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Engineering Groupware for E-Business

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ABSTRACT

This paper introduces an engineering approach to the modeling, design and implementation of collaborative systems, applied to e-business. This approach, called Groupware Engineering, is based on the 3C collaboration model (Communication, Coordination and Cooperation). Initially, the 3C model is studied by means of an analysis of each one of its three elements. Then, other phases of Groupware Engineering, such as requirement analysis and component implementation, are introduced. Finally, an example presents the application of this approach to a business-web.

Keywords

Collaboration, Groupware, Software Engineering, Business-Web.

1. INTRODUCTION

The creation of shared spaces and the exchange of information supported by groupware provides for distributed and decentralized collaborative work. The environments for sharing information and conducting commercial transactions enabled by e-business technologies perfectly fit these notions of shared space and collaborative work. Therefore, e-business technologies should be developed keeping an eye on groupware achievements.

In this paper we introduce our concept of Groupware Engineering, aiming to identify the elements needed to develop collaborative applications [7]. The collaboration model behind this approach is called the 3C model (Communication, Coordination, Cooperation), based on the work of [5].

In order to illustrate the potential of Groupware Engineering approaches in the development of e-business environments, we present an example applying the 3C collaboration model to a business-web.

This article is organized as follows: Section 2 presents the proposed Groupware Engineering approach, Section 3 shows the business-web example and Section 4 presents the concluding remarks.

2. GROUPWARE ENGINEERING

Software Engineering, which has advanced substantially in the development of single-user applications and recently started addressing the human factor problem [3], fails to cope with the group aspects so needed in collaborative applications [9]. The formulation of Groupware Engineering, based on Software Engineering, enhanced by concepts originated from the field of CSCW and CHI, seems suitable for developing e-business applications.

In order to put the groupware development cycle into context, the phases of software development [15] are shown in Figure 1 together with the topics that are being studied on this research project. The domain analysis phase, which in this case deals with the human side of groupware, is elaborated on in this paper following a collaboration model based upon the concepts of communication, coordination and cooperation.

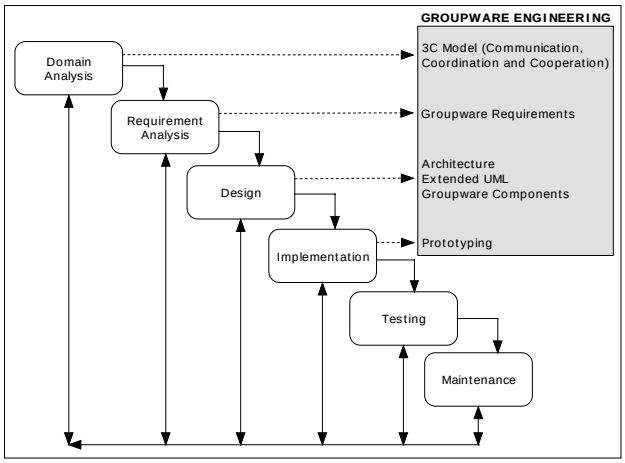

Figure 1. Cycle of software development in Software and Groupware Engineering.

Groupware requirements are developed in the requirement analysis phase, where attention is centered on the software. To provide instruments for the project phase, where the software is conceived in a manner that satisfies the requirements, toolkits and the concepts groupware components, component architectures and UML language extensions are necessary [24], [26]. In the implementation phase, the choice for rapid prototyping [22] is very useful for collaborative applications, because they are specially prone to failure [10] and they demand iterative evaluation during the development

In this section, we detail some phases of the groupware development cycle. Section 2.1 discusses the 3C collaboration model. Sections 2.2 and 2.3 deal with requirement, design and implementation.

2.1 The 3C Collaboration Model

At least potentially, collaboration can produce better results than individual work. A complementing of skills and individual efforts occurs in a group. By collaborating, the members of the group receive feedback that early on permits them to identify inconsistencies and breakdowns in thinking processes and, together, they can seek ideas, information and references to carry on their duties. The group also has more capacity to generate alternatives in a creative fashion, surveying the advantages and disadvantages of each one of them in order to select those that are feasible and to make decisions [27].

More than a potential for better results, in the e-business arena collaboration is a necessity. This necessity appears in the early stages of designing the software infrastructure, a task that usually requires collaboration among different professionals to deal with its several aspects [8], and remains during the e-business operations (B2B, B2C, C2B and C2C are collaborative activities, as their names clearly indicate).

