Understanding and Evaluating Collaborative Work in Multi-Site Software Projects – A Framework Proposal and Preliminary Results

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Abstract

Global enterprises have met challenges in managing and leading multi-site projects, working in virtual teams, sharing knowledge, and utilizing new communication technology. Several claims stress that conventional face-to-face practices form an essential part of successful project co-working. But, this is often impossible in globally dispersed projects. New information and communication technology solutions are needed for converting collaborative actions into virtual ones.

We introduce a framework for analyzing and developing work activities in multi-site projects. Four areas of work are distinguished: personal work, work with people, project/team work, and knowledge work. The framework is used for studying interaction between an individual and her work environment. Our interest is to help multi-site projects to successfully collaborate in distributed circumstances.

The framework was tested by analyzing two case projects at Nokia. This paper presents our findings of the framework usefulness to guide organizational and team development and characterizes R&D work in multi-site circumstances at Nokia.

1. Introduction

Companies in telecommunication business are faced with a dynamic and turbulent environment that requires fast responses to changing business needs. As a result, many organizations have adopted emergent, team-based, and geographically distributed structures as a respond [1, 2]. Stonehouse et al. [3] and Carmel [4] have discussed the pressure for global structures, and Yip [5] has presented an extensive set of determinants for globalization. Today collaboration[1] comprises of a mixed set of local and distributed interactions between individuals. Information and communication technologies help in eliminating the perception of distance. Thus, new organizational structures have better possibilities to profit from location transparency. However, there is a demand to develop new productive ways of working in a globally distributed environment.

Working in social networks and utilization of personal relations is common for professionals. A key feature in network organizations is a high degree of informal communication [2]. Empirical studies [6, 7, 8] show the necessity of informal and "ad hoc" communication among software engineers. Furthermore, the benefits of tacit knowledge in high technology firms is reported [9, 10]. Distributed work, however, is challenging because of the added overhead, delays, and lower richness in cross-site communication. As studied by Allen [11] distance affects to the frequency of communication. Especially, this concerns informal and "ad hoc" communication and knowledge sharing. Furthermore, distance may also influence the management function, but literature [e.g. 4] suggests typically conventional solutions that are based on physical presence.

Several studies have shown that distribution and the use of virtual communication (instead of face-to face situation) affects group processes. Distributed teams are not as cohesive as local ones [12]. Teams with increased virtualness are associated with less trust, poor cooperation, and conflict management problems [13]. Virtual teams can trust each other, but teams starting on low trust will continue operating on low trust [14]. Cross site-work introduces delays and it changes helping behavior of a distant member [15]. Furthermore, Olson and Olson [16] reports only few cases of successful utilization of CSCW technology, and concludes to suggest four elementary factors behind successful distant collaboration. These are common background, loose-coupled tasks, collaboration readiness, and technology readiness.

Collaboration readiness is closely related to the working practices used in a company. Practices have often evolved from co-located ones due to the background and legacy skills of people. For example, expert boards are assembled for face to face meetings, closest co-workers can meet each other several times during a day, and significant amount of knowledge created in team interactions is neither shared nor documented. In many cases, actors who initiate an interaction select means that

[1] Working jointly with others or together especially in an intellectual endeavor (Webster).

suits best to their personal needs (c.f., discussion of groupware and critical mass [17]). It is evident that old practices are becoming inadequate because the dispersion of work has increased to a level where distant working requires well founded virtual ways of collaborating and a purposive use of groupware. Furthermore, in a context of e-business, there exist a strong tendency towards virtual interactions.

We aim at gaining productivity improvements in distributed teamwork by supporting interactions between people and within their personal networks. We propose a framework, that we call the 4Q framework, to understand multi-site work and to identify potential pitfalls in a studied entity, e.g., in a project [18]. The framework opens up a functional perspective to multi-site and distributed projects. It also enables us to visualize and describe how project functions in these circumstances. More specifically, it describes how individual project members experience their work with personal, project and knowledge related tasks and, in general, working with people from other projects or companies. Besides the framework, this paper presents experiences of the framework use and preliminary findings of work in distributed projects. We characterize two multi-site projects that are software factories that produce components for mobile phones at Nokia.

This paper is organized as follows. Section 2 discusses the basic concepts and theories behind the 4Q framework proposal. Section 3 presents more closely the framework: four areas and their theoretical background, and seven aspects in each of them, suggesting what data to collect for each Q and how to visualize this data. Section 4 presents the research approach, limitations and the selected process. Section 5 discusses findings from two case projects at Nokia and experiences of the framework use. In Section 6 we draw conclusions and based on experiences summarize future objectives and research activities.

