Coordination 2.0: Using web-based technologies for coordination support

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Abstract. This paper presents a coordination framework called Coordination 2.0 describing the use of Enterprise 2.0 technologies for coordination purposes in (virtual) enterprises, first, by summarizing relevant coordination theories and systems in related research, second, by introducing Coordination 2.0 as a framework to support coordination in enterprises, third, by applying Coordination 2.0 in case studies to illustrate how to provide a solution for coordination in distributed work groups, and finally, by presenting a tool based on a questionnaire to capture the coordination qualities of a work group in terms of direct/indirect, explicit/implicit, dynamic/static, situated/predefined, informal/formal, detached/coupled, individual/cooperative, and to calculate the ratio C2.0 to show the degree of artifact-based or oral coordination needed in the work group studied. Cases are described for time-based, product-based, and process-based coordination. Coordination 2.0 combines artifact-based and oral coordination, as well as organizational tools with Web 2.0 technologies. It tries to answer the questions how we can support coordination work in a larger scale by extending the varieties of coordination mechanisms, by opening up connectivity on formal and informal levels, by offering easy use and user configurability, and by integrating private and professional exchange between people. The paper concludes after discussing the benefits and problems of Coordination 2.0.

Keywords: Coordination, Web 2.0, Enterprise 2.0, CSCW, Collaboration

1. Introduction

A collaborative work cannot be arranged without coordination. Coordination becomes much more relevant when cooperation is established between distributed groups, probably located in different companies at different geographic places. Especially in virtual enterprises, where a temporary network of independent institutions, businesses or specialized individuals are built to work together in a spontaneous fashion by way of information and communication technologies, in order to gain an extant competitive edge, coordination systems are essential tools to initiate, monitor, and maintain the distributed interdependent work. Integrating vertically, unifying core-competencies and functions as one organization require interaction on personal and on technology level. This type of interaction is mainly supported by coordination systems building a bridge between human and non-human resources assigned to work processes.

Do existing coordination systems support collaboration activities in virtual enterprises? So far, there are several approaches and systems available for coordination support from different perspectives [29, p.28ff]: support provided by CSCW (Computer Supported Cooperative Work) systems and workflow systems, different coordination models and languages, approaches and systems from artificial intelligence. To adapt Web 2.0 technologies and business possibilities provided by connectivity in the Internet, Enterprise 2.0 offers a platform "that companies can buy or build in order to make visible the practices and outputs of their knowledge workers" [9, p.23].

Considering existing coordination systems and the nature of virtual enterprises supported by Enterprise 2.0, we still identify the lack of the focus on coordination support for enterprises. Coordination is more than communication and exchange between people. It involves managing interdependencies between tasks.

The dynamic character of project work, especially if it is carried out by distributed groups, requires flexible and easy-to-use tools, not only to exchange information between team members, but also to exchange coordinative information by supporting several issues from CSCW perspective like awareness, mutual support, situated action, formal and cultural level of language, sharing material, equality in cooperation, etc.

This paper tries to deal with this problem. It presents a coordination framework called Coordination 2.0, first, by summarizing relevant coordination theories and systems in the related research (Section 2), second, by introducing Coordination 2.0 as a framework to support coordination in (virtual) enterprises (Section 3), third, by applying Coordination 2.0 in case studies to illustrate how to provide a solution for coordination in a distributed enterprise by focusing on time-based, product-based, and process-based coordination settings (Section 4), and finally, by presenting a tool based on a questionnaire to capture the coordination qualities of a work group (Section 4.4) in terms of direct/indirect, explicit/implicit, dynamic/static, situated/predefined, informal/formal, detached/coupled, individual/cooperative, and to calculate the ratio C2.0 to show the degree of artifact-based or oral coordination needed in the work group studied.

2. Theories and systems for coordination

The most of the CSCW systems support collaborative activities by combining the support for content work and the support for coordination in a collaborative application. The coordination is a function of the collaborative application that contains encodings and representations of the content it is dealing with. There are several approaches in the design of CSCW systems which try to deal with the relationship between content and coordination functionality: One approach tried to embed collaborative functionality in new tools [9] [24] [17]. Some studies showed that the introduction of new tools for everyday activities hinders the acceptance of the introduction of collaborative tools [10] [23]. Another approach was based on the collaboration of transparent systems like Matrix [18], DistView [25], and JAM [3]. LaMarca and his colleagues introduced a new approach to the integration of content and coordination in collaborative systems [20]. The so called *document centered collaboration* moves coordination functionality out of the application to documents themselves. For this the document infrastructure must be exploited: documents get resources like operations on documents such as reading, writing, moving, updating to maintain application integrity. By means of active codes associated with the document, necessary actions can be taken. That means that computation is attached to documents, which enforce coordination conventions of a workflow process. At the same time documents are used as conventional electronic documents. There is a middleware layer that enables building active documents [20, p.4]. This layer is located between applications and document repositories like file systems. Through this layer it is possible to execute a certain code when a certain document is accessed.

This approach is further developed to *artifact-based coordination* [11] offering coordination support implicitly in work practices when the workflow driven by artifacts makes use of different types of artifacts, which can be composed or atomic, accessed simultaneously or asynchronously, owned by one or many (which requires version and access control mechanisms), visual or textual, material or virtual, common or private. Some artifacts are shared and host several coordination-related data accessed by many. These artifacts enable (implicit or explicit) communication between actors cooperating. They mediate the status of work-in-progress and make participants aware of others' activities. They sometimes act as coordinators of work by being communication objects, by creating a common understanding of a task, by enabling talking about tasks, by reminding principles, approaches, and methods connected to a task, by keeping track of activities and materials, by hosting work plans, and so forth.

So, one can say that artifacts can be used to initiate and establish coordination within a work group. They can be used to exchange data and deal with dependencies between activities. They can be used to exchange work-in-progress implicitly, to support articulation work, e.g., by representing work carried out, to point out possible and actual gaps in coordinating dependencies between tasks, to communicate the todos explicitly, to assign tasks to persons, to define and refine work to do, etc.

In artifact-based coordination environments, artifacts help reduce coordination effort, e.g., by making coordination a part of the product to be developed or integrated in the product and therefore by making additional communication or articulation obsolete. An artifact can be accessed any time by all with granted access. There is no need for any additional face-to-face or oral communication. It helps avoid communication

gaps and misunderstandings between stakeholders regarding, e.g., the devision of labor, because the information is captured and represented clearly and is available for all involved.