Despite its advantages, collaboration requires additional effort to coordinate the members of a group. Without such coordination, much of the communication effort will not be taken advantage of during the cooperation. That is, for the group members to be able to operate together in a satisfactory manner it is necessary that the commitments that have been assumed during the participant interaction be carried out during joint work in shared space.

In order to make collaboration possible, information about what is happening is also required. This information is supplied through the awareness elements that capture and condense the information that has been collected through interaction between the participants. To become aware, in this context, is to acquire information through the senses about what is happening and what other people are doing. The diagram shown in Figure 2

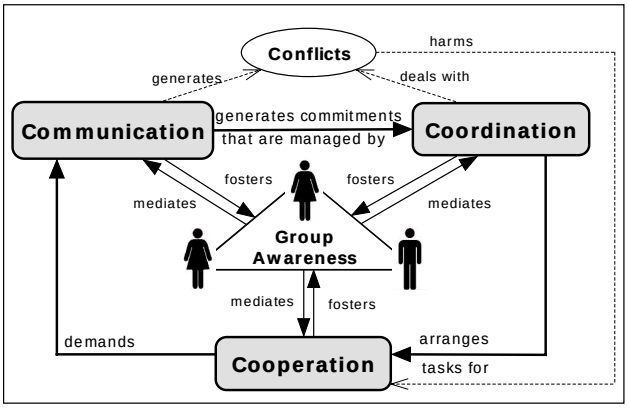

Figure 2. Overview of the 3C Collaboration model.

summarizes the main concepts of the 3C model discussed above.

Details of the main elements of the diagram and their inter-relationships are presented in the following sections. It should be remembered that despite the separation of these concepts for the purpose of analysis, it is not always possible to consider them monolithically, since they are intimately dependent and inter-related.

2.1.1 Communication

In collaboration it is important to ensure the understanding of the message in order to guarantee that the intention of the sender results in commitments assumed by the receiver, or by both. However, there is no way to check if the content that was received is equivalent to that which was sent, and if the receiver assimilated it. A communications failure thus would consist of disagreement between the intentions of the sender and the actions of the receiver who carries out the commitments.

The communication is conducted through expression elements that are available in the environment. The sender encodes the message using the available expression elements. The message is transmitted through the awareness channel. The receiver has access to the message through the awareness elements that are available in the environment.

Before expressing himself through the elements in the environment, the sender must prepare the message within the language structures defined by the expression and awareness elements that are available in the environment. Besides the elements of the environment, the cultural context, the domain in question and individual knowledge influence the language structures that are used by the sender and interpreted by the receiver. It is the communication channel that makes it possible to transmit the information between the members of the group.

In a process prior to the preparation of the message within a language structure, the sender conceives the content to be transmitted based upon its intentions. Upon interpreting the message, the receiver takes on commitments.

Conversation for action generates commitments [28]. In order to ensure compliance with these commitments and the realization of collaborative work through the sum of individual labor, it is necessary to coordinate the activities. This coordination organizes the group in a manner that avoids the loss of communication and cooperation efforts and ensures that the tasks are carried out in the correct order, at the right time and in compliance with the restrictions and objectives [17].

2.1.2 Coordination

Collaborative work was defined by Karl Marx as multiple individuals working together in a planned manner in the same production process or in different production processes that are linked to each other (cited in [1]). In the center of this definition is the notion of planning, ensuring that the collective work is the result of a set of individual tasks.

In CSCW the planning notion present in Marx's definition is carried out by the so-called articulation work, which is the additional effort that is necessary for achieving collaboration from the sum of individual labor. Without the articulation work there is a risk that the participants will become involved in conflicting or repetitive tasks. In a more ample definition, coordination is synonymous with articulation work.

According to this definition, coordination involves the pre-articulation of the tasks, their management and post-articulation. Pre-articulation involves the actions that are necessary to prepare the collaboration, normally concluded before the collaborative work begins: identification of the objectives, the mapping out of these objectives into tasks, the selection of the participants, the

distribution of tasks among them, etc. The post-articulation phase occurs after the end of the tasks and involves the evaluation and the analysis of the tasks that were carried out and the documentation of the collaborative process (the process memory).

The management of the carrying out of the tasks is the most important phase of the coordination process, since it is the most dynamic part, needing to be renegotiated in an almost continuous fashion throughout the collaboration period. Looking just at this dynamic and continuous action of coordination, it can be defined as the act of managing interdependencies between tasks that are carried out to achieve an objective [13].