2. Basic concepts

This section discusses and defines our method of studying collaboration in multi-site environments. We distinguish between four intertwined categories of collaboration (Section 2.1) and focus on interactions taken place in these categories. We examine the phenomena by using two concepts: *the degree of distributedness* and *active network* (Sections 2.2 and 2.3).

2.1. Four categories of collaboration and "human capital"

We describe the context of collaboration from the perspective of an individual person. Multi-site work can be seen as a set of concrete activities performed by individuals who work in a distributed environment and who interact with local and distant parties that may be people or systems. In Figure 1 these activities are represented by four categories: *personal work, work with people*, *project/teamwork* and *knowledge work*. These form the basis of the framework.

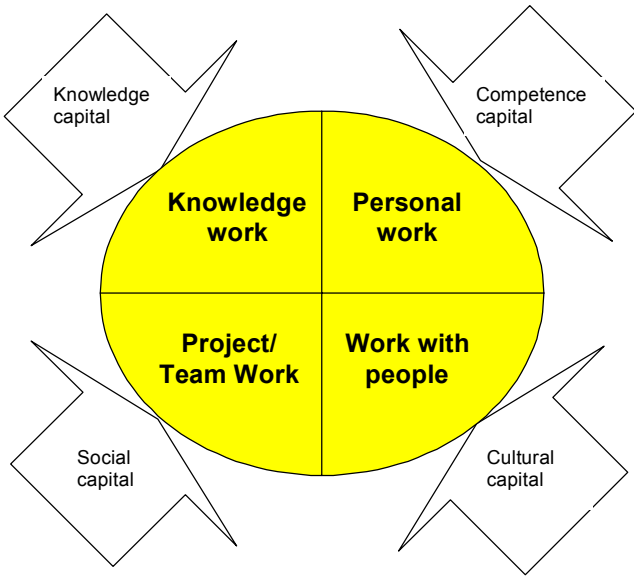

Figure 1. Four categories of collaboration.

Next we present the theoretical background of these categories and explain how an individual person is related to them at work.

Firstly, the categories are considered under the general notion of "human capital" as follows. Four main components are included in human capital:

- *knowledge capital*, that is accumulated by various knowledge creating processes, cf. [19],
- *competence capital* that is typically discussed by theorists analyzing core competencies of organizations, cf. [20],
- *social capital* as described by Coleman [21], and
- *cultural capital* which we define as an organizational characteristic as described by Schein [22].

These capital forms are not static and they are both overlapping and interdependent but they form a fruitful basis for considering the role of multi-site work in contributing to the performance and life of organizations.

Each of the four categories has a significant contribution to human capital. Knowledge work contributes to the knowledge capital while personal work is typically more focused on and linked with creating competencies. Work in teams and projects is critically dependent on the relationships between team members, that is, on social capital. Work with people in our 4Q framework is critically dependent and determined by the cultural values, conventions, and beliefs of the organization. From this perspective the 4Q framework is a holistic tool that can be used for evaluating the role of virtual collaboration in building organizational capital value. It may also offer insights into how to develop new

practices of collaboration, management, and virtual technology to improve organizational performance.

2.2. Degree of distributedness

Software engineering in telecommunication companies takes often place in multi-site, multi-project and multi-cultural environment. A multi-site project is an entity organized around co-located and distributed teams. In order to find out what takes place in such circumstances we have examined individual activities and experiences and try to capture the effect of distribution on everyday work. For this purpose, we have defined the concept of the *degree of distributedness*[2] in a studied entity. We have focused on social and cognitive aspects and started by defining distributedness in terms of the amount of *interaction that takes place with a partner without close physical contact or existence*. A partner can be a group or even a virtual system or source.

We constitute the degree of distributedness with a set of variables that are related to the quadrants in Figure 1. These variables are derived from our consultancy experiences and earlier studies [24]. Hence, they provide a subjective view to the topics of interest. We aim to gather both "facts" and "experiences". For example, the variables "the amount of critical partners" and "the density of virtual contacts" can be derived from activities during a certain period of time. Furthermore, "global team spirit" and "easiness of finding contacts" are variables that are biased by experiences. Each of them can be discussed and a quantitative value can be derived (see Section 3.4) in the interviews with the members of the observed organization. Based on the accumulated information we can describe the possibility of an individual to work successfully in a distributed environment and compare it to the planned reality. In order to increase coherency in the proposed framework we have grouped variables into seven aspects that will be discussed later in Section 3.3. In this phase of the study we do not have sufficient data for using factor analysis or related multi-variate methods for grouping the items used.

