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Collaborative Working Environments

Group Needs Approach to Designing Systems for Supporting Spatially Distributed Groups

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Abstract

Collaborative Working Environments – Group Needs Approach to Designing Systems for Supporting Spatially Distributed Groups

Collaboration in spatially distributed groups requires technological support for mediating collaborative activities and members' interactions over time and distance. Technology provides multiple tools for supporting individual, social and task requirements of collaborative groups. Nevertheless, many aspects of computer-mediated interactions are not sufficiently explained and creating an effective computer-supported environment for collaborative groups as a combination of these tools remains a challenge. Meeting this challenge requires taking into consideration different aspects of collaborative interactions from both social and technological perspectives.

This thesis discusses the social and technical aspects of collaboration in spatially distributed groups and introduces a design approach for collaborative working environments. Firstly, it presents a comprehensive overview of research on collaborative groups, summarizing three interrelated elements under the umbrella of the group needs approach: individual, task and group maintenance needs. Secondly, it proposes a design approach for collaborative working environments on the basis of group needs and thus presents an alternative for designing computer-supported environment for collaborative groups.

This research considers two main types of systems for supporting collaborative groups – groupware and social software – and discusses functionalities originating from these systems. It introduces the Quality Function Deployment method and utilizes its House of Quality concept in order to develop and initially evaluate the First-Stage Prototype – the prototypical implementation of the collaborative working environment combining these two main types. The presented framework is used as a benchmarking tool on the basis of which selected existing platforms for supporting collaboration are evaluated.

This research contributes to the area of the Computer-Supported Cooperative Work and discusses actual trends in development of collaborative systems related to the application of new social tools for purposes of computer-supported collaboration.

Kurzfassung

Kollaborative Arbeitsumgebungen – der Gruppenbedürfnisansatz zur Entwicklung von Systemen für die Unterstützung räumlich verteilter Gruppen

Die Zusammenarbeit in räumlich verteilten Gruppen erfordert technologische Unterstützung um Interaktionen innerhalb der Gruppen über Zeit und Distanz zu ermöglichen. Dabei bieten heutige Technologien verschiedene Tools zur Unterstützung von individuellen, sozialen und aufgabenorientierten Anforderungen der Gruppen. Allerdings sind viele Aspekte von computervermittelten Interaktionen nicht ausreichend erforscht und die Gestaltung von effektiven computerunterstützten Umgebungen für zusammenarbeitende Gruppen als eine Kombination dieser Tools bleibt eine Herausforderung. Die Erfüllung dieser Anforderungen erfordert die Berücksichtigung unterschiedlicher Aspekte der Gruppeninteraktionen sowohl aus sozialer als auch aus technologischer Perspektive.

Die vorliegende Arbeit untersucht die sozialen und technischen Aspekte der Zusammenarbeit in räumlich verteilten Gruppen und präsentiert einen Entwicklungsansatz für Systeme zur Unterstützung der Zusammenarbeit. Zum einen gibt sie einen umfassenden Überblick über den aktuellen Forschungsstand zum Thema kooperative Gruppen und fasst dabei die drei verbundenen Elemente individuelle Bedürfnisse, Aufgabenbedürfnisse und Bedürfnisse zur Aufrechterhaltung der Gruppen unter dem Dach des Gruppenbedürfnisansatzes zusammen. Zum anderen präsentiert die Arbeit ein Entwicklungskonzept für kooperative Arbeitsumgebungen auf Grundlage dieses Ansatzes und somit eine Alternative für die Gestaltung von computerunterstützten Umgebungen für kollaborative Gruppen.

Für diese Forschungsarbeit werden im Wesentlichen zwei Arten von Systemen sowie deren Funktionalitäten zur Unterstützung von kollaborativen Gruppen diskutiert – Groupware und Social Software. Um eine prototypische Implementierung einer kollaborativen Arbeitsumgebung zu entwickeln und eine erste Evaluation durchzuführen, wird die Quality Function Deployment Methode und das damit verbundene House of Quality Konzept verwendet.

Die Forschungsergebnisse leisten einen Beitrag auf dem Gebiet der computerunterstützten Gruppenarbeit (Computer-Supported Cooperative Work) und diskutieren aktuelle Trends im Bereich der Entwicklung kollaborativer Arbeitsumgebungen, die sich mit der Integration von neuen sozialen Tools zum Zweck computerunterstützter Zusammenarbeit beschäftigen.

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1 Introduction

"If I could solve all the problems myself, I would" – Thomas Edison, asked why he needed twenty one assistants (cited after CBR Institute 2004).

1.1 Problem Statement

History of human development has been founded upon the need of carrying out mutual actions. Driven by hunger, our ancestry came together in groups to hunt for big mammals in order to feed their families. Joint activities enabled achieving more than individual efforts.

But groups are not only stimulated by the need of performing tasks. They also play an important role in every individual's life, enabling fulfillment of social needs that have influence on such human-related aspects as individual's satisfaction or self-esteem. Individuals change and develop, influenced by experience gained from individual and group interactions. Like people, groups evolve and develop over time. Different factors affect group development patterns, e.g. smaller groups are characterized by more intensive interactions while communication in larger groups may be hindered because of the group size.

Groups develop towards a stage of optimal performance, where a group's social life is satisfactory for its members and group activities are carried out effectively. Smaller groups focused on project tasks develop high levels of cohesion and trust in this stage, which facilitates performance. Cohesion and trust building is more difficult in larger groups. Larger groups experience contribution fluctuations over time, since involvement and commitment levels of group members vary over time. Henry Ford described group development as follows: "Coming together is a beginning. Keeping together is progress. Working together is success." However, although coming together is a rather easy step, keeping together in order to work together proves to be a challenge for a group.

Spatially distributed collaborative groups – the subject of this research – are groups that experience problems related to all three mentioned elements: group forming is impeded and its cohesive existence and successful mutual interactions are hindered. These problems are related to the necessity of mediating collaborative interactions by technology and influence the quality of social interactions between group members and their mutual actions' performance.

Technology provides multiple tools for supporting individual, social and task needs of collaborative groups. Nevertheless, many aspects of computer-mediated interactions are not sufficiently explained and creating an effective computer-supported environment for collaborative groups as a combination of these tools remains a challenge (Koch 2008). Meeting this challenge requires taking into consideration different aspects of collaborative interactions from both social and technological perspectives.

Social perspective analyzes the influence of such interrelated aspects like e.g. individual satisfaction resulting from membership in a group, motivation influencing the level of commitment to the group purpose and cohesion facilitating development of good social relations between group members. Technological perspective discusses aspects of the ability of technology to meet requirements of collaboration not only for task-oriented interactions, but also related to social group processes. Often however, collaborative systems are regarded as technical systems only and not sufficiently meet social needs of collaboration participants (Koch and Gross 2006).

Recent developments in the area of adoption of computer-based tools for group communication, cooperation and information processing resulted in a paradigm shift of previous research and suggested direction of research towards involving aspects related to social software into existing design patterns (Koch 2008). It should lead to more user-oriented design, human-centric development and therefore better fulfillment of social collaboration needs. This combination requires taking into consideration the new potential emerging from incorporating new functionalities into collaborative platforms. Tools originating from social software have already found their application in collaboration environments as stand-alone applications, e.g. microblogs in higher education (Ebner et al. 2010) or folksonomies, wikis and weblogs in organizations (Richter and Koch 2007), but their influence on collaborative environment in combination with other functionalities has not yet been analyzed.

This multiplicity of potential interaction patterns resulting from application of combination of different tools leads to problems identified as media choice problem (King and Xia 1997) and multiple media use problem (Woerner et al. 2004, Munkejord 2007). Collaborative working environment should provide combination of functionalities that are appropriate for meeting collaborative group needs. This selection of an appropriate set of functionalities for the purposes of collaborative group able to meet individual, social and task needs of collaboration is a challenge for designers of collaborative systems.

1.2 Objective and Research Questions

The approach of this research is multidisciplinary, as it combines multiple disciplines and bases on elements from different research areas, e.g. psychology, sociology, social psychology, anthropology, organizational behavior or Computer-Supported Cooperative Work. Collaboration can be therefore discussed from different perspectives: individual (e.g. Tajfel 1981), group (e.g. Levi 2007), organizational (e.g. Adair 1983), social (e.g. Karau and Williams 1993) or psychological (e.g. Hardin et al. 2006).

However, it is important to distinguish the main types of collaboration in order to define the field of focus for this research. There are two typical collaborative settings discussed in literature (Stanoevska-Slabeva and Hoegg 2006, p. 175):

- *Process-oriented collaboration settings*: comprise aspects related to the support of operational part of an organization; the objective of this type of collaboration is to efficiently exchange information, documents or create collaborative plans, e.g. within global supply networks (Schiefer 2004)
- *Knowledge-centered collaboration settings*: where human interaction is in focus – the objective of this collaboration type is integration of knowledge resources and focus on knowledge and idea generation

Figure 1 (based on Stanoevska-Slabeva and Hoegg 2006) presents classification of collaborative systems arranged in two dimensions: knowledge and human interactions.

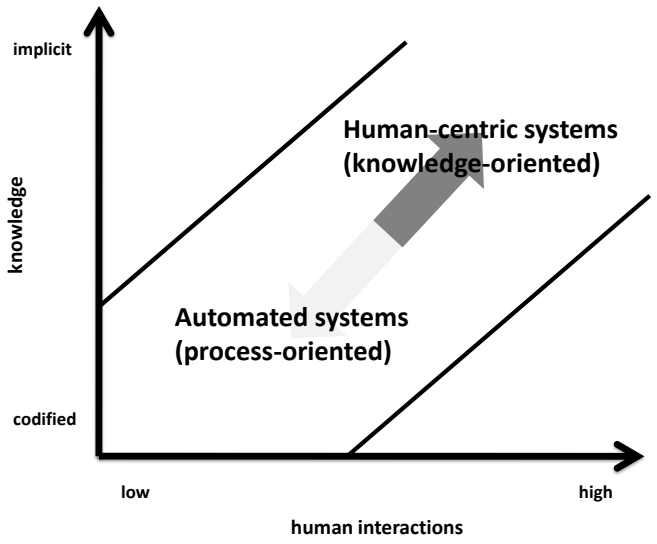


Figure 1. Classification of collaborative settings

Process-oriented collaboration settings are characterized by a high degree of codified knowledge and a low level of human interactions. Examples of technologies for process-oriented settings are e.g. Electronic Data Interchange (EDI), Enterprise Resource Planning systems (ERP), Transaction Processing Systems (TPS) or Radio-Frequency Identification (RFID). On the process level, technologies for supporting collaboration enable real-time exchange of information for collaborative actions throughout the network, e.g. facilitate collaborative planning, order management or coordinating production (Fritz and Hausen 2007).

Knowledge-centered collaboration settings are characterized by high degree of implicit knowledge and high level of human interactions. Examples of technologies for knowledge-oriented settings supporting human-centric interactions are applications like e.g. synchronous and asynchronous communication tools, collaborative editors or meeting rooms. These technologies may contribute to e.g. building innovation potential in form of supporting network communication for building and exchanging knowledge across networks (Fritz and Schiefer 2008).

This research is focused on technologies for supporting human interactions in settings of high degree of implicit knowledge and requiring high levels of human interactions. Systems for supporting this type of collaboration will be referred to as *collaborative working environments*.

Collaborative working environments are socio-technical systems, in which technology is mediating human interactions. Both technical and social aspects of this relation are characterized by high level of complexity. This thesis discusses the social and technical aspects of collaboration and introduces a design approach for collaborative working environments. Firstly, it presents a comprehensive overview of research on collaborative groups summarizing three interrelated elements under the umbrella of group needs approach: individual, task and group maintenance needs. Secondly, it proposes a design approach for collaborative working environments on the basis of group needs and thus presents an alternative for designing computer-supported environment for collaborative groups.

Designing collaborative working environments is a complex task requiring taking into consideration both social and technical aspects of collaboration and its technology support. This research presents an extensive analysis of social-related aspects and tries to establish a link between group needs and their support by technology in order to create an environment that can support all three aspects of collaborative group's life: individual, task and group maintenance needs.

The initial statement of the present research is that existing approaches for designing collaborative systems do not satisfy the requirements of collaborative groups and do not provide sufficient support for all areas influencing group collaboration. For that reason, a group needs approach is introduced in order to introduce such orientation of design process that meets both task- and human-centric needs of collaborative groups.

The objective of this research is to create and evaluate a framework for designing collaborative working environments basing on group needs approach. The framework provides basis for creating a first-stage prototype of a collaborative working environment. Therefore, the main objective of this work is:

to provide a methodology for designing collaborative working environments

for collaborative groups.

This main objective leads to research questions related to both social and technical aspects of design.

Initially, collaborative group characteristics will be identified in order to provide a basis for specifying generic types of collaborative groups:

- What are the generic types of collaborative groups?

Then, group perspective will be studied to examine the set of needs influencing group collaboration and, in relation to that, the second question is formulated:

- What are the main group needs influencing interactions in collaborative groups?

In this step, a set of central collaborative group needs will be derived. Since different needs may be of a different importance for various groups, the generic collaborative group types will be introduced and the importance of different needs will be analyzed in order to answer the following question:

- What is the importance of different group needs for generic group types?

Spatially distributed groups are real groups, in which interactions are mediated by technology. The next research questions result from effects of this mediation and refer to the ability of technology to support collaborative group needs:

- To what extent can technology support needs of collaborative groups?

Collaborative platforms offer different tools for supporting interactions of collaborative groups. Problem of media choice and multiple media use discussed in Chapter 4 determines the next question:

- What is an appropriate set of tools for meeting needs of collaborative groups?

This question refers to such combination of tools that allows for sufficient support of collaborative needs of groups. The framework for generating collaborative working environments will combine results gained from the analysis related to the previous questions, which will allow defining this appropriate set.

1.3 Research Method

This work presents an interdisciplinary, design-oriented approach combining, amongst others, aspects of research fields originating from social and human sciences. The main purpose of these descriptive science fields lies in the investigation of human activities and explaining reality. However, multidimensionality of this research and complexity of the analyzed elements determines the need for a comprehensive approach leading to a technical implementation of the collaborative working environment. To meet these requirements an engineering approach is applied. Engineering approach is present in defining design steps for creating collaborative working environment, structuring its conceptual framework and operationalization of design concepts.

Orientation of this research is closest related to the field of Computer-Supported Cooperative Work, which tries to analyze and explain social interactions and, on this basis, develop computer systems for their support. It is an interdisciplinary domain combining mechanisms and methodologies from different research areas and therefore it can be seen as an 'umbrella' encompassing activities with similar goals in the aforementioned disciplines (Borghoff and Schlichter 2000, p. 93). The design-oriented nature of this field benefits from engineering approach, the purpose of which is to design or develop structures basing on creative application of scientific principles.

Socio-technical dependencies investigated in this research and their impact on design of collaborative working environment are analyzed and evaluated using a methodology comprising literature research, expert interviews, observations and design-oriented methods e.g. Quality Function Deployment.

1.4 Structure of Thesis

Chapter 2 presents a comprehensive summary of group-related research from the perspective of collaboration, which provides basis for defining generic collaborative group types. Firstly, groups are defined as a subset of social aggregations and group influence on individuals is discussed. To create a background for defining generic collaborative group types, group typologies are introduced and main analysis criteria are elicited. Finally, generic collaborative group types are introduced and characterized.

Chapter 3 discusses aspects related to the performance of collaborative groups. Three classes of interrelated group needs are introduced: individual, task and group maintenance. This analysis enables defining of a weighted importance ranking of needs for every generic collaborative group type presented in Chapter 2.

Chapter 4 elaborates critical aspects of technology support for collaborative groups. Firstly, virtual groups are defined as real groups and problems emerging from computer-mediated interactions are discussed. Then, theoretical view on computer-supported collaboration is presented and two approaches for designing collaborative systems is compared. Finally, functionalities of collaborative platforms are analyzed and main issues regarding designing collaborative working environments are discussed.

Chapter 5 presents the group needs approach for designing collaborative environments. Firstly, the idea of collaborative working environment is presented. Secondly, a design framework consisting of three elements – collaboration environment, collaboration needs and collaboration support –is introduced and their interrelationships are discussed. Also, an initial analysis and evaluation of interrelationships between group needs and technology based on theories introduced in Chapter 4 is carried out.

The Quality Function Deployment method presented in Chapter 6 provides methodological basis for validation and evaluation of a framework. This analysis bases on results of an expert interview and allows for defining a set of functionalities to create collaborative working environments for every generic group type. First-Stage Prototype for one selected group type is presented and evaluated.

In Chapter 7 a benchmark of existing collaborative systems is presented. The comparison bases on framework introduced in Chapter 5 and allows for identifying optimal existing systems for support of generic group types.

2 Groups, Individuals and a Common Purpose

This chapter is an introduction into the field of research on groups. The content of the chapter is based on an analysis derived from the literature research. At first, groups are identified as a part of a bigger set of social aggregations. An overview of main group characteristics is presented. Then criteria for classification of collaborative groups are analyzed. Basing on those criteria, five collaborative group types are introduced: community, informal network, work group, project team and a high-activity team.

2.1 Introduction to Group Research

Group research traces its origins to different areas of science. Social psychology of the 1930s started to analyze and tried to conceptualize a structure of small informal groups relying on friendship patterns and informal interaction (sociometry). In 1950's sociologists and social anthropologists started to analyze communities and community structures of urban societies (Scott 1988, p. 110). American psychologist Tuckman (1965) contributed to the area of small groups' development and group dynamics. More research on small groups followed the needs of industry – the field of organizational behavior laid ground for an analysis of groups in an organizational context and evaluated groups performing tasks (Hackman 1968, McGrath 1984). Literature overview on the subject of group research development may be found e.g. in Zigurs and Buckland (1998, p. 314).

McGrath defines two main origins of groups: concocted – created for research purposes; and natural – existing independently of researcher's activities and purposes (McGrath 1984, 41). Concocted groups do not fall within the scope of this dissertation. Hence, the following sections will introduce factors describing natural groups.

There are many characteristics of a group in literature and theorists are not agreed when it comes to defining the word *group* (Forsyth 2009, p. 2; McKenna and Green 2002, p. 117). Different points of view stress different aspects of dependencies between people involved in a mutual interaction. Main characteristics of groups concern issues of interdependence, interaction, mutual awareness, mutual past, anticipated common future (McGrath 1984, p. 6; Jäckel and Rövekamp 2003, p. 397), specified roles, common aims, status definitions, sense of membership (Staehle 1998, p. 247; Knoll and Jarvenpaa 1998, p. 10; Luft 1984, p. 7) or the subjective sense of togetherness, we-ness, or belongingness (Turner 1982, p. 16).

Figure 2 presents a summary of those characteristics.

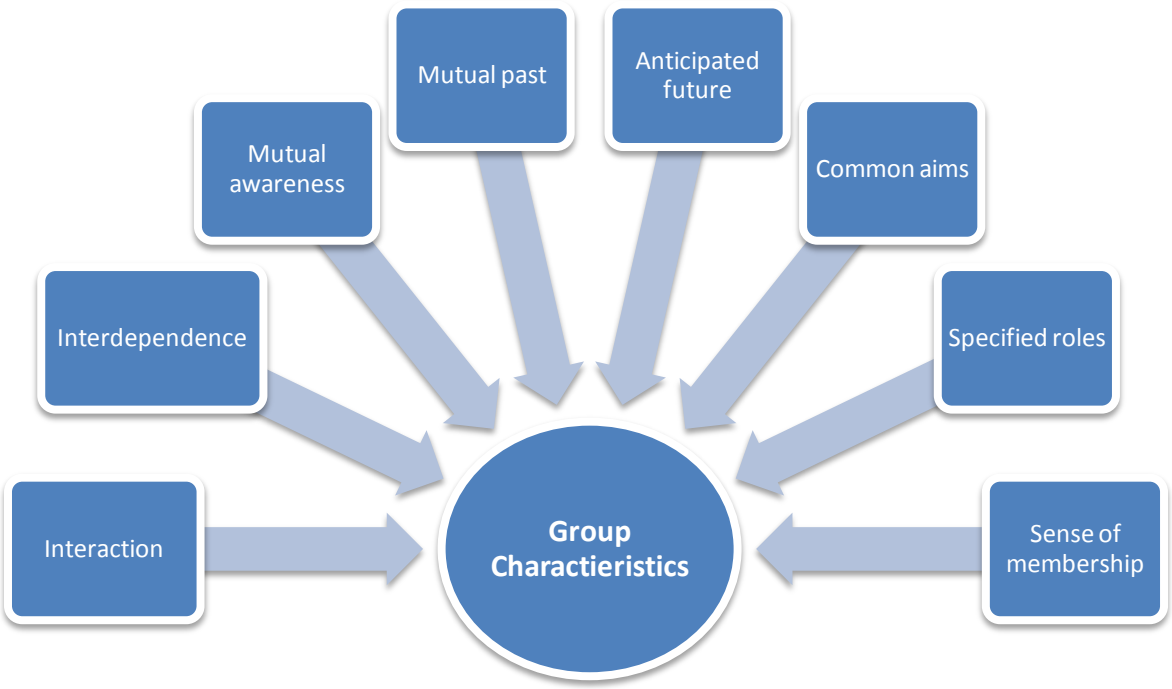


Figure 2 . Examples of group characteristics in literature

Groups are a part of a bigger set – a set of social aggregates, however, not every social aggregate is a group (McGrath 1984, p. 6; Luft 1984, p. 7). To stress the difference between social aggregates and groups and to bring closer those aspects that will be of importance for purposes of this research, examples of group and social aggregate examples will be presented in the following sections.

2.1.1 Social Aggregations

McGrath (1984, p. 8) tries to define a group as a social aggregate that involves mutual awareness, potential mutual interaction between individuals and consists of at least two people. Mutual awareness and potential interaction impose a relatively small size on a group and specify to some extent its structure and organization. If group size increases, it is more difficult to engage members in common interactions.

McGrath's definition is deliberately "fuzzy" and therefore does not try to set fixed boundaries between 'groups' and 'nongroups'. Rather, it specifies certain features that enable defining a given collection of people more as a group than the other. Most important characteristics of a group refer to a size, broad- or narrow-band scope of interaction and interdependence, barriers to or constrains on interaction and the temporal pattern of relations of these groups. Referring to McGrath's definition, an aggregate is *more a group* as:

- The number of its members decreases (increased chances of potential interaction)
- The range of content of its members' interaction increases
- There are less barriers to free interaction
- Members' history and their anticipated future involve longer period of time

McGrath's definition therefore excludes the following social aggregates: a *social category* or a *statistical group*, defined by attendants that have some statistical characteristic (age, gender) in common; an *audience* – e.g. a set of people attending to a presentation (individuals are not necessarily aware of one another or have relation to one another); a *crowd* – a set of individuals attending to a common set of stimuli characterized by physical proximity; an *association* (an interest group) whose attendants share and are aware of common interests in certain issues and seek interactions on those issues (if interpersonal relationships remain limited they correspond to publics; if interactions become important, they correspond to organizations). *Cultures*, *subcultures*, *societies* and *communities* (as a location based subdivision of society), *organizations* and *suborganizations* will also not count as groups because of the size hindering mutual awareness and potential interaction between all attendees (McGrath 1984, pp. 7). An overview of main social aggregation types is presented in Table 1 (based on McGrath 1984, pp. 7).

Table 1. Types of social aggregates

Type of a social aggregation	Characteristics
Artificial aggregations	
Statistical group, social category	Having some property in common; members not necessarily aware of one another or in relation to each other
Unorganized aggregates	
Audience	Attending to the same set of stimuli; members not necessarily aware of others activity or aware of in relation to one other
Crowd	Attending to the same set of stimuli and in physical proximity; members interrelated at least in terms of mutual sensory stimulation
Public	Attending to a common set of issues, in some form of indirect interaction regarding these issues; individuals aware of common interest, not necessarily in direct interaction
Units with patterned relationships	
Culture	Sharing common set of value orientations and common language; members interdependent with respect to the aspects of the culture, not necessarily aware of all relations

Subculture	Sharing a set of value orientations and language; members are likely to share many aspects of the surrounding subcultures
Kinship group	Members related by birth and/or marriage
Structured social units	
Society	Large social aggregate, usually within a single culture, in defined geographical region and with an integrated political system; members have structured formal and informal relations
Community (location based)	Location based subdivision of a society; members live close together, are highly interdependent, interact frequently, aware of mutual interaction and interdependence
Family	A kin based and/or residence based basic unit of social structure; members highly and pervasively interdependent and aware of it
Deliberately designed social units	
Organization	Large aggregation of people and other resources deliberately designed to pursue certain goals; members formally related to one another
Suborganization	A portion of a large organization where members are located fulfill their roles
Crew (or work team)	A relatively small set of persons within an organization; members highly interdependent in terms of organizational roles
Less deliberately designed social units	
Association (or interest group)	Sharing common interests; members aware of common interests and deliberately seek interactions on these issues
Friendship group	A relatively small aggregation of individuals; members interact voluntarily, frequently, and on a broad band of activities, with positive interpersonal feelings

Source: adapted from McGrath (1984, pp. 7)

When a social aggregate becomes too large, mutual awareness of all members and their potential interactions are hindered, hence *size of a group* is a crucial factor in terms of a social aggregate as a group. Dimension of a common link allows defining the type of *ties bonding individuals*: physical, social (less or more intimate) or organizational. Some aggregates exist only for a certain time (audience), other (friendship group, family) may share mutual past or even future (*lifetime*).

McGrath's view on groups specifies aspects allowing for defining a given collection of people more as a group than the other. His approach specifies general settings (i.e. mutual interactions,

interdependence) but does not try to evaluate relations between individuals. Social network research focuses on groups in terms of an analysis of these relations.

2.1.2 Group as a Network

The term *social network* paints an image of a social reality where individuals are tied to one another by a mesh of connections. *Network view* in sociology considers a group as a subject to a mathematical analysis, but this view has its roots in the basics of sociological approach – with social relations as a main subject of interest. This approach emerged in 1930s and laid ground for the development of a study of *group dynamics* (Scott 1988, pp. 109). Group research emerging from the area of analytical sociology considers a group as a structure of relationships between *all pairs and actors* in the system (Krackhardt 1987, p. 113). *Social network analysis* tries to determine the structure of a network (dependencies between network actors) and therefore evaluates the strength of ties (strong ties, weak ties) through the examination of the frequency of interactions between network actors (Rohde and Shaffer 2003, p. 23).

This approach considers a group as a social network where connections (relations) are dense and limited to a finite area, so that almost all network elements are in relationship to others (Wellman 2003, p. 127). The strength of a tie determines the type of relation between actors and depends on the amount of time, emotional intensity, intimacy and the reciprocal services that characterize the tie. Strong ties relate to close and intimate bonds (friends, family) while weak ties define bonds e.g. between acquaintances (Granovetter 1973, p. 1361).

2.1.3 Group Definitions

Previous sections shaped a group's universe and grounded the term *group* in the social aggregation environment. This part will focus on explaining group characteristics in more detail.

Approaches to group definitions differ slightly depending on the field from which the research originates. Literature analysis gives insight into a broad range of aspects in the area of group research.

McGrath's studies focus on generic aspects of human groups; Knoll's definition originates from the field of group dynamics, Luft's definition from group psychology while Staehle considers groups in the organizational context. Those definitions are not exclusive, but share common aspects and, depending on the field, are enhanced by aspects crucial for a certain domain.

Table 2 presents exemplary comparison of aspects mentioned in the definitions.

Table 2. Examples of group definitions in literature

Theorist	Characteristics
McGrath (1984)	two or more people, mutual awareness, potential mutual interaction, interdependence, common history, anticipated common future
Luft (1984)	Interaction, shared goal or purpose, differentiation of behavior or function, value of being within a group
Knoll et al. (1998)	two or more people, awareness of mutual relationships, sense of teamness, interdependence
Staehle (1998)	direct interaction between members, physical proximity, sense of membership, common aims, values and norms, role and status definitions, behavior influenced by others, long-term relationship

Source: Own elaboration

The perspective of these definitions presents an overview of factors that are essential for a set of individuals to be recognized as a group. A group should:

- Consist of two or more
- Interacting individuals
- Aware of their mutual and interdependent relationships
- Sharing common history and anticipating common future

Psychological perspective on groups states that two processes define a group: *social identification* and *social representation*. Those processes shape an individuals' perception of a group.

Social identification combines both cognitive and emotional processes:

- Cognitive: in terms of classifying the world into categories
- Emotional: rating certain groups as better than other

Identification refers to an awareness of group members recognizing that a group exists separately from others. Group members create a sense of 'we-ness' and describe non-group members as 'them'. The combination of shared values, ideas and beliefs that people have about the world defines a social representation. A group member's perception of the world changes

over time and a shared worldview develops over time through member interactions (Levi 2007, p. 4).

In the following sections the aforementioned aspects will be discussed in greater detail.

2.2 Individuals as a Part of a Group – Theoretical Concepts

Groups consist of individuals. The reasons why people join groups are different – one may perceive a group with a common interest as attractive, others may find other aspects of a group interesting enough to convince them to join it. There are different motivations behind the decision to join a group – security, affiliation, esteem or task achievement (Capon 2004, p. 91). Depending on the motivation, an individual decides to join a group when a certain structure of relations and members' influence exist. But what is the background of this decision? How a person becomes an aware member of a group? The following section discusses the, motives behind the questions "why do people join groups" and "why do people stay in groups".

Social psychologists tried to analyze dependencies of the individual-group relation. Two important theories emerged from this research: theory of *social identity* and *social categorization*.

2.2.1 Social Identity Theory

Formulated by Henri Tajfel (1981, pp. 254) social identity theory is founded on the hypothesis that individuals aim to achieve a positive social identity seeking positively valued features of their own groups in comparison to other groups.

According to this theory, individuals strive to enhance their self-esteem. Self-esteem consists of a personal identity and various social identities that come from groups individuals belong to.

Individuals increase their self-esteem when they perceive their *ingroups* (groups they belong to) as better than *outgroups* (groups they do not belong to). Hence, self-esteem may be enhanced by stressing positive aspects of groups an individual belongs to and by depreciating groups a person does not belong to. Self-esteem rises when a group is successful. Low level of self-esteem determines the need for ingroup favoritism that leads to a higher self-esteem level (Johnson and Johnson 2005, p. 428).

Social identity theory is presented in Figure 3 (based on Johnson and Johnson 2005, p. 429).

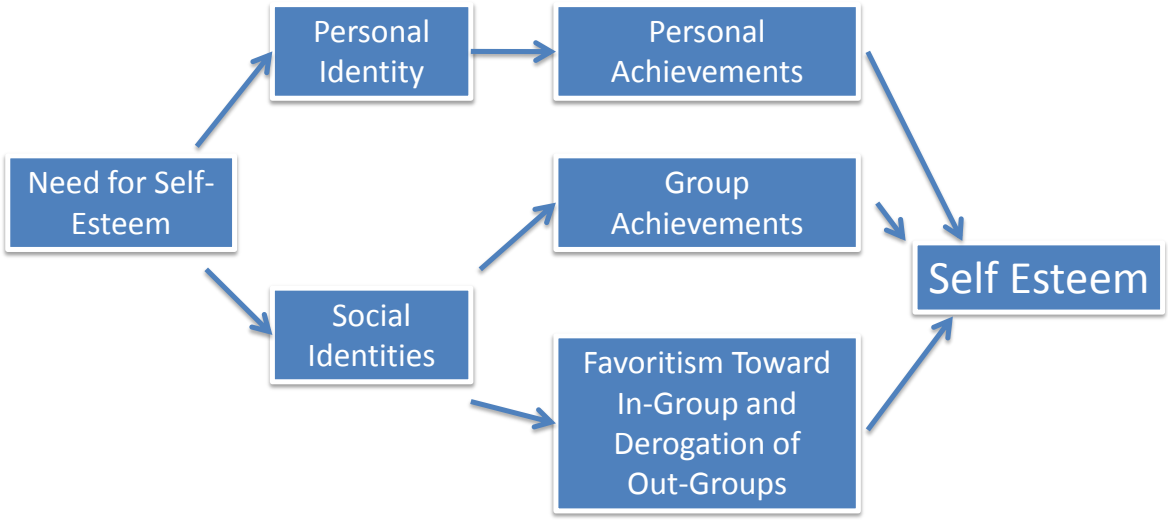


Figure 3. Social identity theory

According to a postulate of a social identity theory individuals strive to achieve a satisfactory concept of them in a society. Social identity refers to that part of an individual's self-concept that originates from his knowledge of membership in social groups, and is completed with values and emotional importance attached to that membership. Tajfel's assumption (1981, p. 254) is that some aspects of an individuals' view on relations between them and surrounding social and physical world are contributed by the membership of certain social groups and categories. Some memberships can be more salient than others and salience of some may vary in time. Social identity is a term to describe limited aspects of a self-concept that are relevant to certain aspects of social behavior (Tajfel 1981, p. 254). Social identity should not be understood as membership in a group or a social category – membership may be voluntary or mandatory while social identity is chosen (Brewer 1991, p. 477). It is strongly related to those social categorizations that simultaneously provide for a sense of belonging (Brewer 1991, p. 478).

This intergroup perspective of social identity states that every individual recognizes his or her own identity in terms of social definitions. These definitions are considered 'real' as individuals live in society, because society not only defines but also creates psychological reality. Being real, it provides an 'objective knowledge' to its members and consists of a repertoire of identities that are a part of this knowledge (Tajfel 1981, pp. 255).

How many identities are there? Due to the fact that every individual deals with many different roles and statuses (i.e. brother, director, player), it seems that there are as many selves as there are different groups that an individual belongs to (Luft 1984, p. 20).

Recognition of identity in socially defined terms has influence on certain aspects of group membership:

- Individuals tend to remain group members and look for new similar groups if they have a positive influence on their social identity and when they may derive satisfaction from membership in those groups
- If this requirement is not met, individuals tend to leave groups unless it is impossible to leave this group for some reason or it is in conflict with some important values of an individual
- If because of the abovementioned difficulties leaving the group is impossible, individuals try to change their interpretation of group attributes (problematic issues justified or made acceptable through reinterpretation) or accept the situation and engage in social actions leading to change (there can be also both actions performed in combination)
- As groups live among other groups in society, positive aspects of social identity, all social actions and reinterpretations need to be considered in relation to or in comparison with other groups

2.2.2 Social Categorization Theory

From the intergroup perspective of social identity, social categorization – the second and connected theory described hereafter – may be considered as an orientation system for an individual, helping in creating and defining an individual's place in society (Tajfel 1981, p. 255).

Individual's ability to differentiate *ingroups* and *outgroups* bases on social categorization. Social identity is linked to the social categorization through a mechanism of social comparison. Tajfel (1981, p. 256) suggests that social comparison exists in every human organism and drives the need to evaluate his opinions and abilities in comparison to opinions and abilities of others. Later research shows that not only abilities and opinions, but also other aspects (gender, attractiveness) are evaluated (Pelled et al. 1999, p. 4).

Social categorization allows classifying other individuals into categories. There are many different categorizations that may be differentiated (female, friend, enemy), but two main and basic categorizations are: *a member of my group* and *a member of a different group*. Social categorization theory bases on the assumption that personal and social identities are self-categorizations that are sufficient for defining distinctive intergroup group behavior (Tajfel 1981, p. 254).

The results of social identity and social categorization theory lead to three principles (Johnson and Johnson 2005, p. 428):

- The intergroup accentuation principle: members of an ingroup are perceived as more similar to the self than members of the outgroup
- The ingroup favoritism principle: positive emotions (trust, liking) are associated with ingroup members but not outgroup members
- The social competition principle: intergroup social comparison is based on perceived negative interdependence between ingroup and outgroups

Theories of social identity and social categorization enable an understanding of the mechanism behind bonding an individual to a group and how the distinction between ingroup and outgroup is made. Furthermore, they provide a basis for understanding when a group is satisfactory to its members. Dependencies between group membership's satisfaction are related to a *sense of belonging*, *trust* and *liking* factors: individuals strive to engage in groups that provide a sense of belonging and offer trust and liking to ingroup members.

The next sections of this chapter will introduce and shape the environment for analyzing collaborative groups.

2.3 Definition and Properties of Collaborative Groups

Views on collaboration in the literature differ and there is no consistent definition of collaboration. Definitions vary. Some researchers try to model collaboration from a process perspective, while others attempt to model it from an organizational perspective. Appley and Winder (1977, p. 281) defines collaboration as a relational system in which individuals in a group share mutual aspirations and a common conceptual framework. The interactions among individuals are characterized by 'justice as fairness'. These aspirations and conceptualizations are characterized by each individual's consciousness of his/her motives toward the other, by caring or concern for the other, and by commitment to work with the other over time, provided that this commitment is a matter of choice. Bratman (1992, p. 328) describes collaboration from the psychological point of view and defines its three main attributes: mutual responsiveness, commitment to the joint activity and commitment to mutual support. Levi (2007, p. 4) underlines the importance of a common goal and an individual motivation as the main stimulus driving a group's life.

The most fitting definition in terms of this research, combining aspects from different points of view, is the definition by Grosz and Kraus (1996, p. 269), who explains collaboration as a:

- Coordinated activity
- Working jointly with each other

- Performing a task together
- Carrying out the activities needed to satisfy a shared goal

A summary of the most important factors characterizing collaborative groups is presented in Table 3.

Table 3. Properties of collaborative groups

Property	Description
Goal orientation	Joining together for some purpose or to achieve some common goal
Interdependent	Being in some type of relationship, seeing connections among group members, or believing that they share a common fate
Interpersonal interaction	Communicating and interacting with other members
Perception of membership	Recognition that there is a collective to which one belongs
Structured relations	Roles, and norms that control interactions between people
Mutual influence	The impact people have on one another because of their connection
Individual motivation	Satisfaction of personal needs through membership in the group

Source: adapted from Levi (2007, p. 4)

A group – a generic term for describing a collection of interacting individuals – includes distinct subsets: groups that may be differentiated by additional characteristics. In the literature on collaborative groups, the terms that are most commonly used to describe groups are: a team, a network and a community (Rohde and Shaffer 2003, p. 4). This distinction, too general, however, for purposes of this research, creates a layer on which the group classification of this research will be based. To provide a basis for defining additional characteristics differentiating these types of collections, the subsets: a team, a social network and a community will be described first.

2.3.1 Teams

A *team* is a rather small group with a task to complete (Rohde and Shaffer 2003, p. 4). In literature, teams are discussed mainly in organizational settings. Team members need to trust each other, coordinate work among them, understand each other's importance for the task at hand and hold each other accountable. Because of a big interdependency between tasks assigned to individuals, team members need to rely on each other. Task interdependency requires coordination efforts; therefore a team cannot consist of too many members and needs to be relatively small. Some authors limit maximal team size to 25. Team members are committed to a set of common goals, each member commits himself substantially to the team's goal –

contributions are visible (small number of team members) and may be a subject to evaluation (Maier 2002, p. 159). Team members hold themselves mutually accountable for common actions towards a goal (Maier 2002, p. 159; Levi 2007, p. 5). Teams are temporary and disband after completing a task, which has the following consequences (Saunders and Ahuja 2006, pp. 667; Rohde and Shaffer 2003, p. 4):

- Team members do not anticipate future interactions
- Team members focus on tasks and tend to not involve in building close social relationships with other team members – ties are weak
- This may lead to complications related to member satisfaction
- Early and imposed technology norms are related to a greater extent to effectiveness (production) while in ongoing groups social norms are related to greater member satisfaction and group identity (well-being)
- Swift trust (also see Chapter 3) is more likely to provide a basis for team interactions and has influence on team outcome and production

Different types of project teams have been described in the literature, differentiated mainly by the task type they perform: there are top management teams or process teams (Maier 2002, p. 159; Simons et al. 1999; Amason and Sapienza 1997; Smith et al. 1994; Priem 1990; Murray 1989), work teams (Hackman 1987), business teams (Johansen 1988), transnational teams (Snow et al. 1996), problem solving, self-managing or special purpose teams (Johnson and Johnson 2005, p. 534). Classification basing on 'what they do' classifies teams in three ways: teams that recommend things, teams that make or do things and teams that run things (Johnson and Johnson 2005, p. 535).