Besides the objectified so called artifact-based coordination, there is spoken *oral coordination*, which is related to artifact-based coordination. To explain the difference we need the distinction between explicit and implicit elements in any communication situation. The explicit elements build the focus and the implicit ones the background for a communication. The background elements reduce coordination workload and complexity in oral coordination [12]. One can notice smooth changes between focus and background paradigms so that speakers can question implicit assumptions. “Oral communication is governed by a protocol of rules and conventions which restrain such aspects as turn-taking, form, and contents” [12, p.84]. Protocols as communicative patterns vary between settings. They are actor or role specific. They form a heterogeneous set of general and specific norms. Some norms are stable over time, some change continuously because of transformations in work environments or in technological infrastructures. Norms act as autonomous, concurrent and heterogeneous guidelines. Some are written instructions, some are embedded in work practices. Norms are communicated explicitly only if they are violated.

On the other hand, in artifact-based coordination the background information is made explicit [12]. Changes between information in focus and in background are not smooth. Additional interaction is needed to deal with uncertainties, mistakes, and other special cases. To stipulate the workflow, protocols are used and made explicit to actors. Because communication is persistent, it is available whenever wanted. This type of coordination provides also an overview of work arrangements.

To specify artifact-based and oral coordination, we need some additional notions [12]. In a *dynamic coordination* changes within a work arrangement are reflected automatically, e.g., they are observed and interpreted and the coordination information is adapted accordingly. In a *static coordination* this is not the case. Oral coordination is dynamic, and artifact-based coordination is usually static.

Organizations and distributed enterprises establish their formal communication channels, on the one hand, to map their formal organizational arrangement onto it, which is very important in case of virtual collaborations, and on the other, to show the flow of the data in an enterprise and to guarantee that information flows as planned, in the expected speed and to the right persons. Certain official mostly regular meetings with a large number of participants, telephone calls among more than two persons, official news bulletins of an enterprise, e.g., are examples of *formal communication*. Predefined rules and conventions are crucial for this type of communication. However, formal channels are not the only possibility to exchange information between people working together. Individual needs, worries, complaints, and sometimes important occurrences like work-related problems are communicated *informally*, the most of the time orally, implicitly, and spontaneously. Not only for efficiency but also for satisfaction of members, both formal and informal communication is essential in en enterprise, especially if project members are originated from different companies cooperating in a specific project. The so called informal workplace communication including interaction and outeraction like “impromptu, brief, context-rich and dyadic" [22, p.79] are important for effective complex collaboration. They are needed for cooperative problem solving including quick questions and clarifications, for coordination of work and scheduling of tasks within the work group, for social bonding especially in distributed teams, and of course for social learning, which is a long-term process in multi-cultural teams. The informality of this type of interactions can be measured in the speed of information or affect exchange.

In an *indirect mode of coordination* the information is provided allowing one to assess what to do. The information signifies a state of affairs within the field of work. No detailed knowledge about the tasks being coordinated is needed. Normally a shared artifact can be a good help to transmit coordination information between cooperating partners.

In an *explicit coordination* one tells to another what to do, and does not communicate *implicitly* by using a common artifact, which is handed over to the person addressed. There is an explicit specification and articulation of the task to be performed. This requires that the coordinating agent has detailed knowledge about the activities being coordinated.

If state changes in a coordination cause a state change outside the coordination then the coordination is *coupled* to the field of work or the work arrangement. While oral coordination is *detached* from the cooperative work arrangement artifact-based coordination is coupled because some artifacts act as work tools and coordination means at the same time [12] [19].

If a cooperative work is defined before hand, normally by using a workflow system, including all tasks and dependencies between tasks, then we are talking about *predefined coordination*. Planning all steps in a work process without letting a space for improvisations and forcing people to do certain things at certain points in time, does not support *situated* action by protecting the work flow from people's interventions.

Most of the work is normally done *individually*, which of course needs to be coordinated also by the same person. Sometimes there are interfaces who need to be defined in cooperation with others, by coordinating the work between different parties working together. Decisions must be then made in a *cooperative* manner, the coordination of single tasks must be done also together.

The Table 1 systemizes the different types of coordination as the persistent artifact-based coordination versus the non-persistent oral coordination, by showing characteristics assigned to them.

Artifact-based coordination	**Oral coordination**
static	dynamic
formal	informal
indirect	direct
implicit	explicit
coupled	detached
predefined	situated
individual	cooperative

Table 1
Artifact-based coordination versus oral coordination.

There were attempts to enable *asynchronous collaboration* around documents by using *in-context annotations* [11]. These annotations are tightly linked to specific parts of a document that is accessible from a web browser. An additional access control mechanism regulates viewing and editing, a notification system is used to inform relevant actors about new annotations.

Due to their differences in formal representation, we have to differentiate between document- and activity-oriented workflows. *Document-oriented workflows* [1] concentrate on providing an environment for sharing common artifacts through replication (e.g., Lotus-Notes), event notification (e.g., GroupDesk), locking and versioning (e.g., CVS[1] or SVN[2]), defining of semi-structured routes attached to shared documents. This is in contrast to *activity-oriented workflows*, where processes are modeled as sequences of activities what documents are attached to.

Rule-driven coordination can be provided by agents [4]. Rule-Driven Coordination Agents are middle agents [15] acting as brokers to individual components in component architectures. They encapsulate the interaction policy definition in terms of rules and aspects of communication, data management and policy execution. These rules are in form of Event[Condition]Action and implemented in several systems [5] [6] [7] [8].

Inter-organizational workflows are defined as a set of loosely coupled workflows and an interaction structure. They define two types of dependencies among activities: asynchronous and synchronous. For instance, in the WISE Project an infrastructure for business-to-business electronic commerce was developed [2]. Virtual business processes can be specified, enacted, monitored, analyzed, and managed. Or, in CrossFlow processes in virtual enterprises were described centrally and executed cooperatively [14]. The CMI Project introduced methods and tools for defining processes that compose services provided by different companies [16]. Casati and Discenza modeled how workflows can publish and subscribe to events by enabling the definition of points – the so called *event nodes* – in the process execution where events should be sent or received [13]. They also provided a simple language "by which event nodes specify filtering rules over events of interest, based on the values of event parameters and on properties related to correlation among event instances" [p.196].

Some of the technologies of Enterprise 2.0 [21] are very crucial for coordination purposes. *Search* enables finding resources to solve a current problem or to rearrange the work setting because of emerged circumstances. One must be able to find what one is looking for. This can be a person, a group of persons, or a piece of knowledge. Keyword search as pre-made categories, tag search as user-defined categories, or searching by example are technologies available. *Authoring* in Enterprise 2.0 means to write for a broader audience. This can happen by means of weblogs for individual authoring, wikis for iterative group authoring or micro-blogs for individual short authoring. People want to contribute with their knowledge, others will actively interact by means of comments, ranking, or additional links. People add new content, undo or redo each other's work. *Tags* are simple, one-word descriptions added by readers of (web) content. Not imposing

[1] Concurrent Versions System, http://www.nongnu.org/cvs/
[2] Subversion, http://subversion.tigris.org/

an up-front categorization scheme opens up new possibilities of key-wording, identifying information infrastructures and relationships that people actually use, filtering relevant information, and keeping track of the platforms visited by people. *Signals* inform users about new content of their interest. E-mail alerts or RSS (really simple syndication) query sites of interest for new content, making headlines available for people. This makes surfing constantly obsolete.