2.3. Active network

We use the concept of *active network*, to capture all relevant interaction and communication activities. The active network describes all relationships which an individual has with her working environment, either closely or loosely connected with her work and which are actively used (or should be used) when working. It covers person's interaction related to her own work and knowledge, interactions with people loosely involved in one's work, controlled team collaboration, and interactions related to common or external knowledge (e.g. learning). Thus, the active network covers and concretizes interactions related to the 4 categories of collaboration discussed earlier.

Interaction theories [25] emphasize that new knowledge is created and mutual understanding is increased when people interact. This is essential in innovative product creation and complex engineering projects. For example, personal networks are a widely used and accepted way of working in Nokia. We believe that focussing on the realization and maintenance of personal relationships in a turbulent environment has a significant organizational potential.

Several theories have been developed to understand group interactions, team dynamics [26], virtual teams [23], communities of practice [27], and self-managing work groups [28] as examples. We do not argue that some specific theories and concepts should be applied to global and virtual circumstances in a straightforward manner. The reason for this open view is the diverseness of interactions, which can be more or less organized, based on communities or groups around application area, expertise, nationality, working method, or just requests from outsiders. Also, personal working and learning habits vary considerably, and variability can be seen as a potential creativity factor in changing environments.

3. 4Q framework

3.1. Development of the 4Q framework

Nokia has been the case organisation for several studies that describe knowledge creation [29] and organisational learning [30]. These studies focus on how certain theories are applied and should be applied in practice and present designs of collaboration on a theoretical level. Furthermore, software process improvement approaches have been applied when designing multi-site software factories [31]. However, these studies do not tell much how individuals experience their working environment.

During summer 1999 we made an analysis of collaboration experiences from distributed R&D and product creation projects at Nokia. We interviewed project managers, team leaders, experts and chief engineers who have led or worked in multi-site projects at Nokia. Based on the study we became convinced of the value of active network concept (Section 2.3) as a powerful determinant of knowledge creation and sharing. In addition, we observed a collection of core problems and challenges that are related to, e.g., team spirit and trust, roles and responsibilities, documentation, informal/formal collaboration, and differences between sites [24].

Managers need to act and fine-tune their ongoing projects in a dynamic environment under specific conditions. Thus, there was a need to a comprehensive "snapshot analysis" in order to offer more concrete and detailed action proposals for projects. We were also faced with understandable business demands to collect data

[2] Lipnack and Stamps discusses [23] virtual teams. Although one extreme form of organizing work is virtual team we prefer in this study the term distributed team instead of virtual team, and, respectively distributedness instead of virtualness. Most of our factors are related to difficulties due to dispersion or distribution.

without disrupting daily routines in a studied entity, and to get recommendations quickly to management's use.

The first step was to create a research approach to be based on the active network concept and to comprehensively target on collaboration challenges. This resulted in the first version of the 4Q framework including, for example, four areas of work (see Section 3.2), quantitative data collection technique and variables (see Section 3.4), and visualization of the degree of distributedness (see Section 3.5).

The 4Q framework was tested in one case project during spring 2000. We were not satisfied with the clusters of variables used for each quadrant (Q) in the 4Q framework. This was seen as disruption of the clarity of radar visualizations we used. Based on qualitative analysis of these pilot data we arranged variables over seven functional aspects (Section 3.3) in each quadrants. These aspects were derived both "bottom-up" (by generalizing the existing variables) and "top-down" manner (we derived new variables and changed old ones to fit into aspects). As a result we concluded that the following aspects constitute each of the quadrants: *distribution, capabilities, facilities, satisfaction, efficiency/effectiveness, awareness,* and *change readiness.* This new 4Q framework proposal (to be shown in Figure 2) has been used and tested in two case projects during fall 2000.

3.2. 4Q framework quadrants – areas of the active network

The 4Q framework is based on the active network concept described in Section 2.3, and it can be derived from "human capital" as we discussed in Section 2.1.

