The GroupSPACE Concept

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Abstract

A unified computational model called GroupSPACE is presented for groupware applications of repetitive-collaborative tasks in Computer Supported Cooperative Work (CSCW). GroupSPACE is a generalisation of the concept of workspace. It is inherently a distributed multimedia environment that provides specialised elementary composition and synchronisation operations on multimedia objects placed into this shared-space environment. Different views (viewpoints) of media objects and their relations are defined. According to their viewpoints, human users of GroupSPACE interact via direct manipulation on multimedia objects of GroupSPACE. The means by which different media objects are related, the control within GroupSPACE, is described by objects that can also be manipulated directly because the architecture of GroupSPACE is based on the paradigm of computational reflection.

Keywords: *CSCW, groupware, multimedia, groupwork pattern, GroupSPACE, distributed system*

1 Introduction

The basic ideas of our ongoing groupware research and development project are described. The work [1] [2] in progress deals with the problems of distributed application design for supporting repetitive-collaborative groupwork patterns.

The collaborative tool development (groupware) research is one of the most important research areas of Computer Supported Cooperative Work (CSCW). CSCW is a generic term that integrates different models, (information, computer, communication etc. technologies) for the purpose of supporting cooperative work of a human group [11]. Understanding of the way how people work together in groups is a primary subject of cognitive sciences. Therefore, CSCW is inherently a multidisciplinary research area which draws extensively from sociology, anthropology, psychology etc. and computing and communication sciences. CSCW opens a new area for the application of computer networks and distributed systems. New types of distributed architectures are under development where different multimedia and communication modes (synchronous and asynchronous communication within a single application) are applied. CSCW challenges the communication technology research towards the direction of multi-point communication protocols from point-to-point protocols and the research of concurrency control and synchronization among others in distributed systems.

Groupware (group supporting system) is a computer based system that supports people engaged in a common task (goal) and that provides an interface to a shared computer environment [24]. In broad terms, groupware is a hardware/software system which incorporates the scientific research results of human oriented sciences of CSCW and the available computer and communication technologies. Up till now, several groupware applications have been developed [17]. This stack of groupware applications currently includes workflow and group coordination systems, advanced messaging systems, multimedia desktop conferencing, group tools such as shared editors, shared drawing tools, group decision and negotiation support systems, traditional communication systems, distributed bulletin boards [16]. Although the key CSCW theoretical research areas include the analysis of groupwork patterns of human teams and special group requirements for CSCW applications, the design of multi-user shared interfaces, distributed architectures, organization modeling and the theoretical research in the area of (semi-)formal models of group coordination belong to the most significant topics of groupware technology research.

2 Motivation

The basic motivation behind this research is the need for computer support of repetitive-collaborative work patterns of small human teams in medical environments.

In the Hospital Information Systems (HIS), patients records are usually stored in a centralized database. Patient records contain personal and financial data and other, possibly multimedia, information (such as X-ray, CT pictures, measured laboratory data, along with the history of the recuperation process). These records are used by several physicians and offices of the hospital.

As medical treatment might be a highly collaborative process where several different specialists have to be involved, the demand for computer support for

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this collaborative process is very high. A workstation based groupware application can assist in the group discussion among physicians and specialists while they stay in their offices. From their offices, they can reach all data fields of patient records containing simple text, numerical data, pictures or even motion video, using the service provided by a client-server architecture to reach the centralized data. Physicians can initiate consultations with the best specialist of a particular field on-line, synchronously. This requires the application of a workstation based group conference tool. During these synchronous conferences all types of multimedia information of patient records are shared among the physicians of the discussion. They can exchange images, textual, and verbal information along with numerical data.

This type of groupwork has a highly repetitive character, as similar work patterns can be followed in the cases of many patients. Unfortunately (from the engineering point of view) the complete structure of this groupwork can not be invariable while the elementary workpattern fragments can be easily discovered, since medical treatment can be highly creative.