In order to complete the coordination process it is necessary to have a clear definition of tasks, collaborative activities and interdependencies. In the model adopted in this paper a collaborative activity is a set of tasks carried out by several members of the group in order to achieve a common objective (commitments) [18]. Tasks are the building blocks of the collaborative activities and linked by interdependencies. Tasks can be atomic or composed of sub-tasks. A group of sub-tasks can be considered to be a task on a higher abstraction level when it does not present interdependencies with tasks that are external to this group. This ensures the modeling of collaborative activities on several levels of abstraction.

The coordination can take place on two levels—the activities level (temporal) and the object level [6]. On the temporal level, the coordination defines the sequencing of the tasks that make up an activity. On the object level, the coordination describes how to handle the sequential or simultaneous access of multiple participants through a same set of cooperation objects.

Based on the separation between the tasks and their interdependencies, it is possible to characterize different types of interdependencies and to identify the coordination mechanisms that are capable of satisfying a wide range of collaborative applications [12]. An example of a set of coordination mechanisms that uses Petri Nets to model the tasks and the treatment of the interdependencies is found in [19].

Some activities involving multiple individuals do not require formal planning. Activities linked to social relationships are well controlled by the so-called social protocol, characterized by the absence of explicit coordination between the tasks and by the confidence in the skills of the participants to mediate the interactions, as normally occurs during text chats. On the other hand, activities that are more directly aimed at group work require sophisticated coordination mechanisms in order to guarantee the success of the collaboration, as is the case of workflow systems.

In practice, however, it is not always clear what should be left to the social protocol and what must have a coordination mechanism associated with it. The ideal is that collaborative systems do not impose rigid standards of work or of communication. Facilities should be provided so that the users may interpret and exploit these standards, deciding to use them, change them or reject them [21]. The big challenge, upon proposing coordination mechanisms for group work, is to make them sufficiently flexible so they adjust to the dynamics of the interaction among the participants as well as avoid conflicts.

Conflicts may occur as a result of problems of communication or awareness or through differences in the interpretation of a situation or a subject of interest [16], [11]. Coordination must deal with the conflicts that prejudice the group, such as competition, disorientation, problems of hierarchy, diffusion of responsibility, etc. [20].

In order for there to be coordination, awareness information is essential for transmitting changes in plans and to help carry out the commitments that have been assumed. Each member of the group has to understand how the work of his or her colleagues is getting along: what was done, how it was done, what needs to be done until it is finished, what are the preliminary results, etc. [4], so as to avoid unnecessary duplication of effort during the cooperation process.

2.1.3 Cooperation

Communication and coordination, although vital, are not enough: “it takes shared space to create shared understandings” [23]. Cooperation is the joint operation of the members of a group within a shared space that strives to accomplish tasks that are managed through coordination. Individuals cooperate by producing, manipulating and organizing information, building and refining cooperation objects such as documents, spreadsheets, charts, etc. In order to work with these objects, the members of the group count on expression elements. Awareness elements supply information about the changes made in the shared space.

The recording of the interactions of the members of the group is filed, catalogued, categorized and structured in the cooperation objects. This is the manner of ensuring that the group memory and collaborative products are saved. This type of so-called formal knowledge is different than informal knowledge, which are ideas, facts, questions, points of view, conversations, discussions, decisions, etc. Although informal knowledge permits recovery of the history of the collaboration and the context in which the decisions were made about the carrying out of the tasks, it is difficult to capture.

Individuals seek in the awareness elements the information that is necessary to create the shared context and to anticipate actions and requirements related to the collaboration goals. This allows identification of the intentions of the colleagues of a group in such a way as to make it possible to provide assistance in terms of their work when it is desirable and necessary. Such interaction generates new facts and information in the shared space, which in turn will be reflected in the awareness elements. It is in these elements that the individual will seek the knowledge for communicating and coordinating subsequent interaction.

The designer of a virtual environment must anticipate what awareness information is relevant, how it can be obtained or generated, where the awareness elements are necessary, how to present them and how to give individuals control over them. Excessive information can cause overload and complicate the flow of the collaboration. To avoid overload, it is necessary to balance the need to supply information with that of preserving attention to the work.

2.1.4 Awareness

To be aware, in this context, is to acquire information, through the senses, of what is happening and what other people are doing [2]. Awareness, which is inherent in human beings, thus becomes a central part of communication, coordination and cooperation in a

work group. Through awareness, individuals realize the changes caused in the environment by the action of participants in a manner that enables them to direct their attitudes and predict possible needs [14]. To be aware of the activities of other individuals is also essential for the flow and the naturalness of work and in order to diminish feelings of being impersonal and at a distance, both common in digital environments.