3. Coordination 2.0

Besides the available tools for coordination support, what is in fact needed for coordination of work? Let's think about possible actions in coordinated work environments. We have normally to discuss issues. Sometimes we have to negotiate more or less hardly and try to find a solution what we then have to decide centrally or distributed. We meet others, which we have normally to schedule beforehand. Our work must be articulated the whole time, very often we look for support of others. We estimate our own staff effort or of others. We define dependencies between our work and try to establish mechanisms to manage the identified interdependencies. Especially in complex projects, we distribute the work and constantly integrate intermediate results to one common piece of work. To support the management of work dependencies we create or choose coordinative artifacts and conventions or procedures within the work group. We want to know how to access common resources, how to create common artifacts – this not only regarding their format but also their semantic. Of course we need to monitor the ongoing tasks and compare our work, and so forth.

So, the question is how can we support coordination work in a larger scale by extending the varieties of coordination procedures, the openness of connectivity on formal and informal levels, the easiness of use and configuration, the integration of private and professional exchange in one, and to give attention to both content and coordination work. The answer to that is Coordination 2.0, which is a framework describing the use of Enterprise 2.0 technologies based on Web 2.0 systems for coordination purposes in (virtual) enterprises. It combines artifact-based and oral coordination, organizational tools with Web 2.0 technologies (Table 2).

Coordination 2.0 expands the borders of a traditional coordination system by including social and personal environments of persons cooperating to achieve a common goal, no matter whether it is an enterprise with distributed offices, or a (virtual) enterprise consisting of different companies around a common project.

Coordination 2.0 enables the use of multiple media throughout a communication event, like instant messaging, shared workspaces, configuration management repositories, tagging and searching, at the same time, not only during meetings but also in usual periods of work. Informal communication is supported by instance messaging or micro-blogging. Instance messaging is mostly useful to initiate a conversation [22]. Though, less awareness information would be better to avoid participant asymmetry. Coordination 2.0 must consider this problem and offer user-configurable awareness feature in instance messaging tools.

To manage *interdependencies*, answers to the following questions must be given: Are there known interdependencies between tasks, product parts or allocation of human and non-human resources for the project? Are there resources shared between groups or individuals? Are there producer/consumer relationships where prerequisite constraints, transfer or usability of outputs must be considered? Are there activities, which must be executed simultaneously? Are there tasks, which are divided into subtasks having sub-goals? How can task decomposition be done in such task/subtask dependencies?

Coordination 2.0 meets the requirements for managing interdependencies in following terms:

Shared resources: The main shared resource in Coordination 2.0 are common coordinative artifacts and people. The allocation of these non-human and human resources can be provided by several technologies, e.g., by establishing and monitoring access rights to access certain common artifacts to dedicated periods of time, by offering awareness information about the shared resources, like showing the status of a resource, last access to it including updates and notes provided by different actors, or the history of the resource created by all, by tagging, commenting or ranking the shared resource, by searching and displaying the results of a customized search process, or by handing over a token.

Producer/consumer dependency: Monitoring the progress of work and the status of development of producer makes the consumer aware of the actions of producer. In case of unexpected situations or problems, consumer can contribute or can be involved to solve a solution quickly. Monitoring and following the progress happens by presenting the status of the task or artifact preferably visually. This can also be a work-

Coordination 2.0 support for artifact-based coordination	Coordination 2.0 support for oral coordination
static: artifacts like emails, documents in common information spaces	*dynamic*: texting, voicing, (video) conferencing, blogging, micro-blogging, commenting, ranking, tagging
formal: todo-lists, workflow systems, emails, specific documents	*informal*: VoIP (audio, video), additional personal information, texting, voicing
predefined: workflow systems	*situated*: customizable CSCW systems/groupware
indirect: common artifacts	*direct*: texting, computer conferencing, VoIP (audio, video)
implicit: common artifacts	*explicit*: texting, computer conferencing, VoIP (audio, video)
coupled: common information spaces, groupware	*detached*: wiki, shared resources, version controlling systems
predefined: groupware, workflow	*situated*: common information spaces, version controlling systems
individual: single -ser configuration management systems, personal to-do lists	*cooperative*: multi-user configuration management systems, social awareness, presence display, availability, double level language

Table 2

Coordination 2.0 consists of technologies to support artifact-based and oral coordination.

flow system, in which status change can be shown by coloring or by moving a token. But the main mechanism to create awareness is notification. It avoids temporal gaps between delivering the output and starting with the output of producer as an input by the consumer. Notification mechanisms are RSS feeds or micro-blogging with a short message of the producer to consumer following producer's twitters.

Simultaneity: One of the strengths of Coordination 2.0 is the support of simultaneity. On the one hand, enabling oral and multimedia communication between cooperating people, on the other, having simultaneous access on common artifacts and authoring these shared artifacts in real time are provided by several Web 2.0 tools, like instance messaging, computer and video conferencing, VoIP, model and text editors for co-authoring. Simultaneous access can be logged to facilitate future history tracking in case of articulation of work or decisions made in the project.

Task/subtask dependency: The main mechanisms for managing task/subtask dependency is notification by means of RSS or status visualization. Delays or interrupts in subtasks are made transparent on the level of entire task by means of notifications, event visualizations, or work awareness functionalities. Describing or commenting tasks or their products and the interfaces to other tasks including their outputs as blogs or wikis in which co-editing and tagging is possible is another mechanism for this matter.

The next issue is how the *distribution of work* is covered in Coordination 2.0: How is work distributed within the work groups? Who decides on what base to assign persons to tasks? How are dependencies between works of project members defined and monitored? Are meetings used to discuss the work progress and (re)distribution of work in ongoing projects?

Distribution of work is determined by the organizational structure of a cooperative project. This can be top-down and centrally decided, or bottom-up and distributed. The nature of a project has also impact on this. Routine work can be split into subtasks, which can be assigned to according people, mainly based on experiences gathered so far in an enterprise. Non-routine work can be completely new, risky, with uncertainties, complex, and unforeseen. In this case, job matching can be done by involving the project members. A common tool like a shared todo- or issue-list, possibly integrated in an electronic shared calendar with texting and emailing facilities can be configured as a shared platform for project members. Meeting facilities with or without moderation, documentation and instance messaging, configurable for private or shared texting, help to discuss and negotiate the assignments or considerations to rearrange the already finished work distribution. Meetings can be arranged in different scales, using different media, more or less sophisticated visualization facilities.

Regarding the *planning and execution* of interdependent tasks we have to ask the following: What is the role of plans during the execution of project steps? Are plans used during the project as active documents? Are they updated regularly and referred to during the coordination of processes?