2.3.2 Social Networks

Members of a *social network* are bonded by ties based on social contact and require appropriate communication. The more intensive the communication, the stronger the ties indicating the group's structure (Rohde and Shaffer 2003, p. 4). Two types of ties between network members may be defined (Goecks and Mynatt 2004, p. 329):

- Strong ties: between family members, friends or close colleagues
- Weak ties: between acquaintances, other colleagues or people in shared interest groups

A strong tie connects an individual to someone in a group, with whom he is closely affiliated. Hence, information shared via a strong tie often stays in a group, while information shared via weak tie is often shared outside a group. This leads to a conclusion that sharing information in

social networks is a complex and nuanced process that may be related to the trust individuals create within a network (Goecks and Mynatt 2004, p. 329).

2.3.3 Communities

A *community* is a set of individuals characterized by shared interests, norms and practices (Rohde and Shaffer 2003, p. 4). The term *community* has been used as a central concept in sociology describing a major form for the organization of social life and characterized individuals living together, having intimate, cooperative and personal relationships, i.e. villages or cities. Over time the term has been used not only for geographical communities, but also for so-called social-psychological communities. In this case it refers to individuals connected by common interests (Maier 2002, p. 161). Individuals become community members voluntarily and involve in community life with strength that depends on their own initiative. Community is mostly self-organizing and members are often loosely integrated. Community members do not necessarily need to interact or know each other, but they have to recognize their membership and that of other members (Maier 2002, p. 167).

A summary of community properties identified in the literature is presented in Table 4.

Table 4. Overview of community properties

Theorist	Characteristics
McMillan & Chavis (1986)	sense of belonging, influence, integration and fulfillment of needs, shared emotional connection, shared history, shared place, shared time, shared experiences
Lave & Wenger (1991)	similar goals, similar interests, common practices, common language, similar beliefs
Unsworth (1996)	shared location, shared interests, shared government, shared property
MacQueen (2001)	sense of place, common interests, joint action, social ties, diversity
Sewell (2004)	shared location, shared interest, shared government, shared property, interaction, communication, obligation

Source: Own elaboration

Communities also exist in organizations and there they are encompassing individuals with both social and business relations having mutual interests and sharing common practices (Hildreth et al. 1998, p. 8; Maier 2002, p. 161).

Among different communities, following types are mentioned in the literature: community of practice, community of interest, community of knowledge practice, strategic community, community in cyberspace, electronic community of practice, on-line community or virtual community (Maier 2002, p. 160; Fischer 2001, 2001a).

2.4 Group Typologies as a Basis for Collaborative Groups Analysis

Literature defines groups as a combination of properties summarized in Figure 2 (page 9). Those characteristics also allow differentiating certain group types depending on which of the regarded factors is a primary characteristic – e.g. size or interactions intimacy. In the following section, main classifications basing on those criteria will be introduced.

2.4.1 Small and Large Groups

Group *size* factor allows distinguishing *small* and *large groups*. While it is still being discussed in literature if a dyad or a pair is a group, small groups count between 2-3 and 20-25 members. Groups with member count bigger than 25 are counted among large groups (Staehle 1998, p. 249). Group size factor affects the amount of interactions between members. Potential interactions between members of larger groups are hindered (see also 2.1.1). Lack of frequent communication may lead to deficiencies in trust between group members. Members of smaller groups may therefore develop closer relationships and mutual trust (Becerra and Gupta 2003, p. 33).

2.4.2 Primary and Secondary Groups

Depending on *interactions intimacy,* there are *primary* and *secondary* groups differentiated in the literature. Members of a primary group share personal relationships (strong ties) with other group members (e.g. family, small military units) while relationships between members of secondary groups are usually planned or organized and ties are rather weak, e.g. work groups (Staehle 1998, p. 249; Thiedeke 2003, p. 35).

2.4.3 Formal and Informal Groups

Depending on *formation reasons,* one can distinguish *formal* and *informal* groups. Relationships in formal groups are defined by organizational rules and are predetermined. Formal groups may have limited time-span (e.g. project team) or operate without time boundaries, e.g. division or department (Staehle 1998, p. 249). Formal groups can be further differentiated to *command* (hierarchically organized small groups) and *task* (group of people working on a common assignment) groups (Staehle 1998, p. 250, Capon 2004, p. 91). Informal groups develop within

or out of formal groups. Members of a formal group develop socio-emotional relations what leads to creation of informal groups within a formal group. Within informal groups there may be interest and friendship groups distinguished (Capon 2004, p. 91). Members of informal groups maintain informal relationships based on commonalities, e.g. hobby or mutual interests and develop their own group structure and cohesion (Thiedeke 2003, p. 36).

Unequivocal classification to a formal and informal category seems to be a hard task, since groups (especially in organizations) may combine different formal and informal aspects and some research suggests even resigning from this categorization (Staehle 1998, p. 251). Still, it is a helpful tool for defining the type of relations between members and the type of ties that bind one another to a performed task.

2.4.4 Time-Activity Typology

The typology proposed by McGrath (1984, p. 44) considers groups according to two aspects: constraints in temporal and activity scope of a group (Figure 4). This typology arranges groups in two dimensions:

- *Lifetime*: some groups exist only for a short time, while other last for many years
- *Activity*: depending on a *purpose*, some groups perform a big variety of activities while others focus only on few

		Constraint in Activity Scope	
		Broad-band	**Limited-band**
Constraint in Temporal Scope	**Very long-term**	Embedding systems	Standing crews
	Limited time	Expeditions	Task forces

Figure 4. Time-activity typology of groups

Lifetime dimension is an important factor influencing those aspects of group's life that are determined mainly by the speed of interaction, i.e. communication or coordination processes. Performing difficult and interrelated activities within a limited timeframe may require faster and more frequent interactions between group members than performing those that are rather

simple and not correlated. Time constraints may also negatively influence members' satisfaction, whichleads to performance problems: members tend not to develop social relationships and trust because they do not anticipate future interactions (Saunders and Ahuja 2006, p. 668).

The purpose of a group has influence on the scope of group activity. Activity scope of highly specialized groups is limited, while members of groups with strong developed social relationships are involved in a broad scope of activities.

Depending on a quadrant, four group types were introduced by McGrath (1984, p. 44). A type *embedding system* encompasses groups with a broad band scope of activities and very long-term lifetime (e.g. family). A type *standing crew* is a group performing narrow scope of activities, lasting for a longer time (e.g. work team, activity group). Broad-band scope of activities and limited time characterizes type *expeditions* (e.g. space crews) while a *task force* type is characterized by a limited time and limited band of activities (Figure 4).

There are also group classifications based on other properties, e.g. content of a group, its origin (Schopler 1987, p. 703), ties or goal – such classifications would bring probably hundreds of group types. The purpose of this research is to define rather small number of group types. Therefore, other characteristics will be useful, especially for further and more accurate specification.

A summary of different exemplary group categorizations is presented in Table 5.

Table 5. Examples of group classifications

Characteristic	Classification
Group Size	Small group, dyad, large group
Lifetime	Limited time, long-term
Activity scope	Broad-band, Limited-band
Amount of direct interaction between members of the group	Work group, virtual group
Intimacy of interactions	Primary group, secondary group
Relation to the individual membership	Ingroup, outgroup
Relation to organizational tasks	Instrumental group, socio-emotional group
Relation to the organizational structure	Formal group, informal groups
Creation motives	Natural groups, concocted groups

Source: adapted from Maier (2002, p. 157)

Group typologies help identifying dimensions for further group analysis. Factors like group size, interactions intimacy or relation to organizational structure shape analysis environment for

collaborative groups. Not all of these factors are of importance for analyzing collaborative groups. The next section will attempt to specify the exact frames for identifying collaborative group types.

2.5 Criteria for Analyzing Collaborative Groups

One of the fundamental theories of social psychology – and one of the earliest one – is that groups are always unique. As individuals have different faces and personalities, every group has its own individual personality (Adair 1983, p 27, Peck 1987, p. 86). The goal of this section is to describe collaborative groups according to a set of most important criteria in order to narrow and concretize borders of their characteristic. It is not an easy task because of the spectrum of variables playing role in group's life. The previous sections will serve as a background for creating this set.

A list of the most important factors analyzed in group literature referring to collaborative activities within groups includes: *membership* (Dube et al. 2006, p. 71; Maier 2002, p. 169; Schopler 1987, p. 704; Wenger and Snyder 2000, p. 142), *group size* (Dube et al. 2006, p. 71; Maier 2002, p. 169; Schopler 1987, p. 704), *time span* (Dube et al. 2006, p. 71; Maier 2002, p. 169; Wenger and Snyder 2000, p. 142), *goal*, *purpose*, *ties* (Maier 2002, p. 169; Schopler 1987, p. 704; Wenger and Snyder 2000, p. 142), *contributions* (Maier 2002, p. 169), *group orientation*, *cultural diversity* (Dube et al. 2006, p. 71), *group composition* and *task difficulty and importance* (Schopler 1987, p. 704). More detailed aspects and dimensions of group characteristics can be found e.g. in the literature review by Scott (1999, p. 440) and in Maier (pp. 167).

There are different group classifications based on those factors. Those of the greatest importance were introduced in the previous section. Due to the purpose of this research, only the criteria that allow creating the basis for a group classification and their definition will be pertinent.

Research on collaborative groups originates from the theory of interorganizational groups. Schopler (1987, p. 703) defines two dimensions in which interorganizational groups can be classified: *group origin* (mandated or voluntary), and *degree of externally imposed task structure* (high vs. low). Mandated groups are created by regulations of an external body while creation of voluntary groups evolves from interdependent needs, e.g. special interests. High degree of externally imposed task structure means that a purpose of a group, its structure, tasks, member roles, responsibilities and activities are defined by an external force. In groups with low degree of externally imposed task structure, there is a limited influence of an external force on group activities and its structure. An external agent constitutes a general purpose of a group and his

influence on structuring activities is limited. Schopler (1987, p. 704) suggests a significant influence of this membership-task relation on a group outcome and performance, i.e. members' satisfaction, length of formative phase or quality of output.

The analysis presented in the previous sections based on literature research highlights the importance of the following factors for collaborative groups:

- Size of a group
- Temporal scope of a group
- Goal and purpose of a group
- Type of membership
- Ties bonding group members
- Members' contributions to a group
- Intimacy of interactions

Similar basis for collaborative group research is presented by Wenger and Snyder (2000, p. 142), an approach which was extended by Maier (2002, p. 169).

A summary of these results is presented in Table 6 and will be a basis for further analysis.

Table 6. Criteria for collaborative group analysis

Criteria	Example
Goal/Purpose	Defined, limited, related to task completion
Size	Small, large
Lifetime	Short-term, long-term
Membership	Voluntary, mandatory
Ties	Organizational, social
Contributions	Frequent, regular, occasional

Goal or *purpose* explains a specific reason for a group to come together. Completion of the goal and serving a group's purpose is the aim of group members. Goals may be specific, i.e. related to accomplishment of a given task, target-oriented limited: i.e. by time boundaries or resources; defined by organizational rules or related to mutual agreement on sharing and exchanging knowledge or other information.

Size factor differentiates groups according to a number of its members.

Lifetime defines the boundary of a group existence. Some groups may exist as long as there are reasons or mutual needs of its members to come together while others have time boundaries specified by task, assignment or project requirements.

Membership defines rules for admitting a new member to a group. Membership may be mandatory (individuals assigned by an external agent) or voluntary (individuals join the group because of their internal motivation).

Ties specify the art of bonds between group members. It may be the requirements of the job, assignment or a project, but also relations of common interests or passions.

Contributions define involvement of a group member in group activities and output. Contributions depend on the strength of individuals' motivation towards being in a group. Ideally, all members should contribute to a group; in reality – their efforts vary. The bigger the group is the more difficult is to evaluate member's engagement. As a consequence, there may be large number of passive members observed, mainly in larger groups.

2.6 Collaborative Groups – Analysis of Generic Types

The settings for an analysis of collaborative groups defined in section 2.5 and the criteria summarized in Table 6 will provide a basis for the introduction of collaborative group types.

Team, social network and community are the most discussed group types in group literature (Rohde and Shaffer 2003, p. 4). Those types help as a background for the classification presented in the following section. The structure of this typology bases on the view of Maier (2002, p. 169) that extends model by Wenger and Snyder (2000, p. 142).

The introduced types are: high-activity team, project team, work group, informal network and community. This typology serves as a general description of the characteristics of main group in order to provide a quick and rather exact guide for differentiating collaborative groups. The categories are not necessarily mutually exclusive, as groups are dynamic and their actions may vary over time. There also may exist groups combining properties of various group types defined here, depending on stage they are currently in.

2.6.1 Type "High-Activity Team"

Type "High-Activity Team" is a relatively small collection of individuals. It is a temporary group created to deal with issues that require fast outcome in the form of solving emerging problems. The main purpose of a group is to accomplish the goal of the task fast and effectively. Because of the short time of operation a group relies on rapid communication. Group members work under

time pressure, so they focus mostly on task requirements and focus less on interpersonal interaction. Group membership is rather mandatory and the degree of externally imposed task structure is mostly low or moderate, which in effect may influence the quality of output and member satisfaction, according to the classification by Schopler (1987, p. 703).

2.6.2 Type "Project Team"

Type "Project Team" describes a relatively small, temporary group committed to a common, measurable, clear and short term set of goals. Members' actions are interdependent, which requires coordination efforts. Members of a project team are aware of their positive interdependence as they strive to achieve common goals and have specific roles or functions to perform (Johnson and Johnson 2005, p. 532). The main difference between the "High-Activity Team" refers to the required coordination aspects and is short, but longer than in High-Activity Team time span, as there is a set of interrelated actions considered. Group membership is rather mandatory and the degree of externally imposed task structure is moderate. Group members require attention in terms of the output quality and members' satisfaction (Schopler 1987, p. 703).

2.6.3 Type "Work Group"

Type "Work Group" describes a collection of individuals performing formal activities related to organizational design. It is a rather small, ongoing group in which each group member has a task to complete and interdependency between individuals' actions is low (Maier 2002, p. 158). Group members do not engage often in tasks requiring combined work of two or more members. Group members are individually accountable for their work products (Katzenbach and Smith 2003, p. 214, Levi 2007, p. 8). Leader shapes the group purpose, objectives and approach (Katzenbach and Smith 2003, p. 90). Group membership is rather mandatory and degree of externally imposed task structure is high what may cause low member satisfaction and low quality of output (Schopler 1987, p. 703).

2.6.4 Type "Informal Network"

Type "Informal Network" is an ongoing, relatively small group of individuals sharing common needs and lasting as long as there is a reason for mutual interactions. Ties and frequency of interactions define such networks (Rohde and Shaffer 2003, p. 23). Group members in such network are connected primarily by strong informal ties (Goecks and Mynatt 2004, p. 329). They build, develop and maintain social relationships and trust. Informal type of relationships determines the art of membership – relying on maintaining friends and business acquaintances

relations (Maier 2002, p. 158). Voluntary type of membership and low degree of externally imposed task structure lead to high member satisfaction.

2.6.5 Type "Community of Practice"

Type "Community of Practice" stands for a collection of individuals connected by mutual needs and interests in a certain subject. It is a collection of people who voluntarily exchange experiences, knowledge and develop capabilities (Wenger and Snyder 2000, p. 139). Goals and tasks of a community are in line with members' goals and are accepted by the whole community. Group exists as long as its members are willing to maintain it. Individuals' contributions vary and an increase in group size causes decrease in member's activity (Maier 2002, p. 158). There are different examples of communities (Maier 2002, p. 160) – a shared interest is a bond that conjoins their purposes. Voluntary type of membership and low degree of externally imposed task structure lead to high member satisfaction and high quality of output. Larger communities may experience under-contribution, i.e. only small minority actively participates in group activities (Beenen et al. 2004, p. 212).

Table 7 (based on Maier 2002, p. 169) presents main collaborative group types with characteristics based on the criteria derived from the analysis in section 2.5.

Table 7. Collaborative group types

	High-Activity Team	**Project Team**	**Work Group**	**Informal Network**	**Community of Practice**
Goal/purpose	Accomplish a specified task within a certain amount of time	Accomplish a specified project within a certain amount of time	Formal, organizational design goals: e.g., perform value adding activities, deliver a product or service	Collect and pass on business information; build trust and social relationships	Serve needs of its members, e.g., develop capabilities, exchange knowledge
Membership	Members are assigned	Members are assigned	Everyone who reports to the group's leader	Friends and business acquaintances	Members select themselves
Ties	Task requirements	The project's milestones and goals	Job requirements and common goals	Mutual needs	Passion, commitment and identification with the group's expertise
Lifetime	Short time	Until the projects has been completed	Until the next reorganization	As long as people have a reason to connect	As long as there is interest in maintaining the group
Size	Tend to be small	Can be large or small	Tend to be small	Can be large or small	Can be large or small
Contributions	All members actively contribute in the group	Contributions of members vary widely	All members actively contribute in the group	Depending on individuals' needs	In large communities there are a large number of passive members

2.7 Summary

The group types discussed above differ in dimensions derived and presented in section 2.5. Working groups differ from teams e.g. in aspects referring to the degree of task coordination, which may influence communication intensity. Members of a working group perform their tasks individually, usually not depending on each other's activities. Team tasks are mostly interdependent and interconnected. Communities often count more members than a team and usually consist of far more than 25 members (Maier 2002, p. 167). Teams disband after project

completion while communities last until there is no members' interest. Community members have different motivations to join the group than members of a project team. Relationships between members of an informal network are more intimate than those of a work group or a project team. The size of a high-activity team tends to be much smaller than that of a community of practice, because of a purpose and, consequently, task requirements. Smaller size facilitates equal contributions while in larger groups member activity differs and not all members contribute actively.

Factors allowing defining group types derived in this chapter put different requirements on different aspects of group collaboration. The execution of a group task in collaborative groups depends on different characteristics depending on the group type. This static perspective enables deriving implications for structure of dynamic group processes and their requirements. The next chapter will introduce these requirements and will underline aspects that are of greater importance for group collaboration.

3 Analysis of Group Needs and Their Impact on Collaboration

Groups are unique like individuals and like individuals they tend to differ and to share commonalities. Individuals differ e.g. in terms of appearance or personality. Groups are different due to differences related to the structure of their members, size or purpose. Like humans, groups share similarities, however compared to individuals groups share their *needs* (Adair 1983, p. 28).

Collaborative groups perform actions – individual and common – in order to achieve mutual objectives. To successfully reach its goal a group must perform well in three interrelated areas: *task completion*, *individual support* and *group maintenance* (Adair 1983, p. 28; Hackman 1987, p. 316; McGrath et al. 1993, p. 407). These three areas – areas of group needs – will be the subject of a further and detailed analysis.

The background for the analysis of group needs presented in this chapter is literature research. Firstly, the importance of meeting group needs will be discussed. Then a group needs analysis will be presented. Lastly, the needs structure for collaborative group types discussed in Chapter 2 will be introduced.

3.1 Dimensions of Group Interactions

First research related to area of group dynamics began in 1898 with the observation of bicycle racers that were able to race faster in groups than while cycling alone – this effect is currently known as 'social facilitation'. Group dynamics is a scientific discipline that analyzes actions, processes and changes that occur within groups and between groups and their members over time. It tries to answer questions such as: what factors influence sense of cohesion between group members, what determines trust between them; how members develop common identity or how do group members coordinate their efforts and energies (Forsyth 2009, p. 2). Dynamic systems change perpetually, hence group dynamics describes reciprocal influence between groups and their members evolving over time.

In a literature review by Shaw (1961, p. 129) different aspects of group dynamics research are presented as factors playing role in group interactions over time:

- Participation and performance
- Group composition
- Group structures
- Tasks

- Size
- Interpersonal perception

Group dynamics tries to describe rules of group interaction processes and therefore allow an understanding of their influence on collaborative actions. In terms of this research, group dynamics will provide illustration for the dependencies between factors influencing quality of a group performing a task – a collaborative group's quintessence.

3.2 Group Development Patterns

Group development is anchored within group dynamics research and defines a set of phases a group goes through – stages of a group's life from its forming until its dissolution. Researchers created different models describing evolution of a group over time. Despite the fact that depending on a type of the analyzed group the results proposed by models differ and e.g. number of phases or their names varies, trends and commonalities may be observed (Luft 1984, p. 34). Interesting approaches are presented e.g. by Glaser (2005, p. 39) or Wenger et al. (in Dube 2006, p. 75). Models developed by various researchers are compared and summarized e.g. in Luft (1984, p. 33), Glaser (2005, p. 41) or Levi (2007, pp. 40). An extracted comparison of theories of group development stages is presented in Table 8.

Table 8. Stages of group development – comparison

LaCoursiere (1974)	Yalom (1975)	Tuckman (1977)	Peck (1987)	McGrath (1990)
orientation	orientation	forming	pseudocommunity	inception
dissatisfaction	conflict	storming	chaos	problem solving
production	closeness	norming	emptiness	conflict resolution
termination	termination	performing	community	execution
		adjourning		

Source: adapted from Luft (1984, p. 33); Glaser (2005, p. 41); Levi (2007, p. 40)

The number of phases, their names and duration time varies depending on the model, however similarities may be found in a sequence a group development follows. After an orientation phase that is often described as an anxiety and confusion phase there comes a phase characterized by conflict. If a group overcomes this phase it moves into a working phase described as a stage of trust, cohesiveness and performance. The last phase is group termination when the group is dissolved.

Stage theories underline the importance of building social relations and group norms between members and provide basis for understanding why some groups do not perform effectively from

its beginning (Levi 2007, p. 42). However, rules defined by models may not necessarily always apply – groups may e.g. dissolve after first stages or before reaching their optimal performance. Theories of group development stages help to understand dependencies between the effectiveness of a group performing tasks and group 'maturity'. Characteristics such as mutual trust or cohesiveness, impacting group performance and effectiveness, influenced by internal group process change, emerge between group members along with development phases.

Social relations within a group are more important as they provide a basis for task orientation. However, because of emotional highs and lows a group may go through periods of lower and higher task performance depending on the amount of conflicts that need to be resolved (Levi 207, p. 42). A barrier to creating such relations is related to effective communication. Having resolved communication problems, a group comes into the stage of performance (Peck 1987, p. 95).

The most accepted and popular model for group development is Tuckman's *Stages of Group Development Model*. This model (Tuckman 1965, Tuckman and Jensen 1977, p. 425) includes the following phases:

- Forming
- Storming
- Norming
- Performing
- Adjourning

Forming is a phase of orientation, testing and dependence. By testing, individuals try to identify boundaries of interpersonal and task behaviors, and establish dependency relationships with leaders. Interactions are mainly oriented towards a task.

Storming is a phase of resistance to group influence and task requirements. It is characterized by an intragroup conflict. Individuals may respond emotionally to task demands. Interpersonal issues may polarize individuals and, in consequence, reactions to task issues may become emotional.

Norming is a stage of openness to other group members. Individuals develop ingroup feelings and cohesiveness. New roles are adopted and more intimate and personal opinions on tasks are expressed as the information exchange becomes more open.

Performing is a phase of constructive action and is described as group maturity. Structural or functional issues have been resolved and group is oriented towards task performance.

Interpersonal structure is supporting task activities and group energy is oriented towards performance. After resolving a conflict a group focuses on a mutual support and cohesiveness associated with 'we-ness' feeling develops. This stage of cohesion and emotional support facilitates a climate in which learning can take place effectively. In this phase, group identification increases on a conscious-level, group roles are accepted and individuals act in a goal-oriented fashion. Group members are able to communicate their feelings constructively and in a creative way. Emotions still play a big role but are contributing to work. The social function of this stage is to create a unique and cohesive group structure and to direct it towards effective task performing.

Adjourning is a phase of disengagement and a group termination occurs. This stage was added to the model later (Tuckman and Jensen 1977). The generic Group Development Stages model consisted of four phases.

Table 9. Stages of group development

Stage	Activity
Forming	Orientation: members getting to know one another
Norming	Conflict: disagreement about roles and procedures
Storming	Structure: establishment of rules and procedures
Performing	Work: focus on completing the task
Adjourning	Dissolution: completion of task and end of the group

Source: adapted from Levi (2007, p. 39)

In order to achieve the stage characterized by the greatest performance, member's satisfaction and focus on task (performing), a group needs to cope with conflict (storming phase) and develop rules and social relations which evolve into mutual trust and cohesiveness (norming).

In the performing stage, a group can fully focus on a task and its performance remains cohesive – the group is most effective during this stage (Glaser 2005, p. 39).

These dependencies between group stages and performance are illustrated in Figure 5.

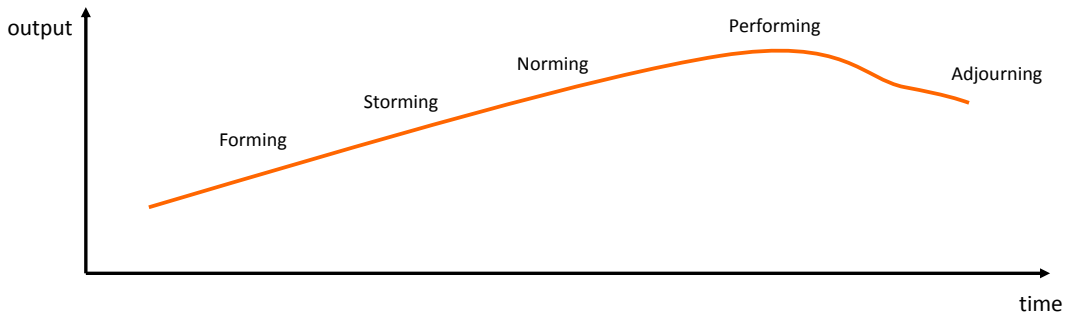


Figure 5. Tuckman's stages of group development

Interpersonal processes developed in first stages create a background for an effective performing of other group processes (Marks et al. 2001, p. 368).

3.3 Collaborative Groups – Analysis of Generic Needs

Collaborative group consists of individuals acting towards a common goal and interacting mutually through activities related to its purpose. Previous sections gave a basic insight into the dependencies between an individual's membership and the group as a whole and illustrated how group development process affects performance of a group working towards a common goal. This section will attempt to definine the areas influencing performance of collaborative groups – the needs of collaborative groups.

The three primary factors defining collaborative group interactions are related to:

- Individual support
- Task orientation
- Group maintenance

These three areas build up an interdependent set of conditions required for a group to effectively perform common activities (Adair 1983, p. 28; Hackman 1987, p. 316; McGrath et al. 1993, p. 407). Adair (1983, p. 28; 2006, p. 14) defines them as: *individual needs*, *task needs* and *group maintenance needs*. According to Hackman (1987, p. 316) a group interaction process is influenced by *individual level factors*, *group level factors* and *environment level factors*. In McGrath et al. (1993, p. 407) a set of activities and outcomes generated through those activities by group members manifests itself in three generic group functions: *member support*, *task production* and *group well-being* (Table 10).

Table 10. Three areas of group needs

Adair (1983)	Hackman (1987)	McGrath et al. (1993)
Individual needs	Individual level factors	Member support
Task needs	Environment level factors	Task production
Group maintenance needs	Group level factors	Group well-being

Source: Own elaboration

A successful collaborative group completes its tasks and reaches its goals. Developing social relations between group members supports common work performance and helps maintaining a feeling of group 'well-being'. Group membership is personally rewarding for an individual e.g. because of social support, learning of new skills or rewards given by organization participation (Levi 2007, p. 20). These three areas and interdependencies between them frame the core elements of The Three-Circles Model (Adair 1983, p. 33).

3.3.1 The Three Circles Model

According to The Three Circles Model, groups share their needs. There are three areas of needs present in collaborative groups (Adair 1983, p. 28):

- To achieve the common task
- To be held together or to maintain themselves as cohesive unities
- Needs which individuals bring with them into the group (Figure 6)

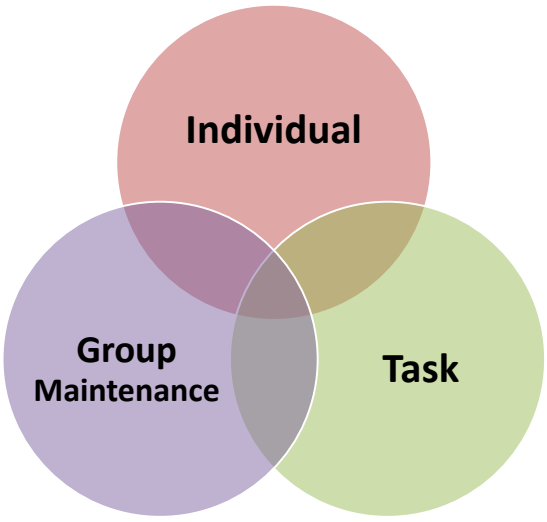


Figure 6. The Three Circles Model

Although in different cultures there may be different emphasis on the importance of an individual in a group, in respect of a common task two other aspects need to be taken into consideration: group needs and each individual's needs (Adair 1983, p. 34).

Individual needs, task needs and group maintenance needs create a model of The Three Circles – overlapping circles denote interdependencies that every set of needs has in common with other sets.

3.3.2 Individual Needs

Members bring their own personal needs into the group– not only physical ones, but also their psychological needs. Adair (1983, p. 29) suggests those personal needs may be more profound than some may realize. They may refer to recognition, sense of doing something worthwhile or status. Individuals are determined by those needs – not only in individual life, but mostly in group life (see section 2.2). These needs influence especially collaborative groups, while many individuals spend much of their everyday time on working activities (Adair 1983, p. 29).

Maslov's hierarchy of needs (1943, 1954) and its reviewed version (Maslov 1971, 1998) is one of the most known theories referring to individual needs. In his model Maslov tries to put individual needs in a hierarchical order (Figure 7).

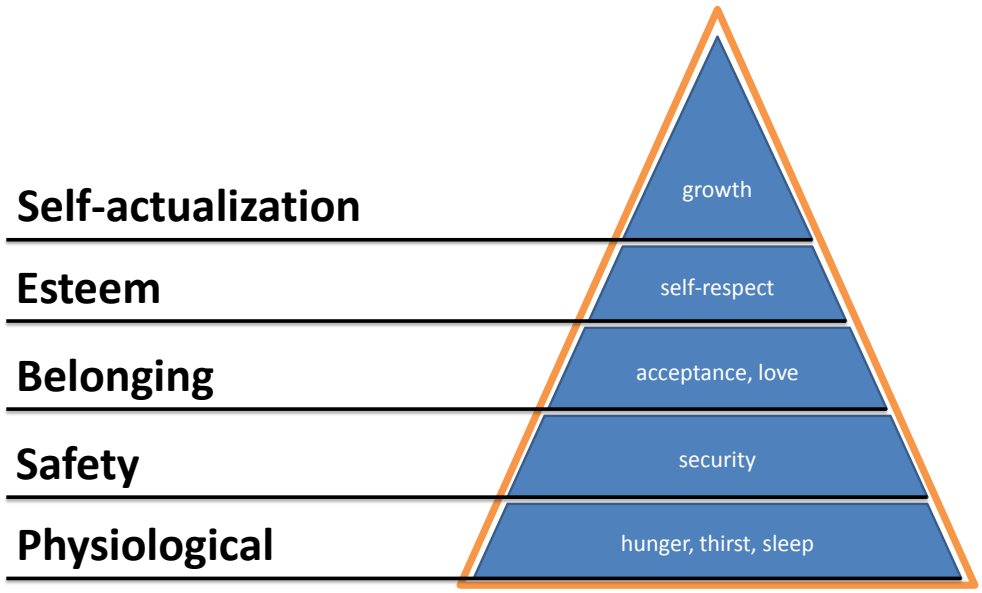


Figure 7. Maslov's hierarchy of needs

According to this theory individuals strive for higher need levels when they fulfill needs that are lower in the order. After satisfying their basic physiological and safety needs individuals try to satisfy needs from higher levels in the hierarchy: belonging, esteem and self-actualization

(reviewed theory contains cognitive, aesthetic and self-transcendence needs, which are related to a more general self-actualization need). Higher levels are related to self-esteem and self-actualization – individuals achieve those states by problem solving and creativity connected with social acceptance by others.

Self-actualized individuals tend to be problem-focused, concerned about personal growth and willing to learn and to explore.

Other theorists argue with this theory mostly in regards of hierarchical arrangement of needs and suggest it is possible to achieve higher level of satisfaction although lower levels are not fulfilled. Some researchers propose other approaches and theories explaining individual needs, e.g. humans driven to actions by desires (Bishop 2007). Still, there is little agreement on the list of basic human needs. The broad list of needs contains characteristics that tend to merge into each other and cannot be precisely isolated (Adair 2006, p. 14). However, for the purpose of this research, it is perhaps not necessary to isolate them, but only to indicate their character for shaping directions of their importance. A summary of the theories dealing with the subject of individual needs is presented in Table 11.

Table 11. Theories of individual needs – comparison

Theorist	Characteristics
Maslov (1954)	Physiological, Safety, Belongingness, Esteem, Cognitive, Aesthetic, Self-actualization, Self-transcendence
James (1892, 1962)	Material, Social, Spiritual
Mathes (1981)	Physiological, Belongingness, Self-actualization
Alderfer (1972)	Existence, Relatedness, Growth
Nohria et al. (2001)	To acquire, To defend, To bond with others, To learn

Source: adapted from Huitt (2007)

This summary underlines the importance of two factors. Firstly, researchers agree that humans need to develop social relations, bond with others, feel socially related to others and experience a sense of belongingness. One of the most basic interpersonal needs is to 'belong' (McKenna and Green 2002, p. 116). It is also in line with the previously discussed theories of social identity and social comparison (see section 2.2).

The second important direction that may be observed is an individuals' striving for satisfaction in the areas related to self-actualization, growth and esteem. These areas are described by different authors in terms of developing competencies, knowledge, skills, character or making

creative or productive effects on individual himself and his environment. Nohria et al. (2001) define this level as the 'learn' level in which individuals learn and make sense of the world and of them (Huitt 2007).

According to this summary, two factors were extracted as the most important for shaping the needs of an individual in terms of this research. They will be named by the specific character of areas they relate to: *need for belonging* and *need for learning*.

3.3.3 Task Needs

The main purpose of a collaborative group is to perform a task. One of the reasons why people come together is to achieve performance that a single person is not able to achieve (Adair 1983, p. 28). A group seems to be oblivious of any sense of need if it performs effective towards the goal. The signs of meeting those needs are not seen until satisfaction and happiness related to successful completion of the goal arises (Adair 2006, p. 13). In order to define more specific need areas related to the task, group task models will be introduced.

3.3.3.1 Task Classifications for Defining Task Needs

Four main types of task description were summarized by Hackman (1969, pp. 103) and include the following approaches:

- **Task qua task.** This view focuses on pattern of stimuli impinging on the subject. Task properties have 'real world' dimensions in this view: e.g. physical nature of the task, its subject matter or the characteristic materials (stimuli, instructions) involved.
- **Task as behavior requirement.** This approach focuses on responses the subject *should* emit, given the stimulus situation, to achieve some criterion of success. These are task demands that specify resources needed to reach maximal productivity.
- **Task as behavior description**. In this approach, the most important facet is which responses the subject *actually* emits, given the stimulus situation, to achieve performance criterion – actual behaviors of individuals performing a task.
- **Task as ability requirement.** This approach, employed to describe tasks, involves specification of patterns of personal abilities or characteristics which are required for successful task completion.

Hackman concludes that the best basis for defining tasks is represented by the *task as behavior requirement* approach. This model differentiates tasks basing on critical behaviors required for task success. Critical behaviors remain relatively constant for a given task and therefore this approach provides a solid ground for comprehensive analysis. The *task as behavior description*

and *task as ability requirement* approaches rely on characteristics of task performers, which are not constant across individuals for any one task, therefore are considered as unsuitable. *Task qua task* model is inappropriate because of the number of potential stimuli and task dimensions, the number of which is almost infinite. In this case, identification of key characteristics that should be used to define the task is difficult (Mennecke and Wheeler 1993, p. 20). More detailed analysis of approaches to task classifications may be found in Mennecke and Wheeler (1993) and Zigurs and Buckland (1998).

A summary of selected group tasks classifications representing four previously mentioned approaches is presented in Table 12.

Table 12. Examples of task classifications

Authors	Classification Basis	Task Categories
Carter et al. (1950)	Group activities	Clerical, discussion, intellectual construction, mechanical assembly, motor coordination, reasoning
Shaw (1954)	Complexity	Simple vs. complex
Bass et al. (1958)	Difficulty	Easy vs. difficult
Hackman (1968)	Behavior requirements of intellective tasks that yield written products	Production, discussion, problem solving
O'Neill and Alexander (1971)	Behavior requirements of intellective tasks	Discussion, decision, performance
Steiner (1972)	Unitary tasks ultimately classified into one of four types on basis of how member contributions are permitted to be combined to produce the single final product	Unitary vs. divisible, maximizing vs. optimizing, prescribed process vs. permitted process (disjunctive, conjunctive, additive, discretionary)
Shaw (1973)	Six non-exclusive continua	Difficulty, solution multiplicity, intrinsic interest, cooperation requirements, population familiarity, intellectual manipulative requirements
Davis et al. (1976) Laughlin (1980)	Group member relationships and task performance processes	Among cooperative groups: intellective vs. decision; among competitive or mixed-motive groups: two-person, two-choice tasks vs. bargaining and negotiation vs. coalition formation

Poole (1978)	Dimensions of tasks at the work-unit level	Difficulty, variability, interdependence
McGrath (1984)	What the group or individual is to do; presented as a 'circumplex', a circle divided into four quadrants with two categories in each quadrant	Generate (planning vs. creativity); choose (intellective vs. decision making); negotiate (cognitive conflict vs. mixed motive); execute (contests/battles vs. performances/psychomotor)
Campbell (1988)	Various combinations of four basic complexity attributes	Simple, decision, judgment, problem, fuzzy

Source: adapted from Zigurs (1998, p. 314)

Task as a behavior requirement approach is not only defining a view of what group members are supposed to do to in order to achieve a goal, but also how these goals should be accomplished and which materials to use (instructions, stimuli, verbal directions). *How* determines a set of processes on which this task bases and therefore defines its requirements. Hence, task needs in terms of these processes are defined here as *behavior demands required for accomplishing specific goals, via some processes and using given information*.

3.3.3.2 Hackman's Model of Group Tasks

Hackman's model (1968, p. 168) presents a group task classification basing on task as behavior requirement approach and therefore this classification will be suitable for providing a basis for this research. This model attempted to assess the nature and the magnitude of the relationships between 'intellective' group tasks and group output.

The three task types defined by Hackman are:

- Production tasks
- Discussion tasks
- Problem-solving tasks

Production tasks type is related to production and presentation of ideas, images or arrangements.

Discussion tasks type contains activities of discussing and evaluating values or issues, usually with a requirement of group consensus.

Problem-solving type is associated with tasks requiring that a solution to a specific problem be worked out, usually within a set of constrains. Problem-solving tasks involve instruction with respect to some overt actions.

Hackman's model bases on three main task types placed in dimensions of *process emphasis* and *task content*. However, this model also enables classification and interpretation of tasks that could not be clearly associated with an instance of one of the three main task types. Tasks that would fall into the off-diagonal cells of the matrix may be seen as a composition of three main types (Figure 8, based on Hackman 1968).

