation projects. The main challenges have been related to finding feasible evaluation methods to be used together with the typology, and managing evaluation and analysis data. This section presents selected application examples and experiences.

5.1 Analysis of Existing Collaboration Tools

The first application of the WCT typology was related to an analysis of the existing collaboration tools in Statoil in 1999. The purpose was to consolidate the portfolio of tools, and identify overlapping and missing functionality. The functional capabilities of each general IT tool for collaboration was mapped to the functional areas defined in the WCT typology, which at this point was entitled "CoEx – The Collaboration Expert". A Lotus Notes application was built to support the analysis, which focused both on the tools used for collaboration within Statoil and the tools used for collaboration with external partners.

At this stage of the development of the WCT typology, the functional area of *content management and process integration* was not included. Instead, *archiving* was defined as a sub-function of production, and *workflow* was defined as a main functional area along with coordination, production and decision-making. The functional area *workflow* then covered *process integration* as defined in section 3.2.4.

The analysis was mainly qualitative, and the supportive quantitative analysis was based on a binary evaluation of the support for collaboration sub-processes and communication styles. Using a more comprehensive analysis tool enabling other evaluation methods and also supporting analysis of methods, would have improved the analysis process. However, the results became a useful basis for the upcoming needs analysis, product feasibility study and strategy work.

5.2 Product Feasibility Study

After the solution analysis and consolidation phase was completed in 1999, Statoil conducted a technical feasibility study and pre-evaluation assessment of the collaboration product portfolios of two major vendors. This study was based on thorough knowledge of their product range, achieved through extensive cooperation with the two companies during 2000. The product assessment was related to the same functional areas focused in the analysis of the existing collaboration solution. However, the functional area *workflow* was now replaced by *functional integration*, and a more fine-grained quantitative evaluation method was applied for evaluation of the product portfolios' functionality. A six-point scale was used, with one indicating "No support" and six indicating "High level of support in available products". The main evaluation results for the collaboration functions are shown in Figure 3.

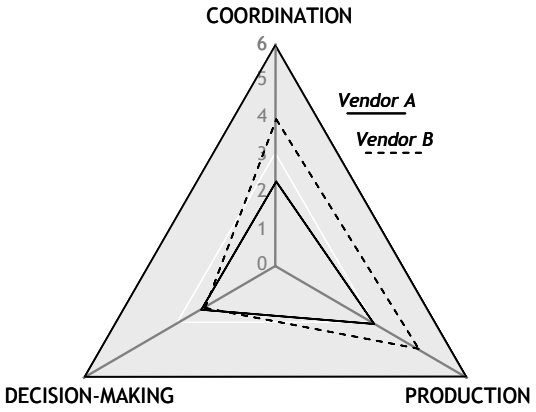

Figure 3. Vendor collaboration portfolio assessment

This assessment proved to be in accordance with the overall judgments of advisory agencies such as Giga Group and Gartner Group, thus serving to verify use of the WCT typology for this type of vendor assessment. It was followed by the implementation of a partially renewed collaboration solution which was introduced during summer 2001, still with Lotus Notes/Domino as the main platform but with Microsoft Office 2000 replacing Lotus Smartsuite as the standard authoring tool.

5.3 E-Collaboration Strategy

The refinement and application of the collaboration framework and the WCT typology continued in 2002 through the development of Statoil's e-collaboration strategy for 2002-2004. The wheel metaphor and the term "Wheel of Collaboration" were introduced, in addition to including the functional area *information management and security* as the hub of the wheel. The strategy presented a vision, goals and recommended initiatives for improvement of collaboration support in Statoil, including tools, services, and organisational measures. The recommended initiatives related to tools were grouped in the functional areas *information management and security*, *collaboration functions,* and *collaboration portals and facilities,* corresponding with the three main layers of the WCT typology.

The e-collaboration strategy founded the basis for the implementation of the Collaboration@Statoil (C@S) solution, introduced in 2005. The C@S solution is based on products from Microsoft, replacing Lotus Notes/Domino as the general solution for collaboration and document management in Statoil. Though the C@S project did not adopt the detailed implementation plan in the strategy, several of the recommended main initiatives for improvement of the collaboration tools have been implemented through the C@S solution. The strategy for organizational measures and services was less emphasized by the C@S project initially, but has proven its relevance during the deployment of the solution.

5.4 Requirements Specification and Product Evaluation

The WCT typology was used in all phases of the implementation of the C@S solution during 2002-2005, including the concept development, requirements specification and product evaluation phases. The concept development phase including feasibility studies and scenario analyses in 2002-2003 mainly focused on the functional area of information management and security, resulting in a refined typology for this functional area which was renamed *content management*. The typology served as a useful basis for discussions with major vendors about the conceptual schemes underlying their collaboration and content management products, also identifying limitations in these schemes.