We characterize collaboration and knowledge intensive work in terms of various relationships between an individual and her environment. In collaboration we distinguish between working with people in general and working in a more socially bounded and organized entity such as a project or a team. Thus, the framework distinguishes between "work with people" and "project/team work". Similar distinction is made between "knowledge work" and "personal work". The former requires, e.g., an individual to work with socially articulated knowledge (e.g. reports of a work group) or to use others' expertise and the latter focuses one's individual efforts to create new knowledge. As seen in Figure 2 the framework can be used both when the focus of work is on communication or knowledge intensive activities, and when the emphasis is on social or individual activities.

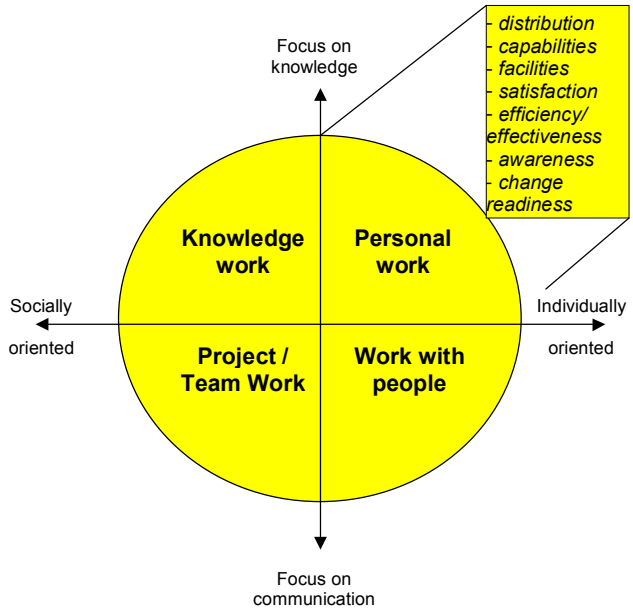

Figure 2. 4Q framework.

Personal work focuses on issues around personal tasks of an individual in a distributed environment. This area covers the following issues: competencies, mental frameworks, motivation, stress, personal ambitions, individuality, working style, beliefs, and values [see e.g. 32]. Factors in our study include time spent for working alone, freedom to decide over tasks, desire to co-operate, amount and quality of feedback received, and disturbance in a working place.

Work with people focuses on general social interactions that, firstly, take place between persons not having a close or formal relationship, and, secondly, are often affected by organizational culture, traditions, values, and experiences. Personal goals, needs and earlier experiences are often driving forces for fruitful collaboration. For example, how willing one is to give information or put effort in helping other people than her closest teammates. We analyze here people relation to, e.g., contacts, customers, "ad hoc" requests, capabilities to work virtually, and working with other cultures and sites.

Project/teamwork focuses on how people are involved with production as a member of projects and teams. Here, project goals are controlled and schedules are tight. In this area personal values and capabilities are considered against project rules, processes, schedules, managerial styles and the values of closest teammates. In order to manage such a production the group interaction is supposed to be well supported [9, 24]. Factors in this area consider issues such as project dispersion, management, goals and schedules, team spirit, and project procedures and rules.

Collaboration can be accentuated by the relationship "me and the others". Respectively, **knowledge work** can be regarded as a relationship between "me and information/knowledge", e.g., internalization as an example. This enlarges management of personal

information with learning capability [e.g. 27], and knowledge sharing and creation [e.g. 9]. In knowledge work one needs to deal with various forms and qualities of information, variety of sources (also human), and means that help in achieving, managing and producing information and knowledge. The focus here is in the creation, use, and management of knowledge. It may be related to technical and/or human activities, but its outcome is a better understanding or simply better information. Factors used in this study include amount and global[3] availability of sources, quality of external information in sources used, quality of written rules or process guidelines (e.g. inspection rules and checklists), and capabilities to follow research and trends related to the one's working field.

3.3. Functional aspects

As discussed earlier functional aspects were elicited because of the need for coherent organization of the 4Q framework. These aspects should be considered as authors' suggestion of important focus in collaboration phenomena[4]. The same aspects in each quadrant help to capture the "degree and subjective meaning of distribution", i.e., how distributed the environment is and how it has been experienced. We believe that individuals need facilities for distributed work, they should feel capable, satisfied, and efficient in their work, and they should feel awareness of what takes place around them. In addition, for managers the information of change readiness is valuable. Based on these assumptions we describe in the following the seven aspects:

Distribution covers factual information to figure out individuals' active network: density of collaborating, dispersion of their project, and dispersion of information sources.