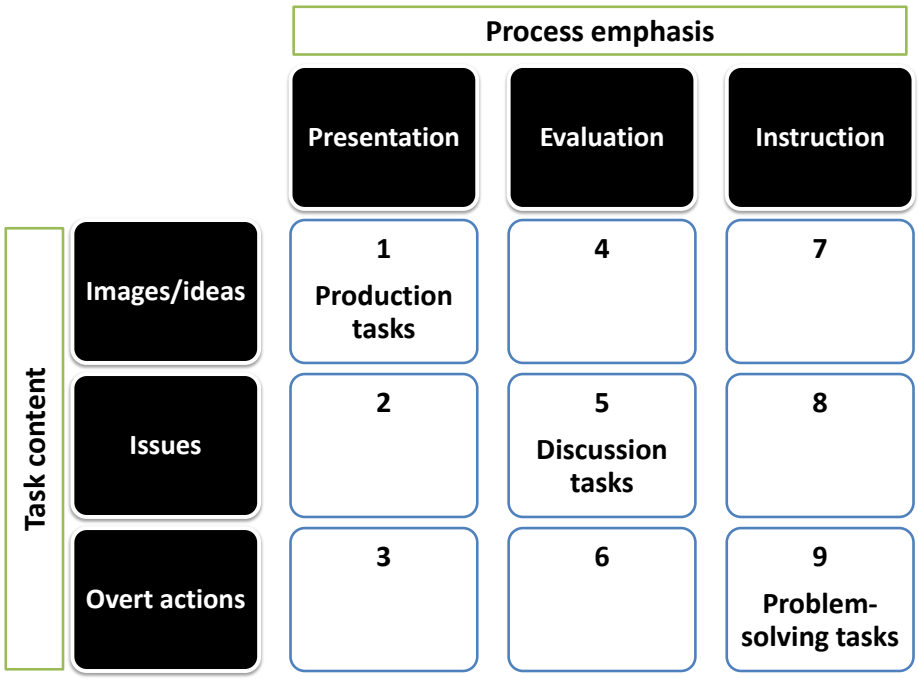


Figure 8. Dimensions of task types

Three main task areas defined as: production, discussion and problem-solving will serve as a background for task requirements in this research. The three main task needs will therefore be defined as: *production needs*, *discussion needs* and *problem-solving needs*.

3.3.4 Group Maintenance Needs

The third area of group needs is related to creating and promoting cohesiveness between individuals to build good relationships between them (Adair 1983, p. 29). An example helps to understand the importance of those factors. A group threatened by forces aimed at its disintegration is trying to maintain itself against those pressures and tries to keep cohesiveness at all cost. A common feeling exists instinctively across group members that can be illustrated by words "united we stand, divided we fall". This example illustrates the group need of keeping up good and cohesive atmosphere among group members. In order to achieve a common goal, a collaborative group needs to be maintained as a cohesive unity. This area of group needs was named *group maintenance needs* (Adair 2006, p. 14).

Group maintenance needs are crucial in regards of group performance and therefore have influence on the quality of a group output. According to literature, group performance and effectiveness is positively influenced by: *group cohesiveness and members' identification with a group* (Staehle 1998, p. 263; Levi 2007, p. 63), *members' motivation towards contributing to the group* (Levi 2007, p. 58) and *trust that group members share among them* (Levi 2007, p. 98).

3.3.4.1 Cohesiveness and Identification with a Group

Group cohesiveness is defined as forces that influence members to stay in the group and refers to the interpersonal bonds that hold a group together (Luft 1984, p. 18; Thiedeke 2003, p. 35; Levi 2007, p. 62). Cohesion is a multidimensional concept and for many theorists it is directly correlated with a group's pride or social identity. Members of cohesive groups find their membership personally important and have shared social identity. Cohesion may be also seen as a type of a social attraction. Members of cohesive groups feel bonded and tend to like each other (Levi 2007, p. 62). Group cohesiveness is associated with different characteristics e.g. motivation of members to work towards group objectives, attraction of members to themselves or a goal achievement (Luft 1984, p. 19). It can be also seen as a measure for group stability and attraction of its members towards a group (Staehle 1998, p. 262). Cohesive groups are actively seeking facts and reaching consensus (Knoll and Jarvenpaa 1998, p. 7).

Group task may influence cohesiveness – joining together for a purpose of a task can create a sense of cohesiveness (Levi 2007, p. 62). Promoting more interactions among group members, reducing status differences or ensuring that everyone is aware of one another's contributions can enhance cohesion (Levi 2007, p. 64).

Performance of a group is inseparably related to group cohesiveness, i.e. members of cohesive groups show more satisfaction about their jobs than members of non-cohesive groups. Individuals are more supportive of one another and that facilitates reduction of stress in a group. Group performance is generally positively influenced by cohesion, especially in smaller groups. Cohesion can help to improve performance and performance can positively influence cohesion: this relation works in both ways. If group tasks require high level of interaction, coordination and interdependence, the effects of cohesion are more important. The quality of social interactions among group members is influenced by cohesiveness and therefore cohesive groups are able to communicate and coordinate their actions more effectively (Levi 2007, p. 64). However, high level of cohesion may adversely influence collaboration (e.g. groupthink) it is also possible to reduce this level by adopting methods against group conformity (Staehle 1998, p. 259).

A sense of identification with a group occurs in cohesive groups and has important implications. If a group has a solid sense of itself as a distinctive group, it can manage stress and conflict among group members more effectively. This sense of identification with a group causes individuals to view group members as similar and at the same time different from members of other groups, therefore different member's characteristics e.g. skills, background or status, do not prevent the development of cohesive group (Levi 2007, p. 62).

3.3.4.2 Group Motivation

Another factor influencing group performance is strength of its members' motivation to actively participate in the group's actions. The phenomenon of lower contribution to a group that occurs when individuals work less hard to achieve some goal, when they think they are working jointly with others than when they are working by themselves, is known as free riding or social-loafing (Beenen et al.2004, p. 212; Ford and Jewels 2008, p. 2). The model explaining why some people work harder individually than in a group was developed by Karau and Williams (1993). According to the *collective effort model* (Figure 9) individuals working on common tasks as a part of a group tend to show lower motivation as they would show working individually.

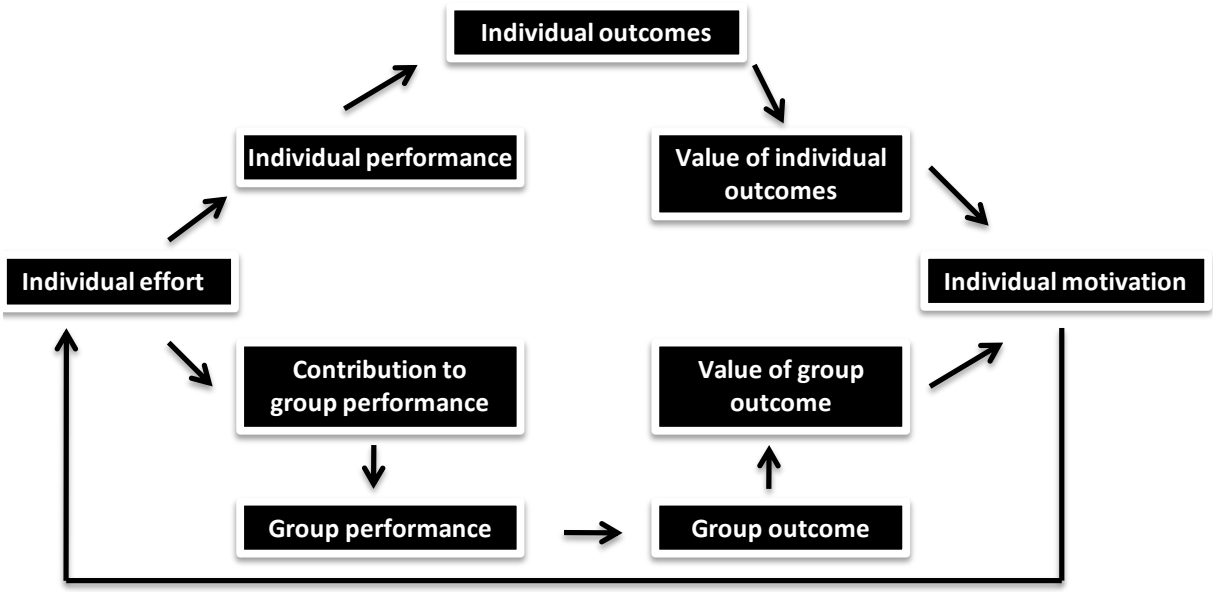


Figure 9. Collective effort model

People work harder when they think their effort will help them to achieve outcomes that are of a higher value to them. Individuals perceive working in groups differently than working individually in terms of their perception of the importance of the contribution to the common goal.

Individuals tend to social-loaf less under the conditions identified in the model, e.g.:

- When they believe that their contributions to the group are identifiable
- When they believe that their effort is important to the group's performance
- When they like the group they are working with

Not only identifiable contributions may positively stimulate motivation of individuals collaborating in a group. Individuals knowing that they are evaluated tend to perform better, however only on simple tasks (Forsyth 2009, p. 288). Theory of self-presentation explains motivational impact of evaluation apprehension. It assumes that group members actively display social behaviors that establish or maintain a particular social image or *face* to control other's impressions of them and to make a good impression (Forsyth 2009, p. 288).

Awareness of the reasons why social loafing occurs allows identification of factors encouraging group motivation. Increasing a group's motivation relates to the task it performs, how the performance will be evaluated and rewarded, group goals and members' sense of commitment or belonging (Levi 2007, p. 58). A group tends to show higher motivation if a task is interesting, involving and challenging as well when individual contributions are identifiable and linked to the reward system. Group members are more motivated when they value membership in the group; therefore increased group cohesion influences the strength of group motivation (Levi 2007, p. 61).

3.3.4.3 Trust

The concept of trust has been extensively discussed in diverse research within different disciplinary backgrounds and methodologies. It has been defined as a general disposition toward others, a rational decision about cooperative behavior or an affect-based evaluation of another person (Becerra and Gupta 2003, p. 33). Trust was also described as the confidence of group members that other group members will honor their commitments or as the expression of confidence in group relationship among group members (Levi 2007, p. 98). It makes relationships possible, reduces uncertainty and risk, and furthermore it is a factor influencing the decrease of vigilance and the need of control others. Trust impacts different aspects of group relationship, e.g. it makes it possible to give oneself over to another group member, to give attention, consideration, time, energy or information. Trust is reciprocal – individuals experience tangible and intangible satisfactions as the other person reciprocates (Luft 1984, p. 27). While a member's satisfaction is an important factor influencing group well-being, lack of trust negatively affects functions related to group maintenance (Saunders and Ahuja 2006, p. 685).

Group members have different knowledge and are not able to fully engage e.g. in validating each other's work. Trust facilitates engaging in the situation's ambiguity, enables work within cognitive complexity and facilitates the appreciation and support for differences among group members (Poggenpohl 2004, p. 147). Furthermore, trust has a direct and indirect influence on interpersonal communication, cooperation and collaborative group work. Members of groups with a high level of trust are more willing to commit to group goals and tend to ignore personal goals. When trust is high they are more willing to engage in group activities as well (Levi 2007, p. 99).

Trust is a multidimensional construct including trust in various trustee's characteristics e.g. reliability, openness or competence (Ardichvili et al. 2003). Research on trust shows that trust may be stimulated and influenced by different factors. While researchers do not negate the effect of individuals and their own characteristics on the perceived trustworthiness, they agree that the final effect may depend on the presence of moderating relational variables that represent the intensity of interaction, like communication frequency (Becerra and Gupta 2003, p. 41). Open information flow, willingness to exchange experience by providing help and resources stimulates trust building as well as accepting the contributions of other group members and supporting of their actions (Levi 2007, p. 99).

Trust is built on social ties and is a result of investment in developing and maintaining those relationships. The process of building trust requires time. However, temporary groups formed around a clear purpose and common task within finite life span tend to develop an unusual form of trust – *swift trust* (Coppola et al. 2004, p. 95).

The concept of swift trust is framed on *temporary systems*, characterized e.g. by the following properties (Meyerson et al. 1996, p. 169):

- Group members represent diverse skills
- Group members have limited history of working together and possibility of mutual work in the future is low
- Tasks have deadline, are complex and require interdependent work
- Tasks are non-routine, not well understood and continuous interrelating is required to produce an outcome

Main characteristics of swift trust include the following:

- Vulnerability: the belief (hope) that others will care for what is being entrusted with good will
- Uncertainty: a willingness to suspend doubt in order to execute the task performance
- Risk: a willingness to take risks
- Expectations: a positive expectation of benefits of temporary group activity

Members involved in temporary groups have limited amount of time to become familiar with one another, therefore they 'import' trust basing on previous personal and professional experiences. In these settings swift trust is sustained and reinforced by a high level of activity. Willingness to trust and more rapid development of trust happens when the actions are forceful (Coppola 2004, p. 96).

A more detailed analysis of literature regarding trust and its influence on group performance is presented in Saunders and Ahuja (2006).

3.3.5 Interaction of Needs

The Three Circles Model illustrated by three overlapping circles denotes the interaction and interdependency of all three areas of group needs: individual, task and group maintenance. Circles overlap, because there is always some degree of interdependency between them and each circle always has to be seen in relation to two other circles. Achieving performance of a collaborative group requires awareness related to all three circles i.e. all three areas of group needs simultaneously.

A disc placed over a 'task' circle covers partly the two other circles. Lack of task or failure to achieve it will affect the two other areas of needs. Individual satisfaction of group members will be lower and disruptive tendencies may occur, which will have impact on group well-being. Lack of meeting group maintenance needs will influence the quality of the performed task and individual satisfaction of group members as well. However, when a group achieves its task, group cohesiveness and simultaneously enjoyment of group members should go up. Furthermore, if a group will get on extremely well and group members will find that they can work closely together, work performance will increase because important individual needs will be met (Adair 2006, p. 15).

The Three Circles Model was a basis for a more detailed analysis of areas of group needs. Among other needs, a set of the most important group needs was presented and categorized into three areas of needs.

The result of the literature research is an extracted set of needs that includes:

- Individual needs
  - Need for belongingness
  - Need for achievement, learn and explore
- Task needs
  - Production and presentation of images and ideas
  - Discussion and evaluation of issues
  - Problem solving and carrying out some plan of action
- Group maintenance needs
  - Need for cohesiveness
  - Need for creating group identity
  - Need for group motivation
  - Need for trust

This set of needs was found to have influence on group performance. The analysis presented in this section is summarized in Table 13.

Table 13. Collaborative group needs

Category	Need
Individual Needs	Learning, Belonging
Task Needs	Production, Discussion, Problem solving
Group Maintenance Needs	Motivation, Trust, Cohesion, Identification

Source: Own elaboration

3.4 Analysis of Needs Structure for Generic Group Types

The framework for the group analysis presented in chapter 2 provided a basis for defining generic group types. This typology consists of factors allowing differentiation of five distinctive generic group types: high-activity team, project team, work group, informal network and community of practice. These types define sets of groups that differ in terms of e.g. their purpose, lifetime or ties bonding their members. Different characteristics of groups imply differences in requirements these groups have in order to perform their tasks effectively. To analyze the types of requirements of the defined group types, different areas of group needs were reviewed in order to create background for the analysis.

The defined group types present different characteristics, however they require support in the three areas of needs introduced earlier: individual, task and group maintenance. The differences

between the types will be presented in regard to a structure of the introduced set of needs. The presented group types differ in the dimensions of a given factor, e.g. lifetime – high-activity team is constrained by time while community does not have duration limitations. The ties bonding the members of an informal network involve close social relationships, while bonds between members of a project team are not that intimate. Differences will affect a structure of needs for every generic group type.

Table 14 presents a structure of needs for group types defined in Chapter 2.

Table 14. Needs structure for the generic group types

	HIGH-ACTIVITY TEAM	PROJECT TEAM	WORK GROUP	INFORMAL NETWORK	COMMUNITY OF PRACTICE
Individual Needs					
Learning	middle	middle	low	low	high
Belonging	low	middle	low	high	middle
Task Needs					
Production	middle	high	high	low	middle
Discussion	high	middle	low	middle	middle
Problem solving	middle	high	middle	low	low
Group Maintenance Needs					
Motivation	low	middle	middle	low	high
Trust	middle	middle	middle	middle	middle
Cohesion	middle	middle	low	high	middle
Identification	middle	middle	low	high	middle

Source: Own elaboration

The presented needs structure for group types was mainly based on a characteristics of group types described in Chapter 2.6. The table does not serve a purpose of a comparison of the presented group types according to selected criteria. Every column of the table – every group type – needs to be considered separately rather than in relation to other columns. Most important needs specifying the shape of a given group type are considered as having a relation of a 'high' importance i.e. meeting this need is significant for this group type. Accordingly, 'middle' and 'low' importance denotes strength of priority of a given need for a group.

The learning aspect is the most important need of the type community of practice because of the purpose of this group type defined as developing capabilities and sharing knowledge. The need for belonging shapes the informal network type, while the purpose of this group is to build trust and develop social relationships within a circle of friends or business acquaintances.

The task shapes needs structure of groups related to performing tasks that may require interrelated actions: high-activity group's domain is discussion, whereas project team and work group types are rather production-oriented. Time constraints of a high-activity group put requirements on an intensiveness of interactions – a project team or a working group's lifetime is not that short and therefore not necessarily imposes that amount of direct communications. An interrelated characteristic of actions within a project team type determines a high priority in the 'problem solving' row.

Motivational aspects of groups influence e.g. the amount of contributions: the larger the group, the smaller the rate of active involvement in a group's life. Bigger groups experience more problems with low rate of actively contributing members, therefore high priority of a 'motivation' need for a community of practice. Trust plays an important role in every group's life as it creates a background for developing social relations. Cohesiveness and sense of identification with a group facilitates effective communication and satisfaction of its members. Groups characterized by close social relationships tend to be cohesive; however groups bonded on the basis of different ties (e.g. project or task requirements) must develop cohesiveness and create sense of identification within its members.

3.5 Summary

This chapter presented the importance of meeting group needs in order to achieve effective performance of a group working on a task. Firstly, group development patterns were introduced to underline the importance of group performance as a function of meeting its needs. Secondly, an analysis of areas of group needs was presented. Basing on this analysis, three areas of group needs were defined: individual, task and group maintenance. Collaborative groups require attention in those three areas simultaneously in order to effectively perform a task, maintaining group well-being and providing satisfaction to its members. In the last part, a structure of needs for group types defined in Chapter 2 was presented and group types were characterized according to the elicited list of needs.

4 Theoretical and Conceptual Aspects of Computer-Supported Collaboration

The content of previous chapters was focused on understanding the mechanisms of groups working in collocated collaborative settings. This chapter will present aspects of communication and collaboration in virtual settings as well as introduce and analyze the effects of computer-mediated collaboration on groups working in spatially distributed environment. In the last section of this chapter the systems for supporting collaboration in spatially distributed groups and their functionalities will be presented, and challenges for designing such systems will be discussed.

4.1 Characteristics of Spatially Distributed Groups

Groups of spatially distributed individuals interacting through the usage of computer technology are referred to in the literature as e.g. online groups (Maier 2002, p. 160), virtual groups (Thiedeke 2003, p. 60), electronically linked teams (Johnson and Johnson 2005, p. 536), distributed teams (Saunders and Ahuja 2006, p. 667), geographically distributed teams (Handel and Herbsleb 2002, p. 1) or virtual teams (Anderson et al. 2005; Levi 2007, p. 258). Members of an electronically networked group can be dispersed around the world and work in different locations, while usage of e.g. groupware applications or web conferencing systems allows holding meetings with users sitting at their computers, wherever they are (Johnson and Johnson 2005, p. 536). Interactions between group members are mediated by time, distance and technology (Levi 2007, p. 258).

Other than by face-to-face groups in virtual groups there exists no direct contact and no physical testable acquaintance between interacting individuals. Individuals may choose to be anonymous or to appear as a person with invented characteristics or status of their own choice. Virtual groups are based on cohesion of an artificial type that facilitates creative flexibility and productive efficiency, however it is also causing particular eccentricity of social relationships, emotional disappearance of inhibitions or nonconforming behavior in social contacts. Compared to face-to-face groups, virtual groups show these paradox characteristics. The communication of a virtual group is characterized by strong emotionality and formalized by socio-technical requirements of the environment it takes place in. Intimate cohesion – love or friendship relationships – develops on the basis of indirect social contacts. Communication is spontaneous and ephemeral, however it mostly takes place in a written form and therefore can be archived for a longer time (Thiedeke 2003, p. 61).

A comparison of a virtual group's characteristics with other social forms is presented in Table 15.

Table 15. Comparison of a virtual group to other social communication systems

	Social aggregation	Social group	Virtual group	Organization
Type of interaction	diffuse, no acquaintance on a personal level between interaction partners	diffuse, acquaintance on a personal level between interaction partners	diffuse, acquaintance on a personal level between virtual interaction partners	acquaintance on a formal level between interaction partners
Social orientation of communication	reactive, indirect	emotional, direct	emotional, socio-technically indirect	functional, indirect
Control medium of communication	random actions and reactions	focused emotion expressions	focused emotion expressions, technical requirements	specific rules
Stability over time	short-term	relatively long-lasting	relatively long-lasting	long-lasting, static

Source: adapted from Thiedeke (2003, p. 60)

4.2 Virtual Group as a Real Group

A question if a set of individuals interacting virtually using technology can be acknowledged as a group may be answered by analyzing a list of group properties presented in Figure 2 (page 9). Although some group definitions implicitly assume face-to-face interactions between its members, crucial elements of a group definition are related to the cognitive perception of a membership in a group by individuals. Therefore, it is essential to establish if a sense of membership and the subjective sense of togetherness, 'we-ness' or belongingness develops (Turner 1982, p. 16) and not if an interaction occurs directly or by using communication medium (e.g. chat or discussion board). Members of virtual groups may know each other only by nicknames, be completely anonymous and not share a physical meeting place. However, despite the fact of being physically isolated from each other, they share a sense of being in close proximity and being together when they interact through a chat or newsgroups in a shared virtual space. Individuals refer to virtual spaces like they were real places and have the feeling of being with others together in one physical locality. Hence, membership in virtual groups involves a sense of physical togetherness and subjective sense of 'we-ness' (McKenna and Green 2002, p. 117).

It is still being discussed if virtual groups can meet the social needs of members. Researchers argue whether online relationships are weaker and less rewarding than offline relationships. The results of studies are not unambiguous, however two-year longitudinal studies showed that individuals involved in virtual relationships perceive them as being as close, important and real, as non-Internet relationships, but also that these relationships were remarkably stable over time (McKenna 2002, p. 120). McKenna and Green (2002, p. 125) concludes, that online groups are indeed real, however active participation plays a key role in determining if a person will experience benefits from group membership. .

Studies show that individuals find their interaction partners more appealing after a first-time encounter when that initial meeting took place over the Internet than when it was face-to-face. When interacting individuals met for the second time, greater liking continued to hold if first-time encounter was over Internet, whereas if individuals met face-to-face both times, this effect was not observed. Because in face-to-face interactions initial liking is driven by gating features (e.g. physical appearance), lack of these features in online interactions facilitates establishing bonds based on more substantive features of the encounter (McKenna and Green 2002, p. 123).

4.3 Communication in Spatially Distributed Groups

The first basic model of communication by Shannon and Weaver (1947) explained the process of communication in three terms: sender, receiver and a channel. Although it has been criticized for its narrow focus, it provides an essential view on elements involved in the communication process. The sender selects and encodes a message for a transmission, the transmitter converts the message into a signal sent over the communication channel, the channel delivers the message to the receiver who decodes the message. In face-to-face interactions the sender communicates with the receiver verbally and transmits his voice over the air. Computer-mediated communication differs with respect to the aspect of a channel used to transmit the message: technology is the communication channel here. Technology mediates messages sent as text (email) voice (VoIP) or video (video conference) and enables their transport to the receiver over the Internet. A more detailed explanation of communication theory and its embedment in technology can be found e.g. in Melzer et al. (2007).

4.3.1 Characteristics of Computer-Mediated Communication

Computers and communication technology enabled another kind of computer-supported information processing that helped people to communicate. Computers serve not only to make computations on the information people use, but instead, they allow people to exchange natural language, text and make sense of information. Computer-supported communication systems

allow overcoming the problem of a group size, making communication with a few people as simple as with many.

People use communication technology not only for formal communication, but also for informal information exchange (Kiesler and Sproull 1992, p. 101). Since informal communication is pivotal for such aspects of collaboration as e.g. coordination, problem solving or social learning, developers of computer-mediated communication tools attempt to support informal contacts as well as those of a formal nature (Isaacs et al. 2002, p. 11).

Computer-mediated communication offers opportunities that do not exist in face-to-face contact: e.g. asynchronous communication, anonymous communication or archival of communication (Dillenbourg 2005, p. 247). This puts virtual relationships to work in an environment where some aspects of face-to-face contact are missing; however other features not present in face-to-face contact enrich computer-mediated communication. Both aspects influence the interactions in spatially distributed groups communicating through computer-mediated systems.

To enlighten some behavioral implications of electronic group communication, it can be contrasted with face-to-face interactions. McGrath and Hollingshead (1990, in Kiesler and Sproull 1992, p. 102) list the following characteristics of face-to-face interaction:

- All members are linked in all modalities with no time lags
- One and only one person has the floor at any one time. Except for momentary silences, someone is always holding the floor
- Speakers exercise some control over who the next speaker will be, as well as when they can interrupt
- Group members share floor time unequally
- Speakers cannot pause too briefly or for too long a time (hence few interruptions, few silences)
- Speakers signal transitions using multiple cues in different modalities or channels
- The audience for each act is all, but only, the set of participants present
- The set of potential next speakers is all, but only, the set of participants present
- There is no anonymity in face-to-face groups
- Group members expect each input to be logically or psychologically connected to preceding or anticipated inputs

Computer-mediated communication takes place in different physical and social environment where characteristics of face-to-face interactions are absent or diverse. Usage of communication

technology helps people to interact across space and time, whatever their location or time zone is. It is not necessary to create discussion sequences for text-based communication – individuals can exchange information all at once, in illogical order or not at all; addressing few people or many. Messages saved in database can be retrieved later and may e.g. provide basis for future communication (Kiesler and Sproull 1992, p. 102). Computer-mediated communication provides tools that structure how people and groups communicate, however, individuals do not passively adapt to constraints imposed by technology, but adapt and modify the technology to suit their needs (Levi 2007, p. 258).

Spatially distributed groups are reported to have substantially reduced communication frequency, particularly this of an informal type. These issues slow virtual work down and cause coordination problems (Handel and Herbsleb 2002, p. 1). Furthermore, informal communication provides basis for sustaining ongoing collaborative relationships and plays an important role in both formal and informal activities (Snowdon et al. 2001).

4.3.2 Psychology of Virtual Communication

Two factors add complexity to already complex group interactions, when considering virtual interactions: lack of collocation and the need to use sophisticated information technology to communicate (Hardin et al. 2006, p. 71). Virtual relationships occur when individuals involved in communication process are not in physical contact. Although such interactions take place in an artificial socio-technical communication environment, they are perceived to be real, as they may potentially occur in a real context. Computer-mediated communication tools provide support for virtual relationships. Although communication through text-based tools is bereft of elements supporting social perception, e.g. gender, age, status, facial expressions or gestures, some elements can be replaced by artificial expressions to some extent, e.g. emoticons (Thiedeke 2003, p. 24).

Virtual relationships in computer-mediated environment are shaped through the following properties: anonymity, self-disclosure, interactivity and optionality.

4.3.2.1 Anonymity and Deindividuation

With the exception of formal or official contacts, computer-mediated communication is mostly anonymous or pseudonymous (Thiedeke 2003, p. 25). Anonymous text-based communication may result in greater closeness and intimacy between group members in some cases, but also may lead to greater hostility and aggressive behavior in others (McKenna and Green 2002, p. 116). Even individuals appearing with their real names tend to feel at least moderately

anonymous. People interacting in virtual settings may experience the feeling of being one of the hundreds or thousands among others (McKenna and Green 2002, p. 119).

Anonymity according to psychologists leads to deindividuation which has negative social effects. However, positive aspects of anonymity in computer-mediated communication have been also found. Individuals interacting virtually more likely express how they truly feel and think and when group's identity salience is high, individuals interacting under conditions of anonymity more likely conform to group norms than members of nonymous groups (McKenna and Green 2002, p. 119).

Anonymity associated with membership in virtual groups leads to deindividuation: loss of self-awareness and evaluation apprehension caused by feeling anonymous. People more likely engage in social loafing in groups and more likely perform negative acts if they have a feeling of not being evaluated. Deindividuation occurs when a person is a part of a large number of people and actions of one are submerged in a group. Reduced individual's self-awareness and feeling of anonymity may increase aggressive and nonconforming behavior more likely to occur in computer-mediated communication than in face-to-face interactions. In these settings, individuals communicate more critical and uninhibited negative remarks because they feel freer to express emotions of all types. Less anonymous virtual work teams do not experience this problem to that extent and mostly develop communication norms regulating emotional communication (McKenna and Green 2002, p. 119; Levi 2007, p. 263).

4.3.2.2 Interactivity and Effects of Status Differences

Interactivity is "an expression of extent that in a given series of communication exchanges any third (or later) transmission (or message) is related to the degree to which previous exchanges referred to even earlier transmissions" (Rafaeli 1988, p. 111).

In these terms, interactivity refers to individual possibilities and necessities of designing and mediating computer-mediated communication. The specific feature of interactivity of virtual relationships is a result of its design diversity and demand for self-organized field of interaction. Interactive communication participants in computer-mediated interactions are potential designers of not only contents, but medium as well (Thiedeke 2003, p. 30).

Interactive participation through communication medium influences the perception of status by group members. Collaborative groups rely often on hierarchical structures in order to improve the organization of activities in a group. Status differences concern mainly groups operating in formal settings, where relations between group members are more official than in informal groups. Research shows that status differences in virtual groups are reduced, which facilitates

equal participation in virtual group discussions. Discussions in face-to-face groups tend to be influenced by few dominant people with higher status. Group members with lower status limit their discussion activity to supporting one of the main emerging positions. Interactions in virtual discussions are more democratic because of the reduction of social cues. Members of virtual groups make decisions according to their knowledge, not affected by their social status as it is in a face-to-face group (Levi 2007, p. 262).

However, this equalization effect was not found in typical work team settings. The results of field studies on groups with established status hierarchies (military or medical teams) did not show change in communication if it was mediated by technology (Levi 2007, p. 262).

Effects of status differences on group performance are mixed. Status differences may help with group's decision making, however to the extent that they reflect differences in ability, expertise or organizational knowledge. If awareness of status differences is reduced, it may lead to uncertainty that increases stress in a group and affect judgment tasks where a group needs to reach consensus. However, effect of status differences on group's communication tends to decrease over time, as group members get to know each other (Levi 2007, p. 262).

4.3.2.3 Self-disclosure

Anonymity and pseudonymity facilitate the violation of social borders. Because of the lack of physical presence, sanctions like degradation, reprehension or physical punishment are more likely to be avoided. Social norms disappear behind the veil of anonymity and social interactions are free from the pressure to conform (Thiedeke 2003, p. 27).

Self-disclosure is a term describing willingness of individuals to share personal information, thoughts and feelings with other people, especially in interpersonal relationships. Individuals tend to be more likely disclosed to a stranger, because they could be rejected sharing information with friends or acquaintances who may have impact on the discloser's life (Qian and Scott 2007).

4.3.2.4 Optionality

Virtual relationships base on unlimited diversity of options, allowing choosing from a long list of subjects, interaction forms, identities or communication environments. Fast development of the Internet provides a basis for expansion of options. Optionality has been even increased by integration of single subject areas (Thiedeke 2003, p. 31). Problem of selection of interaction form is known as media choice problem and will be described in the following sections.

4.3.3 Effects of Communication in Virtual Settings

Although electronic communication has many advantages, it has also negative features. Advantages of computer-mediated communication (CMC) in terms of supporting collaborative groups relate to e.g. the speed of communication or more opened discussions in web conferencing sessions; however lack of personal contact may cause disadvantages as well (Jonhson 2005, p. 536; Levi 2007, p. 258).

Spatially distributed teams benefit from computer-mediated communication by usage of its synchronous and asynchronous features. Advantages (Levi 2007, p. 258; Johnson and Johnson 2005, p. 536) are e.g.:

- Improved speed and dispersal of communication
- Increased access to information
- Increased amount of communication
- Easier connections to others
- Improved planning and decision making
- Asynchronous communication between meetings enables fast and uninterrupted channel for information exchange
- By usage of communication media individuals tend to be less influenced by status or prestige of other discussion partners and share their thoughts more freely, throw out new ideas and are more likely to show if they disagree with a person of a higher status
- Ability to link groups between different offices and locations is another benefit

Computer-mediated communication, however, is ephemeral, may quickly appear and disappear from a screen at least in its text form for conveying messages. Furthermore, this artificial art of interaction causes different consequences which result (Johnson and Johnson 2005, p. 536; Levi 2007, p. 258) e.g. in the following effects on communication and social perception:

- Information overload
- Inconsistent access
- Decreased face-to-face communication
- Disrupted organizational relations
- Increased isolation
- A sender has a feeling of being out of the touch with the audience
- A sender feel less constrained by conventional norms and rules of behavior in communicating information
- Individuals feel less empathy and less guilt

- Individuals are less concerned over how they compare with others
- Individuals are less influenced by social conventions
- Lack of social interaction may prevent new social relations from developing

4.3.4 Communication for Collective Information Processing

All groups, but especially collaborative groups, exist if they are able to share individual knowledge of their members with the group and if the group is able to effectively evaluate and use the knowledge of its members. Members of a group learn from one another and influence one another in a process of achieving their goals through information sharing and processing. Processing of information takes place at an individual cognitive level, however in a group context communication is the medium helping to shape and share cognitions between members (Propp 1998, p. 227).

Collective information processing may be defined as "the degree to which information, ideas, or cognitive processes are shared, and are being shared, among the group members and how this sharing of information affects both individual- and group-level outcomes" (Hinsz et al. 1997, p. 43 in Propp 1998, p. 225). Hence, the way information is processed impacts group outcomes, such as task performance. These processes rely on communication medium that in terms of collective information processing may be sub-classified in three aspects in which interactions play a significant role:

- Information search
- Information storage and retrieval
- Weighting and usage of information

These interrelated and interdependent sub-processes have influence on group outcomes. A further list of factors influencing collective information processing is related to non-communicative elements including group-size, status or relationships within a group (Propp 1998, p. 225). An effective flow of information has a pivotal influence on successful performance of a large set of different collaborative tasks and relies on interaction patterns that are a result of social processes in a group (Bavelas 1950, p. 725).

4.4 Theoretical View on Collaboration in Virtual Settings

The process of human communication in its richest form i.e. face-to-face contact, engages not only a message communicated verbally, but is also influenced by important non-verbal aspects impacting social perception of a communication. These aspects relate to an audiovisual perception of a sender by an individual that receives the message and include e.g. tone of the

voice, body movement or behavior. Process of communication mediated by technology relies on an artificial way of an imperfect substitution of face-to-face contact by this medium. Text-based communication (chat, discussion board) lacks such features of face-to-face contact like tone of the voice or visual elements of a contact. Communication medium transmitting voice (telephone, audio-conference) does not support visual elements, however in comparison to text-based medium provides a richer form of communication. Although video conference supports transmission of both audio and visual cues providing richer communication environment than text-based or audio-based, the fact of indirect interaction with a receiver through an interface of a computer still inhibits communication process on both sides, not sufficiently supporting the conveying of social elements of an interaction. The importance of examining social aspects of computer-mediated communication has been underlined in many different studies (Gunawardena 1995, p. 148) and resulted in theories trying to explain these dependencies.

The bottlenecks of computer-mediated communication in terms of group collaboration relate not only to social aspects but also e.g. to the capacity of the medium (whether a medium is capable to transmit the message and to what extent), to the aspects of an adjustment of individuals and technology used in the process of communication (how individuals interact with an interface or computer) or to the fit of a provided technology solution to the (group) task. Furthermore, group communication mediated by technology has impact on interpersonal relations and an organizational environment of a group.

Communication researchers tried to explain the effects of technology on communication process and developed theories that illustrate dependencies between social and technology aspects of computer-mediated communication. In the following section, the most important theories in terms of this research will be presented to provide a basis for further sections.

Theories addressing issues of technology in the field of computer-mediated collaboration are associated with different science disciplines. They deal mostly with dependencies of interactions between human and technology. They can be further divided into *social theories* (e.g. social construction of technology, structuration technology, systems theory), *group theories* (dealing with influence of technology on a group process – social presence theory, media richness theory, media synchronicity theory) and *analytic* (effects of technology).

Tanis and Postmes (2003) argue that to fully understand the disparity of social effects of computer-mediated communication it is necessary to extend the consequences beyond the interpersonal level. There is a need for a much more careful consideration of the wide range of consequences hiding behind the general term ‘social effects’. Studies focused on the question of the effects of the visibility of personal identifiers on interpersonal outcomes show more uniform

results. Even relatively minimal cues, e.g. portrait picture and biographical information give people a feeling of knowing a person they interact with. Such cues reduce ambiguity about others and also lead to more positive impressions. Research on new, unacquainted teams shows that affection and social attraction is facilitated by usage of a portrait picture (Tanis and Postmes 2003, p. 958).

Theories presented in the following are related to the subject of lack of non-verbal or bodily communication in computer-mediated communication environments in comparison to face-to-face interactions. Through these changes, effects on interpersonal outcomes such as e.g. decreased presence, disambiguation or diminished awareness of individuality are expected. Although the origin of those theories is similar and they refer to similar characteristics, there is one important aspect of them: they all relate to the same meta-theory: social effects of a communication technology emerge from disembodiment of interpersonal communication. Furthermore, they assume that these social effects will be valid at any level of social abstraction: both at the psychological and inter-personal level, and within dyads, groups, communities and large-scale categories (Tanis and Postmes 2003, p. 957).

4.4.1 Social Presence Theory

Social presence theory tries to explain social aspects of computer-mediated communication. Founded by Short et al. (1976), social presence is defined as a "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships" (p. 65) and therefore is to some extent a degree to which a person is perceived as a 'real person' in mediated communication. According to this theory, social presence defines the quality of a medium – this quality is different for various media types. Media differences determine the way individuals interact. Social presence of a medium is specified by the capacity of the medium to transmit such aspects of interaction as e.g. facial expression, posture, direction of looking, dress or non-verbal cues. These aspects are important for the interaction process and determine how an individual perceives the characteristics and qualities of the other person. Greater presence facilitates better perception of an individual (Gunawardena 1995, p. 151).

Social presence is closely related to concepts of *intimacy* and *immediacy*. Social presence of a medium influences the level of intimacy, where higher levels of intimacy are stimulated by such factors like e.g. physical distance, eye contact, smiling or personal topic of conversation. Observations showed that usage of video communication contributed to higher levels of intimacy. The level of psychological distance occurring between two communicating individuals can be defined by immediacy. Immediacy or non-immediacy can be conveyed verbally (non-immediacy: creating distance using e.g. formal language; immediacy: adopting attitude of

informality in conversation) or non-verbally (physical proximity, formality of dress or facial expression). Immediacy facilitates social presence while non-immediacy inhibits it. Social presence is therefore at the same time a characteristics of a medium, but is also to some extent influenced by communicating individuals and their presence in a sequence of interaction (Gunawardena 1995, p. 151).

Studies show that immediacy facilitates learning activities substantially both in face-to-face and computer-mediated interactions. Both verbal and non-verbal cues work together to generate immediacy (Gunawardena 1995, p. 153).

In comparison to face-to-face interactions, computer-mediated communication is said to be low in social presence. Messages in computer-mediated interactions tend to be impersonal and task-oriented. It is a result of problems with transmitting non-verbal cues through computer-mediated communication channels. As a tool, social presence theory can be therefore used to measure interpersonal effects of lack of these cues in computer-mediated communication (Gunawardena 1995, p. 154).

Research on relationship between social presence and computer-mediated communication shows, that in spite of lower social presence of communication channels in comparison to face-to-face interactions, individuals are able to project both 'real-' and 'pseudo-' identities. They experience the presence of others and engage in groups with common norms and conventions. For purposes of enriching social environment, some social aspects of non-verbal communication are substituted by e.g. emoticons (a text representation of a facial expression or mood) or other messages communicating emotions (Gunawardena 1995, p. 156).

4.4.2 Reduced Social Cues Approach

Similarly to social presence theory, reduced social cues approach is concerning how mediated communication influences interpersonal interactions and analyzes the effects of lack of social cues in interaction if a medium is not able to convey them: non-verbal signals (gaze, facial expression), proximity and orientation (physical distance between communicating individuals) and physical appearance. Cuelessness means absence of non-verbal cues and other aspects contributing to identity cognition. These aspects are responsible for communicating a broad spectrum of information influencing the orientation of an individual to the conversation and a discussion partner. Absence of these cues in computer-mediated communication increases 'psychological distance' between individuals and therefore leads to impersonal and task-oriented communication. Such type of communication leads in turn to a deliberate, unspontaneous style and particular type of outcomes (Tanis and Postmes 2003, p. 957).