In the requirements specification phase in the fall of 2003, the WCT typology was used as a basis for specification of the functional requirements by which the vendor's products were evaluated. However, after the products had been selected and acquired, the WCT typology was replaced by the products' functional component architecture as the main framework for specifying the functional configurations and customizations of the products in 2004-2005. The design specifications for the C@S solution were structured according to the solutions' functional component architecture based on the vendor's terminology. The effort of reconceptualizing according to the WCT typology has so far not been undertaken, although it is considered that such a reconceptualization would strengthen the implementation by providing an overview of the solution with the accustomed concepts. This demonstrates the challenge in continuing to apply the concept also after installing the products.

6. DISCUSSION

6.1 Assessing the Collaboration Framework

The gradual development of the collaboration framework has been motivated by practical needs and concerns in a large industrial company, and not as a research activity by itself. The limitations of existing frameworks found in both research and practice fostered a need for developing an integrated, holistic framework of collaboration processes and functions. The development approach can be described as eclectic, combining findings from academia and practice (as represented by vendors

and consultancies) in an attempt of applying "the best of both worlds". For example, at the time of development of this framework, little academic research was available on content management, at least from an enterprise perspective. Thus, the content management function typology in the WCT is mainly influenced by models developed by vendors involved in the implementation of the new e-collaboration solution. We argue that this pragmatic approach actually represents a strength of this framework, by bringing together areas of practice and research that most often are treated separately within communities with limited cross-interaction. For example, coordination, decision support, and information management largely represent distinct research areas. The role of content management as an integrative foundation for the collaboration sub-processes in our collaboration framework also represents an extended perspective as compared to former frameworks.

Overall, Statoil has found itself to be in the forefront in adoption and use of large scale collaboration solutions, implying limited possibility for guidance from vendors or for benchmarking its solutions against other companies. Thus, the development and utilization of the e-collaboration solutions, both the former Lotus Notes based solution and the new C@S solution, have been a longitudinal learning process where functionality of the technology has been gradually adapted and configured to organizational needs. During this process the framework has proved useful for explicating project objectives and analyzing solution alternatives. Further, lessons learned from this process and discussion of these in academic forums have contributed to gradual refinement of the framework, and it would have been difficult to arrive at the concept presented in this article without gaining experiences from its actual use during different stages of development.

A similar learning and configuration process has been reported in other settings, related to assimilation of collaboration tools both at the organizational and the individual level [13, 27]. However, in contrast to former accounts emphasizing the reciprocal development of organizational routines and technology use, our experience is that the ideals for collaboration processes in Statoil have remained fairly stable over this period. This can to some extent be ascribed to the role of the initial versions of the framework in conceptualizing collaboration functions independently of technology support. Thus, we argue that if Statoil would have had access to the fully developed conceptual framework as outlined in this article when they started the improvement process in 1999, these efforts would have been an easier endeavour.

As outlined in this paper, the framework has provided useful support for a range of application areas in Statoil related to evaluation, analysis, planning, and specification of collaboration solutions. A pertinent question then is whether this framework also is useful for other companies? Statoil is a large organization operating in an intensive collaborative business environment. Organizations as Statoil must provide their people with collaboration support that manages the scale and scope of their business activities and with sufficient sophistication to run them effectively. We would expect the framework and applications presented here to be relevant also to comparable companies. When it comes to less comparable companies in different collaboration environments we expect differences in what will be useful applications. This is in accordance with the assumption in section 3 that the three elements of collaboration environment, processes and support constrain each other through a structuration process. The framework has gained interest from leading vendors of collaboration technologies, considering its holistic perspective useful for analyzing possible incoherence in their product portfolios. Thus, the framework may also offer useful support for developers and vendors of collaboration software in developing their products and portfolios in a coherent and strategic way. Of course, the only way to explicitly verify the usefulness of the framework beyond the experiences presented in this article is to study its application in other companies. As a first step towards facilitating this, we are currently incorporating the framework in different industry training programs and university courses in which we are involved.

The WCT depicts what tool attributes that may support an organization's collaboration processes. It must not be comprehended as if every organisation is in need of all the attributes. Rather, the WCT makes it possible to examine whether a collaboration process could be strengthened by applying or improving collaboration tools with specific attributes. Clearly, the current version of the framework has its limitations, for instance regarding the level of granularity in distinguishing among different types of collaboration sub-processes, the representation of process integration, and the relationship with the collaboration environment. These and other potential areas for further development are discussed in the next section.

6.2 Areas for Further Development

6.2.1 Decomposing the Collaboration Framework

In Figure 1, we briefly introduced an overall framework for collaboration comprising the collaboration environment in which the collaboration sub-processes enact, and the support for these processes. The part of the framework focused in this article mainly applies a functional perspective in that major collaboration sub-processes are decomposed into their constituent functions. These collaboration sub-processes are represented as generic, without distinguishing between different types of instances of these processes and functions. Further, the concept of the collaboration environment, defined earlier to consist of the nature of the task and the organizational setting has yet to be operationalized in the form of characteristics that may influence on the collaboration processes and related tool utilization. In this section we point to some relevant research that may form the basis for further decomposition of these elements of the framework.