Another example is the collaborative work within cockpit of an aeroplane or within air traffic control station. Different media types carry information during communication among pilots and the availability of particular information depends strongly on the actual flying situation. During this type of collaborative task, there is generally limited time for searching for particular information. Computer based support tools may provide an aid to present the necessary information for the user (pilot) at the best moment within the collaborative work situation. The preparation for searching and/or presenting (multimedia) information can be fully automated if the repetitive-collaborative workpattern was fully understood. In reality this can not be achieved even if some critical flying or controlling situations are disregarded.

From these examples one can conclude that the ability of handling multimedia objects is essential for a group support tool such as the ones previously sketched. On the other hand the flexibility of collaborative computing applications gives the impression of being a more important issue than the existence of invariable work patterns. "Designing for change" [9], the need for static, dynamic, and implementational flexibility and tailorability led us to our idea of direct manipulation multimedia GroupSPACE concept.

3 Overview of GroupSPACE

GroupSPACE is new unified computational model for groupware applications of repetitive-collaborative tasks of Computer Supported Cooperative Work (CSCW) area. GroupSPACE has been designed as an environment for cooperative work. Numerous tools and techniques have been developed for supporting the individual (such as co-authoring, shared editing, screen and application sharing, group decision making, video conferencing, media spaces) areas of group-computing [17]. A common character of these tools is the support of a complex but individual task. Very few tools have been designed for orchestration of these separate collaborative tasks. The support of this orchestration is the main target of GroupSPACE. From this point of view GroupSPACE is similar to a distributed ***groupware shell*** teleservice used for controlling the individual groupware applications. It creates a computational environment based on a homogeneous paradigm of collaboration.

GroupSPACE is a generalisation of the concept of workspace. Traditionally, workspace consists of user-interface objects that a human user manipulates. These user interface objects represent local and/or remote entities of the environment. (e.g. SUN NFS provides service for seamless remote file representation and access similarly to the local file access.) In distributed system design enormous efforts have been devoted to the design and implementation of different distribution transparencies. Distribution transparencies as a collective of different kinds of transparencies tend to try to mask out various characteristics of distributed systems. Location transparency hides the location of an object in a distributed environment. The location of a server object for a particular service is not necessarily known for the user. The decision about the location of a server is made by the system and not by the user. Access transparency hides the different access methods used inside a distributed system. A distributed system gives a homogeneous way to access all of the objects of the system. For example the RPC (remote procedure call) service hides the differences between local and remote procedure calls. Therefore the control is generally embedded into distributed systems and cannot be tailored as it is required in the area of groupware.

In GroupSPACE different types of media objects can be placed[3]. Objects incorporated into GroupSPACE can include traditional objects such as text, image, sound, but more complex, structured objects including video or complete multimedia document [18] can be incorporated as well. The objects of GroupSPACE are automatically shared among the partners of the collaboration. This default sharing means that partners (human users) can visualise and use the shared objects like other local objects.

Objects are autonomous entities. They offer sets of operations for the environment. These operations are defined according to the media types of particular objects. Objects can autonomously initiate interactions with other objects of GroupSPACE. The autonomous behavior of objects can be regulated by protocols. A protocol (structured ordering of operations) is the rule by which the individual operations of an object can be initiated and the sequence of operations invoked by the object itself. Protocols are specifications of temporal ordering of operations. Formally, this specification can be described by an FSM (Finite State Machine). A protocol can control the behavior of a particular object in such a way that it

[3]As GroupSPACE is intended to be implemented as a specialised collaborative tool, it may coexist with the traditional software tools within a traditional operating environment. Therefore objects can be moved into GroupSPACE, from the local computational environment.

can mask out several objects operations and/or can initiate operations of other objects. Objects representing protocols, like other objects, exist within the environment. In order to create a particular protocol compliant object, the object is associated with a copy of the particular protocol objects. The basic functionality of GroupSPACE, the object sharing is a protocol as well. This protocol is automatically associated with all objects of GroupSPACE by default.