Awareness involves various cognitive aspects related to human skills. In the interaction between people and environment in a face-to-face situation, obtaining information is rich and natural, given that the senses are fully present. The participants may stay current of the situation just by paying attention to the things that are happening around them. In virtual environments, awareness support is less clear since the means for transmitting the information to the sensory organs of human beings are limited. Typical workstations are limited to being able to provide information through a two-dimensional screen and, in some cases, through loudspeakers. On the other hand, in a digital environment, dispersions can be filtered in order to not disturb the participants.

Awareness elements are elements of the shared space where information designed to provide awareness is disposed. Digital environments for e-business must provide awareness elements in a way that they supply the information necessary for collaboration among the members of a supply chain. Guided by their awareness, participants can assemble their work context and a shared understanding and can coordinate themselves so that individual efforts at communication and cooperation add value to the work.

2.2 Groupware Requirements

Both the collaboration aspects previously discussed and the requirements cited below aid groupware analysis, evaluation and development. An initial set of groupware requirements was presented in [26]. We are currently evaluating and extending this set of requirements for Groupware Engineering.

The requirements are divided into two categories, user and developer requirements. User requirements are raised for people that are going to use the groupware tool (in e-business, the user may be the product consumer, the bank client, the student – in e-learning, and so on). As previously mentioned, the development of an e-business environment is itself a collaborative activity. Therefore developer requirements are also necessary. They are raised for those that are in charge of the creation and maintenance of a groupware application, using the available infrastructure (a component architecture or a programming language extension, for instance).

It is out of the scope of this paper to discuss groupware requirements in detail. We are just going to overview those that are particularly interesting to e-business applications.

User requirements:

- Support the choice of the appropriate tool. When the user is faced with more than one way to do the same task, the system should indicate him the most adequate one according to the user's preferences and necessities.
- Provide awareness information. As reinforced by the 3C model, awareness elements offer indications of other users activities and presence, enabling the activities coordination and the construction of the user's own work context.
- Provide both synchronous and asynchronous services. This is particularly important in e-business applications, which involve diverse situations. Asynchronous interaction is a necessity when making transactions over different time zones, for example. Synchronous interaction is a necessity in other situations, for instance, for consumer support.
- Support access from mobile devices, such as PDAs and mobile phones. This kind of device is increasingly present in daily life and, since they have limited capacity (specially in the display area), its software should be able to provide suitable simplifications.
- Provide high performance. Although the notion of high performance is somehow abstract, related aspects should be considered when designing a groupware application. For instance, synchronous collaboration has a stronger necessity of feedthrough (modification of one's interface due to the action of others) than asynchronous one.

Developer requirements:

- Reuse previous knowledge and experience. Groupware development should make the most of developers skills in programming single user applications as a means to reduce the development time and the time to integrate a new member in a development team.
- Reuse data models. The development infrastructure should use existing data models, as a means to reduce development effort.
- Access awareness information. Since groupware and e-business development are collaborative activities, awareness elements are also important for the development team.
- Be scalable. The system performance should not degrade perceptibly when the number of users increases.

2.3 Groupware Design and Implementation

The use of techniques based on software components is an approach that facilitates groupware development, making it more flexible. The components development is usually associated to a component framework that defines how components are created and combined.

A special kind of component treated in Groupware Engineering is the groupware component. These components implement collaborative tools and are coupled to a component framework, which offers the infrastructure through which they are going to inter-communicate and access shared objects and information.

Figure 3 depicts the proposal of a general framework, called collaboration framework, that implements functionalities common to all services of a groupware. Coupled to this framework there are communication, coordination and cooperation frameworks. Each groupware tool (component) is coupled in one of these frameworks according to its functionality. For illustration purposes, a single component is attached to each intermediary framework, but actually there may be several communication, coordination and cooperation tools. Moreover, these components

may also be framework instances that develop a set of functionalities of a group of tools.

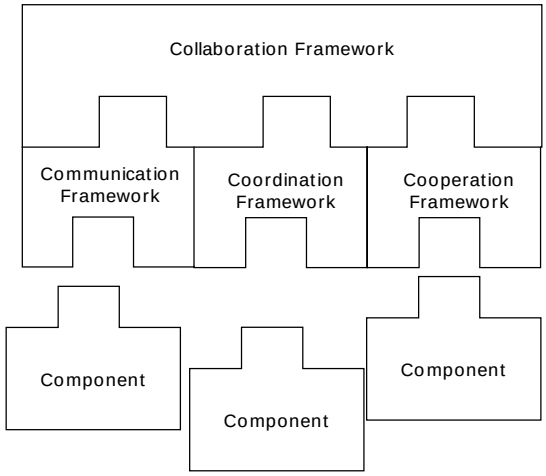

Figure 3. Collaboration framework with communication, coordination and cooperation frameworks.