A problem related to decomposition of collaboration processes is the lack of a standard set of collaborative tasks or applications [10]. Several suggestions for functional decomposition of collaborative systems have been presented [e.g., 10, 12], but these have mostly been developed from a design perspective, rather than intended for user organizations in defining requirements for collaboration support. The different task typologies available in the literature [e.g., 23] have been applied as the basis for attempts of matching technology to task [8, 36]. Several point to the limitations in the deterministic approach implied in these contingency theories, based on objective characterizations of tasks and technology [37]. For example, it is argued that

organizational activities often include a mix of both procedure-like and ad-hoc type parts [2], defining a continuum with highly specified and routine organizational processes at one extreme and highly unspecified and dynamic processes at the other extreme [ibid]. Further, as collaboration develops and changes over time, this implies a need to focus on the dynamics in the transition between collaborative activities [1]. In critique of the media richness theory, it is argued that a fixed view of media characteristics is inconsistent with how people use modern technologies. Instead, the same medium can become "richer" as communication partners gain experience with each other, the task or the context [4]. Based on these critiques, the evolution of task-technology fit perspectives can be characterized as moving toward a richer and more complex view of the fit issue, with explicit recognition of the appropriation and feedback process that occurs through group interaction [37].

While acknowledging the evolving nature of appropriation and use of collaboration tools, and the potential contextual influences on these processes, organizations need to develop some guidelines for selection of tools for different tasks and contexts. An example is the suggested strategy for selecting the "Best Medium for Virtual Collaboration" developed by the Rand Corporation [34], providing guidelines for selecting among videoconferencing, audioconferencing, computer-mediated communication, and face-to-face interaction, for various forms of virtual team interaction. Another example is the collaboration engineering concept [3], defining repeatable collaboration processes through a comprehensive set of components (thinkLets) that specifices facilitator actions, tool configuration, and scripts defining group collaboration patterns. The thinkLets concept has so far mainly been developed related to use of group support systems in co-located settings (workshops, meetings), and it remains to be seen to what extent this approach can also be applied in a larger scale e-collaboration setting, involving a portfolio of collaboration tools applied in multi-mode collaboration processes. In general, the issue of scale of the collaboration represents an important area for further refinement in the characterization of collaboration sub-processes in the collaboration framework. Examples of different levels at which collaboration can occur include individual, project/team, community of interest/practice, organizational, and across enterprises [17].

6.2.2 Collaboration Process Integration

While the collaboration framework provides an integrated perspective on e-collaboration functions, the integration aspect of the framework needs to be scrutinized further. As outlined in Section 4.3, the WCT typology includes content lifecycle management and process integration. Content lifecycle management includes all functions related to storage management, distribution and disposal of all forms of digital content required for performing the collaboration processes, while process integration covers transition and flow of process results and context information between these processes. However, it could be argued that the conceptualization of these functional areas in the current version of the WCT is less explicit than for the decomposition of the collaboration functions. As such, the integration aspect of the framework is so far mainly maintained through providing an integrated conceptual representation of the major collaboration sub-processes in the organization and their related functions, rather than conceptualizing the operational integration of these processes and functions. Further development of the framework could aim at explicating the relationships between the collaboration functions within and between the three collaboration sub-processes, and how different collaboration tools support these relationships.

6.2.3 Collaboration Support

The framework defines collaboration support as consisting of organizational measures, services and tools. While the WCT represents the tools part, similar comprehensive concepts for organizational measures and services are not developed. However, a distinction on the highest level for organizational measures (co-worker, service provider and line and discipline management) and services (advisory services, training services and facilitation services) are made, as described in section 3.3. Both these types of support could be further developed, increasing the granularity and comprehensiveness. We would additionally suggest that the most interesting venture would be to explore the relationships among the different kinds of support in creating effective collaboration processes. We expect these relationships to vary in different collaboration environments and evolve over time. Several have documented the challenges related to evaluation of collaboration technologies and applications [15, 29]. An important area for further development thus includes identifying and applying appropriate methods for justification and evaluation of implemented collaboration support initiatives.

7. CONCLUSION AND IMPLICATIONS

This article has presented a conceptual framework for e-collaboration, developed in industry. The framework provides a holistic perspective on collaboration sub-processes and tools, and has proved useful as the basis for the entire process related to defining, acquiring, and implementing a new solution for integrated e-collaboration in Statoil. The company's experiences with the framework indicate that this offers better support for these activities than other frameworks.

While the primary contribution from the collaboration framework is at the practical level, the framework also contributes to research by integrating concepts from research areas that often are treated separately, such as coordination, decision support, and information and content management.

We have outlined several potential areas for further development of the framework, including further decomposition of the collaboration environment and process, more explicit representation of process and functional integration, and developing the support services and organizational initiatives needed for effective implementation and use of e-collaboration. The article is intended to stimulate discussion and further research related to this type of collaboration modeling, and we encourage feedback from the CSCW research community as well as other user organizations undertaking similar e-collaboration initiatives.

8. REFERENCES

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