In Coordination 2.0, plans can be used as an integrated part of coordination mechanism. Initiating tasks

as they have been planned beforehand can be implemented by a trigger, causing according notifications to relevant members of the project, or showing the status in an awareness system. Plans can be used as common coordinative artifacts, which all project members have access to. Or they can be protected from all, being owned by its creator. This is again a decision of the work group. For both there are tools supporting the process.

How and how often are *decisions made*? Who is involved in the decision-making processes? What types of artifacts are used to support decision-making process?

One of the most important issues considered in Coordination 2.0 is to support decision-making. As mentioned in the description of work, decisions can be made during meetings, where Coordination 2.0 offers a lot of different tools. Decisions can be also made about issues other than distribution of work, like decisions about technology or partner choice, about features or scales of a product, about tools and development environment for production or other processes in the project, etc. For all, detailed information is needed to prepare the decision-makers for the process of decision making. Information can be gathered and cooperatively edited by authoring systems offered in Coordination 2.0. In a blog, remarks of others to a piece of information can be captured and included in the decision process. Ranking, tagging and voting are supported, even if no dedicated group decision support system is used.

What about the *coordinative constructs* in Coordination 2.0? What type of specialized artifacts is used to support coordination? Are coordinative constructs formalized, and do they have impact on organizational structure? What ordering systems in use can be identified?

Coordination 2.0 hosts several coordinative constructs like common artifacts meant to be used as shared todo-lists, co-authored documents managed in a configuration management system attached to an awareness mechanism, which displays changes to it, and of course also all notification and communication systems necessary to organize access onto and exchange tacit and explicit knowledge about the common artifacts. Coordinative artifacts make coordination information permanent and can be accessed whenever necessary. Form-based artifacts like database entries accessible for all project members can be the coordinative artifact to formalize processes in an enterprise. Naming the artifacts, procedures and norms in doing things can be described formally to ensure the establishment of a standard in carrying out processes.

Regarding the *coordination mechanisms* the important questions are: What is the coordinative protocol in the group? Which set of conventions and procedures are established in the cooperative work environment? How is coordination carried out during the project? Are there differences between coordination practices of routine and non-routine work? Who is in charge for coordination in different phases of the project? What type of coordinative artifacts is used for coordination purposes, by whom? More systematic questions like, is standardization, direct supervision or mutual adjustment necessary or applicable for coordination purposes?

In Coordination 2.0 a coordinative protocol can be implemented by using a dedicated coordination system like a workflow, or by using a composition of tools used also for other type of communication and exchange with people other than in a project. Coordinative artifacts described earlier can be combined to create a specific coordination protocol to a certain group working together.

4. Application of Coordination 2.0

Based on our long-term ethnographic studies and previous research work, we differentiate between different settings of coordination, in which coordination is driven and managed by several factors. In this section we first briefly describe the identified coordination settings [12] by using the terms described in the previous section (interdependencies, distribution of work, planning and execution, decision making, coordinative constructs, and coordination mechanisms), and second, we show how Coordination 2.0 supports these coordination environments by illustrating its application in cases we studied so far.

4.1. Time-based coordination

In time-based coordination, interdependencies are managed by defining and agreeing on deadlines and temporal conditions in a project. These deadlines drive the projects. A time-based approach is used by project managers to create a project plan, starting from the end delivery date by calculating the time periods backwards, in which certain activities must be carried out. For cases of unexpected contingencies, buffer times could be of a great help to create temporal space for

improvisations. Simultaneity is common and coordinated between the persons directly involved. Decisions are mainly made distributed. Meetings are used to up-to-date the project progress and, in case of troubles, to reallocate resources. Regular meetings are used as coordination mechanisms. With a todo-list as a coordinative artifact, the status quo of project progress can be captured and modified if needed. No additional coordinative constructs are needed. Success is measured mainly if deadlines are met, and of course, only in case of delivering the expected results.

The task of *Telecom*[3], which is a development team of four designers in an international telecommunications company, had been loosely defined as designing and developing innovative products and services by using the very newest technologies with the degree of innovation and the speed of the design and development being considered the main success factors. Being part of a large company, they have to make use of its products in their projects: infrastructural elements they need for presenting their product at a trade fair, such as file servers, networks or a demonstration server on site; or technology solutions developed for very specific mobile devices. This creates sometimes constraining dependencies.

In our previous work [27] we identified the following characteristics of work processes in multimedia companies like in *Telecom*: the iterative character of the design process, the multiplicity and the special role of representations (storyboards, mock-ups, prototypes, etc.), the lack of design methods (in comparison to software engineering) and best practice examples, the cooperative character of the design process and the relevance of intensional networks and strategic partnerships. In our case studies in multimedia production teams we could observe most of these characteristics. At the same time we identified interesting differences in work practices and similarities in coordination work.

Multimedia production is an intensively cooperative endeavour. There is a need to arrange collaborations dynamically among both, internal and external, professionals. Coordination of several parallel activities is a demanding task – especially for the coordinator or project manager. Keeping deadlines and customers' requirements in mind and using companies' human and non-human resources effectively call for sophisticated coordination processes, which might be supported by computer systems or other types of mechanisms.

In *Telecom* most of the design work is carried out in the team. The team members come from different disciplines (graphic designer, software developer, system analyst, and project manager) and each of them has a crucial role and responsibility for all activities. Although their communication is rather chaotic, they are well-organized, always present in the same room and involved in all decisions – no matter whether technical, strategic, or organizational. For one of the team members "the consensus is the product". There is no hierarchy in the team. To have fun while working is as important as to be open to critique and discussion and act as a competent member of the team. The most important thing is that the members participate actively in the design process.

This small team works in isolation from the rest of the department, not only locally. They talk about themselves as a "garage company". Their work is not accepted and appreciated by the large software engineering team within the company from which they split off. One reason for this is the difference in style and working culture of both teams.

In *Telecom* several artifacts are used simultaneously during meetings: flip charts, PDAs, desktop computers, sketches and notes on papers or computers, lists, MS Word documents, spreadsheets, Web browsers, a wallet, the image of the wallet, etc.

The main constraint in the projects of *Telecom* is the date of the trade show. It is an annual event and all mobile communication companies need to join the trade with their brand new products or services. This is always the main step to be present in the current market. If they miss one year they have problems in acquiring customers during the whole next year. Being aware of this strong constraint, *Telecom* tries to design new products and services within a relatively short period of time.

The distribution of work is done by the competencies of the group members. In emergencies the whole group acts together, to solve a problem or to distribute the unexpected additional work in the group. Improvisations are usual.