Absence of social cues contributes to reduction of awareness of self and others resulting from anonymity of online interactions. Computer-mediated communication is therefore being discussed in literature as an environment facilitating multiplication of 'weak ties' (Tanis and Postmes 2003, p. 957).

4.4.3 Uncertainty Reduction Theory

Presented theories assume that direct face-to-face contact and bodily communication are facilitators reducing uncertainty about key factors in interaction. Uncertainty Reduction Theory (URT) assumes that uncertainty reduction is one of the main objectives in initial interaction between individuals. Both verbal and non-verbal communication serves an input enabling people to describe the other, make judgments, predict and explain other's behavior, even if information is believed to be non-evaluative. This need to reduce uncertainty is not different for interactions done in mediated environments, where uncertainty tends to be quite high, especially because of anonymity or a lack of guidance for proper behavior (Tanis and Postmes 2003, p. 957).

4.4.4 Social Identity Model of Deindividuation Effects

The Social Identity model of Deindividuation Effects (SIDE) is a more recent theory focusing on those aspects of computer-mediated communication that are related to its impact on a social level of interaction. This approach differs from approaches of social presence theory or reduced social cues approach and distinguishes effects of computer-mediated communication at the interpersonal level (outcomes related to individual perception of interaction) from effects at a more abstract social level: outcomes related to 'us' as entity and concerning aspects of collaboration (Tanis and Postmes 2003, p. 959).

Social Identity model of Deindividuation Effects proposes that anonymity may facilitate a shift in focus from individual identity to a social identity. Therefore, anonymity in computer-mediated communication may be associated with a relative amplification of the social and contextual dimension of a group life. Because of decreased visibility of individuality in virtual interactions, the focus of an individual can be directed not towards own individual needs, but rather towards mutual needs and group concerns (Tanis and Postmes 2003, p. 959).

This is an interesting view on computer-mediated interactions suggesting that not only the capacity of a medium to convey social cues should be taken into consideration in analyzing effects of computer-mediated communication on group interactions. Since identity cues may enable the formation of personal evaluations and lead to the underlining of the importance of the interpersonal dimension (I and you), they simultaneously contribute to the decreasing of the

perception of mutuality and solidarity. Social Identity model of Deindividuation Effects distinguishes the outcomes at the interpersonal level (interpersonal evaluations) from the outcomes at the social level, related to a group as an entity. At the dimension of the task and the evaluation of medium of collaboration SIDE model has so far not attracted a lot of attention (Tanis and Postmes 2003, p. 959).

4.4.5 Media Richness Theory

Daft and Lengel (1984) proposed a theory of media richness that tries to define rules for effectiveness of medium usage in mediated communication. The amount of information and the variety of the communicated cues differs depending on the type of communication medium. According to the theory, a richer medium is able to transmit more cues and information than a leaner medium and therefore ambiguous and uncertain tasks require the adoption of a richer medium than tasks with less ambiguity and uncertainty.

Media richness is defined according to four criteria:

- Capacity of immediate feedback
- Variety of cues and communication channels utilized
- Language variety
- Source

An overview of different media according to these characteristics is presented in Table 16.

Table 16. Media characteristics

Medium	Feedback	Channel	Source	Language
Face-to-face	Immediate	Visual, audio	Personal	Body, natural
Telephone	Fast	Audio	Personal	Natural
Written, personal	Slow	Limited visual	Personal	Natural
Written, formal	Very slow	Limited visual	Impersonal	Natural
Numeric, formal	Very slow	Limited visual	Impersonal	Natural

Source: based on Daft and Langel 1984

Face-to-face communication is richer than audio communication. Feedback of an audio communication is fast, however visual cues are not transmitted. Individuals need to rely on language content and audio cues to reach understanding.

The feedback of written communication is low. Only the information that has been written down is conveyed and only visual cues are transmitted. Audio cues are absent, however, natural

language can be used. Addressed documents are more personal than anonymous and impersonal flyers or bulletins.

Hierarchy of media according to their richness is presented in Figure 10.

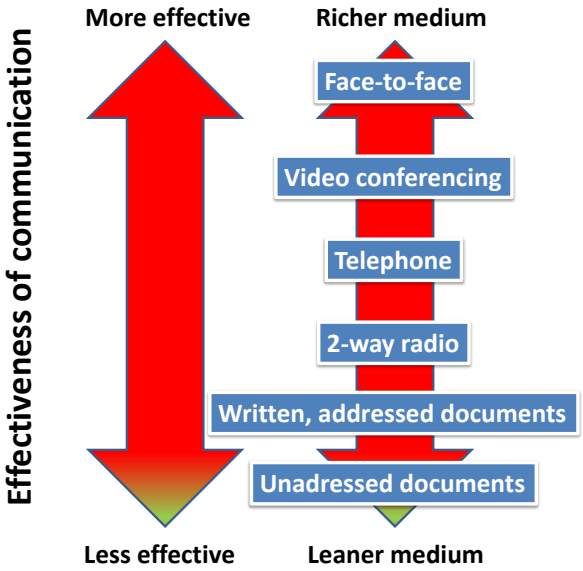


Figure 10. Media Richness Theory

The premise on which the theory is based is that the success of an organization relies on its ability to process information of an appropriate richness to reduce *uncertainty* and clarify *ambiguity*. Uncertainty is regarded in psychological terms and means the absence of information – when information level increases, uncertainty decreases. Definition of uncertainty as the absence of information is present in organizational theory and means the difference between the amount of information needed to perform the activity and the amount of information already possessed. Ambiguity (or equivocality) is the existence of multiple and conflicting interpretations about a situation. High ambiguity leads to confusion and lack of understanding (Daft and Langel 1986, p. 556).

According to media richness theory richer, a medium is able to convey more cues than leaner media and therefore tasks with high ambiguity and uncertainty need richer medium than those with low level of ambiguity and uncertainty. Media richness theory determines the fit between the type of task and optimal media for performing this task.

There are both positive and negative effects of information richness. Virtual groups tend to perform better than face-to-face groups e.g. in brainstorming, because working in the presence

of others (and therefore exchange of big amount of social cues) distracts individuals from the task. Individuals in face-to-face brainstorming session do not share all their ideas because of the anxiety for being criticized. Usage of communication medium decreases these feelings, individuals feel free to contribute and therefore the effectiveness of brainstorming in virtual environment is higher than in face-to-face settings. Hence, usage of medium that is too rich for a task is inefficient as well as usage of medium that is not rich enough (Levi 2007, p. 261; Haythornthwaite et al. 2003, p. 359).

Revised version of the media richness theory includes e-mail and contains additional selection criteria of geographical separation of communication partners, time pressure and the unavailability of critical mass of communication partners in computer-based networks.

Results of studies on media richness theory argue that the model is applicable more to the traditional than the new media and communication activities rather than the complex tasks. Experiments often do not support the model – e.g. studies on performance show that matching channel capacity to equivocality has not improved performance. Task-medium fit has also not been supported (Saunders and Ahuja 2006, p. 683). However, research groups for these studies were often laboratory groups, consisting of students or individuals that have never worked together and therefore these results have been often criticized as not being representative (Haythornthwaite et al. 2003, p. 359).

Furthermore, it has also been shown that because of e.g. convenience, the large number of coworkers using the medium or positive symbolic value individuals often decide to use leaner media although the theory would suggest an adoption of a richer medium (Hinds and Kiesler 1995, p. 375). Some researchers argue that the adoption of leaner media for complex problems forces individuals to abstract and decontextualize, which can be seen as an advantage of this media (Fischer and Ostwald 2005, p. 227).

Media richness theory, although not unequivocally confirmed by research, has provided a basis for other medium theories and research on adoption of communication media.

4.4.6 Media Synchronicity Theory

The method of media richness theory bases on the presumption of dependencies between media richness and social presence: a medium is richer if its social presence is greater. Media synchronicity theory extends this approach and states, that not only social factors, but also information processing capabilities are related to the ability of a medium to change understanding within a time interval. This theory is focused on the ability of media to support communication processes used by individuals working on tasks.

Media synchronicity theory defines communication as a composition of two primary processes:

- The conveyance of information with deliberation of its implications
- The convergence on meaning

According to this theory, alignment of media capabilities and requirements of these two processes will enhance communication performance. Conveyance-related interactions should be supported by media providing low synchronicity while convergence-related interactions require media providing higher synchronicity. Furthermore, media synchronicity theory defines five capabilities of media (immediacy of feedback, symbol variety, parallelism, rehearsability and reprocessability) affecting effectiveness and efficiency by which individuals perform conveyance and convergence processes and differentiates newly formed groups as well as established groups as having different requirements for media capabilities resulting from differences in shared experience between group members (Dennis et al. 2008).

Dennis et al. (2008) anchor media synchronicity theory in an environment of group work and recognize the importance of social factors for performance of group. For purposes of simplicity, group well-being and member support factors are combined here into a factor called *social function* in order to create a model with two main categories of functions to examine: social and production. Such approach of considering two main categories of interactions in a group work has already been present in literature and was discussed by Dennis et al. (2008), e.g. teamwork and taskwork, socialization and task participation, social-related and task-related interactions.

The five capabilities of media affecting effectiveness and efficiency by which individuals perform communication processes defined by media synchronicity theory are:

- Immediacy of feedback
- Symbol variety
- Parallelism
- Rehearsability
- Reprocessability

Immediacy of feedback can be understood as the extent to which a medium is able to provide to a user a rapid feedback on the received communication. It is the ability of the medium to support rapid bi-directional communication. Immediacy of feedback allows the message to be assessed and modified quickly, even during the transmission itself. It has been shown that that immediacy of feedback affects communication outcomes by increasing interaction between communicating individuals.

Symbol variety describes in how many ways information can be encoded for communication by a medium. This characteristic encompasses Daft and Lengel's (1986) multiplicity of cues and language variety and by Dennis et al. (2008) is termed as the 'height' of the medium. Symbol variety may affect communication and understanding of messages in four distinct ways:

- *Some information can be conveyed more easily in symbol format than in any another*: it has been shown for certain task types that some symbol formats can emphasize the same information in different ways and therefore influence decision outcomes depending on the presentation mode used
- *Verbal and non-verbal symbols allow senders easier transmission of information beyond the words when the message is transmitted*: some media allow transmission of additional verbal and non-verbal symbols such as emoticons, smiles or gestures used e.g. to show doubt or uncertainty, indicate acceptance or facilitate turn-taking and communication interaction
- *Some media require more time and effort to compose or encode a message and to process or decode an incoming message than other*: this may impose delay or production cost and alter the way of message creation (sender) and the understanding of the message (receiver)
- *Lack of verbal and non-verbal symbols* can significantly influence social perceptions in terms described previously in section 4.3.2 and related to the effects of lack of social presence

Parallelism describes the ability of a medium to provide support for a number of simultaneous conversations. Telephone communication can be effectively used only by one conversation at a time while electronic media can support many simultaneous interactions. Parallelism can increase the amount of information transmitted simultaneously; however, an increased number of conversations may lead to problems with monitoring and coordinating conversations and lead to information overload.

Rehearsability describes the ability of a medium to enable support for rehearsing or fine tuning the message before sending, also termed editability. Rehearsability is important for ensuring that the intended meaning is expressed exactly and with no extraneous information. Rehearsability may influence communication imposing delays if individuals spend time on editing activities and trying to control and define the meaning that they want the receiver to grasp from the message. Rehearsability may be important from the information processing perspective – it allows editing messages to ensure accuracy.

Reprocessability can be understood as the ability of a medium to reexamine or reprocess the message within the context of the communication event. It reflects the capability of media to store the contents of communication. Reprocessability allows individuals the opportunity to reread and reconsider the message many times and therefore may cause communication delays. It also may serve as a source of a group memory allowing new group members a faster introduction to group activities (Dennis et al. 2008).

A comparison of selected media according to five described media capabilities is presented in Table 17. Some media are configurable and therefore their capabilities are described as a broader range – e.g. a written mail may also contain tables or graphics.

Table 17. Selected media and their capabilities

	Feedback	Symbol Variety	Parallelism	Rehearsability	Reprocessability
Face-to-face	high	low/high	low	low	low
Video conference	medium/high	low/high	low	low	low
Telephone	medium	low	low	low	low
Written mail	low	low/medium	high	high	high
Voice mail	low	low	low	low/medium	high
Electronic mail	low/medium	low/high	medium	high	high
Electronic phone (chat)	medium	low/medium	medium	low/medium	low/medium
Asynchronous groupware	low	low/high	high	high	high
Synchronous groupware	low/medium	low/high	high	medium/high	high

Source: based on Dennis et al. 2008

Three conclusions may be drawn from this comparison, which extend the view of media richness theory:

- There is no medium characterized by highest values in all dimensions – no medium therefore can be labeled as 'richest' in terms of media richness theory
- Media are not monolithic: different media may have different levels of communication capabilities depending on their configuration and usage
- Using absolute terms for purposes of media ranking is not practical. Media richness theory suggests that media can be ranked according to their richness without consideration of the context they are used in. While media are characterized by many capabilities more or less important in a given context, the choice of 'the richest' medium is dependent on the situation and variables: individuals, the social context of their

interactions and communication processes. Therefore Dennis et al. (2008) suggest that face-to-face communication in the age of new media is not appropriate to be considered as 'the richest' anymore

According to studies, media richness theory was found to be applicable more to the traditional than the new media (Saunders and Ahuja 2006, p. 683) while media synchronicity theory (Dennis 2008) approach suggests a set of media capabilities that reflects capabilities of the new media better. Even though computer-mediated communication is not able to replace face-to-face interaction, it provides tools for effective supporting of a group task in a given situation.

The approach presented by media synchronicity theory defines tasks as composed of two fundamental processes: conveyance and convergence. Conveyance can be described as information exchange followed by deliberation on its meaning. Convergence means development of shared meaning for information. Individuals strive to agree on the meaning of information and must understand each other's views (Dennis et al. 2008).

Assumption of media synchronicity theory is that, in general, media with low synchronicity are preferred for conveyance, because to convey information and enable deliberation individuals not necessarily need to work together simultaneously. Media with high synchronicity used for conveyance may hinder deliberation process and decrease performance. Media with high synchronicity according to the theory are suitable for convergence. Development of a shared meaning requires mutual work and simultaneous performing of communication processes related to tasks. Media with low synchronicity that is used for convergence may hinder development of common understanding and cause delays (Dennis et al. 2008).

Media synchronicity theory explains further dependencies between media capabilities and their influence on both convergence and conveyance processes and proposes that communication environments supporting low parallelism and high immediacy of feedback encourage high synchronicity that is key to performance. Environments supporting high parallelism and low immediacy of feedback provide low synchronicity that is key to performance in conveyance processes (Dennis et al. 2008).

4.4.7 Theories Overview

Communication technologies have been widely adopted in organizations and society through the usage of tools e.g. email, discussion boards or blogs. These tools add new dimensions to already existing patterns of interpersonal communication. Researchers have been trying to identify these aspects of computer-mediated communication that have influence on patterns of communication, social networks and interpersonal relationships. Depending on the type of

medium individuals use, interaction patterns vary from regular face-to-face interactions. The virtual communication channel affects natural communication process and puts additional requirements on this process simultaneously hindering ephemeral aspects of interaction.

The presented media theories discuss dependencies between individuals and a medium they interact through. They strive to explain social aspects of mediated communication (social presence theory, reduced social cues approach) as well as effects of medium on the quality of this interaction (media richness theory) and furthermore its impact on group interactions (media synchronicity theory). Generally, social effects are considered at the interpersonal level, at the collaboration level and at the performance level (Tanis and Postmes 2003, p. 957). From the perspective of a collaborative group information delivered by these theories provides essential insight into aspects of media characteristics important for effective interactions. Primarily the theories discuss the social effect of communication technology and factors such as non-verbal cues on interpersonal, relational and social consequences of computer-mediated communication (Tanis and Postmes 2003, p. 956).

A comparison of selected media according to the speed of communication, their interactivity, richness, social presence and a type of message is summarized in Table 18.

Table 18. Analysis of media according to selected criteria

Method	Speed	Interactive	Richness	Social Presence	Document Message
Face-to-face	Slow	High	High	High	No
Group Meeting	Slow	Moderate	High	High	No
E-mail	Fast	Moderate	Low	Low	Yes
Web Page	Moderate	Low	Low	Low	Yes
Print	Moderate	Low	Low	Low	Yes
Video Broadcast	Fast	Moderate	High	Low	No
Videotape	Moderate	Low	Low	Low	No
Teleconference	Fast	Moderate	High	Moderate	No

Source: adapted from Levi (2007, p. 161)

It is important to notice that although the aspects of influence of media on interactions are described differently in each theory, all of these paradigms recognize one general element as the most important: social effects of computer-mediated communication are caused by disembodiment of interpersonal interactions. Furthermore they assume these effects will be felt

analogical at other social levels: psychological and interpersonal level, as well as within dyads, groups and communities (Tanis and Postmes 2003, p. 957).

On the basis of the previous sections it can be stated that because groups that interact via technology exchange less information and their communication is less intensive, deindividuation may occur and a number of negative social effects can be observed (Levi 2007). Studies show that satisfaction of members of virtual groups is lower than in a face-to-face group because of the feeling of lack of social support and increased stress related to this form of communication. Although negative effects disappear over time it may take longer for a group to develop social relations that improve communication. Virtual groups experience problems in developing cohesion; their members feel more anonymous and group identification develops more slowly. Simultaneously, other group maintenance activities: building trust and supporting motivation are more difficult in virtual groups to emerge. Levi (2007) stresses the importance of face-to-face meetings for easing all those problems and suggests that member satisfaction in virtual group depends on opportunities offered in face-to-face meetings and related to the exchange non-job-related, personal information (Jonassen and Kwon 2001; Levi 2007).

Because of the importance of communication for maintaining social relations and the pivotal influence of quality of social interaction on the performing of a group task (Herold 1978; Grudin 1994), the lack of social information that occurs in every interaction that is 'virtual' may prevent development of new social relations and negatively affect the building of a sense of community. Negative effects of using communication technology include e.g. information overload but also a feeling of increased isolation or decreased interpersonal contact (Levi 2007).

Although the theories presented in previous sections do not explicitly answer the question how or if computer-mediated communication is able to substitute face-to-face interactions, they provide an insight into an effective arrangement of media in order to provide the most effective environment for such interactions with defined medium constraints.

Firstly, the theories recognize the importance of social aspects of communication and the need of transmission of social cues which serve as a basis for creating interpersonal understanding on a social level. These social aspects of computer-mediated communication influence individual satisfaction and define effective interaction environment in terms of building a social understanding as a basis for effective collaboration.

Secondly, task level is discussed here as a fit between media capabilities and characteristics related to a type of task a group (or individual) needs to perform. Effective task performance

depends on an appropriate alignment of media characteristics, task type and group familiarity (media synchronicity theory).

Overview of discussed theories with their focus is presented in Table 19.

Table 19. Theories related to computer-mediated communication and their focus

Interpersonal Level	Social Level	Task Level
Social Presence Theory	Social Identity model of Deindividuation Effects	Media Richness Theory
Uncertainty Reduction Theory	Reduced Social Cues Approach	Media Synchronicity Theory

Source: Own elaboration

Studies examining theories do not always deliver results predicted by theorists. It seems that computer-mediated communication cannot be always fully described and explained in terms of face-to-face interactions. Studies conducted by Tanis and Postmes (2003) showed e.g. that embodiment in computer-mediated communication may have different effects at different levels of social abstraction. The consequences of embodiment were found to be both positive and negative: positive in terms of its effects on interpersonal relations and attraction. Negative effects may appear on such dimensions as: satisfaction with the medium, outcome and interaction per se. The assumption that richer media (in terms of media richness theory) were supporting collaboration better than leaner was not confirmed by their research.

The presented theories discussed different aspects of media (media capabilities) and created settings for the analysis of a medium in terms of its fit to a task. These settings involve effects of a medium on individuals and interactions as well as define dependencies between activity types and medium which helps creating an effective environment for group collaboration.

4.5 History and Development of Systems for Computer Supported Collaboration

The last decades brought not only enormous advancements in the technology sector (hardware, software, network infrastructure) but also simultaneously caused a shift in the approach to collaborative work caused by rapid development and new opportunities enabled by this progress. Usage of a computer as a tool caused changes for an individual and social environment of a working place. At first, serving only as a computing engine, nowadays computer technology supports not only individual work, but also group work and group communication through a computer network (Gross and Koch 2006, p. 1).

4.5.1 Computer-Supported Cooperative Work

Connecting computers into a network, enabled through a successful work on an ARPANET project (1960s) started an era of a rapid information exchange through communication networks between computers. In the 1980s expansion of personal computers connected to Local Area Networks (LAN) and Wide Area Networks (WAN) enabled new paradigms of work supported by technology to emerge.

The term Computer-Supported Cooperative Work (CSCW) has its origins in the 1980s and combines multidimensional aspects related to the economy, social psychology, anthropology, organizational theory, education theory and other subjects more or less connected thematically to the subject of group interactions as well as fields related to the human-computer interaction and information systems. The term CSCW was coined after an earlier approach to technology-supported work – "Office Automation" – was not able to support the growing demands and provide sufficient background for understanding requirements of a group work (Grudin 1994a, p. 19). In his article, Grudin (1994a) presents historical shifts, demographic patterns and geographic distinctions that underlie contributions to the subject of Computer-Supported Cooperative Work in Europe, United States, Japan and Asia and was the first one to summarize all aspects of the field of research related to computer supported collaboration.

Analysis of CSCW research shows its focus on the support of small collaborating groups. Computer-Supported Cooperative Work is defined as follows: "In its most general form, CSCW examines the possibilities and effects of technological support for humans involved in collaborative group communication and work processes" (Bowers and Benford 1991 in Gross and Koch 2006, p. 4).

4.5.2 Groupware Systems

Groupware paradigm was summarized by Marca and Bock (1992 in Gross and Koch 2006, p. 4): "Groupware is a conceptual shift; a shift in our understanding. The traditional computing paradigm sees the computer as a tool for manipulating and exchanging data. The groupware paradigm, on the other hand, views the computer as a shared space in which people collaborate; a clear shift in the relationship between people and information". Human-computer interaction is here in the background – human-human interaction through a computer as a medium is of a greater importance.

Hence, the field of Computer-Supported Cooperative Work considers e.g. economical, social, psychological and technological aspects of a technology-mediated collaboration, defines and

explains the dependencies between them, while the term groupware refers to a concrete adoption of this knowledge in the form of a computer application.

Different definitions of groupware are summarized in Table 20.

Table 20. Groupware definitions

Krasner et al. (1991)	Ellis et al. (1991)	Baecker (1993)
Computer-based technology that actively facilitates two or more users working on a common task, possibly simultaneously, using a shared environment and provides synergistic mechanisms for coordinating each user's actions with respect to the rest of the group and the system	Computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment	The multi-user software supporting CSCW systems or (...) information technology used to help people work together more effectively

Source: Own elaboration

Grudin (1994a), describing groupware as CSCW applications, presented an analysis of different approaches to label different applications with the term "groupware". The view of researchers and developers with a small-system orientation and those with an organizational perspective differs. Grudin proposes an alternative to this conflict and states that such classifications are less helpful than considering how the tools can be used in a particular setting. Email used only as a broadcast medium (e.g. sending organization-wide messages) is not supporting groups, however a distribution list enabling internal information exchange for group members is a factor allowing the email to qualify as a group support technology.

The field of Computer-Supported Cooperative Work consists of multiple views from different (social, technological, etc.) perspectives. This multidimensionality of the CSCW field is a reason why this discipline resembles a forum and a "market of ideas, observations, issues and technologies" rather than a uniform substance (Grudin 1994a, p. 25).

Groupware applications support multiple group processes and are represented by e.g.: email, shared calendar systems, project management systems, workflow management systems or discussion boards (Pfohl 1997, p. 33; Richter-von Hagen and Stucky 2004, p. 181; Guimares et al. 1998). Emerging from the organizational need of facilitating group processes they offer support for strictly defined and structured cooperation patterns, i.e. project management systems or workflow management systems (Richter-von Hagen and Stucky 2004, p. 181; Scheer et al. 1998, p. 165) but also for the less structured e.g. discussion boards, email.

4.5.3 Classifications of Groupware Systems

Different classifications explain core aspects of groupware and allow gaining overview in a structure of groupware systems. Time-space taxonomy and 3C model are the most recognized approaches to groupware classifications.

4.5.3.1 Time-space Taxonomy

Time-space categorization by DeSanctis and Gallupe (1987) allows for better understanding of the aspects underlying the groupware (Figure 11, adapted from Dix et al. 1998, p. 465).

	Same place	Different place
Same time	Face-to-face	Telephone
Different time	Post-in note	Letter

Figure 11. The basic time-space matrix

This typology explains how activities can be carried out: cells represent different combinations of proximity of group members and time-span of the activity and the basic support for the communication over time and space. Activity can be held in the same place at the same time and through face-to-face interactions communication happens in real time. Real-time activities over distance, when interacting individuals do not share the same place, require technology supporting real-time communication e.g. telephone. Interactions can also take place in one place over time and then require other tools than if an activity is carried out by individuals in different places and over time.

This typology facilitates communication and has been widely used, especially in an organizational perspective. The risk here is that most of the real work activity does not fall into one or another of the presented categories (Grudin 1994a, p. 24). Time-space classification emphasizes communication, however, most work involves both communication and coordination, tasks interact and are dependent on other activities, often overlapping and impacting one another. Therefore tools supporting activity in one cell may potentially inhibit other activities in other cells (Grudin 1994a, p. 25).

Figure 12 (adapted from Johansen 1988, in Baecker 1995, p. 742) presents an extended time-space matrix with a classification of different collaboration technologies. Collocated

collaborative groups can be supported by such collaboration technology as: decision rooms, single display groupware or a shared table.

	Same place Collocated	Different place Remote
Same time Synchronous	**Face-to-face interactions** Decision rooms, single display groupware, shared table, wall displays	**Remote interactions** Shared view desktop conferencing systems, video conferencing, chat, shared screens, whiteboard
Different time Asynchronous	**Ongoing task** Team rooms, large public display, shift work groupware	**Communication and coordination** Email, calendar, bulletin board, wiki

Figure 12. Time-space matrix for classifying collaboration technology

Synchronous communication support for remote groups is provided by a shared view desktop conferencing systems, video conferencing systems, whiteboard or chat. Collaboration of collocated groups over time may be supported by such technology as: team rooms or shift work groupware. Geographically dispersed groups can use email, calendar or bulletin board for supporting their interaction over time and space.

4.5.3.2 The 3C Model

Three key areas of group interaction were defined by Ellis et al. (1991, p. 40) to gain insight into groups supported by technology. Communication, collaboration and coordination processes created a background for the development of systems for supporting spatially distributed collaborative work. Today, they are considered as the 3C Model (Figure 13, adapted from Borghoff and Schlichter 2000, p. 125) and are likely to be presented as a pyramid in a diagram (Teufel et al. 1995, Borghoff and Schlichter 2000). At first, this classification was commonly used only for groupware classification purposes. Since then it has also provided a basis e.g. for groupware implementations (Fuks et al. 2005) or modeling and developing of groupware (Gerosa et al. 2006). The 3C Model also provided a basis for other conceptual models for computer-mediated group work, e.g. Clover model, in which the three main process spaces are: communication space, coordination space and production space (Laurillau and Nigay 2002).

According to approach of the 3C model, effective group collaboration relies on three processes: communication, cooperation and coordination. The model has been widely adopted in a literature: to analyze and interview groups whose activities are conducted outdoors, to improve computational support of software processes, to analyze user interface elements or to classify collaborative tools (Gerosa et al. 2006).

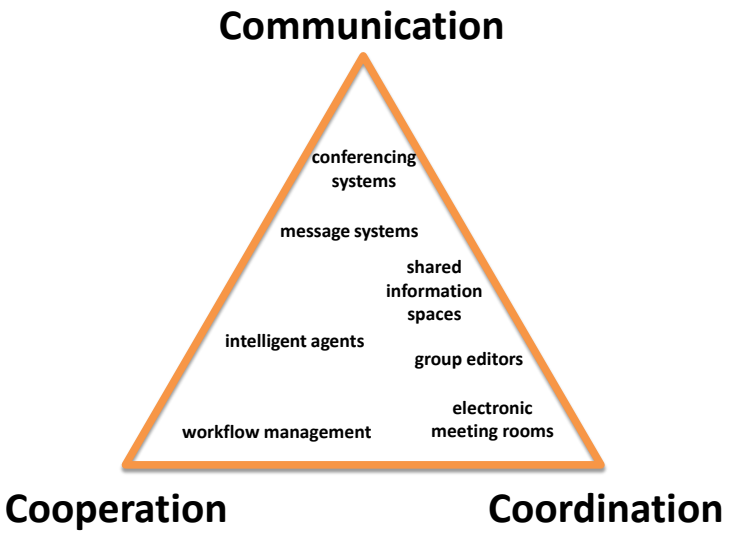


Figure 13. Communication, cooperation, coordination – 3C Model

Information exchange between remote agents relies on communication processes. Effective collaboration depends on information sharing, however communication is not sufficient for effective collaboration – group members need to communicate well to collaborate well (Knoll and Jarvenpaa 1998, p. 13). Communication is an enabling factor for message exchange and negotiation of commitments. Coordination can be described as mutual production activities of group members – creating and editing cooperation objects in order to complete the task. Coordination processes help to manage group members, their activities and cooperation objects. Coordinated communication and cooperation activities contribute to the effectiveness of collaboration. Coordination activities may be seen as an activity in itself and may be considered as a necessary overhead when different individuals are performing a task (Ellis et al. 1991, p. 40).

4.5.3.3 Functional Groupware Classification

Functional classification of groupware presented by Koch and Gross (2006) consists of the following elements:

- Awareness support: collaborative software interlinks users enabling them coordination of mutual activities – awareness tools support perception of activities beyond current interactions of a user and contribute to creating and maintaining a shared background of understanding called common ground
- Communication support: although awareness contributes to communication in an indirect form, support of synchronous (chat, video conference) and asynchronous (discussion forum) communication tools is required
- Coordination support: at the very general level awareness contributes to coordination, however there is a need for supporting coordination activities more explicitly
- Team support: this category relates to the support of special group types and fulfilling their special needs; team rooms can serve as a generic application for this domain
- Community support: communities have different structure of needs and require applications e.g. from knowledge management domain

4.5.4 New Collaboration Potential and Web 2.0

Tim O'Reilly summarized the concept of Web 2.0 (O'Reilly 2006) and at the conference on the development of the World Wide Web in 2004 he explained the term in the following words: "Web 2.0 is the revolution in the computer industry caused by the move to the Internet as a platform, and an attempt to understand the rules for success on that new platform. Chief among those rules is this: Build applications that harness network effects to get better the more people use them" (Shuen 2008, p. xvii). This approach shows a different view on interactions over the Internet than before. The paradigm of Web 2.0 is that the content generated by users creates value. It has not been possible without the changes and advancements in technology. Web 2.0 is characterized by easy-to-use web interface allowing users easy interactions, opening up to the others and allowing sharing self-generated content. This approach facilitates frequent interactions between users which leads to community building, creating trust and self-policing norms (Shuen 2008, p. 7).

Systems basing on a Web 2.0 paradigm are not homogenous and closed applications, but can be described as a combination of (Richter and Koch 2007, p. 5):

- New technology: web services, AJAX, RSS
- New application types: weblogs, wikis, mashups, social bookmarking etc.
- Social movement: contribution and self-presentation of the end users
- New business models: software as a service, the long tail

User is not only a consumer of content, but also an active designer and creator providing content to the other users as well. Technologies enabling development of this approach are e.g. AJAX, web services, RSS, REST or mashups.

4.5.4.1 Ajax

Ajax (Asynchronous JavaScript and XML) is a concept of an asynchronous data transfer between a server and a browser which allows multiple HTTP-requests within one HTML website without the necessity to reload it. This concept bases on already widely accepted and implemented existing technology (JavaScipt, XML). The innovation is that every part of the website can be now downloaded separately and therefore a web-application can be developed as an interactive application with the feeling of a desktop application (Koch and Richter 2007, p. 8).

4.5.4.2 Web service

Web service is a remote application that can be accessed by a client through a HTTP protocol with a list of defined parameters. The request and answer of a web service can be realized with SOAP (Simple Object Access Protocol), XML-RPC or REST technologies. Ajax-based applications or mashup applications can access remote data using web services (Koch and Richter 2007, p. 9).

4.5.4.3 REST

The term REST (Representational State Transfer) describes a model of distributed hypermedia information systems architecture, like World Wide Web and defines principles how should the Web function. It describes how web standards should be deployed to implement web services (Koch and Richter 2007, p. 9).

4.5.4.4 RSS

RSS – defined differently as: Rich Site Summary, RDF Side Summary or Really Simple Syndication – is an XML format for representing data allowing sharing different content between applications. In a weblog system RSS allows to publish weblog entries or comments to a blog-reader application. RSS enables syndication of content without necessity to go on the publishing website. Through usage of RSS content of different Web 2.0 applications can be interconnected and integrated under one interface. Because of limitations of RSS (Trott 2003) an alternative standard – Atom – has been developed. Atom standard emerged because of the need of consolidating multiple versions of RSS and expanding its capabilities.

4.5.4.5 Mashup

A mashup is an application that aggregates or combines content or functionalities of other services in order to create a new application. Paradigms of Web 2.0 assume that content of a

Web 2.0 service is not only available through a provided interface, but can be accessed by other standardized interfaces or protocols (e.g. RSS or HTTP) as well. For purposes of this integration application creators provide an access through an API (Application Programming Interface) enabling other parties access to the data (Koch and Richter 2007, p. 9).

4.5.5 Social Software as a Tool for Supporting Collaborative Interactions

Social software can be described as a system for supporting human interactions over the Internet and using Web 2.0 technologies presented in the previous section. A definition by Coates (2005) explains in greater detail what social software is: "Social Software can be loosely defined as software which supports, extends or derives added value from human social behavior – message-boards, musical taste-sharing, photo-sharing, instant messaging, mailing lists, social networking".

Social software enables and supports collaboration and communication between different users. The term refers primarily to the new functionalities (e.g. wikis, weblogs, contact networks, instant messaging) but also older forms of computer-supported collaboration may be a part of it (Bächle 2006, p. 121). The concept of social software explains the paradigm shift in creation of computer-supported communication tools and discussed intensively under the keyword Web 2.0: user is not only a consumer any more, but an active designer of information (Richter and Koch 2007, p. 6). Social software applications support different forms of collaboration between participants: establishing contacts, information exchange or collaborative information generation (Stegbauer and Jäckel 2008, p. 7).

As in the case of groupware, the main aspects of social software can be presented from a functional perspective. The classification presented by Schmidt (2006) defines the three main social software components:

- Strategies, routines and expectations for the selection and reception of information – influencing *information management*
- Strategies, routines and expectations for the self-presentation in Internet – influencing *identity management*
- Strategies, routines and expectations for the creation and maintenance of networks – influencing *relationship management*

Basing on this typology, a social software triangle containing these three functional aspects of social software has been proposed by Koch and Richter (2007, p. 14).

Different media have been arranged according to the appropriate social software function (Figure 14).

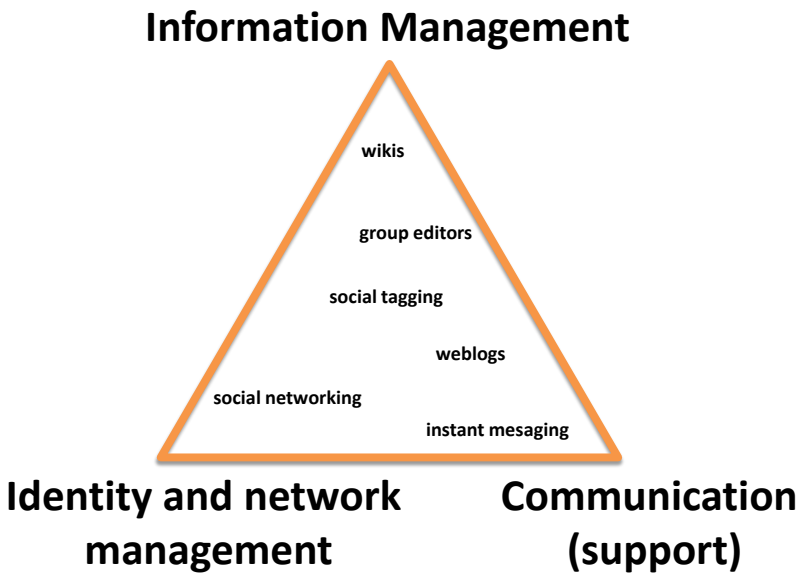


Figure 14. Social Software Triangle

Both groupware and social software support interactions between individuals and provide functionalities enabling group collaboration. However, differences exist and relate to the basic design approaches.

4.5.6 Comparison of Groupware and Social Software Approaches

Different factors characterizing groupware systems and key success and failure aspects have been identified and widely discussed in the literature. The most important aspects emphasized in the debate on groupware systems are (Richter and Koch 2007, pp. 9):

- **Taking into consideration potential differences between efforts and benefits for users**: some groupware users may have to perform more work (temporarily) than the others in order to provide benefits from system usage for other users. Such higher-than-average efforts of single users should be kept minimized or balanced by motivational methods in order to create critical mass of system users. Furthermore, potential hurdles of system usage should be possibly also minimized, e.g. with the implementation of such technologies as Ajax or mashups in order to minimize the effort for users (usability) to work with the system. It has been also shown that communication and clarification of benefits of the system usage to users is very important.

- **Removing of isolation borders between users**: in order to remove isolation borders, users need to be provided with information about other users and their actual and previous activities (awareness). Such information facilitates communication and coordination that allow avoiding potential coordination and synchronization problems and therefore reduce collaboration efforts.
- The third challenge discussed is the need for **cyclic and continuous development**. The involvement of end users in the development process allows creating systems with enhanced benefits and motivation of users. The importance of the user's involvement is discussed from the perspective of the theory of socio-technical systems. The complexity of interdependencies between social and technical systems has been recognized and discussed (e.g. Maton 1988). These dependencies put requirements on designers to embed end users in a process of system development.

Social software designers take into consideration all those three challenges as well. The development of social software can be described by the keywords *Perpetual Beta*. It describes an art of a system in a test phase, however with a functionality provided to end users. Such users are simultaneously testers and active designers of the system. Examples of such developments are e.g. Amazon or Google Mail (Richter and Koch 2007, p. 10; Komus and Wauch 2008, p. 247).

Groupware and social software design share many commonalities, however many differences can be identified. Social software is focused mostly on supporting social networks and communities, while groupware has been based on the support of members of a group in their project work. For this reason social software design is more focused on usability issues, on the other hand the number of interacting individuals is significantly bigger. Social software bases on a 'bottom up' approach – it gives the user multiple possibilities of interaction, but no specific patterns of their usage. The decision how to use the functionality is made by user. From this perspective groupware presents a 'top down' approach: because of its mostly organizational orientation and clear and defined processes between team members, groupware is a support for a defined socio-technical system. End users often participate in its development, however mostly because of the externally imposed organizational reasons (Richter and Koch 2007, p. 11).

Summing up, although social software and groupware share similarities, the aspects regarding basic design approach differentiate them. Social software approach of supporting larger groups contrasts with groupware approach focused on support for smaller organizational teams. 'Bottom up' approach of social software contrasts with a 'top down' approach of groupware.

However, in the meanwhile there can be tendencies seen of incorporating social software into an organizational environment as an extension of groupware functionalities. Simultaneously, the

area of CSCW more closely addresses aspects of larger groups in its research. From this perspective, social software can be seen as a new field of Computer Supported Cooperative Work research (Richter and Koch 2007, p. 11).

4.6 Analysis of Functionalities for Supporting Collaboration in Spatially Distributed Groups

Depending on the purpose of mutual actions, groups interacting virtually are offered a wide range of systems with different functionalities for supporting their collaborations. Functionalities are defined here as *communication and information technologies supporting group interactions*. Other terms for describing functionality used in this research are: *medium* (in terms of an electronic medium) or *tool* and will be used interchangeably.

Computer systems for supporting group work provide groups with a variety of functionalities enabling collaborative work in a virtual environment.