Facilities indicate means, procedures and tools that help an individual to work in each 4Q area. This contains support for personal networking, such as project practices and the possibilities to use collaboration tools as examples.

Capabilities aim at finding out how capable an individual feels to work in the 4Q areas, e.g. how easily one finds relevant contacts or can decide over her tasks. It also describes preconditions for each 4Q area such as team spirit and quality of information.

Satisfaction of results discusses how satisfied an individual is of collaborative activities, how compatible one finds collaboration tools for each of the 4Q areas, and how satisfied one is of results achieved during the process.

Efficiency/effectiveness captures individual feelings how efficient participatory tasks are (e.g., how to reach a consensus), how efficiently one is able to perform personal tasks, and hindrances of knowledge work.

Awareness describes how an individual knows her place in the active network, can follow her contacts, customers, and is aware of project/team members and latest changes in information. In addition to be aware of, one has to be visible to other parties.

By a **change readiness** our aim is to find out how ready people are to accept and adapt to changes in their respective form of work.

3.4. Data collection

There are strong business demands to collect data without disrupting daily routines in a studied entity, and to get recommendations quickly to management's use. The aim is to get as realistic picture as possible of each individual's active network and collaboration. We have applied structured interviews as a main data collection technique. Questions were formulated so as to get an answer in a numerical form (one question – one variable) in order to formalize and visualize results. When collecting data from the case projects we used totally 74 variables.

We focused on two kinds of questions: factual questions (dispersion and facilities) and questions of what people personally feel and experience (capabilities, satisfaction, efficiency, awareness and change readiness). We avoided asking their overall opinions because these – when being too personal or just constructed in ad hoc manner – may contain several biases.

Data from an interview is strongly subjective, and interpreting differences between individuals is not purposeful. We have asked people to describe their experiences from the last three months' period. By repeating the analysis periodically (and interviewing the same people) it becomes feasible to interpret also personal changes.

The collected data is mainly quantitative, although we let people explain what they meant. We received a numeric value following the same pattern: the bigger number indicates more positive – effective, satisfied, aware – experiences one had according to the functional aspect in question. We used the scale from 1 to 5 in our cases. In factual questions we needed to derive values so that the bigger number expresses higher distribution (e.g. "5" means that over 80% contacts are located in other sites than the own one).

3.5. Visualization of results

The data of each individual was visualized in a radar form. The visualization used as personal feedback and a basis for recommendations when discussing with project management. In general, we draft that a high radar area reflects the readiness of an individual to work in a distributed environment, and it also signifies the *degree of distributedness* of a working environment.

[3] Here we asked source's availability to other Nokia project, subcontractors, and other companies (e.g. web sites for SyncML, or Symbian).

[4] We stress that the 4Q areas form a stable part of the framework and aspects are changeable depending on the interests of a researcher. We do not have evidence of whether it is better to represent the areas with the same aspects or derive different ones for each area.

The radar can be used in two ways. Firstly, it can point out a possible emphasis on a certain area, and, secondly specific aspects with highest or weakest results can be easily pointed out and taken into a more detailed analysis. Figure 3 shows example radar from one individual in whose work the emphasis is on personal work and work with people. The highest aspects are distribution (Radar number 7) and efficiency (Radar number 10) in the area of "work with people".

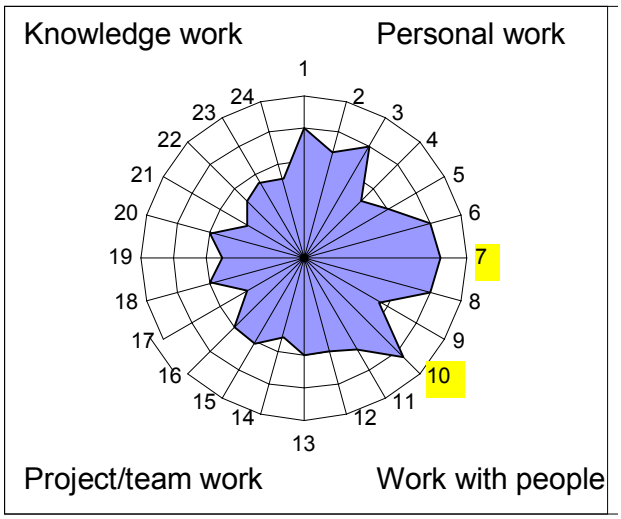

Figure 3. Visualization of 4Q data – an example radar[5].