Decisions are made mainly cooperatively, because the time-dependant definition of project work has impact on everyone's work. Short regular meetings are

[3]Our study was conducted as part of the research project "Systemic Integration of Production and Services. Case Studies in the Software and Multimedia Industries", in cooperation with the Brandenburg University of Technology Cottbus and DJI Munich (2001-2003). The descriptions of this use case is partly based on [26]. We spent couple of months observing the team and their work processes in *Telecom*.

the place of decision-making. Overhead in staff effort like writing down the work hours, minutes of the meetings, documenting design decisions, commenting the code, etc., is kept very small. If it is necessary, quick and dirty solutions are common to overcome difficulties in the production.

Success is measured in meeting the deadlines by expected results. Of course, it is crucial to come up with new ideas, new features, and attractive services at the trade. The output is measured by its quality and by the interest visitors of the trade event show. Still, everything must be ready to show at the trade, the point of time is the most important requirement to the process.

Coordination is carried out in an ad-hoc manner. If a decision has to be made, e.g., regarding the technology used, features planned, problems occurred in work processes or in cooperation with suppliers, the small team come together, no matter what the single members are doing at the moment, to discuss the emerged issues. They do not stop until they decide how to deal with the situation and what to do next. So, they coordinate their work situated, even sometimes they rearrange everything they planned to do beforehand. This flexibility is only possible, because the team is a very small team, team members know each other very well, they trust each other, and they help each other.

In time-based coordination settings, like illustrated by *Telecom*, Coordination 2.0 helps to overcome distance problems and to organize the rather chaotic way of working together. Using instance messaging builds a channel between team members, who need dense interaction in all activities, e.g., to decide what to do next, how to improvise in case of problems, what to prefer in user interface design and in interaction features, how to achieve consensus regarding processes and product's features. The most critical restriction is time, forcing people to act very quickly. Team members must be available any time. Decisions have to be made when needed. Minutes or todo-lists must be created in an ad-hoc manner and the artifacts produced must be available for all any time. Coordination 2.0 offers a common platform to meet all these requirements.

To create and maintain trust depends on private/social informal exchange. Being in the same electronic social network, sharing ideas and opinions, reflecting on each others' likes and dislikes communicated freely and regularly, even planning how to spend spare time together are some issues facilitated by Coordination 2.0. This is a must in a project with a time-based coordination. Besides all these, accessing the shared artifacts without conflicts, and documenting the process or the product iteratively or cooperatively provides a systematic approach to the work, which speeds up the work progress.

4.2. Product-based coordination

A complex product is divided into sub-parts, which are assigned to different persons or work groups. Interfaces between the sub-parts are defined. Interdependencies between sub-parts determine the coordination of work in the whole project. On the one hand, the implementation of the interfaces agreed on, on the other hand, the timeliness in delivering the planned parts in planned quality and quantity are main issues contained in coordination protocols used. Project managers deal with these interface definitions and dependencies between the productions of sub-parts. They create a plan mapping the product structure and assign groups to the sub-parts. They monitor the progress of work on sub-parts, intervene in case of problems, and reallocate resources, if necessary, depending on the availability. Problems occurring between sub-groups can be of different types, personal, technical, commercial, complexity-related, or strategic. Regular meetings can be very useful to bring different groups together to exchange their work progress and other issues relevant to all. Configuration management tools or other central common information spaces are used as coordinative artifacts enabling standardization of protocols. Decisions are made centrally involving the responsible persons for the sub-parts letting them to negotiate their open issues. Success is measured in the quality of the product, in its integrity, completeness, and unity.

In *Carcom*[4], the initial phase of the core of the development process of a vehicle is called Target Setting (TS). It is the definition of the technical and economical objectives that will drive the vehicle development until the production. It follows a methodology that has the aim of ensuring the achievement of the satisfaction of the customer by means of the definition of product specifications coherent with the performances expected by the customers.

There is a weekly meeting within the TS Process at *Carcom*. This TS Meeting is the place where participants involved look, e.g., for side effects of changes

[4]We carried out ethnographic studies in a European STREP project called MAPPER (Model-based Adaptive Product and Process Engineering) (IST-016527) at three different industrial sites. Two of them are *Carcom* and *Chipcom* that we refer in this section to.

in sub-systems or for impacts on other sub-systems. The TS Meeting is used to discuss work-in-progress, open issues, and planning for further activities in TS Process. It involves OEM and suppliers: the owner of the development, his assistant who acts on behalf of the owner of the development for technical and administrative issues, approx. 20 Performance Engineers (PEs) who are responsible for the target definition and achieving of sub-systems, component suppliers who supply systems, sub-systems or components in co-design with *Carcom*.

Pre-meeting activities. Normally the assistant has the agenda of the last TS Meeting. This agenda is a list of open issues. It is a structured list of problems with suggestions for possible solutions consisting of the issue, possible solutions, responsible persons, and deadlines. He sometimes performs a simulation of the complete vehicle, using simplified simulators, and looks for discrepancies in results. Otherwise he checks the results of simulations run by PEs. All simulation results are available in a repository.

Between two TS Meetings, suppliers sent the PEs or eventually the assistant information on their new offers, which include the specifications and technical performance of the refined components. The responsible PE receives the supplier's updated offer and updates the simulation data in the central repository containing all specifications of all sub-systems. He can also trigger the simulation. The simulation repository keeps track of different versions of simulation results and the specifications that were used to configure simulations. The supplier always contacts directly the PE.

For critical sub-systems, the supplier sends the information to both, the PE and the assistant. The assistant updates the agenda of the last TS Meeting with an analysis of the simulation results he finds in the simulation system and information he receives from the suppliers. He analyzes the data and decides whether or not the issue is solved. The simulation system identifies inconsistencies in the entire car system considering all sub-systems. These inconsistencies are new items in his agenda for the next meeting. Then he puts the agenda to the repository. All agendas of previous meetings are also saved in the same repository.

In case of inconsistencies between two in-house-components the assistant invites the responsible PE of the other systems. He, in collaboration with the development owner, decides who needs to be invited. The development owner sends an e-mail (a MS-Outlook invitation) to all participants he wants to invite including a link to the central repository containing the agenda.

Meeting activities. All meet in a meeting room. There is a projector with a computer. The assistant has the keyboard and moderates the meeting.

At the beginning of the meeting he shows first all issues solved during the week and consequences of the decisions taken in the last meeting. If there is nothing additionally to talk about these issues, these are dropped from the list. An issue item can last for a month at most. Issue list is a structured list of problems with suggestions for possible solutions consisting of following data: the issue, possible solutions, responsible persons, and deadlines. This simple document is also a working document, used in its paper-version.

The assistant goes through the list issue by issue, describes the issues and if available their suggested solutions. He does not make modifications to the issue list (except dropping the ones that are solved). He writes the minutes including the decisions taken during the meeting into another document. Minutes are communicated with authorised persons. The issue number is used to relate minutes to issue list items.