4.6.1 Platforms for Supporting Virtual Collaboration

Communication and information technologies support group collaboration in different ways:

- They enable *gathering and presenting information*
- Facilitate *internal and external communication*
- Provide *support for information processing*
- Enable *structuring of group processes*
- Enable *structuring information in networks*

Types of communication and information technologies for supporting group collaboration with examples of functionalities are presented in Table 21.

Table 21. Communication and information technologies for supporting group collaboration

Function	Example
Gathering and presenting information	document management system, whiteboard
Internal and external communication	email, chat, video conference
Support for information processing	recommender system
Structuring group processes	calendar, project management system
Structuring information in network	social tagging, social bookmarking

Source: Own elaboration

Selected groupware and social software applications have been analyzed in order to create a list of functionalities available for supporting collaborative interactions. Platforms were chosen considering their potential to fulfill at least one of the presented functions. Analyzed systems included:

- Collaboration platforms
  - BSCW
  - Microsoft Office SharePoint Server 2007
- Web conferencing platforms
  - Adobe ConnectPro
  - Microsoft Office Live Meeting
- Social networking websites
  - Facebook
  - MySpace
  - Xing
- Other
  - YouTube
  - Delicious

BSCW (Basic Support for Cooperative Work) is a platform for supporting collaborative groups. The features of the platform include: discussion boards, document management, task management, group management, contact management, shared calendars, blog system, notifications or online surveys.

Microsoft Office SharePoint Server 2007 is a collaboration platform for organizational teams. It offers the following features: blog, discussion board, group calendars, task management, document and workflow management or wiki. The social networking features of SharePoint Server include: personal profile and colleagues list in an organizational hierarchy.

Adobe ConnectPro is a web conferencing system for synchronous collaboration. It enables real-time communication through video or audio conference, collaborative work on a virtual whiteboard, chat, creating polls or application sharing.

Microsoft Office Live Meeting is a web conferencing system enabling users real-time collaboration over Internet. The features of the platform include: audio conference, video conference, virtual whiteboard, chat, creating polls or application sharing.

Facebook (www.facebook.com) is a social networking website allowing registered users to create and manage their own personal profile, to add other users as friends, to send them

messages, to upload photos, to share news about themselves and to comment on activities of friends. Registered users may create or join interest groups, discuss on discussion boards or chat.

Myspace (www.myspace.com) is a social networking website which enables registered users to create and customize their personal profiles by using HTML and CSS scripts, upload photos and videos, publish blog entries or update their status. Users can connect with other platform users, add them as friends and communicate with them using private message system or commenting their profile, photos or videos. Furthermore platform users can create interest groups and communicate on discussion boards.

Xing (www.xing.com) is a social networking website for professionals. Features of the platform include: personal profile, contact list, private message system, discussion boards or event management. Xing offers also a job market to its users and two types of membership: free and premium.

Delicious (www.delicious.com) is a social bookmarking website for managing bookmarks. Registered users save in their profile their bookmarks and share them with other platform users. Bookmarks can be described using tag system (folksonomy).

YouTube (www.youtube.com) is a video sharing website allowing registered users to upload, rate, share and comment videos. Users can manage their own friend list and exchange private messages. They can subscribe to other users' channels to receive notifications about new videos uploaded by them. Basing on the list of the videos the user viewed, recommended videos are suggested.

4.6.2 Functionalities of Collaborative Systems – Overview

The analysis of the selected collaborative platforms provided a basis for creating a list of functionalities for supporting group interactions. Because of the purpose of this research especially the functional aspects of media will be elaborated, while technological or organizational aspects will not be discussed at length.

Some of the presented functionalities have already been a subject of an extensive research analysis (chat, audio conferencing) and can be presented in greater detail than the others. CSCW research has been analyzing effects of groupware applications on group work, therefore the functionalities originating from groupware applications can be described in more detail here because of the amount of available studies. In contrast, research on media originating from social software does not have a long history and effects of their adoption are not well

understood and explained to this time. These functionalities will be described according to the current knowledge.

According to the classifications presented in sections 4.5.3 (3C Model) and 4.5.5 (Social Software Triangle) most of the analyzed media can be categorized according to five main functional aspects: communication, coordination, cooperation, identity management and information management (Table 22).

Table 22. Functional classification of media – examples

Communication		Coordination	Cooperation	Identity management	Information management
Synchronous	Asynchronous				
chat	private message	calendar	whiteboard	user's profile	wiki
audio conference	discussion board	task management	application sharing	social networking	social tagging
video conference	blog	voting system	document management	group management	social bookmarking

Source: Own elaboration

For some media however, this table does not show a complete picture of their potential functional applications. According to Levi (2007, p. 258) users adapt and modify the technology to suit their needs. Therefore in some cases functional application of medium extends the initial intentions of a medium designer. Studies have shown that e.g. chat is also used as an asynchronous communication tool (Scholl 2006, p. 330), blogs serve as cooperation or coordination tools (Nardi et al. 2004, p. 230) and private messages are often support for coordination and information management activities (Dabbish and Kraut 2006, p. 432).

Other functional applications of presented tools will be discussed in the following sections.

4.6.2.1 Asynchronous Communication Tools

Messaging system

Messaging system enables asynchronous text communication between platform users. It allows users sending private text messages like email to one or more platform users. Message content, similar to emails, can be often formatted in a WYSIWYG (what you see is what you get) interface, using HTML or BBCode tags. Users can attach files to a message. The system organizes the messages in folders: inbox (for incoming messages), sent (sent messages), draft (draft versions of messages), trash (deleted messages) and allows users creating their own folders for managing messages. Abbreviation for a message is PM which stands for a private or personal message.

Text-based message exchange is not only used for asynchronous communication but also for archiving, task management or information management because many of tasks and their information is exchanged via electronic messages (Dabbish and Kraut 2006, p. 432).

Because text-based communication is a central method of information exchange at work and email is reported to be the most successful and widely used form of computer-mediated communication, the amount of exchanged messages may lead to a problem of information overload (Dabbish and Kraut 2006, p. 431).

Bulletin board

Bulletin board system allows users posting (rather short) public text messages, often to the subscribers (Myspace), e.g. containing news or announcements. The term refers to traditional cork-made bulletin boards situated in public places, where people could pin their messages or advertisements to. In the early days, bulletin board systems allowed users to post and read announcements or advertisements, manage message box or exchange files. Today, the functionality of the original bulletin boards is often covered by Internet forums and bulletin boards are available as a part of bigger systems (Myspace).

Discussion board

A discussion board (Internet forum or message board) allows users holding text-based discussions. Discussion boards are divided into categories where users can start a discussion by creating threads (topics). Responses to the topic (posts) are mostly displayed from the oldest to the latest. Users are often allowed to edit or delete their own posts. Posts can be formatted using BBCode and emoticons are often replaced by small graphical representations. Users are organized in groups with different privileges. Not registered users (guests) mostly can only read discussions. Forum members are allowed to create threads and to post messages. Group of moderators can edit or delete posts of other users and forum administrators manage groups and other technical aspects of a forum.

Microblog

Microblog functionality enables communication in a form of a short message including text, image or a video. Users mostly post a microblog message answering the question “what are you doing?” (Böhringer and Gluchowski 2009, p. 505). There are independent microblog platforms on the web (with the most popular: Twitter), but also social networking websites (Facebook, MySpace) provide microblog functionality called ‘status updates’. The length of microblog messages mostly does not exceed 200 characters (Oulasvirta 2009, p. 237).

Although microblogging history is short, research on this new Web 2.0 tool already analyzes its potential for education (Ebner 2010) or implementation in a corporate environment (Riemer and Richter 2010).

Comments

Comment functionality enables users posting comments on objects, resources, entries or notifications of other users.

4.6.2.2 Synchronous Communication and Collaboration Tools

Chat

Chat is a text-based communication tool for real-time message exchange between two or more users. Exchanged messages (often called instant messages) can be formatted and emoticons are often replaced with animated representation. Chat has been widely adopted by young people as a socializing tool and by adults for both social and work purposes (Isaacs et al. 2002, p. 11).

Although chat dialogue is slower than e.g. in audio conversation, it also offers advantages: despite being simultaneous, it leaves time for reflection – text messages are more persistent than audio. Text-based conversation allows rereading of previous messages if there's a need e.g. to achieve a better understanding. Chat systems mostly have an interaction history which has an important impact on conversations. Users can simultaneously participate in multiple conversations not having to remember all the interactions – interaction history is accessible anytime and creates an art of a group memory. Even though a chat is a synchronous tool, responses do not necessarily have to be simultaneous and conversations may last for hours with an average message exchange rate of 15 minutes (Dillenbourg 2005, p. 247).

Chat has multiple uses, it may support e.g.: opportunistic interactions, broadcasting of information or questions or have 'signaling' function if people need to negotiate availability for other interactions (Handel and Herbsleb 2002, p. 1).

Research on content of chat messages at a workplace shows the following categories of interactions (Figure 15, adapted from Handel and Herbsleb 2002, p. 6).

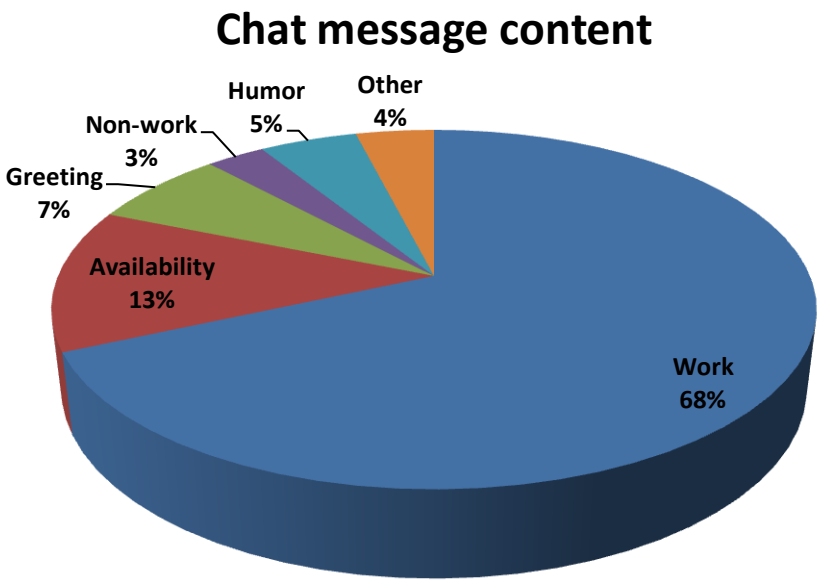


Figure 15. Chat message content by category

Three important aspects of chat communication have been identified: conversations are brief, media switching is prevalent and multitasking is common while in conversations. Therefore chat has been reported to be a tool that successfully supports informal communication and often, within work settings, it is preferred to informal face-to-face communication as it allows multitasking and is less intrusive (Isaacs et al. 2002, p. 11). Individuals exchange messages in near synchronicity and although text-based communication is considered to be of a low presence, synchronicity raises the perceived social presence of chat users. Furthermore, chat provides multiple cues to participants of a conversation offering e.g. audio cues while logging on/off the chat or receiving a message (Kuyath and Winter 2006).

Audio conference

Audio conferencing supports real-time voice communication of one or multiple users. Although the results of Media Richness Theory suggest that audio communication should be preferred to chat communication, users often find chat to be more useful for both private and public communication. Audio conferencing, as a synchronous communication tool, has a high "cost" of interrupting others and is difficult to manage if communication is between larger groups of individuals.

Comparison of audio and chat advantages and disadvantages is presented in Table 23.

Table 23. Comparison of audio and chat communication

Feature	Audio	Chat
Asynchronous communication	disabled	enabled
'Cost'of interrupting others	high	low
Large group communication	difficult	easy

Source: adapted from Scholl et al. (2006, p. 330)

Different aspects of audio conferencing have been examined. It has been found that for problem solving tasks and for simple information exchange tasks audio communication is as effective as face-to-face communication, mostly because participants in such interactions focus on arguments and issues (Daly-Jones et al. 1998, p. 28). However, audio-only communication affected social perception of participants and their preference ratings for people they met for the first time over an audio conversation were lower in comparison to the face-to-face meeting or video conference, which can be explained by social-cue theories discussed in earlier sections (Daly-Jones et al. 1998, p. 29).

Video conference

Video conferencing enables real-time audio and visual communication of one or multiple participants. Since it is able to transmit eye gaze, body orientation or gestures it is able to fulfill certain roles for auditory and visual information in human interactions (Daly-Jones et al. 1998, p. 23): e.g. making contact, however studies show, that individuals find it difficult to coordinate turns at talk or to monitor attention and understanding (Isaacs and Tang 1994, p. 71). The importance of transmission of visual cues has been discussed in the section 4.4.

Video communication facilitates a better indication of presence and enables better feedback on state or activity and people's emotional reactions than audio or chat communication. Therefore, video communication has been reported to be more effective in building trust than audio or chat communication (Scholl et al. 2006, p. 323; Bos et al. 2002). Despite the fact that video communication is expected to improve remote collaboration effectiveness, many studies have not delivered evidence to support the thesis that groups are more efficient at problem solving or decision tasks if using video conference in comparison to audio-only communication (Isaacs and Tang 1994, p. 63).

The reasons why studies on effects of video communication in remote collaboration do not show particular improvements in group collaboration effectiveness can be explained in two ways:

- Test groups created for purposes of studies consisted of strangers not having work relationships with each other
- The effects of video in supporting interactions may be visible over the long term and are too subtle to be captured in short laboratory experiments

Isaacs and Tang (1994, p. 64) suggest that the effects of video communication should be visible for groups of individuals having a working relationship to each other and dealing with issues that motivate them, because transmission of social cues plays important role among individuals who know each other and accomplish real work requiring social negotiation.

A comparison of video, audio and chat social presence properties is presented in Table 24.

Table 24. Comparison of video, audio and chat social presence properties

Feature	Video	Audio	Chat
Indication of presence	high	middle	low
Feedback on state or activity	high	middle	middle
Feedback on people's emotional reactions	high	middle	low

Source: adapted from Scholl et al. (2006, p. 330)

Whiteboard

Whiteboard (shared whiteboard or electronic whiteboard) is a graphical tool that allows users collaborative displaying and editing of slides or sketches. It allows every user to simultaneously work on the content of a whiteboard and broadcasts changes in real-time to other whiteboard users. Users can put their own graphic files on the shared screen and make annotations or write notes. Every user can use a toolbox allowing drawing, writing or removing objects from whiteboard (Villemur et al. 1999, p. 64).

Whiteboard is mainly used as a tool for storing and organizing information. This ability of a whiteboard enables it to function like a group memory or a group working memory: a set of collected information for representing the state of the problem (Stahl et al. 2007; Dillenbourg 2005, p. 247). Whiteboard helps in problem solving tasks as it allows adding pieces of information, but also reorganizing, annotating and deleting them. Whiteboard enables users to collaboratively maintain representation of a problem and therefore is able to fulfill the cognitive function going beyond the simple flow of information between individuals (Dillenbourg 2005, p. 247).

Application sharing

Application sharing enables users in spatially distributed groups to view and interact with the same software application in a real-time. Shared cursor is visible to all users and enables focusing attention of all users at the same point of application simultaneously.

Contrary to video conference, application sharing does not provide information about non-verbal social cues reported to be important for collaboration, such as eye gaze or body movement. However, it has been found that despite that shortcoming it is mainly providing information about the task, application sharing gives users the feeling of presence of others (Bradner and Mark 2001, p. 157). Studies show that collaboration benefits from using application sharing compared to audio conference alone (Bradner and Mark 2001, p. 155).

4.6.2.3 Coordination Support

Calendar

Calendar (shared calendar) is a tool for managing events, dates or appointments and sharing them with other users over network. It usually provides access to different calendar views (day, week, month), enables sending event invitations or managing reminders or notifications. Calendaring tools often support event management or provide access control for privacy management (Tullio et al. 2002).

Voting system

Voting system provides features for supporting collaborative decision making. It enables managing of online polls and surveys and provides functions for real-time evaluation of the results, mostly in a graphical form.

Task management

A task management tool supports collaborative managing of tasks for planning and executing actions e.g. across projects (Bellotti et al. 2004). It enables creating personal and shared task lists e.g. for managing project progress. Task management tools allow prioritizing tasks and sharing them (assigning them) with other users, defining deadlines and therefore support tracking work and project progress.

Group management

Group management functionality enables defining groups, roles and assign users to groups according to their roles in order to manage access to resources, objects or documents.

4.6.2.4 Information Management

Wiki

Wiki (or WikiWiki) is a tool that allows users to collaboratively create, edit and interlink websites. Edition efforts are minimized since the content of a website can be modified and commented by any user anytime – therefore the name 'wiki': from Hawaiian word 'fast' (Richter and Koch 2007, p. 19). Content of a website is primarily pure text, but can be additionally formatted by using simplified markup language (wikitext) or by WYSIWYG interface. The most known application of wiki is Wikipedia – the online encyclopedia.

Wikis have been implemented in companies in the mid 1990's and currently serve as tools for knowledge management (Richter and Koch 2007, p. 19).

Blog

Blog (or Weblog) allows user (or multiple users – authors) publishing information (blog entries) displayed in reversed-chronological order. Blog author (blogger) publishes information related mostly to one specific subject. Entries can be classified into categories and subcategories and formatted without specific programming skills – using WYSIWYG interface. Weblog system offers the functionality of a discussion platform – blog readers can comment on entries (Richter and Koch 2007, p. 13).

Every entry can be accessed via a specific URL address (permalink) which allows creating references in other blogs. If a blogger uses a trackback link to the other entry in his own article, a ping-system informs the author about new reference. Weblog readers can subscribe to a blog and receive information about new entries through RSS feed (Richter and Koch 2007, p. 14).

The usage of weblogs has been acknowledged by organizations and currently blogs are one of the tools not only for an internal (e.g. corporate blogs for project management), but also external communication (marketing blogs) in companies (Richter and Koch 2007, p. 16).

Document management

Document management functionality allows storing, versioning, tracking or searching for documents. It serves as a document repository with the following functions:

- Capture and creation
- Storage and organization
- Retrieval and synthesis
- Transmission and routing

Document management system provides information about status reporting (who has a document), access control (who can read or change a document), and version control (what is a current version of a document). In organizations it serves a role for supporting knowledge management (Sprague 1995, p. 39).

Social tagging

Social tagging (or folksonomy) functionality allows users to collaboratively 'tag' objects with keywords to facilitate retrieval both for the user and for other users. Basing on tags, sets of categories characterizing an object are generated. A 'folksonomy' commonly stands for a set of categories characterizing a resource. Folksonomy in contrast to formal ontology is generated by users, not experts (Halpin et al. 2007, p. 211).

Folksonomies can be visualized in a form of a tag-cloud or word-cloud. An example of a folksonomy is presented as a word-cloud in Figure 16.

Figure 16. Example of a tag-cloud

The most popular tags are highlighted and are larger than the less popular ones.

Social bookmarking

The social bookmarking functionality enables users to collaboratively save, organize, manage and share their bookmarks over the Internet. Users save links to websites and can 'tag' a bookmark, which facilitates searching and finding other bookmarks interesting for a user. Users decide if a bookmark is private or visible for other users. Most popular bookmarks are listed on the 'most-popular' website. Social bookmarking tools enable also a RSS subscription of bookmarks.

Social bookmarking was reported as a search engine delivering prominent results (Heymann et al. 2008).

Social rating

Social rating functionality allows users to collaboratively rate or evaluate the quality of objects or resources. Basing on an idea of collective intelligence, contributions of users are collected and their opinions on a specific resource evaluated on a mass scale. Users can evaluate weblog entries, bookmarks, videos or comments.

The social rating tool can be seen as an extension for a search engine to deliver results that are highly evaluated by users (Gruber 2008).

Social sharing

Social sharing functionality enables sharing of resources with other users over Internet. It allows sending suggestions about resources that users find interesting and want to share with other users. Social sharing tool enables sending suggested resource (as a link) via email, comment or a personal message.

Recommender system

Recommender system functionality enables generating automated recommendations for users basing on evaluation of their previous activity. Recommender systems base on opinions of a bigger group to help identifying resources interesting from a potentially overwhelming set of choices (Herlocker et al. 2004, p. 5). Recommender systems base on a collaborative filtering technology and have multiple adoptions in social networking websites, news portals or in e-commerce (Schafer et al. 1999).

Notifications

Notification system provides functionality for notifying users about actions, activities, status of other users or changes of resource state and contributes to awareness of group members about events beyond their current task-oriented interactions. Users can be notified about collaboration partner's accomplished tasks, uploaded content, opinions or posted information – blog entries or comments.

Notification system supports collaborative awareness contributing to creating and maintaining a shared background of understanding called common ground which is more difficult to establish in virtual than in face-to-face groups.

According to Carroll et al. (2003), notifications provide information for supporting the following aspects of awareness:

- Social awareness: who is around? Providing information about presence of collaboration partners, their motivational state or attitude, timing, frequency or intensity of individual and group activity.
- Action awareness: what is happening? Information about timing, type or frequency of collaboration partner's interactions with a shared resource.
- Activity awareness: how are things going? Information about the creation or changes to shared plans or evaluations, task dependencies based on roles, timing or resources.

Search

Search system is a tool enabling retrieval of information regarding a given query entered into a text field and presenting findings as a list of results. Site-specific search system returns results regarding content, resources (blog or wiki entries) or users of a collaborative platform. Contrary to user-defined approach for searching and browsing (e.g. social tagging, social bookmarking), search engines base mostly on platform-defined algorithms.

Studies on search behavior in the Internet show that approximately half of the users are 'search-dominant'. Other studies claim that users rely on the search engine approximately half of the time. Still, although there are many claims about the motivation for a search function or existing search patterns, there is little empirical data for supporting these claims. (Katz and Byrne 2003, p. 199).

4.6.2.5 Identity Management

User's profile

Profile functionality enables users creating their own virtual visit card, a personal website that may include e.g. personal information, their hobbies or skills. User's profile is a set of personal information which can also contain contacts, bookmarks, blog and microblog entries, photos, videos or calendar information allowing users to decide which information they want to share with others. Depending on the type of the platform users create their account at (business, friendship, entertainment), users publish corresponding information at their public profile: on business platforms skills or professional background is published while profiles on friendship platforms mostly contain other information (see also Social Identity Theory, section 2.2.1). The reason for that is e.g. different purpose of a platform or different interest groups and potential users available for establishing contact (Jiang and He 2007, p. 293).

Such personal information can be valuable for direct contacts as a source of updated information (social perspective) or for indirect contacts e.g. from information and knowledge management (Jiang and He 2007), expert search (Shami et al. 2009) or even personal health (Civan-Hartzler et al. 2010) perspective.

Social networking

Social networking functionality enables users to build and verify an online personal social network. Individuals link to others by connecting their user's profiles and becoming 'contacts' or 'friends' in a virtual environment. The reasons for adding vary and may include: real-world acquaintance, virtual acquaintance, courtesy response to a friendship request (Jiang and He 2007, p. 292), but also business interests, activities, political views or other interests can create background to connect (Boyd and Ellison 2007).

Photos management

Photos management functionality enables users uploading and sharing their photos with other users. Users can add a photo description, 'tag' a photo or annotate a photo with a tag of other user.

Profile guests

Profile guests functionality enables users to track information about users that visited their profile.

4.6.2.6 Other

Video service

Video service enables uploading and sharing of a video content with other platform users.

Applications, widgets

Applications enable extending platform functionality through programs basing on the platform's API.

Maps, places

Map functionality is a geo-location tool for creating map-based information about places or routes.

Table 25 presents overview of functionalities available in the analyzed collaborative platforms.

Table 25. Collaborative platforms - functionalities

	BSCW	SharePoint	Adobe Connect Pro	Live Meeting	Facebook	Myspace	Xing	YouTube	Delicious
message system/email		x			x	x	x	x	x
bulletin board						x			
forum/discussion board	x	x			x	x	x		
blog	x	x				x			
microblog					x	x		x	
chat			x	x	x				
audio conference			x	x					
video conference			x	x					
whiteboard			x	x					
application sharing			x	x					
voting system			x	x					
calendar	x	x	x		x	x	x		
wiki		x							
document management	x	x							
task management	x	x							
group management	x	x	x						
photos management					x	x			
user's profile	x	x			x	x	x	x	x
social networking		x			x	x	x	x	x
social tagging	x								x
social bookmarking									x
social rating					x	x		x	
social sharing/recommending					x	x		x	x
recommender system								x	
profile guests						x	x		
notifications	x	x	x		x	x	x	x	
applications/widgets					x	x	x		
video service					x	x		x	
map/places								x	
comments					x	x		x	
search	x	x	x		x	x	x	x	x

Source: Own elaboration

4.7 Challenges of Designing Collaborative Systems

The previous sections described platforms for supporting collaborative interactions in spatially distributed groups and presented a wide palette of tools for supporting communication, coordination or e.g. information management. Discussion about the most important design

problems and challenges emerging from such issues as variety of available tools or lack of sufficient knowledge is related to both technical as human aspects of collaboration.

Collaborative systems support groups of individuals in their collaborative work and the field of Computer Supported Cooperative Work emphasizes the importance of two core aspects: technological and human factors for their design. The main conclusions from the analysis of collaborative systems allow for discussing design challenges that refer to:

- Difficult process of eliciting requirements of collaborative systems: since there are so many groups and so many non-intuitive aspects that need to be considered (Koch and Gross 2006)
- Domain of functionalities for supporting group interactions offers a wide range of tools, often available as separate applications, therefore individuals often are overstrained in the process of making appropriate decision as to which medium to choose for the activity (media choice problem)
- Collaboration activities are complex and distributed groups rely on different tools performing different actions, often simultaneously, but also sequentially (multiple media use)
- Effects of collaborative systems cannot be measured in one experiment or in laboratory settings, since they involve complex social aspects requiring long-term observations (Gale 1990)

Technical-oriented discussion has often been unfruitful, (Koch and Gross 2006) which puts demand on considering human factors in designing collaborative systems and underlines importance of social aspects in the whole process. Systems for supporting collaboration – because of their complexity and human-centricity – are complex socio-technical systems, where both human and technical factors are important.

Human factors relate both to generic aspects of collaboration and to the fit of collaboration needs to technical tools for supporting group interactions. Extensive analysis of social aspects in group interactions and their importance for collaboration in virtual settings has been discussed in Chapter 2 and 3. In the following section, challenges that emerge from the collaboration-technology fit will be discussed.

4.7.1 Media Choice Problem

Problems related to the process of media choice address the question of how individuals choose a suitable medium for effective accomplishing of their individual and collaborative work. Theories introduced in section 4.4 contribute to a better understanding of this decision process

and try to predict media choice. However, results of studies do not always deliver consistent evidence to confirm the appropriateness of these theories (King and Xia 1997, p. 880). Experiments showed that e.g. in organizational settings high-level managers tend to use leaner media more often than lever-level managers and generally email communication is used even for interactions theoretically requiring higher levels of social presence (King and Xia 1997, p. 880). These discrepancies between theories and experimental findings suggest that it is a difficult task to explain or predict patterns of media choice basing on only one criterion, e.g. social presence or media richness.

Theorists assume that users are aware of the intrinsic properties of media, are able to objectively estimate capabilities of media and rationally choose media fitting task requirements. Social influence model of technology use argues with these assumptions and suggests additional variables determining media choice: social context and user experience with the medium (King and Xia 1997, p. 881). A study on users' experience with the medium showed that the individuals' choice of media does not necessarily base on rationally evaluated task-media fit, but is significantly correlated with individual experience with the media. As experience grows individuals tend to change their attitude towards media and change their choice accordingly and use media perceived as more effective (King and Xia 1997, p. 881).

Media synchronicity theory (see section 4.4.6), extending approaches of social presence and media richness theory seems to deliver a more suitable model considering elements omitted in previous research in order to deliver model of predicable media choice according to a task. Although this theory provides additional insights into the process of media choice, a number of variables and potential sub-processes of conveyance and convergence processes may cause difficulties in the application and operationalization of the theory for an individual user.

Studies and experiments conducted for testing theories and evaluating the process of media choice have been focusing on task-media fit and analyzing how the need for 'rich' communication can be fulfilled by media and their capacity of communicating social cues. However, laboratory settings and one-time experiments cannot explain other important aspects of collaboration discussed in section 3.3: individual and group maintenance. Since collaboration process not only relies on effective fit of task and medium, but also puts requirements on social aspects of interaction over time, it seems that these aspects need to be taken into consideration when analyzing the process of media choice.

4.7.2 Multiple Media Use

Researchers have been trying to analyze the potential effects of the available functionalities on collaboration in studies and derive effective collaboration and communication patterns for media used. Although some research considers some examples of predefined environments consisting of two (Scholl 2006) or three media (Stahl et al. 2007), studies have been mostly considering usage of only one medium (e.g. Dillenbourg 2005).

However, it has been shown that group interactions involve multiple media for collaboration purposes in virtual collaborative environments. Boczkowski and Orlikowski (2004, p. 262) noted that researchers, even though they were aware of co-presence of other media for interactions, did not consider effects of diverse combinations of technological, personal and contextual factors in their analyses. Therefore, the results of their studies describe isolated potential effects of a different single media and ignore the importance of multiple media usage: both sequential and concurrent. Although recently there has been more research documenting multiple media usage (Woerner et al. 2004, Munkejord 2007), still little is known about multiple media use patterns and practices.

Especially in distributed settings people tend to work and interact using multiple media. Additionally, opportunities for using multiple media are increasing since media that can be used concurrently are available (Woerner et al. 2004). Woerner et al. (2005) found that specifically because of the complexity of collaboration and diversity of communication and work practices, collaborative environments offering multiple tools created the opportunity for collaboration partners to engage in a multiplicity of individual and concurrent conversations. Their studies on usage of multiple media in distributed settings of real groups confirmed that communication patterns involve diverse communication tools. The findings show that individuals often choose different media for similar communications, substitute various media for face-to-face communication and engage in polychromic communication using both single and multiple media (Woerner et al. 2004).

Woerner et al. (2004) proposed the media toolbox concept for purposes of describing multiple media in group interactions and explaining which media will be used depending on communication needs. Their concept bases on 'media ecology' approach and requires designing media ecologies as cost effective solutions for communication (medium as an alternative for a face-to-face interaction). Since work tasks are often unpredictable and uncontrollable, this approach has been found difficult and time-consuming (Munkejord 2007, p. 112).

Instead, Munkejord (2007, p. 112), after conducting a long-term real-group research, proposed three sets of conditions for usage of multiple media:

- Access dependent: individuals decide which medium to use considering the availability of the medium for collaboration partner
- Perceived urgency: task urgency may vary between non-urgent to full-scale crisis; individuals choose medium according to the perceived urgency of the task
- Task complexity: individuals may need to choose multiple media working simultaneously on one or many different tasks.

These conditions allow for less complex evaluation, however social aspects of collaboration over time in application of multiple media are not considered.

4.7.3 Quality of Studies on Media Usage

The literature provides a broad range of media usage analysis concerning different aspects of choice of a single medium, e.g. chat (Dillenbourg 2005), video conference (Vertegaal and Ding 2002) or blog (Jones and Alony 2008). The aspects of how individuals make choice between two different media is described e.g. in Scholl et al. (2006). Attempts to explain patterns of medium choice for effective communication have been presented e.g. in media richness theory (Daft and Lengel 1984) or in media ecology approach (Nardi and Whittaker 2002). Different critical concerns have been raised to indicate deficiencies in the presented approaches.

Firstly, the process of media choice is not as simple as deciding between either face-to-face or other medium, especially in spatially distributed collaboration. This choice does not necessarily exclude potential usage of other media (Woerner et al. 2005).

Secondly, the decision as to which functionality to use not necessarily needs to be always based on the assumption that face-to-face interaction is the most effective way of information exchange (Dennis et al. 2008).

Thirdly, performance evaluation of media or effects of collaborative tools cannot be unambiguously explained in one experiment or in laboratory settings. Measuring the effects of just one medium is in itself a complex task (Gale 1990).

Last, but not least, the need for measuring effects of multiple media usage over a long time span has been signalized (Mark et al. 1999; Scott 1999). Since group structure and collaboration requirements constantly change, such complex analysis may require weeks, months or even years (Gale 1990).

4.8 Summary

Spatially distributed collaborative groups have to face not only challenges that are related to the generic collaboration issues, but especially those that emerge from bringing interactions to the virtual field of computer-mediated environment. This chapter summarized the theoretical and conceptual aspects of collaboration in virtual settings: research and theories related to the fields of computer-mediated communication and computer supported cooperative work providing insight and creating background for understanding the important factors of systems for supporting collaborative interactions. It has been shown that virtual groups are in fact 'real' groups, however mediated communication may e.g. hinder development of social closeness and impacts other aspects of social interactions.

Furthermore, two core approaches to designing collaborative systems have been presented: 'top down' for groupware and 'bottom up' for social software. Although nowadays there is a tendency to integrate social software tools into organizational settings and groupware systems seem to evolve towards user-centric design. Moreover, the main differences between the two approaches were underlined. Examples of groupware, web-conferencing systems and social networking platforms were analyzed in order to create a detailed list of functionalities for supporting group collaboration.

Finally, the challenges for designing systems for supporting collaborative work have been discussed. The importance of long-term research for measuring effects of collaborative systems has been underlined and important aspects of the technology fit have been introduced.

5 Conceptual Framework for Designing Collaborative Working Environments

The previous sections shaped the background of the problem complexity related to different aspects of collaboration and its technical support for spatially distributed groups as well as discussed its most important social and technical factors. Virtual collaboration, although basing on technical tools, still needs to be considered as a human process, where technology is basically a mediating tool, and where not only tasks, but especially social processes that emerge need to be taken into consideration and adequately supported. The focus of the discussed subjects referred to the importance of social processes in collaborative groups and to their potential support with functionalities available in collaborative systems.

Collaborative Working Environments (or Collaborative Environments) are collaborative systems that "allow two or more participants to communicate, coordinate and collaborate to accomplish a shared objective" and consist of a combination of existing technologies, like email, chat, whiteboard or video conference (Fontaine et al. 2004). Research on Collaborative Working Environments focuses on improving and developing technologies for purposes of collaboration in groups of e-professionals to provide better communication possibilities and faster access to information. Since collaboration processes are human-centered, the challenges for designing Collaborative Working Environments relate to problems of integration of existing technology in respect of user-centric orientation of collaboration (European Communities 2006, p. 25).

5.1 Group Needs-Oriented Designing Approach

This research proposes a design approach that focuses on generic groups and social aspects of collaboration. Previous studies, experiments and implementations deliver results showing the particular importance of human-centered orientation of such systems. It is a paradigm shift, as it changes balance in design of collaborative systems and puts more interest on group- and social-centric aspects of collaboration. In contrast to e.g. applicational and organizational approach (Figure 17), group-oriented approach discusses and analyzes group needs for purposes of group-oriented design.

Designing collaborative systems has been described as a complex and difficult process that often led to failure (e.g. Olson and Teasley 1996). This research does not try to deny this statement, but proposes an approach not yet extensively explored and contributes to better understanding of a 'group' part in collaborative systems' design.

Research on the dynamics of geographically dispersed groups has showed that groups working remotely may experience problems leading to the decrease of effectiveness of their work and related to e.g. problems with keeping track on conversation and contact management (Whittaker 1996, Whittaker et al. 2002), information overload (Riggs et al. 1996, p. 280; Rheingold 2000, p. 46), media capabilities (Campbell 2006, p. 88) or media choice (Richter et al. 2006). Further problems result e.g. from social aspects of collaboration in virtual environments: individual's uncertainties in virtual relationships, problems with establishing group cohesion or mutual trust in computer-mediated environments. These may result in e.g. decreased motivation or individual's satisfaction from collaboration (see previous chapters).

'Top down' approach of groupware design has been focusing mainly on supporting group's tasks (Richter et al. 2006), as it emerged from supporting groups working in mixed environments (groups to some extent working both in virtual and collocated settings). This lack of sufficient support for social aspects of collaboration could be balanced with social-oriented elements of social software resulting from its 'bottom up' user-oriented approach.

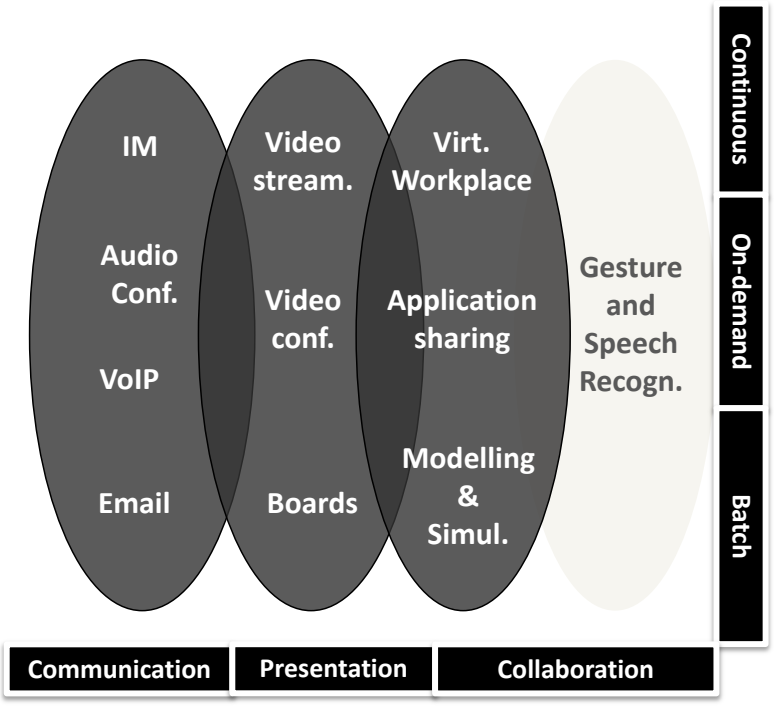


Figure 17. Fit of collaboration technologies into working environments

An analysis of group needs suggests such design of collaborative working environments that takes into consideration all needs that emerge in groups, to not only provide support for tasks, but also users' individual needs, and group maintenance needs, as they influence group

collaboration's performance. There is therefore a need for providing an environment with designed social affordances which fulfill social intentions of a virtual group member (Kirschner and Kreijns 2005). Moreover, because virtual groups with long-term agendas, similarly to face-to-face groups, must take into consideration aspects of developing and maintaining trust and cohesion (Mark et al. 1999), there is a need for supporting these requirements already at the stage of designing collaborative environments.

This combination of both groupware task orientation and social software support for social collaboration aspects creates a functional overview of the proposed environment which can be presented in a similar way as the existing 3C model for groupware classification or social software triangle containing three functional aspects of social software.

The pentagon of collaborative processes (Figure 18) contains the following functional aspects of collaborative working environments:

- Communication
- Cooperation
- Coordination
- Identity and network management
- Information management

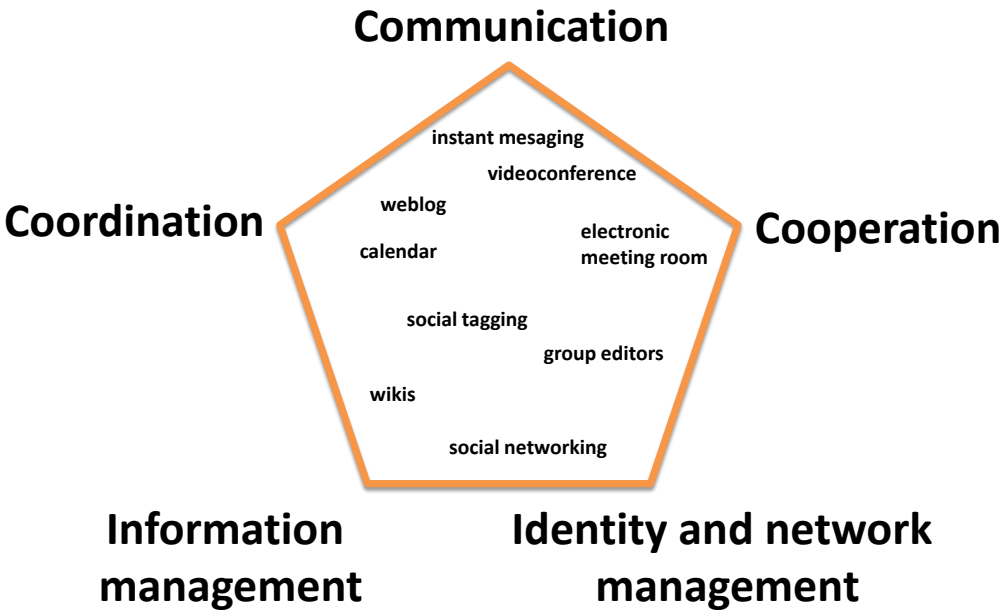


Figure 18. Pentagon of collaborative processes

Functionalities derived from the analysis of collaborative systems can be classified according to their primary function as described in section 4.6.2.