The obtained result for each aspect is based on one or more questions in each quadrant. For example, the "Distribution" aspect in "Work with people" quadrant. was obtained as a mean of scores of the five variables "Amount of contacts", "Diversity of contacts", "Density of physical contacting to other sites", "Density of virtual interactions", and "Density of ad hoc requests". The total number of questions for which we got a 5-scale answer is currently 74.

The data we have obtained is naturally subjective, i.e., they are based on personal interpretations of the interviewee. The 4Q framework measurements can not be calibrated to get individually scaled, comparable results, e.g., one person may answer more positively to the questions than another, but still feel and mean approximately the same. Due to this, we intend to interview the same people at intervals, and focus on possible changes, which will then allow us to make conclusions of possible effects of development actions taken.

[5] 4 x 6 aspects are summarized. We did not quantify the change readiness aspect.

4. The research approach, process and its limitations

4.1. Approach and limitations

The 4Q model is developed for consulting and analysis purposes and it is currently based on one case organization (Nokia) instead of a sample. The use of visualization and seven aspects for balancing visualizations are meant for qualitative understanding of distributed collaboration processes in projects.

Our research approach can be characterized as a formative evaluation. The purpose of such a study is "…to improve a program, policy, organization or product" [33]. Results of the study should form a basis of development discussions and recommendations for improvements. A key assumption is that people can and will use available information to improve what they are doing. Furthermore, generalizations are limited to a specific setting studied. Thus, the preliminary results presented in Section 5 characterize only work at Nokia distributed projects.

Because of the lack of extensive sample data we have not carried out any multi-variate statistical analysis. Our 4Q visualization aims to provide results quickly in the relevant business and management context. The main value of visualization is that it generalizes the results to show "meaningful trends" as we discuss later on our experiences of the radar use (Section 5.3). Statistical analysis does serve as a complementary method, but the formative evaluation constricts generalizations. Here we present preliminary data from a correlation analysis (Pearson) and report these results in Section 5.2 to complement characterization of cases.

4.2. The analysis of case projects

Preparation. All three cases started with a "kick off" meeting with the project management. In this phase the project assigned a contact person, which in all cases was the quality manager of the project. We discussed and decided the special topics of interest (which were subcontracting and interfaces between different projects) and defined the sample for interviews (roles, sites, and amount of persons involved in each site).

Data collection. This phase contained two tasks: the clarification of the project profile, and creation of individual experiences of working in a multi-site project.

The idea behind project profiling is to give basis for understanding of which individual experiences are similar to the planned ones and which of them require actions by the project management. As primary sources we used official project documentation and discussions with project management. In practice, we attached collaboration rules, plans, guidance given, and practices into the framework, each to the closest of the 4Q areas. This gives us an overview how project is equipped to support each 4Q areas.

We used interviews to collect experiences from 4Q framework areas and aspects. Our sample in personal interviews was 10-15% of project personnel. In practice, this is about 10 interviews totally and 2-4 per one site. Table 1 summarizes the case projects. All individuals were interviewed separately. We used either a face-to-face or phone interview, and each interview took 1,5 hours on average. Based on the interviews we created radar for each interviewee and, also, derived summary radar for project (project mean, maximum and minimum values). The summary radar (realized state) was made for articulating it against the project profile (planned state).

	Project A	Project B
Interviews	8 / 10%	12 / 15%
Sites involved	3 out of 4	4 out of 4

Table 1. Interviews in two case projects.

Analysis. Visualization forms the basis for our analysis. Care should be taken in drawing strong conclusions at a detailed level (individual aspects or individual questions). In giving feedback to projects, we focused on wholes, i.e., the radar size and the radar profile in 4Q areas.

In addition to the use of radar, we have used Pearson correlation analysis to analyze correlation between individual aspects.

Dissemination. We organized a feedback meeting with management. This served at least two important goals. Firstly, it increased management awareness of the project status and gave valuable feedback for them. In addition, the feedback to interviewees is critically important. This feedback should cover also recommendations and actions to be taken and avoid research speculations with no practical help.

Secondly, we focused on facilitating positive change in practices. A basic assumption in this research content is that project is willing to improve its ways of working. However, the framework does not give straightforward suggestions. Thus, sustained changes require a follow-up process. For that purpose, it is wise to repeat interviews at suitable intervals. The visualization technique helps to identify effects of changes, e.g., increased efficiency or satisfaction to project work.