In these weekly meetings, decisions about components are made. For each sub-system the responsible PE discusses with his suppliers about his sub-system and its components considering alternatives for technical specifications. They verbally discuss several hypotheses for alternatives for specifications and for targets that can be achieved. All PEs whose sub-system is somehow related to the sub-system that is being currently discussed contribute to the discussions. All impacts on the performance of other PEs' sub-systems are addressed in the TS Meetings.

During the meeting sometimes other people, which are not present but needed in the meeting are called. The meeting room is in the middle of the physical space where people are working on the same platform. The assistant calls other PEs – even additional people from outside the project – if it is necessary. These persons attend the meeting. If the persons in question are not available they participate via teleconferencing.

Post-meeting activities. The specifications document of the car can be modified and refined after each meeting by the assistant. The PE verifies together with corresponding suppliers the decisions taken during the last meeting. Each new alternative is characterized, simulated, and the target is evaluated. If the alterative is not good enough they iterate this process several times until the next TS Meeting.

The PE and his suppliers cannot consider another alternative for the sub-system, this can only happen during a TS Meeting. They just tune the parameters of the

chosen alternative to get better results of the simulation, to compromise between cost, design target, and technical feasibility.

In this type of product-based coordination, Coordination 2.0 is useful to support the main instrument of coordination, the regular meeting (here the TS Meeting). The pre-meeting artifacts like the agenda and all agendas of previous meetings, the repository where the relevant information is shared by project members (like simulation results and analysis with their old versions, change requests, concerns about dependencies and impacts on other sub-systems, etc.), the list of open issues (being a part of the agenda), and even the invitation messages, can be host and managed by Coordination 2.0. The technologies needed here are shared information spaces with configuration management facilities and notification systems, shared issue lists linked to other artifacts, and a platform enabling channeling between people involved. During the meetings besides providing access to the current artifacts, it must be possible to establish additional connection to people from outside if needed. This calls for openness and being able to reach anyone any time by multimedia connections. In *Carcom*, if a PE is missing and during the meeting it comes up that there will be an impact on a sub-system which was not considered so far, the PE of this sub-system must be contacted. This is normally done by a telephone call, where information like simulation results, technical data about the sub-parts, etc. cannot be communicated in an ad-hoc manner through oral communication. Coordination 2.0 would solve the spontaneous connecting of people to a meeting by providing a communication channel and a shared platform to share current artifacts. After the meetings, documents modified so far will be available to all, by additionally adapting other related documents regarding the decisions made during these coordination meetings. A systematic documentation of minutes with accessibility for people involved and keeping track of actions carried out with awareness information taken help to coordinate work between the meetings. Because of the sensibility of product information, the coordination platform used must be protected from outside world, by offering, at the same time, access to the project members and space to build up their communication channels if necessary. This challenge is met by Coordination 2.0 by integrating secure internal enterprise platforms with open channels created in Web 2.0 environments.

4.3. Process-based coordination

Processes are predefined, well structured, and in most parts routine. Several groups are assigned to parts of the processes. A workflow or likely system is used to model the processes and to monitor them in real time. It is the only coordinative construct and defines the coordinative protocols. If there are deadlocks or problems in carrying out certain tasks in the workflow, project managers intervene and reallocate resources or reassign people to tasks. In a supply chain or customer relationship, coordination of work goes further to externals like customers, suppliers, distributed teams from other locations, etc. The system used embodies the coordination mechanism. It enforces people to do certain things in a certain order. To skip or postpone a task is almost not possible. Modifications of workflow can be done in some cases, but normally not in an ad-hoc manner. Improvisations are difficult or impossible. Meetings can be useful to work around the system, or for reallocation of resources. In such work around settings, the cooperative work can also be coordinated directly by people involved. This type of coordination is usually not coupled to the system used. Decisions are made centrally which may then modify the workflow system. People carrying out the work are not included in decision processes. Success is measured in the workflow system. A project of this kind is successful if work processes are carried out according the workflow in an efficient way.

Chipcom has installed a system called TRMS to support distributed design. TRMS can be accessed by multiple users at the same time, and long jobs can be invoked and reported. A sequential workflow is integrated by automating some steps in simulation and evaluation. The aim was to support distributed design between the location A (digital design), B (prototyping), and C (analogue design).

One of the engineers at A working for the USB project performs a synthesis with support of TRMS. After the synthesis has been completed, TRMS sends the results to the CVS repository, which is also accessible from B, where the engineer at B can download the file and start FPGA prototyping. One of the advantages is that the synthesis can be done on one machine (with one single license); the other benefit is that if the engineer at B finds a small error, he can fix it on his computer and invoke the synthesis again remotely. The engineer at A has found a bug, which he needs to correct in the source file. He updates the actual source file

locally, uploads the modification to the repository, updates the file in TRMS, and starts the synthesis again.

Different artifacts are created in this process: log files from the synthesis, where engineers can look for warnings; the result, which is a binary file in MCS format, used for FPGA prototyping, with the software only being available at B; and the scripts, which are evoked by TRMS, which are shared with C in the form of a Netlist.

When the synthesis has been completed, which is hard to predict, the engineer at A switches to the internal chat forum GaduGadu to inform his colleague at B that the update has been completed. He does not chat in the system attached to TRMS "because it does not work".

The engineer at A, who has used TRMS for a few weeks for hardware verification together with his colleague at B, comments: "This is a good thing that everything is automated. There is no possibility to run the wrong script, you are sure that the actual sources are used, you don't have to think about which file to update, it is simplified now, TRMS does the CVS update".

Having a common workflow system makes for all engineers possible to run and debug others' code. However, due to ownership reasons no one tries to fix a bug in the code of a colleague. One can report or discuss bugs found in others' code, but fixing it is the responsibility of the owner of the code. This is a convention in the company and in this way it is an organizational issue. Even the technologies make the handling otherwise possible, the norms established in the company determine how to act and setup the constraints for work processes.

From our observations and discussion with the engineer at A we could identify several issues in TRMS:

- There is no synchronization support, that means there is no way of knowing who else is currently accessing TRMS.
- There are open awareness issues, such as insufficient feedback about the state of the synthesis and no notification when it is completed.
- Although the TRMS team always supposed, "that there would be a workflow manager", they are currently discussing to enable engineers at A or B to configure the workflow.

So, synchronization, awareness, and configurability are features needed by engineers at *Chipcom*, which is barely provided by the system used. To overcome this gap, engineers use texting to communicate with each other, for notification but also for exchange of pieces of code or makefiles to decide how to change them. Not only in the process of simulation, also in design and development phases, engineers in *Chipcom* are used to contact their colleagues of other branches to ask them question about coding (if there is a special case, which must be considered by all), compiling (the exact compiler options) or debugging (when they debug each others' code) issues in development of electronic devices. Even if there are possibilities to message instantly in the workflow system they use for simulation and testing on the common platform, they prefer to use freeware instance messaging systems to maintain their contact to their colleagues.