The identified categories contain a multiplicity of functionalities that contribute to certain aspects of functional configuration of collaborative working environment. The previously mentioned problems related to media choice and multiple media usage begs the question of what is the appropriate combination of functionalities that successfully supports a group. The problem of multiple media use has been widely discussed in the literature. The discussion starts at the point of incorporating multimedia into a computer system, which requires more than just attaching a set of random media. The design challenges are related to the question of how to combine various media in order to create an effective and easy to use collaborative environment (Isaacs and Tang 1994, p. 63).

5.2 Idea of the Generator for Collaborative Working Environments

The objective of the generator for Collaborative Working Environments is to provide an appropriate computer-supported environment consisting of appropriate functionalities defined according to group requirements. Depending on group characteristics, the generator suggests a set of functionalities most fitting the purpose of the group.

The idea of the generator for Collaborative Working Environments bases on four pillars: groups, group types, rooms and functionalities connected by relations as presented in Figure 19.

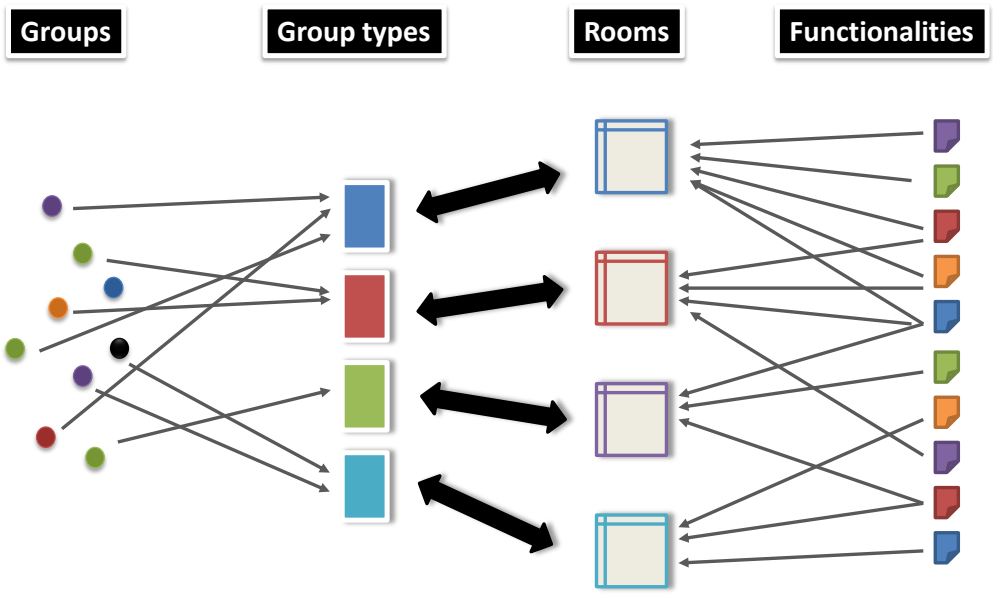


Figure 19. Idea of a generator for collaborative working environment

The generator should be able to create an appropriate virtual environment depending on the requirements of a collaborative group. It should be able to choose suitable functionalities depending on group characteristics. To that end, the following relations need to be defined:

- Groups and group types
- Rooms and functionalities
- Group types and rooms

Groups and Group Types

One of the earliest theories of a social psychology stated that groups are always unique. Every group has its own 'personality' like an individual. Every time a set of two or more individuals can be described as a group, it constitutes a particular social entity. The multiplicity of different groups results in a variety of different aspects to analyze in order to be able to provide an effective support for their collaborative interactions. The complexity of this analysis can be reduced by deriving general categories that define core group characteristics. The research provides tools and models for defining these categories. Such classification attempts have tried to describe common group factors and to categorize groups according to a certain set of criteria. Such set of criteria like e.g. size, purpose, type of membership or lifetime should help defining group types so that every group can be classified as an element of a given type. Being able to characterize a group according to core characteristics enables the reduction of time spent on designing collaborative environment for a group.

Rooms and Functionalities

Technical support for a group (room) is defined as a set of functionalities that effectively supports a group in its collaborative work. Rooms provide a venue for communication, offer tools for collaboration and are inherently persistent (see also Roseman and Greenberg 1996). Functionalities can support different aspects of group interactions, e.g. communication, coordination or information management. There can be different rooms defined consisting of different functionalities, e.g. for supporting real-time communication (video conference), supporting knowledge management (wiki, discussion board and blog) or other aspects of group collaboration.

Group Types and Rooms

Group types are described by core characteristics of a type that provide basis for defining a room with appropriate collaborative tools. Different group types are defined by different characteristics and therefore the required rooms can be derived on the basis of this

configuration. Group types are defined basing on a set of criteria that determines the character of their needs. These requirements provide basis for the room's design. The room should be long-lived and its content should be fully persistent. Further, its requirements should ensure that rooms are accessible from every computer in the Internet network and access should be limited to members authorized to visit the room (Roseman and Greenberg 1996).

5.3 Components of the Generator Framework

The previous sections presented the theories, models, classifications and frameworks influential for designing collaborative systems, e.g.: time-space classification (e.g. as a design framework in Frohlich et al. 2002), 3C model (e.g. as a design framework in Gerosa et al. 2006; Fuks et al. 2005), functional classifications (Koch and Gross 2006), application-level taxonomy (Yen et al. 1999), media richness theory (Daft and Lengel 1984, 1986) or media synchronicity theory (Dennis et al. 1998, 1999, 2008). These models allow for structuring collaborative tools or defining some characteristic of communication media. However, the increasing need for integration of functionalities, their growing multiplicity and complexity, resulting from the need of their combination, demands employment of a practical framework for designing such complex systems, which these models cannot deliver separately (Weiseth 2006, p. 239).

The conceptual approach of models for designing collaborative working environments is anchored in the theory of the socio-technical systems (STS) which discusses the fit between the social and technical subsystem in an organization. The fit is achieved by a design process of Management and Information Systems (MIS) that aims at the joint optimization of the subsystems, as both systems impact each other (Bostrom and Heinen 1997). Figure 20 (based on Bostrom and Heinen 1997, p. 25) presents model components and interaction dependencies.

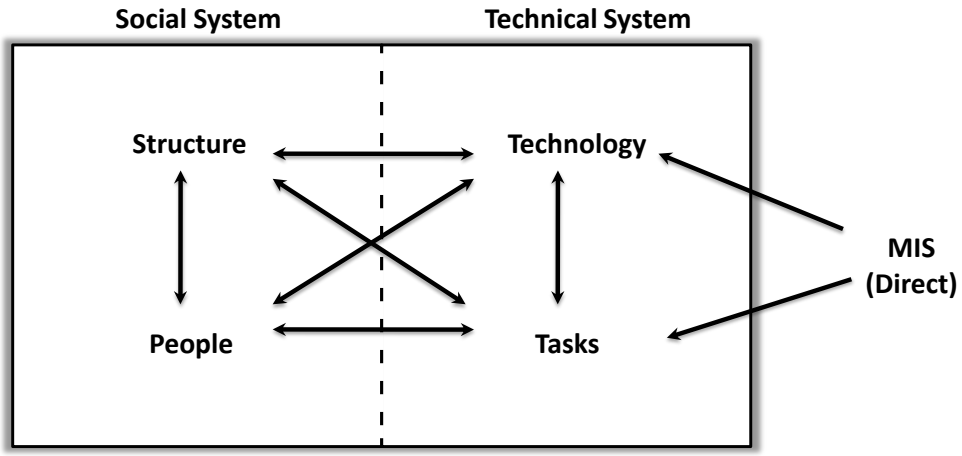


Figure 20. Interacting components of the socio-technical systems theory

The socio-technical model draws intensively on social psychology and small group theory (Adler and Docherty 1998, p. 320). It provides general basis for Computer-Supported Cooperative Work field (Koch 2008) and in its pure form has been a subject e.g. for groupware development (Bikson and Eveland 1996) or community-based collaborative system's design (Cartelli 2007).

Different frameworks have been developed for the purposes of designing collaborative systems and described in e.g. Yankelovich et al. (2004), Baker et al. (2002), Girgensohn and Lee (2002), Tuikka (2002), Gutwin and Greenberg (2000), van der Veer and Welie (2000), Prinz et al. (1998), Hiltz et al. (1996), Salvador et al. (1996) or Ellis and Wainer (1994). These models are rather specific and the framework presented in this research utilizes the methods they are based on only to some extent.

The generator framework that has been found suitable for this research is based on the collaboration framework by Weiseth et al. (2006, p. 241) and extended by characteristics of a group in a collaborative environment defined by McGrath et al. (1993, p. 407). It comprises the aforementioned aspects of designing collaborative working environment. The framework (Figure 21) illustrates the patterns of the 'fit' between a group (entity) and technology. The 'fit' characteristics is mediated through collaboration needs part of the framework.

This model consists of the following elements:

- Collaboration environment (group composition and structure)
- Collaboration needs (generic group requirements and their structure)
- Collaboration support (technology)

Figure 21. Generator framework

This framework allows for modeling of the proper 'fit' between its components. Elements of the model influence each other. In a static case, collaboration needs-support fit describes the extent

to which technology can meet individual, task and social group needs. These relations may possibly vary over time and this dynamics adds more complexity to the dependencies' structure (see e.g. McGrath et al. 1993, p. 407), but it will not be elaborated in more detail in this research.

The 'fit' relation between group composition and collaboration needs has been defined in Chapter 3. The 'fit' relation between collaboration needs and collaboration support parts of the framework will be defined according to the *fit as profile deviation* theory.

'Fit' has been discussed in literature from different perspectives, i.e. fit as moderation, fit as mediation, fit as matching, fit as gestalts, fit as profile deviation or fit as covariation (Venkatraman 1989). In the present thesis, the 'fit' will be discussed from the conceptual perspective of the *profile deviation* approach that defines fit as the degree of adherence to the specified ideal profile. This approach consists of three steps: developing ideal profiles, adding differential weights for the multiple defined dimensions and assessing the power of the test (Venkatraman 1989, p. 435). The first two steps of this approach will be elaborated here in more detail. However, the complexity of the third step will only allow partial analysis and will be based on the expert's evaluation.

5.3.1 Collaboration Environment

Collaboration environment consists of the aspects related to group composition and its structure. It describes the characteristics of a set of individuals and the structure of relation between them. The characteristic of collaboration environment influences pattern of collaboration needs and therefore indirectly determines rules for collaboration support part as well. Collaboration environment defines general settings for collaborative actions and depends on factors determining the purpose of those actions.

The background for this part of the framework is research on groups presented in Chapter 2. The analysis is related to the aspects regarding *criteria for defining collaborative groups* and *collaborative group types*. The identified criteria for defining generic collaborative groups are: goal/purpose, membership, ties, lifetime, size and contributions. The identified types of collaborative groups are: high-activity group, project team, work group, informal network and community of practice.

Every collaborative group type has been described according to the set of criteria. 'Affiliation' of a single group can be determined by an analysis regarding this set of criteria. A single group can be then classified as a group of a determined generic type. In case that a group shows typical characteristics of more than one generic type, such case of a group-mix situation will require additional steps.

5.3.2 Collaboration Needs

Generic group interaction characteristics defined as individual, task and group maintenance needs constitute the central part of a framework. This part describes a set of elements defining patterns of interaction in a collaborative group and related to group well-being, member support and task activities. Collaboration as a common effort in order to achieve the objective involves group needs in terms of processes determining group output. Depending on a type of a group, different needs may have different weights and some needs may be of a greater importance than other. This need characteristic enforces a proper organization of a collaboration support element of a framework. Needs are interrelated and influence collaboration simultaneously.

The background for this part of the framework is the research on needs of collaborative groups presented in Chapter 3. The analysis allowed for defining three main group needs' areas: *needs individuals bring with them into the group, achieving the common task and group maintenance – to be held together as cohesive unities*.

These main need areas contain the following needs important for a collaborative group: need for *belongingness*, need for *achievement, learn and explore*, need for *production and presentation of images and ideas*, need for *discussion and evaluation of issues*, need for *problem solving and carrying out some plan of action*, need for *cohesiveness*, need for *creating group identity*, need for *group motivation* and need for *trust*.

5.3.3 Collaboration Support

The technical part of a framework that defines a set of tools, rules, procedures and resources for supporting collaboration needs is described as collaboration support. The analysis of selected collaborative platforms enabled creating a list of tools for supporting collaboration. Theories and models in Chapter 4 explain the main properties of collaborative tools, their influence and potential effects on core aspects of communication and collaboration in groups.

The framework of the generator defines areas of analysis in which research methods have to be implemented (Table 26). Appropriate research provides background for every part of the framework as well as for intersections. The research methods include:

- Literature research (e.g. criteria for defining collaborative groups or generic group needs)
- Experts interview (e.g. validation of group needs, evaluation of a need-functionality fit)
- Quality Function Deployment (designing collaborative working environment for a given group)

Table 26. Framework structure: areas of analysis

Collaboration Environment	Collaboration Needs	Collaboration Support
Criteria for defining collaborative groups (Chapter 2)		
Types of collaborative groups (Chapter 2)		
	Generic group needs (Chapter 3)	
Evaluation of group needs for a group type (Chapter 3)		
		Analysis of functionalities for supporting collaboration (Chapter 4)
	Theoretical background on need-functionality fit (Chapter 4)	
	Initial evaluation of a need-functionality fit (Chapter 5)	
	Expert evaluation of a need-functionality fit (Chapter 5)	
Generator for Collaborative Working Environments (Chapter 6)		

5.4 Initial Analysis of the Generator Framework

Generator framework defines two 'fit' dependencies: relations between collaboration environment and needs and between collaboration needs and support. Dependencies between each of the framework parts are indicated by arrows (Figure 21, page 111).

First relation (environment-needs) requires an analysis of the relation between group types defined in collaboration environment part and generic group needs described in collaboration needs part of the framework. Its evaluation should answer the question of the importance of the need for a given group type. Chapter 3 provides a background for evaluation and presents analysis of this dependency. A summary of the analyzed dependencies is presented in Table 14 (page 49).

The second relation determines the dependencies between collaboration needs and collaboration support part of the framework. This evaluation should answer the question of how technology can provide support for fulfilling needs of collaborative groups. The answer provides basis for defining the 'fit' between technology and needs (individual, task and social) that are related to group performance.

The initial analysis is based on theoretical aspects of computer-supported collaboration presented in Chapter 4 and illustrates the fact of fit between analyzed functionalities and defined needs of collaborative groups. This analysis should provide basic information if a relation between a given need and functionality can be potentially defined. Initial analysis of the generator should answer the question of the potential fulfillment of the needs by analyzed functionalities.

The task needs defined in Chapter 3 include: need for production and presentation of images and ideas, need for discussion and evaluation of issues, need for problem solving and carrying out some plan of action. However, for the purpose of the analysis, need for discussion has been divided into two parts: synchronous and asynchronous to distinguish the potential of real-time communication from communication which does not require simultaneous interaction. The base for this distinction is the time-space topology. This distinction enables better structuring of communication tools for purposes of group collaboration.

The results of the initial analysis are presented in Table 27 and define the fact of the existence of a 'fit' relation between functionality and a need. A marker informs that a given tool is considered as being able to fulfill a need defined in a row.

Table 27. Initial analysis of relationships between needs and functionalities

	private message/email	bulletin board/newsletter/notes	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference	whiteboard	application sharing	voting system	calendar	wiki	document management	task management	workflow management	content management	group management	photos management	videos	applications/widgets	map/places	user's profile	social networking	social tagging	social bookmarking	social rating	social sharing	profile viewers	recommender system	notifications	comments	web feed	search
Individual Needs																																		
Learning	x	x	x	x	x	x	x	x					x	x						x				x	x	x		x		x	x		x	x
Belonging	x		x	x	x	x													x		x	x		x				x			x	x		x
Task Needs																																		
Production	x	x	x	x	x				x	x			x	x			x											x		x				x
Discussion (asynchr.)	x		x	x		x					x		x	x																	x	x		
Discussion (synchr.)						x	x	x	x	x	x																							
Problem solving	x		x			x					x	x	x		x	x					x										x	x		x
Group Maintenance Needs																																		
Motivation			x																					x			x	x						
Trust	x		x					x															x	x			x	x	x			x		
Cohesion			x			x	x	x				x						x					x	x		x		x			x			
Identification		x	x	x	x								x					x						x		x		x			x			

Source: Own elaboration

The results of the initial analysis presented in Table 27 allow to state that there are collaborative tools able to support needs of a collaborative group. A relation has been found that allows to state, which of the identified functionalities are potentially able to support group collaboration in terms of their ability to meet individual, task and group maintenance needs. The perceived potential ability shows that one can identify functionalities that are able to meet more than one need (e.g. discussion board, social networking) as well as specific functionalities which are potentially able to meet a smaller range of needs (e.g. social tagging). However, this analysis only provides information about the potential fulfillment of a given need by functionality, but does not inform about the strength of this relation, nor if it is satisfactory with respect to fulfilling the need. Therefore, the second analysis of these relations is needed and will be based on expert's evaluation of the relations' strength.

The second conclusion derived from the initial analysis allows to state that analyzed functionalities of collaborative systems actually can be perceived as useful for collaborative groups from the perspective of their needs. There exists no functionality that has no potential relation to any of the needs. There exists a set of functionalities potentially able to meet collaborative task needs, needs of an individual as well as group maintenance needs emerging in collaboration.

5.5 Summary

Increasing integration of functionalities in collaborative systems puts demands on tools that are able to model the socio-technical dependencies of collaboration and are able to provide a general framework for modeling both technical as well as social- and human-centric aspects of collaboration. The existing approaches do not provide such general view and there exists a need for such model (Richter et al. 2006).

This chapter introduced the idea of a generator for collaborative working environments and presented the framework for designing collaborative environments consisting of three elements: collaboration environment, collaboration needs and collaboration support. Framework elements have been described and dependencies between the parts have been analyzed.

Initial analysis of the dependencies between framework elements has been introduced and enabled defining relations between groups, group types and their collaborative needs. Initial analysis of the dependencies between collaborative needs and support allowed for stating that there exist potential patterns of the fit between group needs and functionalities of collaborative systems. This will be a subject to further deliberation.

6 Validation, Evaluation and Implementation of the Concept

The idea of the generator and its framework summarized in Chapter 5 provides a theoretical basis for designing collaborative working environments which bases on extensive literature research. Different theoretical and experimental analysis from areas of groups, group needs and collaborative systems enabled to structure and interconnect framework elements. The analysis of group types and group needs served as a background for evaluation of group needs while theories in computer-supported collaboration and evaluation of functionalities of collaborative systems delivered input on the subject of technological support for potential collaboration needs.

However, theoretical group needs approach to designing collaborative working environment still requires both validation of the suggested needs-oriented design, as well as the evaluation of the fit between collaborative group needs and technical support for them. This 'fit' will provide a basis for creating an operational collaborative working environment for a group. For the purpose of these tasks, a Quality Function Deployment approach will be used.

6.1 Quality Function Deployment Method for Evaluation of the Generator Framework

The complexity of designing collaborative working environment results from the multiple areas that need to be taken into consideration during the design process. A collaborative environment as a socio-technical system consists of multiple interrelated variables and the complexity of correlations results in a need for an evaluation tool that can model defined relations. Quality Function Deployment (QFD) approach provides tools suitable for such evaluation. It has been developed in the late 1960s in Japan and successfully implemented as a design tool in many organizations and industries (Chan and Wu 2002).

6.1.1 Quality Function Deployment and the House of Quality

Quality Function Deployment is defined as a general concept that enables translation of customer requirements into the appropriate technical requirements for each stage of product development and production (Chan and Wu 2002, pp. 463) and has been implemented for development in multiple areas, primarily in e.g. product development, quality management or customer needs analysis and later in e.g. design, planning, decision-making, engineering, management, software process improvement, prototype evaluation, teamwork or costing (Chan and Wu 2002, pp. 467).

Quality Function Deployment reflects the design approach of creating product based on customers' needs: their desires and tastes. The concept of *House of Quality* is a kind of a conceptual map on top of the QFD approach which provides instruments for interfunctional planning and communications (Hauser and Clausing 1998, p. 63).

Quality Function Deployment and its graphical extension – House of Quality – create a methodology to support development process for complex products by linking the planning elements of the design and construction to specific customer needs. Simultaneous development of QFD in different countries and subject areas resulted in slight differences in definition of steps and implementation of Quality Function Deployment. However, the background and main model did not change.

The House of Quality is presented in Figure 22.

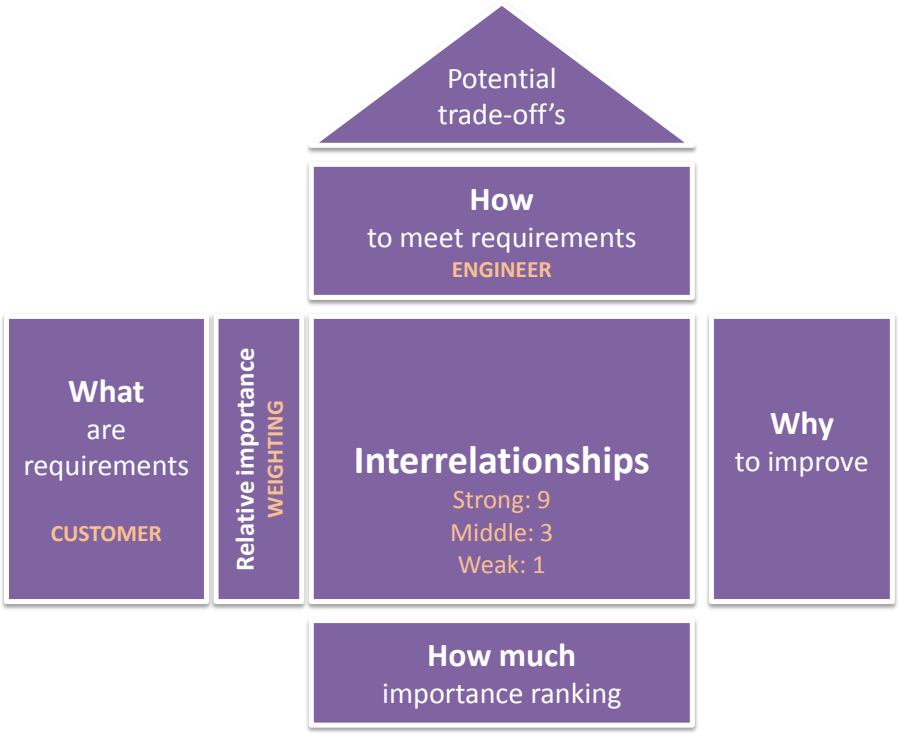


Figure 22. Schematic diagram for House of Quality

Quality Function Deployment method consists of the following main steps (Hauser and Clausing 1988):

- Identification of customer attributes (so called *whats*)
- Identification of the ways of achieving the *whats* – engineering characteristics (so called *hows*)

- Identification of the relative importance of customer attributes
- Definition of relationships between *whats* and *hows*
- Identification of customer evaluation of competitive products
- Identification of objective measures evaluating competitive products

Firstly, the requirements of the customer are identified and the first table of the House of Quality (*what are requirements*) is populated. House of Quality is used also for presentation purposes and therefore customer needs (called also customer attributes – CA's) are often grouped into categories to make reading the matrix easy.

Since requirements are not necessarily equally important, relative importance of customer attributes in House of Quality can be defined. Weightings assigned to customer requirements create the *why to improve* table which defines the relative evaluated importance of given attributes.

The *how to meet requirements* table contains *engineering characteristics* (EC) that may affect one or more of the customer attributes. If any standard engineering characteristic does not affect any customer attribute, it may be redundant to other characteristic or customer attribute is missing. If an engineering attribute does not affect at least one of the customer attributes, the design properties can be potentially expanded. A list of attributes may also contain an indication of how engineers influence customer-perceived qualities – e.g. if the direction of influence is positive or negative (Hauser and Clausing 1998, p. 63).

After defining both *whats* and *hows*, the influence of engineering characteristics on customer attributes can be indicated. A relationship table contains numbers or symbols defining the strength of the relationships. Mostly the strength of relationships is defined as weak (weight: 1), middle (weight: 3) and strong (weight: 9), but depending on agreement, other weights can be used as well (e.g. Herzwurm et al. 2003, Saatweber 2007, p. 181).

The *roof* of the house helps engineers to specify these characteristics that have to be improved simultaneously and informs about potential engineering trade-offs. Depending on a type of a relation defined in the roof part of the house, engineers need to take a decision about trade-offs affecting customer benefits.

Table *why to improve* allows comparing customer's evaluations of competitive products according to the defined customers' attributes.

Bottom table (*how much*) contains objective measures that allow for comparing competitive products and enable benchmarking of competitive products. It also enables creating importance ranking for engineering characteristics.

6.1.2 Expert's Evaluation of the Generator Framework

The Quality Function Deployment is a suitable tool for supporting creation process of collaborative working environment as it supports engineer-oriented design methods for complex problems. Especially its ability to prioritize needs and to specify how to meet requirements makes Quality Function Deployment a proper tool to engage in a design process. Quality Function Deployment approach will be used for different purposes in validation and evaluation of the generator framework processes.

Firstly, the *interrelationships* table will be used for evaluating the strength of the fit between group needs (*whats*) and functionalities (*hows*). The basis for this evaluation will be the data acquired during an expert interview.

Secondly, in connection with the evaluation of group needs presented in Chapter 3 (*relative importance,*) it will be used as a tool for defining an appropriate collaborative working environment for group types derived in previous sections.

Thirdly, *importance ranking* table will enable to evaluate existing collaborative systems and will provide a framework for benchmarking of the selected collaborative platforms in order to rate their ability to support collaborative groups according to the generator framework.

The initial analysis of the fit between group needs and functionalities presented earlier (see Chapter 5) allowed to state that functionalities derived from analysis of collaborative systems are able to support the defined group needs. However, this analysis did not provide information about the strength of the 'fit' relation between group needs and functionalities.

In order to define the strength of the 'fit' relation, experts interviews have been conducted. Four interviews have been carried out in order to validate the framework and to evaluate the strength of the need-functionality interrelationships.

The basis for the selection of experts was their proven theoretical and practical experience in the subject of group collaboration. The interviewed experts are members of the leading German research institutes dealing with aspects of technology for supporting collaborative group work with experience in using, designing and developing collaborative software as well as in social and psychological factors of group collaboration from the Fraunhofer-Institut für Angewandte

Informationstechnik FIT, Rheinisch-Westfälische Technische Hochschule Aachen, University of Siegen and University of Bonn.

The results of the expert interview will be illustrated with House of Quality tables, Pareto cumulative chart and ABC analysis.

The pareto chart is a bar chart displaying prioritized causes of a problem basing on the *80-20 rule* (80% of the effects come from 20% of the causes). The chart shows cumulative percentage of the importance calculated for the causes and visualizes effects of causes ordered according to their importance (Wild 1997, p. 33).

ABC analysis enables classifying causes presented on Pareto cumulative chart into three categories. Class 'A' usually contains items that account for 80% of total value, class 'B': 15% and class 'C': 5%. There are also other recommended class-distribution, e.g. class 'A': 66,6% of total value, 'B': 23,3% and class 'C': 10,1% of total value (Wild 1997, p. 40).

Table 28 (p. 125) presents the results of interviews in a form of a table with an average evaluation of every need-functionality relationship on a basis of expert interview. There are three types of relationship's strength defined:

- * - weak relationship (weight: 1)
- ** - middle relationship (weight: 3)
- *** - strong relationship (weight: 9)

Experts' evaluations have been found analogical to each other, with minor differences in assessment, therefore consistency of the results can be assured. The table illustrating average results can be considered as a representative opinion of the experts on the subject of the need-functionality fit. The answers given by the experts have been also found consistent with initial analysis presented in Table 27 and therefore provided ground for validating initial analysis of functionalities.

The evaluation made by the experts enabled the identification of functionalities that are able to meet the wide range of the analyzed needs. According to the analysis, these functionalities are: forum/discussion board, social rating, social networking and wiki. Table *how much* of a House of Quality presents the importance ranking for the evaluated functionalities in the form of a bar chart (Table 28). The pareto cumulative chart (Figure 23) presents a list of functionalities sorted according to importance as perceived by experts.

ABC analysis enables classifying functionalities presented on the Pareto cumulative chart into three categories according to their contribution to fulfilling group needs. Category 'A' contains

the most important functionalities, while functionalities of categories 'B' and 'C' are perceived as less valuable.

The results of experts' evaluation of the functionality-need relation allow for drawing the following conclusions:

- Collaborative group needs cannot be met by a single tool or a pair of functionalities, but require a combination of tools to effectively fulfill all the aspects of group needs
- There are functionalities that are able to meet a broad range of group needs (e.g. discussion board) as well as functionalities with very limited potential support for collaborative needs (e.g. web feed)
- The most valuable tools for meeting group needs (class 'A' in the ABC analysis) are those which originate from social software and groupware systems; however, they possibly meet different group needs
- Functionalities originating from social software are found valuable not only for meeting social needs, but are also perceived as able to support task needs (e.g. blog, microblog, social bookmarking)
- The social networking functionality is not only perceived as a tool for connecting with friends, but also as a tool helpful in generating trust as well as a tool valuable for learning needs: e.g. finding experts or professionals
- The social rating functionality is perceived as a tool for generating trust – social evaluation helps e.g. identifying valuable content – but also Is a tool stimulating motivation: individuals publish more valuable content because they want to be ranked higher
- The wiki functionality is not only perceived as a tool that is valuable for learning needs, but also as fulfilling potential production and problem solving (coordination) needs, as it allows quick collaborative generating of content
- The microblog functionality has been found valuable for different group needs; although it is a new tool it already is acknowledged as valuable in supporting e.g. learning needs

The implications of this evaluation suggest that meeting collaborative group needs can take place if a proper combination of functionalities originating both from groupware and social software is proposed. Therefore, in the next step a set of functionalities appropriate for introduced generic group types will be generated according to the weighted relative importance of group needs.

6.2 Results of the Quality Function Deployment Analysis

The relationships table filled with experts' evaluations defines the fit between *whats* and *hows* in a Quality Function Deployment approach and provides a basis for the application of the House of Quality for defining a set of functionalities according to group needs (Table 28).

Table 14 (page 49) contains the needs structure for generic group types and includes weighting and relative importance of group needs for every generic group type. Both tables combined create the essence of Quality Function Deployment approach and allow for structuring the importance of engineering characteristics and customer attributes for every generic group type (Table 29).

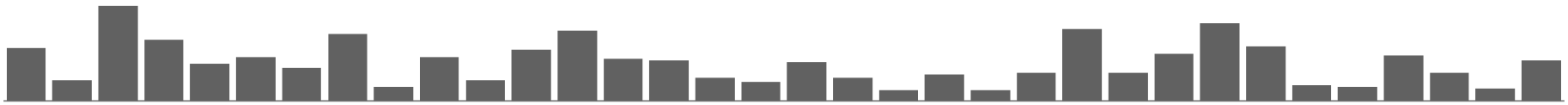
The table containing relative importance of group needs for generic group types enables generating a specific set of functionalities for every group type according to need's weighting. Therefore, a set of the most valuable functionalities can be derived for every generic group type. For this purpose, a scalar product of the needs' weight and potential fulfillment of the need by functionality is calculated. Importance is based on the following weights:

- * - weak relationship (weight: 1)
- ** - middle relationship (weight: 3)
- *** - strong relationship (weight: 9)

For every generic group type functionalities can be ranked according to their calculated importance and classified according to ABC analysis. Class 'A' includes the most important functionalities, while classes 'B' and 'C' contain functionalities with low influence on group needs fulfillment.

Table 28. Expert evaluation: QFD relationships table and importance ranking

	private message/email	bulletin board/newsletter/notes	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference	whiteboard	application sharing	voting system	calendar	wiki	document management	task management	workflow management	content management	group management	photos management	videos	applications/widgets	map/places	user's profile	social networking	social tagging	social bookmarking	social rating	social sharing	profile viewers	recommender system	notifications	comments	web feed	search
Individual Needs																																		
Learning	**	*	**	***	**	**	**	**		*			***	**	*	*	*	*		*	*		*	**	**	***	*	**	*	*	*	*	*	**
Belonging	*	*	*	*	*	*				*		**	*	*		*		*	**	*	**	*	*	***	*	*	*	**	*	*	**	*		*
Task Needs																																		
Production	*	**	**	**	**	*	*	*	**	***			**	**	*	*	**	*	*	*	*			*	*	*		**		*	*	*		**
Discussion (asynchr.)	***		***	**	*	*					*		*	*		*	*	*								*	*	*			*	*	*	*
Discussion (synchr.)						**	**	***	*	*	*					*		*																
Problem solving	*		*	*	*	**	*	*			**	***	**	*	***	**		*		*	**	*			*	*		*	*		**	*	*	**
Group Maintenance Needs																																		
Motivation	*		**	*	*	*	*						*			*		*	*					*	*	*	***	**		*	*	*		
Trust	*		**	*	*	*	*	**					*	*				*	*			*	**	**			***	**	*	*	*	*		*
Cohesion		*	**	*	*	*	*	**		*	*	**	*	*	*			**	*		*		**	**	*	*	*	*			*	*		
Identification		**	**	**	**	*	*	*		*	*	*	**	*	*		*	**	*			*	*	*	*	**	*	*	*	*	*	*	*	



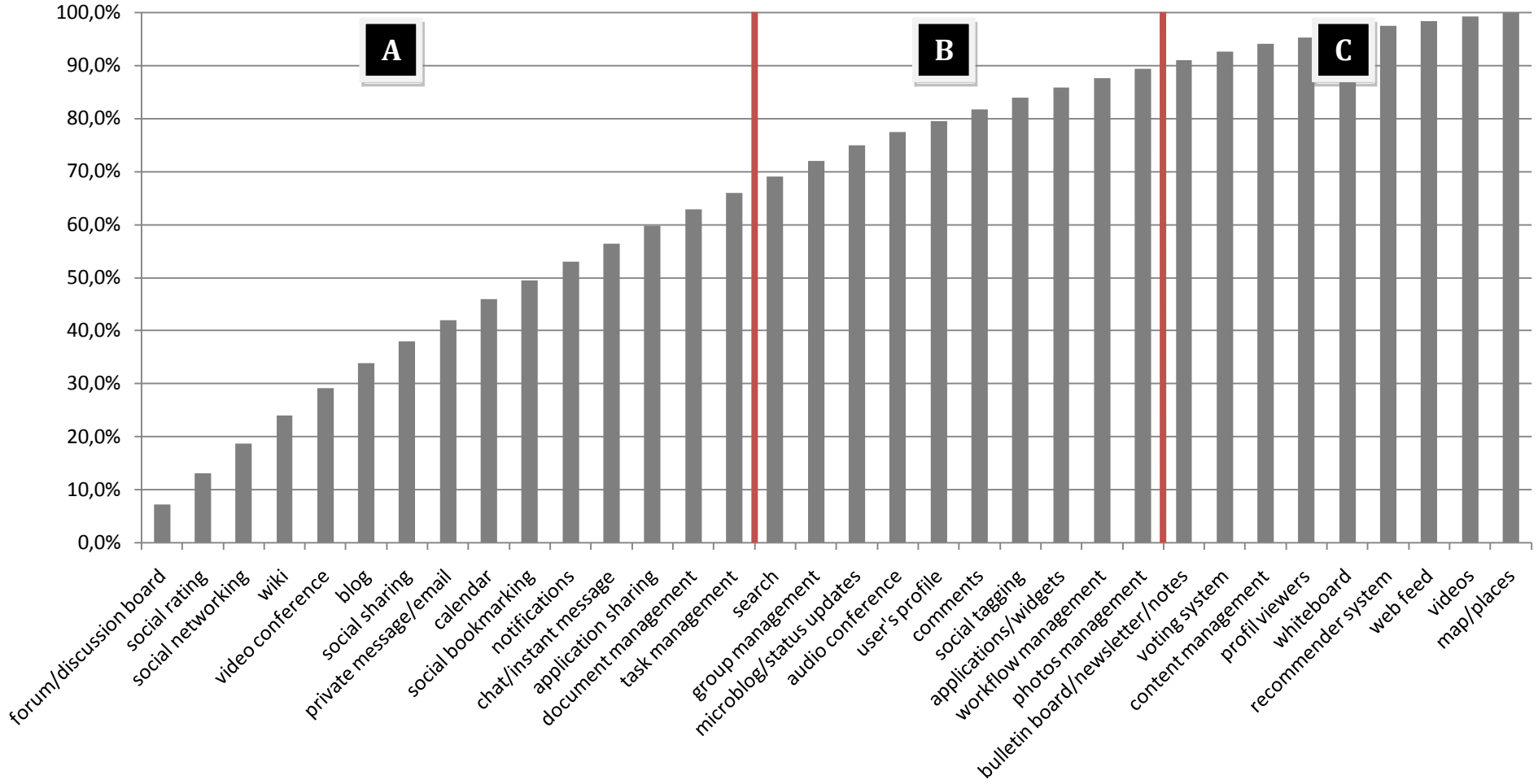
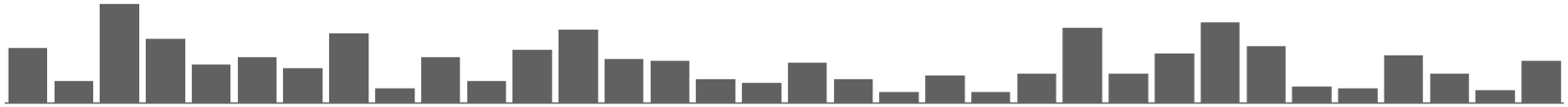


Figure 23. Pareto cumulative chart for analysis of functionalities

Table 29. Quality Function Deployment – interrelationships and weighting tables

	HIGH-ACTIVITY TEAM	PROJECT TEAM	WORK GROUP	INFORMAL NETWORK	COMMUNITY OF PRACTICE	private message/email	bulletin board/newsletter	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference	whiteboard	application sharing	voting system	calendar	wiki	document management	task management	workflow management	content management	group management	photos management	videos	applications/widgets	map/places	user's profile	social networking	social tagging	social bookmarking	social rating	social sharing	profile viewers	recommender system	notifications	comments	web feed	search
Individual Needs																																							
Learning	**	**	*	*	***	**	*	**	***	**	**	**	**		*			***	**	*	*	*	*		*	*		*	**	**	***	*	**	*	*	*	*	*	**
Belonging	*	**	*	***	**	*	*	*	*	*	*				*		**	*	*		*		*	**	*	**	*	*	***	*	*	*	**	*	*	**	*		*
Task Needs																																							
Production	**	***	***	*	**	*	**	**	**	**	*	*	*	**	***			**	**	*	*	**	*	**	*	*			*	*	*		**		*	*	*		**
Discussion (asynchr.)	*	**	**	**	***	***		***	**	*	*					*		*	*		*	*	*								*	*	*			*	*	*	*
Discussion (synchr.)	***	**	*	**	*						**	**	***	*	*	*					*		*																
Problem solving	**	***	**	*	*	*		*	*	*	**	*	*			**	***	**	*	***	**		*		*	**	*			*	*		*	*		**	*	*	**
Group Maintenance Needs																																							
Motivation	*	**	**	*	***	*		**	*	*	*	*						*			*		*	*					*	*	*	***	**		*	*	*		
Trust	**	***	*	***	**	*		**	*	*	*	*	**					*	*				*	*			*	**	**			***	**	*	*	*	*		*
Cohesion	**	**	*	***	**		*	**	*	*	*	*	**		*	*	**	*	*	*			**	*		*		**	**	*	*	*	*			*	*		
Identification	**	**	*	**	**		**	**	**	**	*	*	*		*	*	*	**	*	*		*	**	*			*	*	*	*	**	*	*	*	*	*	*	*	



A ranked set of functionalities was generated for every generic group type (Table 30).