5. Discussion of preliminary results

5.1. Characterization of work dispersion at case projects

We defined the concepts of active network and the degree of distributedness in Section 2. Table 2 shows data that illustrates the active network and distributedness that people experienced in two case projects. It shows the active network of managers (including those having sub-ordinates) and engineers, and illustrates working environment by counting the number of sites and projects the subjects were working with.

Dispersion of active network	Mgmt project A	Engs project A	Mgmt project B	Engs project B
Amount of contacts	20-150	15-20	50-150	10-20
Dispersion of contacts	High variability, 20-80% contacts were in distant sites, the size and location of own site an important factor			
Projects to be followed	10-15	3-5	10-30	2-5
Projects closely working with	3-7	1-3	5-15	1-3
Sites working with	4-8	3-4	4-15	3-5
Information sources	High variability, from few to 100 sources in use. Availability Nokia-wide. The use of public sources exceptional.			

Table 2. Dispersion of active network in two case projects.

The amount of distant contacts in both manager's and engineer's active network varied depending on the size of the site one was working at. On the average, half of the contacts were with other sites than the own one. The amount of information sources (e.g. web sites, Lotus Notes databases) also varied: usually the people were working with 10-20 sources, but in some cases the amount was only few but for some it could be up to 50-100. Most sources were technically accessible Nokia-wide and in exceptional cases they were public sources

Although the projects were distributed they were not organized as virtual networks. We asked how globally tasks were allocated, e.g. are software components requiring several persons' work done in one site or is the work shared among several sites. Our subjects regarded task allocation slightly more locally than globally oriented.

Secondly, we describe our findings related to the analysis of profile and size of individuals' radar in 4Q framework.

Profile: Based on one project profile and earlier studies [24] we can assume that work in multi-site projects is split into elementary components, the responsibility of which is given to individuals. Typically, the emphasis is on guiding and supporting personal work. Collaboration takes place more in a self-organized manner, and is actualized in personal networks (this stresses individual orientation instead of social in Figure 2). In a bureaucracy sense this is a benefit, but it may be a drawback for a teamwork culture. People may prefer tools such as phone or e-mail instead of sharing knowledge via repository based tools. The framework also presents an axis having communication and knowledge as ends. We notice that, managers' work consists of communicative activities and they have more positive experiences of their work (capabilities, satisfaction, efficiency, and awareness) on

communication side than the engineers did. However, in knowledge work, there was not such a clear difference between these groups.

Size. As noticed in several studies people have different roles in the projects. By comparing radar sizes we can notice differences based on two factors: involvement in managerial work and work experience in years clearly affected to the total personal radar area and also its profile.

5.2. Preliminary correlation analysis

Table 3 summarizes the strongest correlations between the variables in each area of 4Q framework.

Personal work: How well a person is aware of who or what parties will use her work outcome, e.g. a deliverable, correlates with two factors. These are travelling (C1) and compatibility of collaboration tools for personal work (C2). Such a correlation was not found in the case of receiving input for work, i.e., between awareness of parties one needs to receive input from and travelling.

Work with people: In the area of working with people the following three correlations were strongest. The first two of them (C3 and C4) relate to distribution of working environment and the use of communication technologies. The last one (C5) suggests that cultural differences can affect knowledge sharing.

Project/team work: Mostly, people were less satisfied with global team spirit than with the local one. However, there is a clear positive correlation (C6) between these two. Based on our sample, experienced compatibility of project goals is inversely to the number of sites (C7) and the distance of project manager correlates negatively to experienced quality of meeting preparation (C8).

Knowledge work: Here we found a negative correlation between the number of information sources and the processes of supervising (C9) but a positive correlation for experienced quality of these sources and experienced ability to learn (C10). In addition, our data supports the common sense claim that keeping material "up to date" helps in knowledge sharing (C11).

Personal Work	C1	The frequency of travelling correlates with the weak knowledge of the parties that are affected by the work of a person (r= .52, p< .05).
	C2	Experienced compatibility of personal collaboration tools correlates with knowledge of the parties affected by the work of a person (r= .5, p< .05).
Work with People	C3	Proportion of contacts outside own site correlates with frequency of ad hoc requests (r = .54, p< .05).
	C4	Proportion of time spent in virtual contacts correlates with experienced influences of cultural differences for work (r = .71, p< .01).
	C5	Easiness of getting news from other projects (in the area of ones responsibility) correlates with absence of cultural differences affecting work (r = .5, p< .05)
Project/ team Work	C6	Global team spirit correlates with local team spirit (r = .5, p<.05)
	C7	The number of sites correlates negatively with the experienced compatibility of project goals and personal work goals (r = -.52, p<.05)
	C8	The distance of project manager correlates negatively with experienced quality of preparations for meetings (r = -.63, p< .01).
Knowledge work	C9	Number of information sources used correlates negatively with satisfaction to work guidance and supervision (r=-.6, p<.01)
	C10	Experienced quality of information sources correlates with experienced ability to learn new issues at work (r = .6, p<.01)
	C11	Easiness of sharing work context correlates with how quickly information is put available for others (r = .51, p<.05).