These chat applications show on the one hand the availability of each other. In case of uncertainties or need for clarification, they contact a knowledgeable person in their "buddy list", who is actually online and available at that time. They normally did not use the chat system intentionally for their work. It is just the tool they prefer to use for any type of contact, actually mainly for their private informal communication with their friends. Because everyone is using the same system, they know that they can reach anyone they want to contact. So, they have added their work partners into their buddy list and communicate with them when needed. This type of networking is essential to speed up the engineering process and development, since virtual and physical production used the same simulation and depended very strongly on each other.

4.4. C2.0: Ratio of Coordination 2.0

What type of coordination support a company needs can be determined by the ratio of Coordination 2.0, C2.0. This ratio shows the relation of oral coordination to artifact-based coordination. E.g., if C2.0 is over 50% than it means that the company needs such coordination tools that support dynamic, informal, direct, explicit, detached, situated, and cooperative ways of working and coordinating. If the ration C2.0 is under 50%, the needs are the other way around. To calculate the ratio C2.0, a questionnaire is used to capture coordination activities carried out in an enterprise. This can be filled in easily by companies directly or consultants involved in the decision process of IT introduction. The questionnaire to capture the type of coordination support for a company is implemented and evaluated in this research. It is a basic tool and uses the dimensions introduced in Section 2. The questions can be answered by "yes" or "no". The answers are

categorized in terms of artifact-based coordination or oral coordination. In the example (Figure 1), one can see how the questions are answered for our cases. If we analyze the answers, the following results can be stated: *Telecom* is a dynamic company and the coordination processes established need support for dynamism, informality between project members, directness and explicitness in communication, detached and situated way of working, and cooperativeness in the team. *Carcom* is a more static and formal company. The processes are strictly coupled and less cooperative. A certain degree of explicitness and directness is necessary to coordinate the product-based collaboration within the company. *Chipcom* tries to change the work habits from oral coordination to artifact-based coordination, but still needs support for informality, directness, detachment and cooperativeness support by Coordination 2.0 environments. The results are represented in Figure 2.

	Telecom	Carcom	Chipcom
Dynamism	100%	20%	20%
Informality	100%	20%	40%
Directness	100%	40%	60%
Explicitness	100%	40%	20%
Detachment	100%	0%	60%
Situatedness	100%	40%	40%
Cooperativeness	80%	20%	60%
C2.0	97%	26%	43%

Fig. 2. The Coordination 2.0 (C2.0) ratio calculated for our three cases.

5. Discussion

Why is using Coordination 2.0 an added value to coordination practices?

Coordination 2.0 encourages project members to communicate with each other more freely. They have a personal space to initiate and maintain their networks, assuming that these additional exchange, outeractions, will have a positive impact on the cooperative work.

Coordination 2.0 tools are rapidly being improved, faster than ones, delivered by dedicated vendors. Tools like Doodle, e.g., are used easily to find a common time slot to meet or to organize a group of people. People prefer Doodle even if they have electronic calendar in their Intranet to schedule meetings. These tools enable linking to people or experts from outside if needed. This makes sense in collaborations with suppliers or third parties. On the other hand, Coordination 2.0 tools provide a space to work around formal structures established in an enterprise normally forced by an Intranet system.

Coordination 2.0 offers tools to combine different channels in coordination, private with professional, one-to-one with many-to-many, oral with textual and multimedia. Tools are free to choose considering one's preferences instead companies regulations. This stands for a bottom up approach by offering more freedom, flexibility, and confidence to people coordinating themselves. Tools are more sophisticated, releases are very often, usability is corrected regularly, and in most cases, the documentation and online help are efficient.

Actually it is not about to decide either the company-wide established internal coordination tool or Web 2.0, but it is about Coordination 2.0 which combines both by trying to get most benefit of both technologies. Web 2.0 tools can be integrated into the Intranet solutions. Interfaces from proprietary systems to open standard tools are essential. For instance, formal exchange can be provided by proprietary coordination systems in the Intranet of an enterprise, but informal communication and personal networks are best established when project members themselves decide which tool to use for texting or blogging.

One of the reasons for Coordination 2.0 is the possibility to reach people better because Web 2.0 technologies are widely distributed, almost everyone working in companies have an Internet access and are integrated in social software platforms. The more people are available and reachable in a communication system, the more that communication tool will be used. The success of Coordination 2.0 depends on this phenomenon. However, the question remains: Is it better to have contact to a person, e.g., in Facebook you are working with? Do you really want to spend time with your co-workers at your spare time? Is this similar to the situation as if you would go to the fitness studio with your boss or your colleagues? Is this desirable? These questions can only be answered by people personally. But some remarks can be made here briefly: First of all, you can gain more trust to a person you work with by using these private channels. Once you have his or her trust, you can easily keep it. Second, you can get to know a person better because you are socially aware of this person. You have better understanding of his or her actions knowing his or her social environment and motivations. Third, the informal communication between people are better supported, especially, knowing that the outeractions are not followed, monitored, logged, and inter-

Questionnaire	Telecom		Carcom		Chipcom	
Dynamism	Yes	No	Yes	No	Yes	No
The shared artifacts are locked by single persons only for a short time; they are always available for all any time.	1			1		1
Temporal conditions like deadlines drive the project work.	1		1			1
Responsibilities and roles can be changed very often.	1			1		1
Improvisations are often necessary.	1			1	1	
Decisions are made often, immediatelly when they are needed, especially during ad-hoc meetings.	1			1		1
	100%	0%	20%	80%	20%	80%
Informality	Yes	No	Yes	No	Yes	No
Project members comment on work processes in between the work, during breaks, not only in work environments, etc.	1			1		1
Project members are partly good friends and spend time together also after the work hours.	1			1	1	
There is a clear hierarchy in project teams.		1	1		1	
Project members reflect on each others' likes and dislikes.	1			1		1
Project members sometimes need to contact people from their informal private network to get support for their work.	1		1		1	
	100%	0%	20%	80%	40%	60%
Directness	Yes	No	Yes	No	Yes	No
Regular meetings are used to up-to-date the project progress.	1		1		1	
Work distribution happens orally between project members.	1			1		1
Work results are represented in haptical forms, like mock-ups, prototypes, flip charts, sketches, notes etc.	1			1		1
Project members are open to critique and discussion; they personally ask for honest feedback in the work group.	1			1	1	
Notification mechanisms of applications used for collaboration and communication are essential for fluent work flow.	1		1		1	
	100%	0%	40%	60%	60%	40%
Explicitness	Yes	No	Yes	No	Yes	No
Project plans exist and are really used during the project.		1	1		1	
Interfaces between intermediary pieces of work are well-documented and are up-to-date the whole time.		1	1			1
Nothing but to-do lists are used to coordinate the cooperative work.	1		1			1
Conflicts are articulated within the project group; consensus is achieved through dense conversations.	1			1		1
A workflow-like system is used for modelling the processes and monitoring them in real time.		1		1	1	
	100%	0%	40%	60%	20%	80%
Detachment	Yes	No	Yes	No	Yes	No
Simultanous work is common, and coordinated by persons involved directly.	1			1	1	
If needed, there are short agile work sessions between some of the project members.	1			1	1	
If needed, everyone in the project group can almost always take each role in the project.	1			1		1
Differences in style and working culture do normally danger cooperation and mutual support in the work group.		1	1			1
In case of problems, project managers intervene and reallocate resources or reassign people to tasks centrally.		1	1		1	
	100%	0%	0%	100%	60%	40%
Situatedness	Yes	No	Yes	No	Yes	No
A to-do list is updated in an ad-hoc manner to coordinate the work-in-progress.	1			1		1
If emergencies occur the whole group acts together.	1		1		1	
Work processes are predefined, well structured and in most part routine.		1	1		1	
Ad-hoc communication channels are created between members or groups during the project.	1		1		1	
The system used to coordinate the work triggers actions which must be carried out by project members.		1	1		1	
	100%	0%	40%	60%	40%	60%
Cooperativeness	Yes	No	Yes	No	Yes	No
The whole group is usually involved in decision-making processes.	1			1		1
Project members are interested and motivated to participate actively in all work processes.	1			1		1
The complete project group has the team feeling and believes to overcome all difficulties to achieve the common goal together.	1			1	1	
Project members trust each other, interact regularly orally and textually, support each other mutually.	1			1	1	
Shared information spaces are used with awareness information about project members and status of common artifacts.		1	1		1	
	80%	20%	20%	80%	60%	40%