This approach enables better software reuse, easier integration of new tools and the possibility of external teams to develop new functionalities. From the framework, it will be possible to instantiate specific groupware for different situations, such as engineering, training, education, and e-business, altering only the components configuration and the used terminology.

3. Business Webs

In their book Digital Capital, Tapscott, Ticoll and Lowy [25] define business-webs (b-webs) as "a distinct system of suppliers, distributors, commerce providers, infrastructure providers, and customers that use the Internet for their primary business communications and transactions". Their b-web typology comprises agoras, aggregations, alliances, value chains and distributive networks.

Zooming into the value chain type of b-web, the authors further differentiate between routine production and shop production. While the former is product-centric and goods are designed for mass markets and production efficiency, the latter supports custom solutions where activities are not routine and are driven entirely by demand, that is, the end-costumer is the one that triggers the value-creating process.

Cisco Systems is the quintessential example of shop production value chain b-web. Using Cisco's Configuration Tool on the company's web page, the end-costumer receives guidance to prepare its order while all kinds of discounts and other services are being offered. Only after selling the good does Cisco make it. But, in reality, Cisco will coordinate the production process instead of actually making it. For example, for pricing information, the end-costumer is referred to a Cisco partner or reseller website.

Cisco plays the coordinator role in this shop production value chain b-web (Figure 4). Using the available configuration tool costumers communicate their orders, triggering the cooperation cycle among manufacturers, assemblers, distributors, component suppliers and the sales channels. The cooperation object itself is the computer (or solution) that will be shipped to the end-costumer.

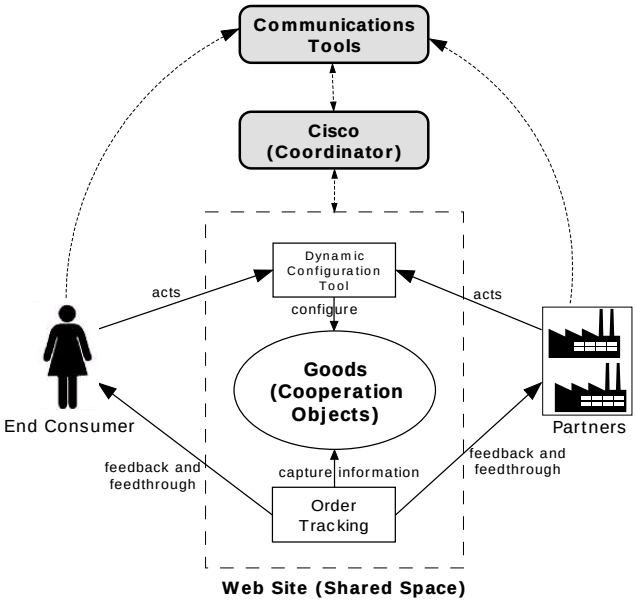

Figure 4. Collaboration model instantiated for Cisco Systems value chain business-web

A similar analysis could be done for the other b-web types. For the sake of concision, only coordinators are shown in brackets: agoras (eBay), aggregations (Amazon.com), alliances (Human Genome Project Organization) and distributive networks (UPS).

Being b-webs critical applications that combine B2C and B2B, security plays an important role. Revisiting the groupware requirements presented in Section 2.2, it is easy to spot the lack of security concerns. This demonstrates that groupware requirements need further refining for e-business applications. On the other hand, the 3C collaboration model showed itself capable of representing business-web collaboration processes.

4. CONCLUDING REMARKS

A growing portion of work in companies and institutions no longer is conducted on an individual basis with a single person working alone until a job is finished. Increasingly, work is conducted on a collaborative basis. This trend is due partially to an increase in the complexity of tasks, which now require multidisciplinary skills, and the need to involve different areas within a company—or even other companies—working together to deliver goods and services to end-costumers.

The objective of our research is the formulation of Groupware Engineering, aiming to identify the elements needed to develop collaborative applications. The research outline is the elicitation of groupware requirements and the adaptation of other techniques deriving from Software Engineering combined with conceptual models and human aspects originating from CSCW and CHI. In this paper, Groupware Engineering is applied to a business-web collaboration process, showing the appropriateness of the 3C model and also the necessity of further enhancements—the case of requirements.

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