Table 3. Preliminary findings from the correlation analysis.

5.3. Experiences of the 4Q framework use

We found both good potential and limitations when using the framework as a tool to organize and visualize collaboration data. In the following we summarize these experiences.

Granularity of results. Framework works well in identifying relevant issues of collaboration. For example, notable differences between work roles can be recognized. However, for single variables and aspects there is a large – and natural – variation, which hinders us from drawing straightforward conclusions. Interpretation using the radar area and profile is feasible by making a distinction between the observed facts and related subjective experiences (in practice this means mapping functional aspects together and reducing radar axes from 24 to 8).

Numeric vs. descriptive data. Pure numeric data does not tell much what is behind an answer. This is why we asked people (but not forced) in the case of low-grade answers (1, 2) to describe if there was anything they want to comment.

Visualization. It is possible that for a single factor we need to summarize an average of up to 6 questions. In such case the resulting smoother radar appears to neutralize some responses. Thus, when consulting the projects it is important to provide more details of the extreme values and highest variability between radar item values.

Importance of a single factor behind a question. All covered issues in the framework are not equally important for single individuals. It would be practical to define a personal weight factor (the factor is considered important, neutral, or not important for the work) for the variables behind the radar. Now this information was obtained in a qualitative way only.

6. Conclusions

We have described a framework for measuring collaboration in a multi-site enterprise. We use a human centered perspective by showing the individual collaboration acts and experiences during a certain time window in the project. We collected numerical values from 74 variables, used the 4Q framework to organize them, and visualized the results as radar form. By the end of the year 2000 we have tested the framework first with one project and after the iteration analyzed two software projects producing software components for mobile phones.

We discuss here our experiences of the use of the framework from three perspectives: 1) as means for data collection 2) as a basis for analysis and recommendations and 3) as means to manage changes in a studied entity.

Firstly, the framework and questionnaire allows quick data collection, which satisfies both the target projects and researchers. Time off from the project is only 2 person days from an example project of 100 persons and 4 sites. For a consultant such a method enables a quick way to collect and organize data, and derive visualizations in a straightforward way.

Secondly, the framework and visualizations provide efficient means to pick up issues that are organized or managed weakly. However, predicting what would improve the working environment most is not a straightforward task. For example, many different factors may decrease or increase distributedness in everyday work. Literature provides conventional practices for improving distributed collaboration, and there are general findings concerning, for example, relationships between dispersion and trust. But they are rather light and sweeping suggestions of not much practical help.

Thirdly, a central assumption of our study is that projects are willing to change their activities. But they need to see clearly and without doubt the practical analysis of their virtual collaboration practices. Small efforts, which do not need extra personnel or training, do not require much time spent, or are free from political issues are more easily accepted. However, in the case of profound change it is necessary to plant seeds and to wait that the project itself recognizes the need. There are potential problems in the follow-up process. If the period is too long the normal labor turnover may affect the sample. Besides, we have noticed that practices and tools for effective collaboration is easily seen as an extra burden to other production issues.

The framework is intended to be an open method for conducting an inventory and improvement of distributed work in multi-site projects. We have not grounded it in any formal theory of collaboration, but hope to offer a structured way of approaching this complicated problem.

Our future work contains the deployment of the framework, and analysis of dependencies between individual factors. Firstly, we have separated the framework and questions: the set of questions can be changed but each of the 24 axes of our framework needs to be covered. Based on this we will test framework usability in other distributed entities besides software component factories. Secondly, based on the current data we are able to see differences in radar size that are due to working years and position. Currently we are analyzing details in order to derive reference frameworks for roles. These reference frameworks may help to organize multi-site projects and allocate resources. However, there is a long road to a knowledge base of projects and roles. We are testing the feasibility of such an approach. At the moment, we have a discovery tool for identifying collaboration problems in distributed projects and building organizational and technological basis for virtual collaboration.

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