Fig. 1. The questionnaire used to capture the coordination processes in an enterprise to calculate the ratio of Coordination 2.0.

preted by others (like managers) in the cooperative work. This encourages people to create personal contact to each other, to know what others know and good at (to be aware of knowledge and experiences of others), to initiate conversations, to establish information exchange informally, to be personal and formal at the same time, in the same project scope. Coordination 2.0 makes this possible. Using only (inter)organizational coordination platforms is limited and too formal to cover the needs of informal exchange between project members. Fourth, people can present and communicate their knowledge and experiences in Coordination 2.0 by signaling an openness to exchange, of course by expecting respect and appropriate reputation among colleagues. At the same time, it prepares the base for mutual support and creation of common knowledge and through these an integration into the group, in the project, and a team feeling. Additionally, being critical and argumentative are encouraged and developed. It is a way to try to argue ideas and discuss common issues to create a common understanding of shared things. This could be very relevant in coordination of work. Knowing each others' skills and knowhow changes the way what we think about our colleagues in cooperation, e.g., are we going to get the planned output in the expected quality from this person at the estimated time (producer/consumer dependency), can we ask for a favor, can we expect support in case of problems, can we estimate and foresee the quality and quantity of work of our colleagues, etc. Finally, people do not even recognize that they are coordinating their work by using Coordination 2.0 because it is integrated in communication and exchange with others.

Coordination 2.0 uses different Web 2.0 technologies and services to provide mechanisms for artifact-based and oral coordination (see Table 2). One would argue that traditional coordination systems do also offer instance messaging to its users. What different does a Web 2.0 instance messaging make? The main difference is that people can choose and initiate their contacts and instance messaging by themselves, with the tool they like (e.g., Skype) or the most people in and

outside the enterprise prefer to use. They know that the external tool they use has nothing to do with the enterprise where they work, the log files will not be accessible to their colleagues or supervisors. They also can configure the tool they choose, e.g., switch on or off the logging, or delete or keep the log files created. That means they have control over their tools they use for sensitive informal, probably at least partly personal exchange with others. This confidence, confidentiality, and independence is a big issue in motivating people to communicate with each other voluntarily, especially when it is about coordinating.

6. Conclusions

In this paper we have shown a new framework called Coordination 2.0. It supports coordination in (virtual) enterprises by combining artifact-based coordination with oral coordination. It offers flexibility, openness and easiness to share common resources, to manage interdependencies, to overcome inconsistencies, to coordinate the work in a distributed workgroup around a common goal.

Coordination 2.0 hosts different modes of coordination: direct/indirect, explicit/implicit, dynamic/static, situated/predefined, informal/formal, detached/coupled, individual/cooperative. It integrates workflow systems and facilitates Enterprise 2.0 technologies like search, authoring, tags, and signals. A tool based on a questionnaire is implemented and used to capture the coordination processes in an enterprise. Analyzing the values entered by companies deliver the ratio C2.0, which indicates the dimension of coordination in terms of artifact-based or oral. Values are captured in categories based on the modes of coordination.

The application of Coordination 2.0 analyzed in the scope of case studies as presented in this paper, show its benefits and drawbacks.

For time-based coordination, time restrictions can be overcome with Coordination 2.0, by using instance messaging and the common platform provided, by enabling linking to each other in an ad-hoc manner including internal and external professionals, by supporting the creation and maintenance of trust between team members, by offering channels to be used for improvisations, by providing mechanisms for distributed, ad-hoc decision making.

For product-based coordination, consistency between sub-parts of a product is crucial, interfaces and dependencies between sub-parts must be monitored and managed. To achieve this Coordination 2.0 offers a common platform with facilities of configuration management and linking to additional tools like simulation and verification, technical reports, what-if-artifacts, etc. Meetings as arenas for exchange, negotiation, decision-making, and coordination are supported by Coordination 2.0. It facilitates all phases, pre-meeting, meeting, and post-meeting activities. Asynchronous and synchronous channeling to all people involved, common repositories with controlled access to all involved, ad-hoc connecting via multimedia communication facilities are some features of Coordination 2.0 for this matter.

For process-based coordination, it is important to consider channeling between people as important and necessary as the predefined structured workflow established to control the work processes. Coordination 2.0 meets that requirement. It combines the workflow system with awareness information, multi-level notification mechanisms, user configurability, and adaptation of workflow. Knowing the availability of knowledgeable colleagues, having the possibility to contact them to exchange a current problem and documenting the actions in an ad-hoc manner make the daily life of engineers working on a common product more comfortable and manageable.

As shown in this paper how these three types of coordination settings can be supported by Coordination 2.0 is a start of introducing Coordination 2.0 to change the traditional ways of coordinating work in distributed groups. It tries to apply Web 2.0 technologies and Enterprise 2.0 ideas, by focusing on coordination issues. Coordination is differentiated as time-, product- and process-based, which is a further step taken in investigating and analysis of coordination settings. Empirical studies combining qualitative with quantitative data would support working on more detailed, applicable version of Coordination 2.0. This would widen the possibilities of its application in enterprises by convincing them of its usefulness and flexibility.

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