Table 30. Generator results for generic group types

	HIGH-ACTIVITY TEAM	PROJECT TEAM	WORK GROUP	INFORMAL NETWORK	COMMUNITY OF PRACTICE
private message/email	**	***	***	**	***
bulletin board	*	*	**	**	**
forum/discussion board	***	***	***	***	***
blog	***	***	***	***	***
microblog	**	**	***	**	**
chat	***	***	**	***	**
audio conference	***	**	**	**	**
video conference	***	***	**	***	**
whiteboard	**	*	**	*	*
application sharing	***	***	***	*	**
voting system	**	**	*	*	*
calendar	***	***	***	***	**
wiki	***	***	***	***	***
document management	***	***	***	**	***
task management	***	***	***	*	*
workflow management	**	**	**	*	*
content management	*	**	***	*	**
group management	**	**	**	***	**
photos management	*	*	*	**	*
user's profile	**	**	*	***	**
social networking	***	***	***	***	***
social tagging	**	**	*	**	**
social bookmarking	***	**	**	***	***
social rating	***	***	***	***	***
social sharing	***	***	***	***	***
recommender system	*	*	*	*	*
profile guests	*	*	*	**	*
notifications	**	***	**	***	***
applications/widgets	*	**	**	**	*
video service	*	*	*	*	*
map/places	*	*	*	*	*
web feed	*	*	*	*	*
comments	**	**	**	**	**
search	**	***	***	**	***

Class 'A': * | Class 'B': ** | Class 'C': ***

The results of the analysis are presented as a class-ranking of functionalities for every group type. Functionalities marked with '***' fall under the 'A' class, the ones with '**' fall under 'B' class while those marked with '*' fall under 'C' class in the ABC analysis.

Detailed results of the analysis for every group type are presented in Appendix as a Pareto cumulative chart with ABC analysis:

- Type: 'High-Activity Team': Figure 37
- Type: 'Project Team': Figure 38
- Type: 'Work Group': Figure 39
- Type: 'Informal Network': Figure 40
- Type: 'Community of Practice': Figure 41

Basing on the analysis, the following conclusions can be drawn:

- Meeting the needs of collaborative groups requires a combination of multiple functionalities
- Functionalities that are able to meet a broad range of group needs are also present as having strong relations in all five generic group types
- Functionalities with specific and limited potential to meet group needs and therefore having weak relationships in all five generic group types
- There can be a limited set of functionalities which can meet most group needs for every group type identified
- The fulfillment of group needs for every group type relies on the adoption of multiple functionalities, no specific functionality exists that would be able to meet the majority of group needs for a given group type
- Synchronous communication tools (video-, audio-conference, application sharing, chat) play a greater role in meeting the needs of the 'High-Activity Team' group type than for other group types
- Tools supporting coordination and contributing to the quality of the delivered resources (social rating, calendar, task management) play a greater role in meeting the needs of the 'Project Team' group type than in other group types
- Tools for social interactions (social networking, social rating, social sharing) contribute mostly to the 'Informal Network' group type rather than to the other group types
- Support for 'Community of Practice' group type can be provided mainly by tools for generating, exchanging and storing ideas (discussion board, wiki, social rating)

- Six tools have been identified that provide basis for every generic group type (class 'A'): discussion board, blog, wiki, social networking, social rating and social sharing

6.3 Implementation of the Collaborative Platform for Project Team – First-Stage Prototype

The results of the analysis of the generator framework provided basis for definition of functionalities for collaborative working environment supporting specified group types. On the basis of this analysis, the First-Stage Prototype (FSP) has been developed for the 'Project Team' group type. This First-Stage Prototype provided a test environment for the evaluation of the implemented collaborative working environment. The first-Stage Prototype is a web-based application for supporting group collaboration.

6.3.1 Architecture of the First-Stage Prototype

The First-Stage Prototype's system architecture is based on the Model-View-Controller (Figure 24, adapted from Fowler 2003, p. 330) software development paradigm which allows for separation of three independent layers for purposes of structured application modeling in object-oriented programming. This division allows for logical separation of the following parts of an application (Krasner and Pope 1998, p. 26):

- The part responsible for the representation of the model of application domain from
- The way it is displayed to the user, and
- The way user interacts with the model

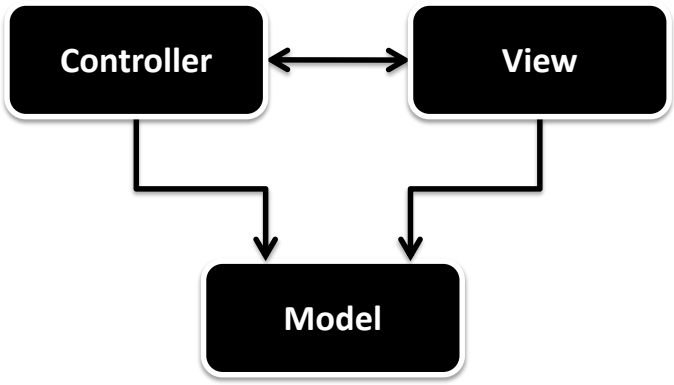


Figure 24. Model-View-Controller interaction scheme

The *Model* part in this paradigm is responsible for components representing information about the domain and, as a non-visual object, contains all the data and behavior different than these

created for purposes of user interface and presentation. The *View* is only responsible for displaying the model through the user interface. The *Controller* is responsible for any changes of information, and depending on the user's input, it manipulates the model and transfers results to the view part responsible for the presentation of results (Fowler 2003, p. 330).

The Model-View-Controller pattern enables separating the data part of the model from the user interface. This has its advantages in development and maintenance of web-applications, since e.g.: visual elements of an application can be independently changed without the necessity of changing data structures and business logic. The application can easily support e.g. multiple languages, as multiple user interfaces can be easily maintained (Leff and Rayfield 2001, p. 118).

In Web-application settings controller is responsible for handling the request sent to a Web server. Then the model performs the domain logic and the view creates a response based on the model displaying the appropriate results. Figure 25 (based on Fowler 2003, p. 57) presents a UML sequence diagram modeling these dependencies.

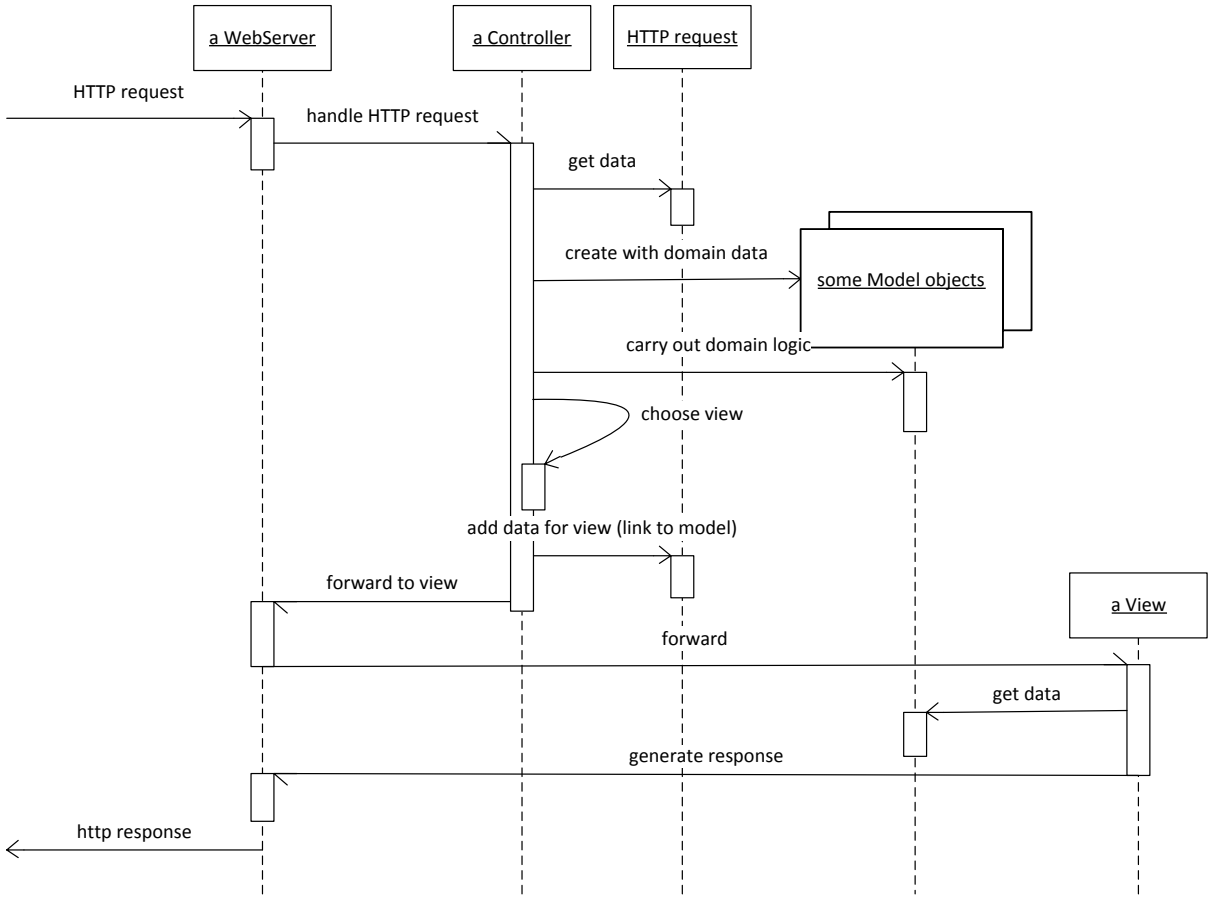


Figure 25. Model-View-Controller: UML sequence diagram

6.3.2 Platform Components

The First-Stage Prototype is a rich Internet application developed using the Adobe ColdFusion 8, Adobe Flash Media Server 2, Adobe Flash technologies and Sybase SQL Anywhere 10 database.

Adobe ColdFusion 8 is a web application server that enables developing Internet applications running on web servers. It is a rapid application development environment allowing for building dynamic websites. It is compatible with Microsoft Internet Information Server (IIS) and Apache web server. ColdFusion provides scripting environment based on ColdFusion Markup Language (CFML). CFML is a tag-based scripting language enabling connectivity to data sources and providing built-in search and charting capabilities. ColdFusion contains the following elements:

- ColdFusion scripting environment: responsible for providing development model for Internet applications
- CFML: a language similar to HTML, based on tags that can perform such functions as conditional operators, high-level formatting, creating Adobe Flash applications or web services
- ColdFusion Administrator
- Verity Search Server: responsible for providing full text search features for data and documents on a ColdFusion website

ColdFusion allows for developing applications in an object-oriented manner and provides such features of object-oriented programming as encapsulation, inheritance and introspection. ColdFusion object is defined in a ColdFusion component (CFC) file that consists of data and functions. ColdFusion components can automatically publish their methods as web services. Web Services Description Language (WSDL) is generated automatically by ColdFusion. CFC methods can communicate and interact with Flash applications through Flash Remoting service and can be called from Flash's ActionScript, both client-side and server-side (Adobe 2007).

Flash Media Server 2 is a media server allowing for streaming audio and video content and creating synchronous multimedia environments. It allows for developing interactive applications that support real-time collaboration with the usage of e.g. audio, videoconference, chat and whiteboard.

The Flash Media Server applications have client-server architecture. The client part of the application is written in ActionScript (1, 2 or 3) and runs in web browsers with Adobe Flash Player 6 (or later), Adobe AIR 1 (or later) or Adobe Flash Lite 3 (or later). The client and server communication is realized by a persistent connection using Real-Time Messaging Protocol (RTMP) which is a TCP/IP protocol for streaming and data services. The server part of the

application is written in Server-Side ActionScript that enables managing of *shared objects*. Clients connect to shared objects for messaging, synchronizing and storing data (Macromedia 2005).

Sybase SQL Anywhere 10 is a relational database system supporting such features as e.g. stored procedures, user functions, triggers, referential integrity or replication. Sybase Central is a tool for managing databases and allows for their administration and development providing access to database settings, properties and utilities in a graphical interface (Sybase 2007).

The Media-View-Controller paradigm of the system relies on the aforementioned technologies applied for different layers of the paradigm. An overview of their logical dependencies is presented in Figure 26 (based on Hediard 2006).

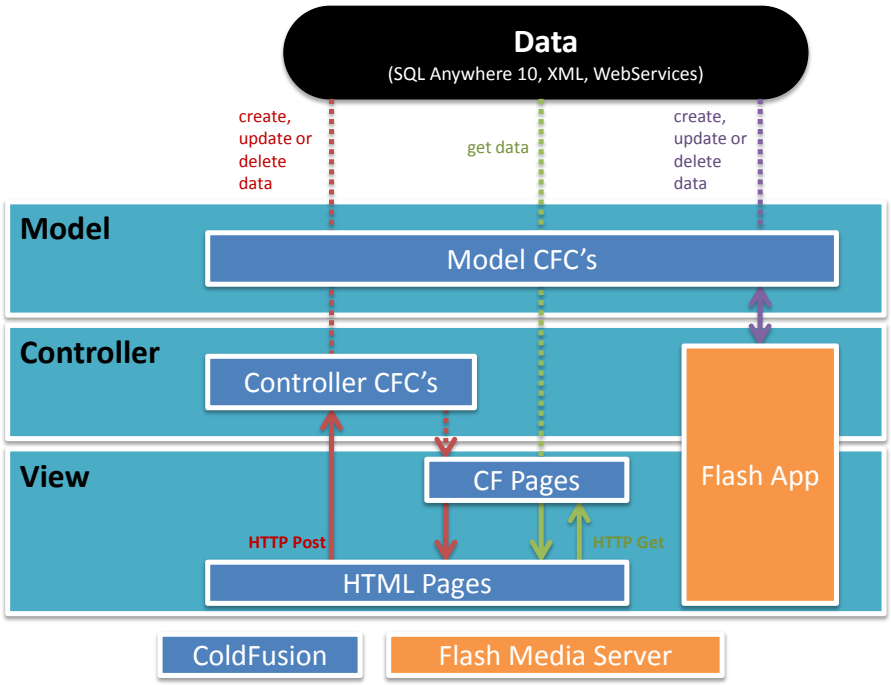


Figure 26. System components in Model-View-Controller approach

The data layer is realized by Sybase SQL Anywhere 10 data management system, XML files and other data provided e.g. by Web services.

The model layer responsible for the application's business logic and data access is realized by ColdFusion Components (CFC's). Model Components can be called by the view layer only to read the model.

The controller layer is responsible for handling data sent by a user, calls specific components in model layer and redirects user to the next web page. Controller Components responsible for

controller layer do not output any content and are called by HTTP Post request. The Controller Components are realized as ColdFusion Components, but also the Flash applications contain controller functionality. Controller Components can be called by the view layer in order to change the model (possible through Model Component calls).

The view layer is a presentation layer built with CFML (ColdFusion Markup Language) pages and Flash applications. The view layer calls the model layer and usually outputs the content as HTML to the browser (other formats for different purposes can be also specified, e.g. WML or C-HTML). The view layer can be also realized by ColdFusion custom tags that encapsulate presentation logic (pagelets). View layer realized by ColdFusion can be additionally separated for purposes of internationalization with the help of i18n library. For purposes of application's performance, a default file-based caching mechanism has been activated. The capabilities of view layer have been extended by implementation of JavaScript-based AJAX technology and Cascading Style Sheets (CSS). Figure 27 presents file structure of the application.

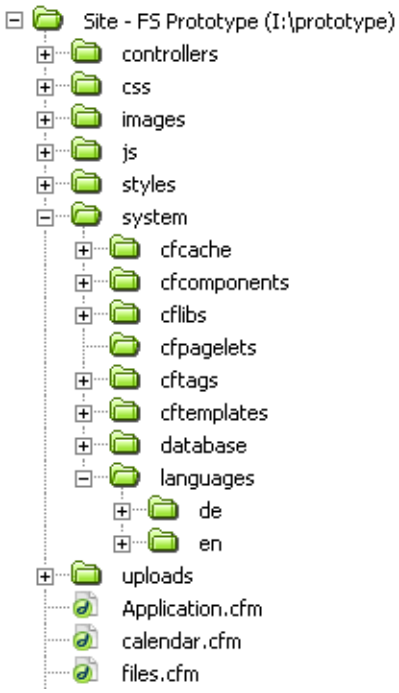


Figure 27. MVC-oriented structure of the file system

6.3.3 Overview of Platform Functionalities

The developed collaborative platform is a rich Internet application accessible via a web browser. The usage of functionalities supporting real-time collaboration (e.g. videoconference, chat) requires Flash plug-in in version 6 (or later).

For purposes of the group type 'Project Team', the platform has been configured to provide functionalities resulting from the analysis presented in Chapter 6.2 and contains the following features: social rating, discussion board, calendar, task management, wiki, social networking, social sharing, video conference, blog, search, document management, notifications, private messages and chat. Due to time limitations, not all of the functionalities could be implemented and therefore the existing tools have been integrated (e.g. wiki). Technological difficulties hindered the implementation of the application sharing functionality.

The combination of implemented functionalities provides support for many aspects of group collaboration. It contains forum and private messages functionalities which support asynchronous communication within a group. Synchronous communication is supported by chat and videoconference functionalities (Figure 28).

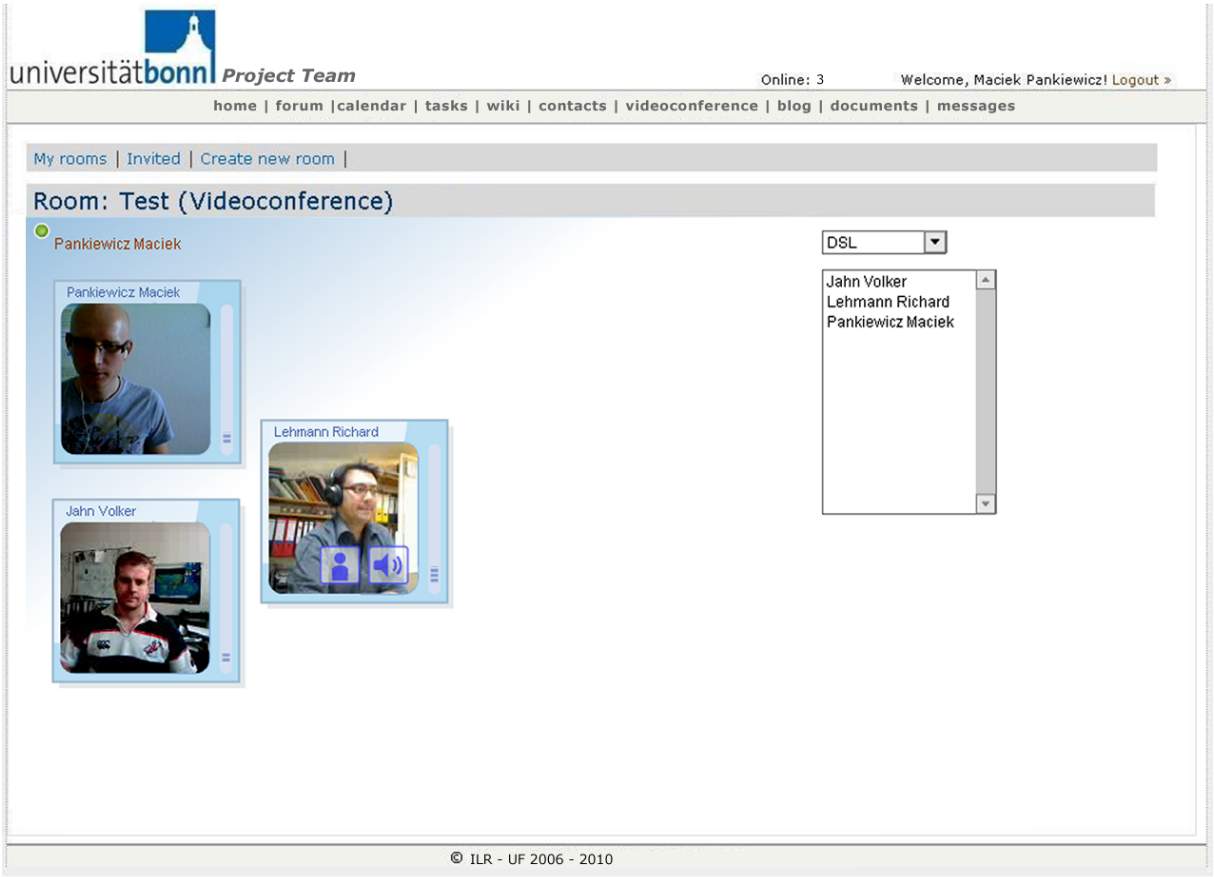


Figure 28. First-Stage Prototype – videoconference functionality

The platform provides functionalities for managing appointments or important dates and allows sharing them between platform users which is of a greater importance in a 'Project Team' group type. Calendar entries can be automatically sent as an email with event information in an iCal format for saving in such compatible programs as e.g. Microsoft Outlook (Figure 29).

Task management allows managing personal or group activities and creating to-do lists with defined tasks and milestones. 'Project Team' group type performs interrelated activities towards a group goal and therefore this functionality should play a greater role for the group.

Managing information across the group can be realized by document management functionality that allows for managing documents across the group and wiki, which provides functionalities for creating, editing and interlinking websites. Interface supporting quick editing of documents may be helpful in activities requiring e.g. fast generation of ideas. Blog functionality allows e.g. for common publication of articles related to the group's activity.

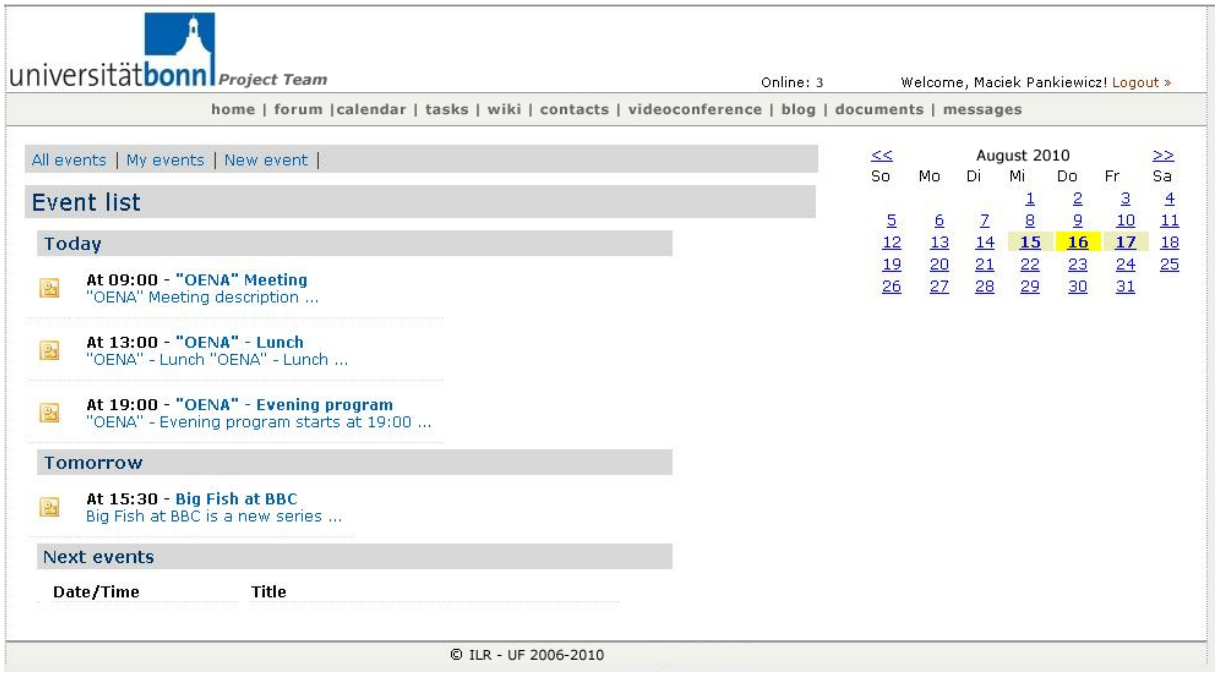


Figure 29. First-Stage Prototype – calendar functionality

The platform supports social aspects of collaboration by social networking functionalities allowing for managing a list of user's contacts. Users present themselves, their areas of expertise and contact info in their platform profiles.

Figure 30. First-Stage Prototype – user's profile functionality

The platform functionalities have been subject to internal tests performed within the Chair for Business Management, Organization and Information Management at the University of Bonn. Additionally, for purposes of the evaluation of the First-Stage Prototype expert interviews have been conducted.

6.4 Evaluation of the First-Stage Prototype

The evaluation of systems for supporting collaboration is a challenging task as variables that need to be considered are more diverse and complex than in single-user applications. This complexity results from the necessity to consider such aspects as e.g.: individual cognitive factors, cooperative and collaborative factors, usability issues for individuals and groups or social impact. Additionally, the need of the longitudinal evaluations also contributes the complexity level of such analysis (Neale et al. 2006; Pinelle and Gutwin 2000). Both time and resource limitations of this study, as well as the complexity of the evaluation approaches resulted in the need of assessment of the First-Stage Prototype based on experts' evaluation, since all implementation stages (e.g. Munkvold 1999, p. 261) have not been completed.

The evaluation of the First-Stage Prototype has been conducted according to the core constructs of the Technology Acceptance Model (Davis 1989). According to Davis (1989, p. 320) *perceived usefulness* is the extent to which individuals believe that using a system will help them to perform better. The perceived ease of use is the extent to which an individual believes that using a system will be free of effort (Davis 1989, p. 320).

Model dependencies are presented in Figure 31 (adapted from Vogel 2008, p. 14).

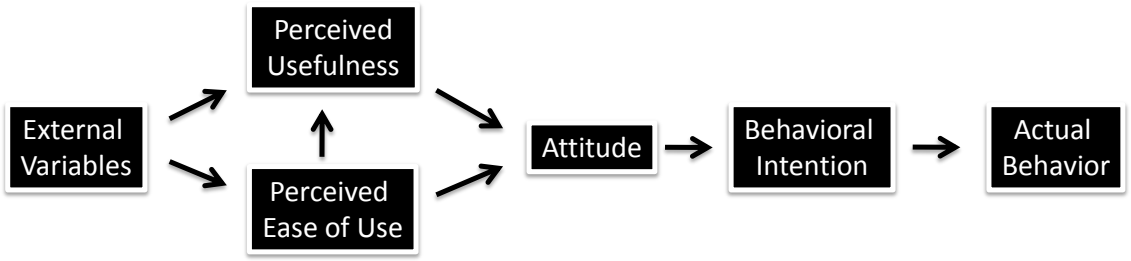


Figure 31. Technology Acceptance Model

This model has been widely used for purposes of understanding and predicting acceptance of information technology (Vogel 2008, p. 14).

The First-Stage Prototype has been evaluated in a series of three expert interviews. The expert's selection was based on their previous experience related to the project work and the application of computer tools for supporting of project tasks. Selected experts have long-standing practical experience in the area of project work, gained through participation in national and international projects performed at the Chair for Business Management, Organization and Information Management at the University of Bonn.

The analysis of the First-Stage Prototype has been conducted in order to evaluate how the platform providing a set of functionalities resulting from this research is able to meet the requirements of the 'Project Team' group type. For this purpose, firstly the expert's experience in the field of project work has been identified. Secondly, a questionnaire for the identification of the group type has been filled to ensure that the discussed groups meet the specification of the 'Project Team' group type. Then, the existing collaborative systems used for supporting analyzed groups have been identified and their application discussed. The final part of the interview was the evaluation of the perceived usefulness (PU) and perceived ease of use (PEoU) of the First-Stage Prototype, its functionalities with its comparison to systems previously used by experts in their project work.

Firstly, it has been identified, that for purposes of the project work there was a necessity for using a combination of multiple applications for supporting different collaboration aspects. The interviewed experts have used a combination of different collaboration and communication systems. An example of such combination consisted of the BSCW collaborative platform for purposes of document management and calendaring, Skype for purposes of synchronous communication (audio, video and chat) and email for purposes of discussion, evaluation or idea sharing.

Experts have stated to have previous experience with most of the functionalities provided by the First-Stage Prototype. However, often for their project work these functionalities have not been available, mostly because of the lack of these functionalities in the provided collaborative platforms.

The expert's evaluation of the functionalities provided by the First-Stage Prototype has shown that the suggested tools are perceived as being useful for different aspects of the project work. However, the application of wiki and blog functionality has been found arguable and dependent on the group's purpose. According to experts, these functionalities would not be necessary since group size was rather small and the purpose of the group did not require these tools. Both wiki and blog were perceived as tools that are more useful for bigger groups rather than small one.

The second important issue regarded the existing potential of substitution of the discussed functionalities by another. For example, blog and forum functionalities are perceived by experts rather as potentially substitutable and their suggestion was that perhaps, depending on group characteristics, some groups might decide to use only one of these functionalities, depending on their experience and group purpose.

First-Stage Prototype has been found to include all the functionalities previously used by experts in their project work. Moreover, additional functionalities, not provided by collaborative platforms available for expert's project work, have been evaluated as important for the purposes of these groups.

Table 31 presents a summarized expert's evaluation of the platform's functionalities.

Table 31. Expert's evaluation of First-Stage Prototype

	Social rating	Discussion board	Calendar	Application sharing	Task management	Wiki	Social networking	Social sharing	Video conference	Blog	Search	Document management	Notifications	Private message	Chat/instant message
Evaluation	++	++	++	+	++	-	+	++	++	-	++	++	++	++	++

++ very necessary | + necessary | - not necessary

The overall expert's evaluation of the First-Stage Prototype was positive and the set of functionalities has been found as being useful for groups represented by experts. The experts rated positively the perceived ease of its usage (as it mostly incorporated functionalities already known by experts), the number of functionalities and their ability to meet the requirements of their groups. However, also critical points have been made, e.g. a potential feature allowing for configuring the availability of chosen functionalities would be also found useful by experts (see also e.g. Kumar et al. 2006).

6.5 Summary

The validation and evaluation of the generator framework presented in Chapter 5 was based on the Quality Function Deployment method. Its House of Quality approach allowed for operationalization of the theoretical framework and provided basis for the implementation of the concept for the 'Project Team' group type.

Firstly, the potential of Quality Function Deployment and House of Quality has been discussed in terms of its appropriateness and applicability for design activities. Then, dependencies between parts of the conceptual framework have been evaluated in a series of expert interviews. This allowed for identification of sets of critical functionalities for generic group types defined in previous chapters and provided basis for implementation of the First-Stage Prototype.

The results of the analysis showed, that only the adoption of multiple combined functionalities allows for meeting the needs of collaborative groups. These functionalities have been identified for every generic group type. According to expert's evaluation, the potential of functionalities that trace its origins from social software is recognized for purposes of collaboration. Therefore, the application of such tools as social networking, social ranking or social tagging for purposes of specific collaborative groups may be considered as reasonable. Moreover, these functionalities may even play an important role as the analysis for the 'Project Team' group type has shown, even though they are not yet widely implemented in commercial products for supporting collaboration.

The application of the Quality Function Deployment method allowed for defining functionalities important for identified generic group types. Applied method enabled identifying the set of six most valuable functionalities in terms of their potential fulfillment of generic group needs. It led to operationalization of the concept and implementation of the prototype of a collaborative working environment. The First-Stage Prototype has been created for the purpose of concept evaluation and was based on the set of functionalities derived for the 'Project-Team' group type.

The functional aspects of the prototype have been evaluated in a series of expert interviews. Expert-based evaluation of the First-Stage Prototype referred to the potential ability of the presented platform to meet the requirements of project groups represented by experts. Although both selection of the functionalities and their applicability have been generally acknowledged during interviews, also some critical points have been made, which can be helpful for further development. Expert interviews confirmed the appropriateness of the framework presented in Chapter 5 and showed the perceived potential importance of functionalities originating from social software for purposes of project team collaboration.

7 Benchmark of the Selected Collaborative Systems

7.1 Generator Framework as a Benchmarking Tool

The selected collaborative platforms presented in Chapter 4 are examples of systems for supporting collaborative group interactions originating from different background and designed for various purposes. Social networking websites (e.g. Facebook) have been originally designed mainly for supporting networks of friends and offer tools mainly for supporting their social interactions, while e.g. conferencing systems provide tools for synchronous communication and are meant to be used by groups with requirements of intensive real-time collaboration.

The benchmark of these selected collaborative platforms is based on the generator framework and results of expert evaluation of functionalities importance in the House of Quality method. Collaborative systems are compared on their potential ability to support group needs according to the introduced framework. These systems consist of different combinations of functionalities and the benchmark shows the 'fit' of platform's functionalities to group needs. There are seven collaborative systems benchmarked: three social networking websites (Facebook, MySpace and mixxt), two collaboration platforms (BSCW, MS SharePoint), web conferencing system (Adobe Connect Pro) and a video sharing website (YouTube).

This benchmark considers a purely functional view on collaborative platforms. It is not considering non-functional attributes such as e.g. system usability. It is based on the fit of functionalities categorized into class 'A' for every generic group type (presented on charts with the upper line). The bottom line presents the summarized fit of all classes: A, B and C from the Pareto cumulative chart.

7.2 Benchmark

The analysis of collaborative platforms for group type 'High-Activity Team' ranked Microsoft SharePoint and Adobe Connect Pro at the top of the benchmark among existing systems (Figure 32). Adobe Connect Pro offers a wide range of real-time collaboration functionalities, while SharePoint lacks these features. However, Adobe Connect Pro does not provide features available in SharePoint, but rated as critical in previous analyzes. Additionally, SharePoint is characterized by a broad range of functionalities that do not fall into the analyzed 'A' class and therefore level of overhead, i.e. tools that not necessarily may be needed by the group, is bigger than e.g. by Adobe Connect Pro. According to benchmark, Adobe Connect Pro may offer comparable level of support as SharePoint. However, these systems provide different, but

complementary sets of functionalities which may suggest, that their combination could provide better support for this group than both systems alone.

The 'High-Activity Team' group type's requirements are characterized by the need of support for real-time collaboration. The video and audio conference tools as well as chat functionality are ranked high, therefore, Adobe Connect Pro as a system for supporting the 'High-Activity Group' type is ranked high in this comparison. On the other hand, SharePoint provides further functionalities important for this group type, not provided by Adobe Connect Pro: discussion board and wiki, hence it ranks high in this comparison.

The First-Stage Prototype provides a combination of the functionalities available in both discussed systems. It integrates asynchronous tools (e.g. discussion board) with synchronous features (videoconference) what results in the high evaluation result according to its available functionalities.

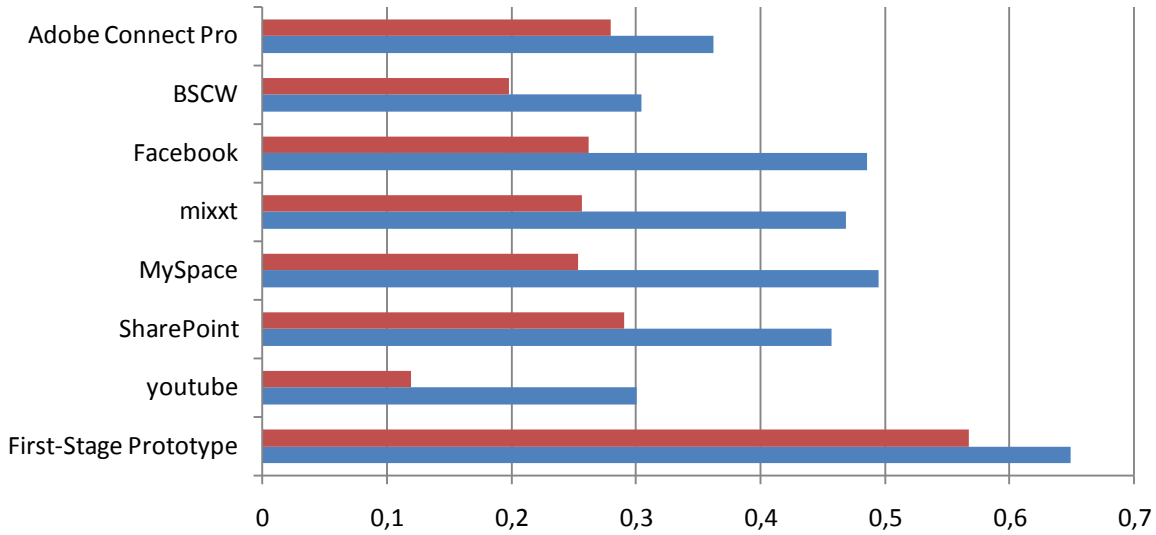


Figure 32. Type 'High-Activity Team': system benchmark

The analysis of collaborative platforms for group type 'Project Team' ranked Microsoft's SharePoint at the top of the benchmark among the other existing systems. The availability of tools for supporting project tasks (document management, wiki, task management) puts this system at the top in this comparison. High ranks of social networking websites (MySpace, Facebook) result from the number of functionalities for supporting social interactions provided by these platforms and their lack in other discussed platforms. Especially the availability of social rating and social sharing tools (not available in SharePoint, but important for 'Project Team' group type) determines their high rank. The availability of social-oriented tools could improve SharePoint's ability to support 'Project Team' group type.

This comparison also shows that social networking websites can potentially support 'Project Team' group type as well, because they offer a range of functionalities critical for this group type. However, a big overhead of additional functionalities available in the analyzed social networking websites (blue line) can potentially lead to confusion of group members if these systems were implemented for supporting 'Project Team' group type (Figure 33).

First-Stage Prototype consists of the features resulting from the analysis performed for 'Project Team' group type and therefore presents ideal configuration of the system for supporting this group type. It consists of all the 'A' class functionalities and therefore its evaluation is marked with 66% on the chart.

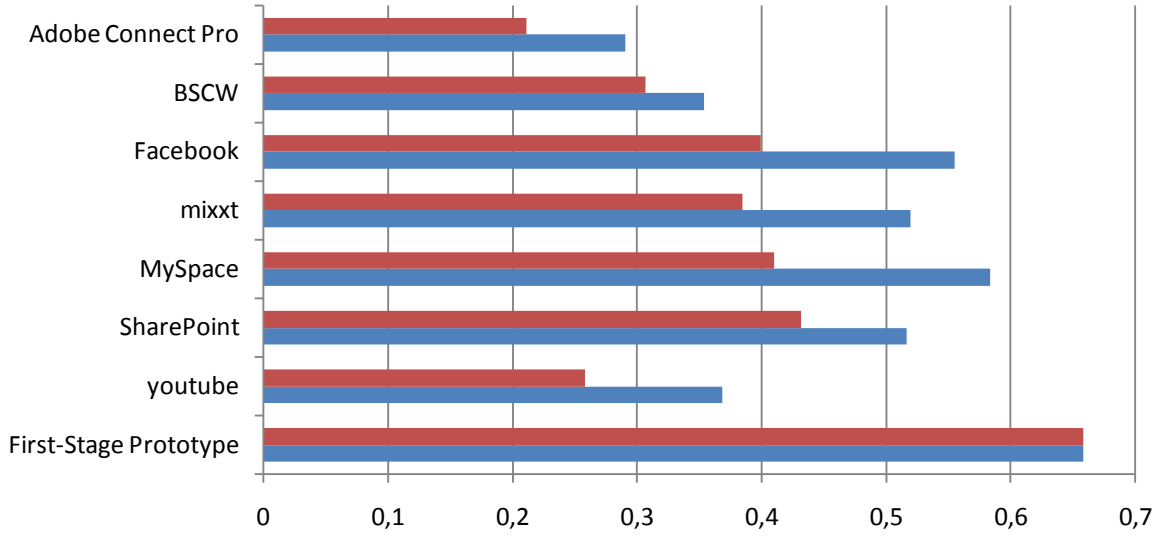


Figure 33. Type 'Project Team': system benchmark

A comparison of collaborative systems for purposes of a group type 'Work Group' ranks the combination of functionalities provided by Microsoft's SharePoint at the top of the benchmark among the existing systems. Low rank of BSCW, which is a platform designed explicitly for supporting collaboration in work and project groups, results mainly from its lack of functionalities for supporting social aspects of collaboration. Since requirements of a type 'Work Group' refer mainly to the support of asynchronous activities, Adobe Connect Pro is at the bottom of this ranking, despite the fact that it is providing application sharing functionality, not present in the other collaborative systems that have been analyzed.

First-Stage Prototype provides combination of functionalities not available in compared collaborative systems which results in high rank in the benchmark. The comparative analysis shows that First-Stage Prototype meets requirements of the three task-oriented groups which

results from their task-orientation. Differences in their needs structure for individual and group maintenance needs lead to the overhead of not necessary functionalities (Figure 34).

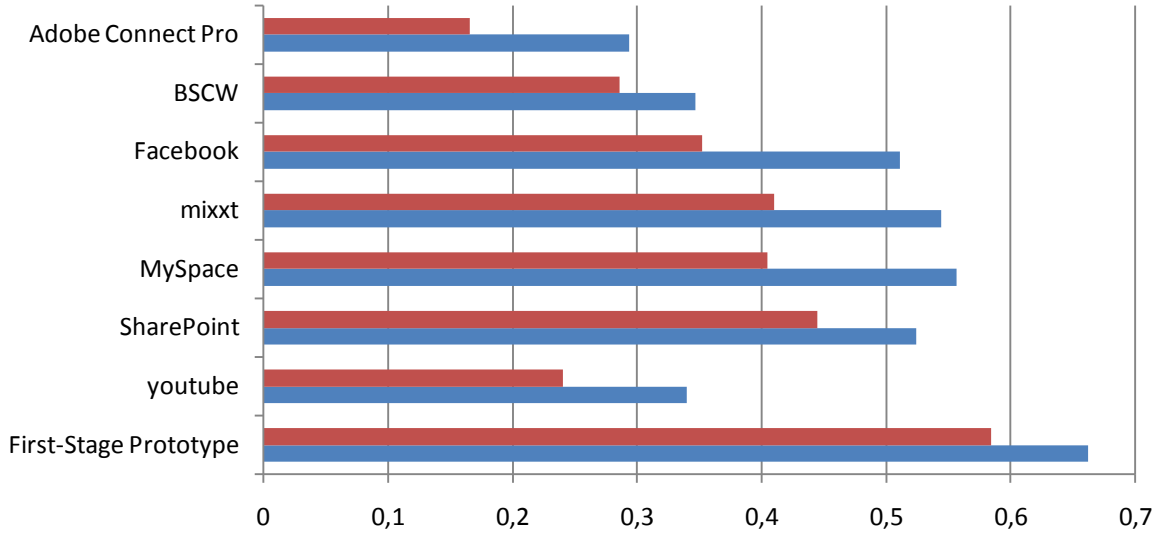


Figure 34. Type 'Work Group': system benchmark

Informal networks focus primarily on social activities, therefore, in comparison to other collaborative platforms social networking websites (Facebook, MySpace) were ranked at the top among the existing systems, as they support social interactions in multiple ways. Facebook and MySpace accounts allow users to customize their profiles, edit additional information and connect to other users on the platform for purposes of e.g. better communication and information sharing. Users of the BSCW platform can also use their profile page, however, it is rather a visit card containing contact information, than a fully configurable feature allowing for virtual networking. BSCW can be therefore seen rather as a support for smaller groups, members of which know each other.

First-Stage Prototype provides social networking and social sharing functionalities that are the most important tools identified for this group type. Its task orientation results in lower evaluation than in previous evaluations, however, in this benchmark it is comparable with two existing systems: Facebook and MySpace (Figure 35).

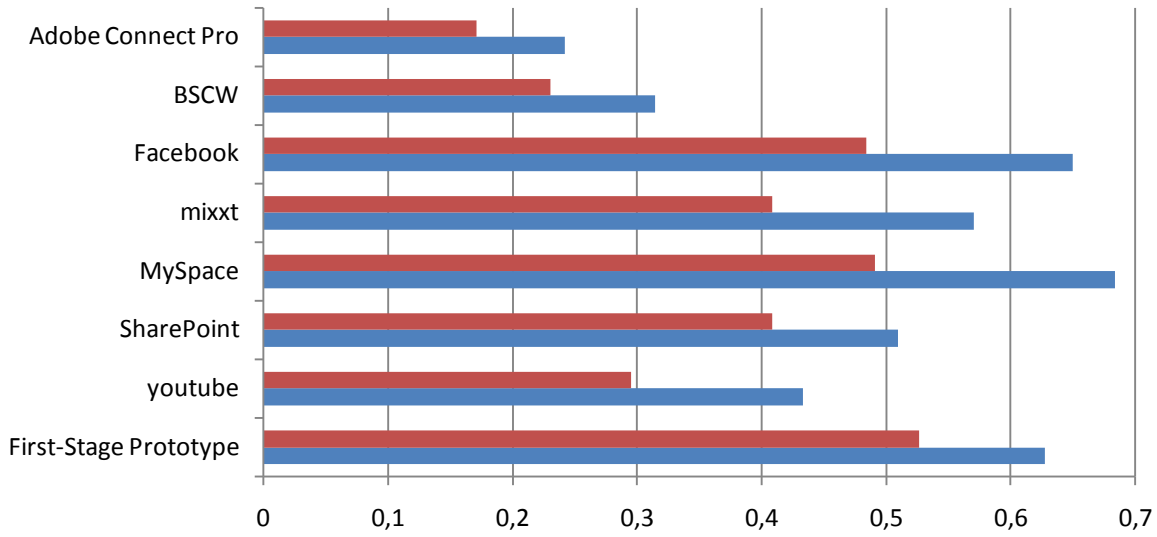


Figure 35. Type 'Informal Network': system benchmark

Communities of practice are rather larger groups connected by mutual interests. MySpace and mixxt collaborative platforms have been highly rated in this comparison and indeed are platforms for supporting such group types. Members of MySpace community are mainly interested in music. Mixxt provides tools for creating workspaces for different communities. SharePoint's set of functionalities also fits community needs. The derived set of most important functionalities for supporting 'Community of Practice' group type includes forum (idea exchanging, discussions), social rating (allowing for evaluation of the most valuable users or helpful resources or responses) and wiki (e.g. for creating knowledge base of the community). Although there exist standalone solutions providing such tools (e.g. phpBB: forum with social rating functionality), their combination has not yet been implemented in evaluated collaborative platforms. Therefore, even though selected platforms seem to meet the needs of the group sufficiently, the conclusion can be drawn that there is improvement potential for this support.

First-Stage Prototype is again evaluated with a high rank resulting from availability of the wiki, social rating and discussion board functionality.

Figure 36 presents a comparison of selected platforms according to the needs of 'Community of Practice' group type.

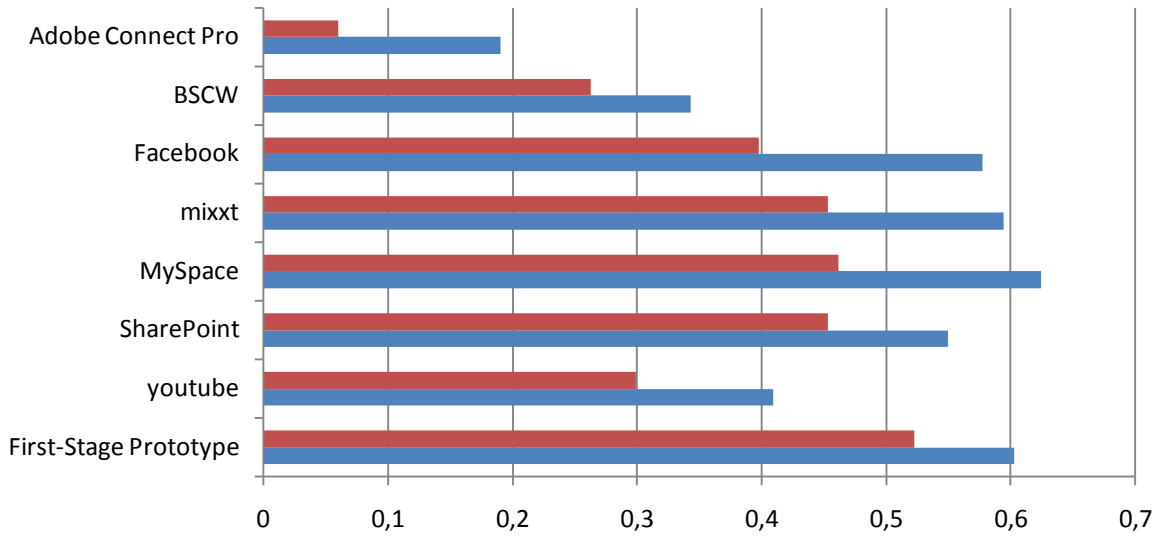


Figure 36. Type 'Community of Practice': system benchmark

The range of selected functionalities for the First-Stage Prototype resulting from the ABC analysis implied the high ranks of the First-Stage Prototype in the benchmark. Identified six most important tools for supporting generic group types (discussion board, wiki, blog, social networking, social rating and social sharing) are not provided simultaneously by any of the analyzed existing systems which led to their low evaluations in the benchmark.

Results of the implemented Quality Function Deployment method and the high rank of the First-Stage Prototype may suggest improvement potential for the method as a benchmarking tool. This improvement may relate to e.g. not only taking into consideration weighting of the group needs, but also the weighting of the ranked functionalities, depending on the group type.

7.3 Summary

The benchmark of the selected collaborative platforms allowed for comparing the potential support of these platforms and their ability to meet the needs of collaborative groups according to the framework proposed in Chapter 5. This comparison showed that there is no integrated solution that would be able to support all of the aforementioned group types and different platforms with different functionalities are required for supporting different group types. Proprietary platforms designed for supporting mainly group work in organizational settings (e.g. SharePoint, BSCW) are indeed better suited for goal-oriented groups than e.g. informal networks. However, this analysis shows also that the implementation of new functionalities could extend their general functionality and allow for better meeting of the needs of the group. The platforms designed for supporting communities or informal networks (e.g. Facebook,

MySpace) were found to support these groups better than other platforms according to the benchmark. However, because of the multiplicity of functionalities they provide, they could possibly also support e.g. 'Project Team' or 'Work Group' types, as they provide functionalities rated as critical for these groups in the previous analyses (e.g. social rating, social networking or calendar).

According to this benchmark, the optimal collaborative working environment for meeting the needs of different groups would profit from customization features allowing for selection of functionalities depending on a group type. Compared platforms would benefit from this feature if this customization would allow for adding of functionalities defined as critical in sets of functionalities presented in section 6.2.

The analysis of the platforms selected for this benchmark also confirmed the general orientation of these platforms: e.g. social networking websites were evaluated positively as platforms for supporting informal networks and collaborative platforms as systems for supporting project-oriented collaboration. This can be to some extent understood as a validation of the framework concept and a confirmation of its appropriateness.

8 Summary and Outlook

Spatially distributed collaborative groups require technology support for effective performing of their collaborative actions. Technology provides tools for supporting e.g. communication, coordination and cooperation activities on which group collaboration bases (Ellis et al. 1991). However, effective collaboration relies not only to task-oriented interactions, but also requires support of individual and social group needs. These aspects need to be taken into consideration in the process of designing collaborative working environments (Richter et al. 2006). However, such approach requires extensive analysis of factors related to group development patterns, its cohesive well-being and the role of the individual in group.

The systems for supporting spatially distributed groups consist of multiple combined functionalities in order to support the needs of collaborative groups. Technological progress led to the development of new tools with potential for supporting different aspects of collaboration needs, e.g. folksonomies, microblogs or wikis. Individually, these functionalities are able to meet certain needs of collaborative groups. However, since needs of collaborative groups are complex their fulfillment requires a proper combination of multiple functionalities. The process of designing a collaborative working environment is therefore required to consider the complex needs of collaborative groups in order to create an effective system for supporting group collaboration.

The purpose of this dissertation was to provide a methodology for designing collaborative working environments for collaborative groups basing on group needs approach. The methodology should provide a basis for a generator of collaborative working environments, where accordingly to the defined group type, an appropriate virtual collaborative environment is created.

To meet this objective, several research questions have been investigated:

- What are the generic types of collaborative groups?
- What are the main group needs influencing interactions in collaborative groups?
- What is the importance of different group needs for generic group types?
- To what extent can technology support the needs of collaborative groups?
- What is the appropriate set of tools for meeting the needs of collaborative groups?

Firstly, the main collaborative group types have been identified (Chapter 2). These types have been defined according to an identified set of group characteristics derived from literature research. The identified group types differ in various dimensions: they are characterized by

different size, have different purpose, are disbanded after achieving their goal or last as long as their members want to maintain the group. The following generic group types were specified according to identified criteria: high-activity team, project team, work group, informal network and community of practice. The identified groups are characterized by different attributes, which imposes demands on the art of collaboration they perform.

Collaboration patterns are defined by collaboration needs and therefore the second analysis was related to the identification of the main group needs influencing interactions within collaborative groups. This analysis was based on literature research which enabled a specification of these requirements. Firstly, collaboration has been identified as an interrelated set of three dimensions: individual needs, task needs and group maintenance needs. In order to mutually perform tasks, additional efforts have to be made in areas of group well-being and individual satisfaction. Group collaboration is depending on the level of cohesiveness of a group and mutual trust between group members which stimulates member's motivation to contributing to the group. Additionally, individual needs related to individual development and sense of belongingness need to be taken into consideration in order to stimulate the individual's satisfaction from being a part of a group.

The results of the literature research led to the specification of generic needs influencing group collaboration that have been classified into three areas: individual needs (need for belongingness, need for achievement, learn and explore), task needs (production and presentation of images and ideas, discussion and evaluation of issues, problem solving and carrying out some plan of action) and group maintenance needs (need for cohesiveness, need for creating group identity, need for group motivation, need for trust).

The identified group types are characterized by different attributes. These attributes impose differences on collaboration needs, e.g. communication requirements of large groups are different than those of small groups, constraints in time-span of a group influence trust building or cohesiveness. Therefore, the requirements of a high-activity team which is a rather small group with a limited time-span are of a different nature than those of community of practice. Hence, collaboration needs have been weighted according to their importance for every group type (Chapter 3).

Spatially distributed groups, even if their members did not meet face-to-face, are real groups. However, their interactions are mediated by technology which has been reported to have both positive and negative influence on collaboration. The analysis of functionalities provided by existing systems for supporting collaboration (web conferencing systems, groupware, social networking websites) allowed for defining a set of functionalities for supporting collaborative

groups. Although the existing collaborative systems provide a multiplicity of functionalities for supporting collaborative groups, it has been showed that there exist several problems in designing collaborative working environments e.g. related to the choice of appropriate media for purposes of collaboration (Chapter 4). This need-technology relation should be appropriate in order to meet the requirements of collaborative groups.

The initial analysis presented in Chapter 5 allowed stating that technology provides functionalities that are able to meet the needs of collaborative groups in a better way than any other factors if considered independently. The analysis based on a theoretical approach has been conducted to show which of the identified functionalities can meet particular group needs. Then, an evaluation of the strength of these relationships has been conducted in an expert interview. The results of these analyses showed that there are needs that can be satisfied more fully by an implementation of a single functionality rather than by implementation of other. For example, a strong relationship has been identified between the need for trust and the ability to meet this need by the social rating functionality. On the other hand, there are needs which do not show these characteristics, e.g. the need for cohesiveness can only be met to some extent by a combination of functionalities.

Further analyses of expert's evaluations showed that some functionalities were able to meet a broader scope of group needs, while others offer only a narrow need support. The potential of wiki functionality in terms of group needs goes beyond the support for learning (knowledge management), enabling support e.g. for coordination activities, since it allows for fast editing of common resources. Similarly, social rating functionality allowing for mutual evaluation of resources is perceived as a tool influencing the need for trust, but also the need for learning and production needs, as it enables faster retrieval of important information. The social networking functionality is not only a tool for connecting with acquaintances and maintaining social relations, but also contributes to issues of trust and cohesion which make mutual working easier. Furthermore, it provides support for the need of learning, as it enables fast connecting and interacting with individuals-experts in a searched domain.

However, because group needs have to be analyzed as a complex and interdependent set (as collaboration relies on their interrelated combination), it has been investigated, which set of functionalities is able to provide support for the identified collaborative group types.

The previous analyses allowed for defining the importance of the identified needs for generic group types. The expert interview provided basis for defining the structure of relationships between group needs and functionalities. This allowed for creating a framework for collaborative working environment's generator. The Quality Function Deployment and House of

Quality approach provided methodological basis for connecting the framework's parts and served as a basis for the generator of the collaborative platform.

The results of the Quality Function Deployment analysis allowed for defining sets of functionalities appropriate for the defined generic group types. For the purpose of concept evaluation, the First-Stage Prototype has been developed and evaluated in a series of expert interviews. This evaluation confirmed the applicability of the concept and the generator framework.

The framework has been also used as a benchmark tool for a comparison of the selecting collaborative platforms (Chapter 7). This comparative analysis could be used as a potential development direction for human-centric development of collaborative systems.

The conclusions drawn from this research refer to both technological and social aspects of designing collaborative working environments. Technology can 'do' the work as it can automate processes and tasks. However, the contribution of the technology to the social part of the collaboration can only be perceived as its ability to mediate human interactions. Although the ability of technology to support task needs can be precisely measured, its application to human-oriented aspects is always related to psychological and sociological concepts that do not always provide solid and concrete answers. The number of generated documents can be easily counted, but trust or motivation emerging in a group cannot be simply measured.

Moreover, it seems that even though social aspects of collaboration can be met by application of appropriate functionalities, the extent to which this fulfillment is viable still remains a question. The ability of these tools to support such social aspects as trust or motivation has been recognized by experts, but its potential usefulness often depends on multiple aspects related to particular individuals.

The results of this research allow to state that meeting the needs of collaborative groups requires the application of multiple combined functionalities which has been showed in an analysis using Quality Function Deployment. According to this analysis, there exists no single functionality that is able to fully meet all of the identified collaborative group needs. The needs of collaborative groups seem to be too complex to be met by an application of a single tool. Six main tools for supporting generic group types have been identified: discussion board, wiki, blog, social networking, social rating and social sharing.

The next conclusion leads to the statement that although there exist functionalities that may contribute to such social aspects of collaboration as e.g. motivation, group cohesion or trust, their implementation does not necessarily assure an appropriate level of trust or cohesion, as

these tools provide only indirect support for these social aspects. This cannot be compared with e.g. ability of videoconference to support communication, as this tool indeed is able to transmit messages between communicating individuals.

It has been also found that the functionalities originating from social software are valuable not only for meeting social needs, but are also perceived as being able to support task needs, e.g. social networking functionality is not only perceived as a tool for connecting with friends, but also as a tool helpful in generating trust. Additionally, social rating functionality is also perceived as a tool for generating trust. Wiki functionality is not only perceived as a tool that is valuable for knowledge management applications, but its ability for rapid edition of collaborative documents contributes to its application for coordination activities. The microblog functionality, although still being a new and yet unexplored tool, has been found valuable for different aspects of group needs.

The Quality Function Deployment method used for the evaluation of the generator framework has been found to be a useful tool for designing purposes in this research. The results of the analysis conducted with QFD have been positively evaluated in the expert interviews and the perceived usefulness of the First-Stage Prototype implemented on the basis of the QFD analysis has been evaluated positively by the experts.

However, the idea of the generator of collaborative working environments, allowing for creating workspaces according to a group type with predefined functionalities and fully configurable, is still a challenge. Challenges are related e.g. to the problems with implementation of the computer environment comprising long list of potentially available functionalities. New technologies, new tools and functionalities continue to emerge, which puts ongoing demands on design activities. Additionally, although the implementation of popular, low bandwidth tools (e.g. discussion board) does not seem to be a challenge (both from design and end-user perspective), its combination with less common functionalities that support real-time collaboration (e.g. videoconference, whiteboard) and with social-oriented tools, may require more efforts. Moreover, individuals using collaborative working environment may possibly be members of different groups, which additionally adds to the complexity of the potential future implementation of the virtual environment. The implementation of the fully operational platform, for which this research can serve as a conceptual base, should be the next step in further analysis and research.

This research can be seen as a first step that provided the theoretical methodology for designing such environments and defined the basis for creating the First-Stage Prototype. Results of the evaluation of the First-Stage Prototype showed that collaborative working environment based

on approach that does not enforce particular processes (like groupware) but acts like a combination of functionalities that can be used for many different tasks related to communication, information management or identity management (see also Richter et al. 2006) should be able to fulfill the requirements of the collaborative group.

The group needs approach for designing collaborative working environments provides a conceptual basis for designing generic platform for supporting group collaboration. The validity of the concept has been assured by the methodology implemented for creating a designing framework. But the area of Computer-Supported Cooperative Work is a dynamically evolving research domain and technological development forces new solutions. A further, in-depth analysis of the presented subject is therefore a necessity imposed by the technological progress and its continuous impact on human perception.

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Appendix

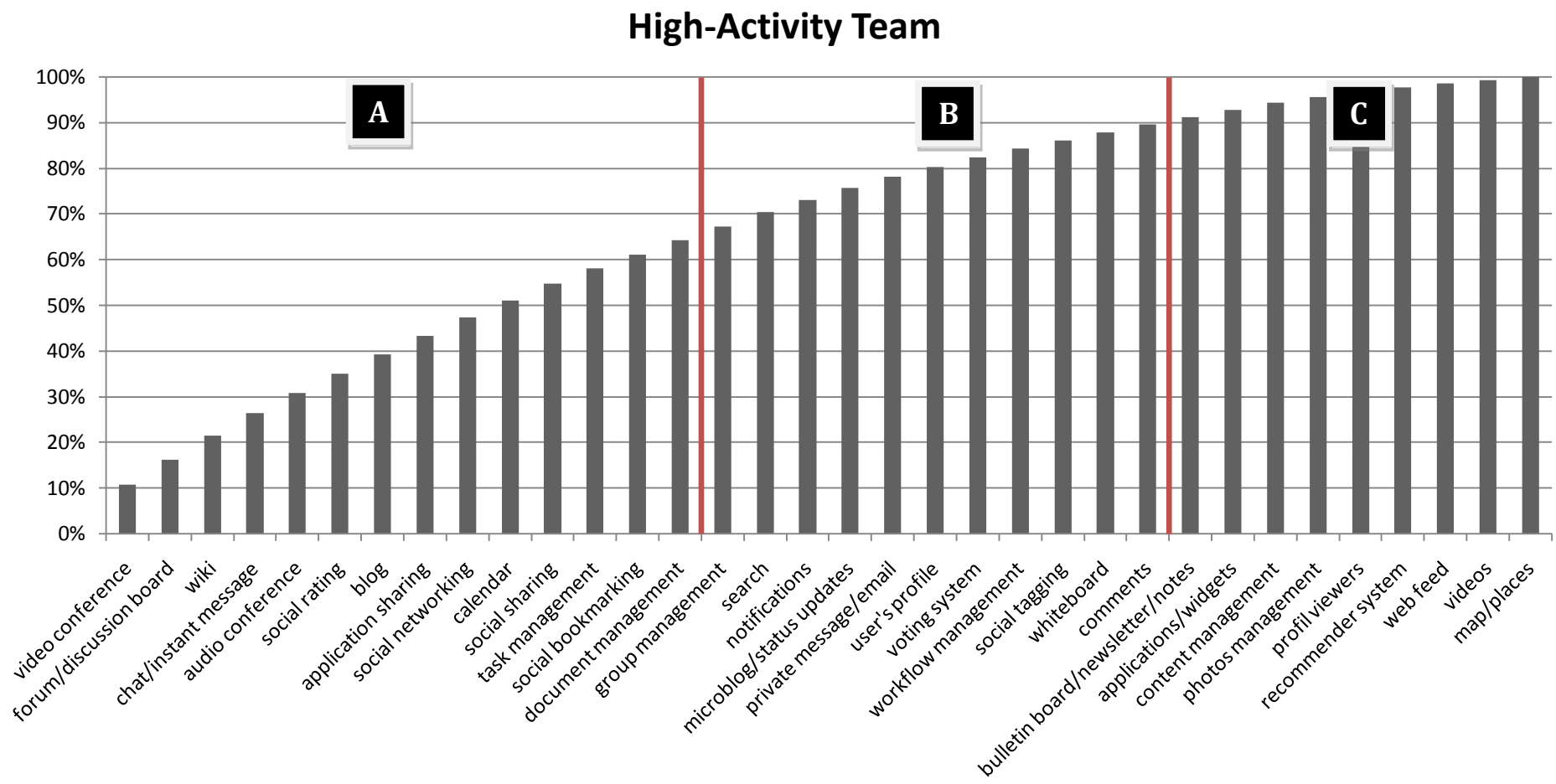

Figure 37. Pareto cumulative chart: High-Activity Team

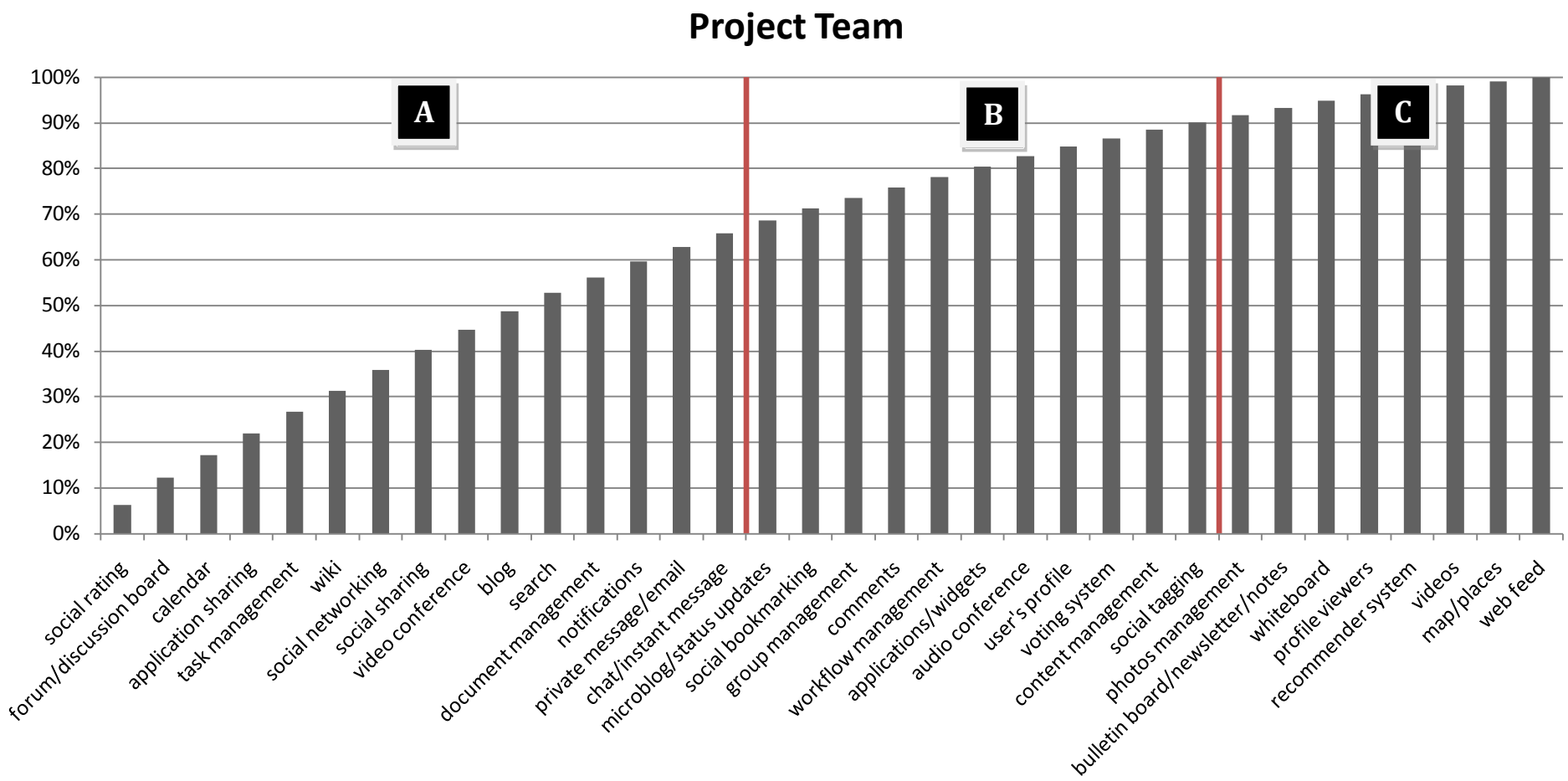

Figure 38. Pareto cumulative chart: Project Team

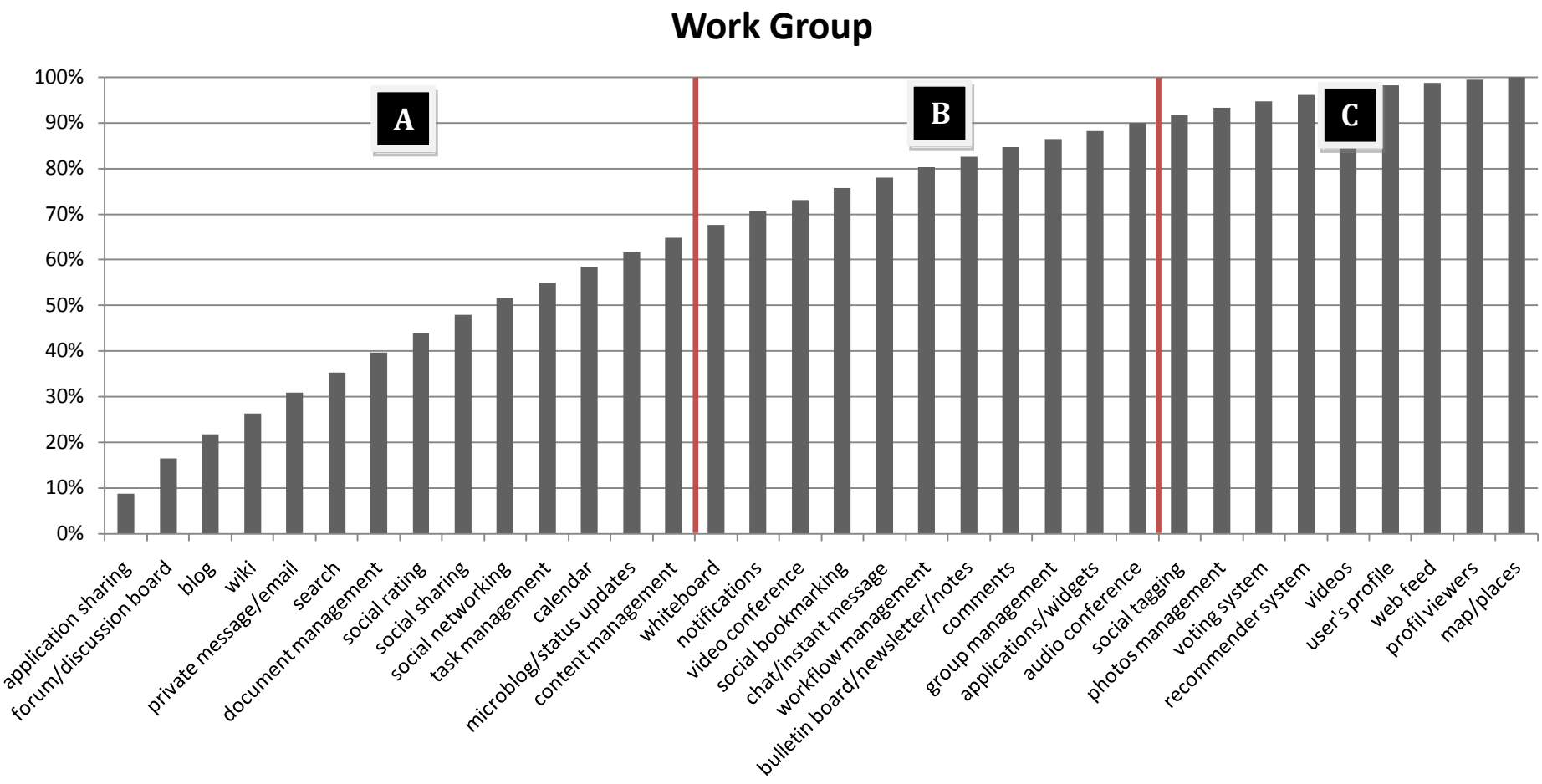

Figure 39. Pareto cumulative chart: Work Group

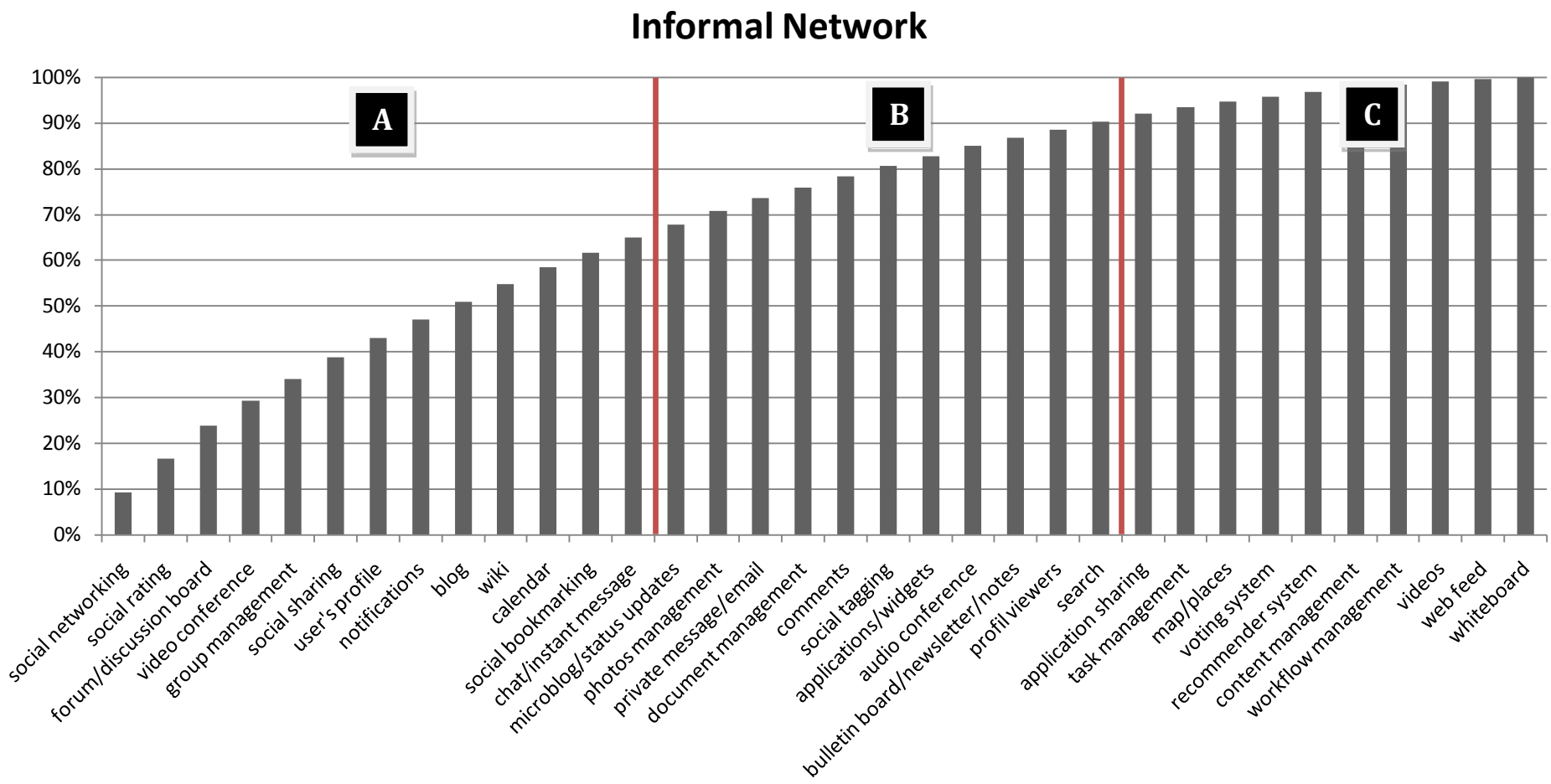

Figure 40. Pareto cumulative chart: Informal Network

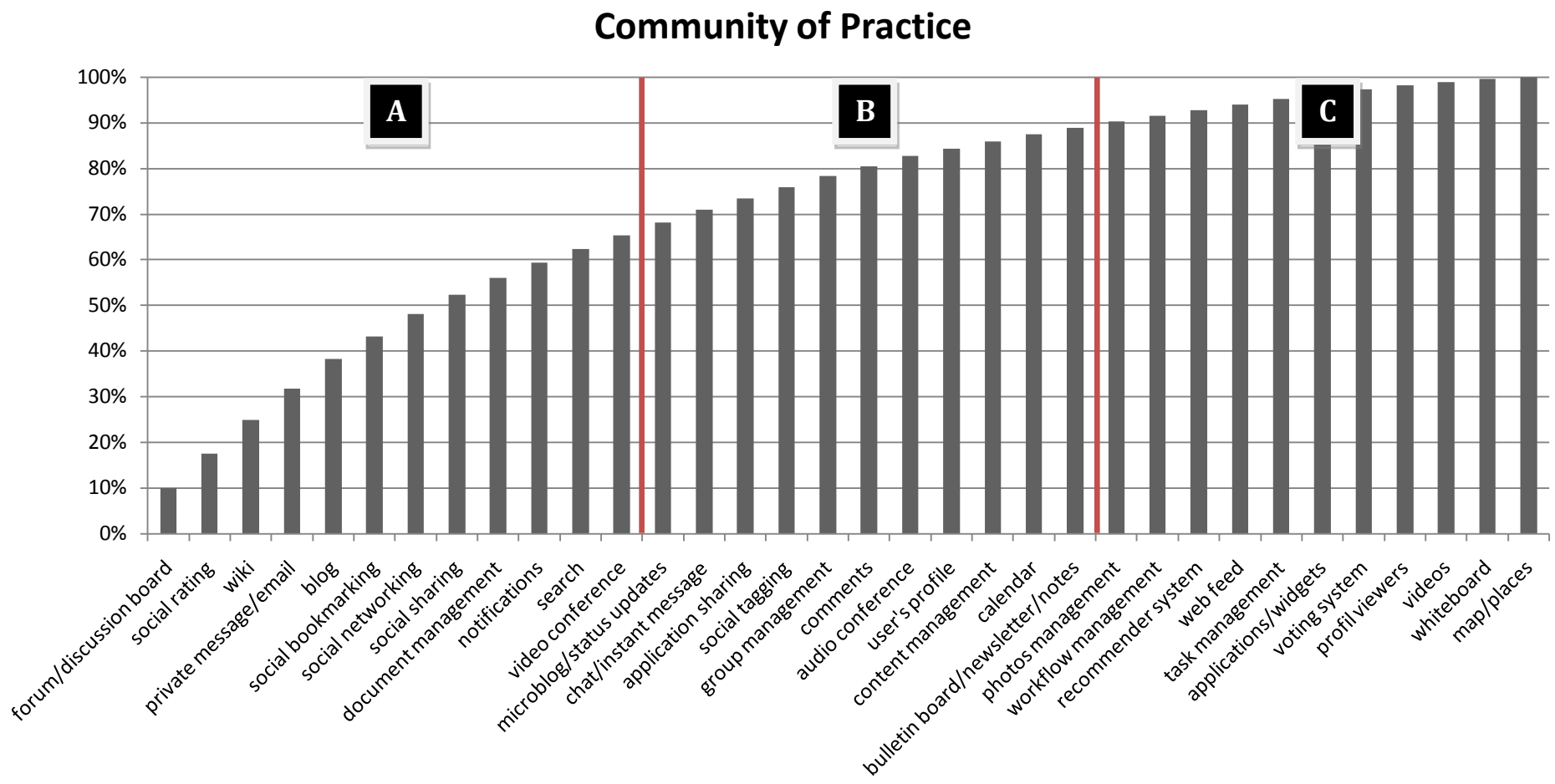

Figure 41. Pareto cumulative chart: Community of Practice