3.1 The use of GroupSPACE

A short overview of a possible GroupSPACE session is described. In GroupSPACE collaborative workpatterns are represented by icons on the screen. The user (for example a physician) can select a particular previously defined workpattern by simply dragging the input (the icon of patient record) into the work pattern icon selected. This initiates the distributed collaborative task. GroupSPACE organizes the task according to a high-level description of work pattern that is a global network-wide program (scenario) of subtask and their temporal and/or spatial relations. The scenario provides a scheme of collaborative multimedia system with remote human and/or computational participants. The collaborative system will be built upon the individual collaborative services provided or registered by GroupSPACE on-the-fly.

In typical cases the selected scenario can be followed and the collaborative task such as remote consultation or conference can be carried out. In our example: according to the scenario, GroupSPACE invites the remote partners for a synchronous multimedia conference. After accepting the invitations GroupSPACE starts picture phone, shared whiteboard and collaborative authoring services for the partners of the conference. During the whole session the picture phone service is on-line. Patient record containing multimedia information is put into the shared whiteboard for joint visualisation. Via picture phone provided audio and video communication, using the shared whiteboard the conference on the problem of patient can be successfully finished. Afterwards the relevant items from the patient record are automatically copied into a new document for joint editing scheduled just after the discussion using the whiteboard service. The final document created by partners is attached to the patient record and mailed automatically by a GroupSPACE registered mail service.

GroupSPACE controls collaborative services and provides multimedia information for them. It can start and finish parallel and sequential subtasks. The organisation of frequently repetitive collaborations is the task of the system instead of human users.

The formal specification technique for collaborative workpattern descriptions has a key importance. During the development of this technique the following requirements could be identified:

- description of parallel and sequential collaborative subtasks (identification and description of subtasks as well as their relations using compositional operations)
- management of (human, computational) partners of collaborations (identification, location, description, their roles and rights)
- handling of collaborative and/or communication services such as
  - session management service
  - picture/audio phone service
  - floor control service
  - shared whiteboard service
  - telepointer service
  - shared authoring service
  - group decision support service
- handling of distributed multimedia (data) objects (remote multimedia presentation specification, global/local temporal/spatial relation description, multimedia data retrieval)

The predefined workpatterns are shared objects in GroupSPACE. They are located in the workpattern repository. Users can visualise and/or modify them on-the-fly. In this way workpatterns can be adapted to the evolution of collaborative works. For example a physician can modify a particular workpattern introducing a new parallel subtask. The modification can be done by graphical or textual editor as GroupSPACE objects give multiple modality views. "Audio icons" are associated with the workpattern objects therefore GroupSPACE can provide audio awareness information about the active (running) collaborative works.

3.2 Sharing of Objects

GroupSPACE does not have a priori knowledge about the multimedia object types to be shared. Rather it provides the way in which these objects can be manipulated.

Two types of object sharing exist according to the inner architecture of an object. An object could be designed to be shared or could not. In the first case, fine-grain sharing is possible, otherwise an object can be shared as a whole. As an illustration, the sharing of a text object is considered. Co-authoring tools allow simultaneous editing of the same text (file) object. Fine-grain sharing of text can be implemented such a way that users can work different parts for example different paragraphs of the text object, simultaneously. The paragraph under the editing operation is locked for a particular user until the operation invoked by the user is finished. This prevents the conflicts between editing operations issued by different users, but allows efficient parallel editing by several users at the same time. If the text object is not compliant with the fine-grain sharing protocol of GroupSPACE, then it is shared as a whole according to the server-views paradigm discussed later. This type of sharing can be ineffective and can give slower user feedback.

The core set of multimedia objects (text, voice, image) of GroupSPACE is designed to be compliant with the fine-grain sharing protocol by default. The architecture of text object allows the description of the structures of the text object down to the level of paragraphs. Stream like multimedia objects (audio, video) can be fragmented therefore operations (and sharing protocol) can be applied on the finer parts. In GroupSPACE a more detailed architecture of multimedia objects is used [19].

A multimedia object of GroupSPACE is a composite object which is a computational model of real world arrangement including multimedia data generators (database, camera, VCR, CD-ROM) and absorbers of data (a window on the screen, database, tape). The generators and absorbers may be located on different time-space coordinates of the distributed system. In the model of [19] multimedia objects are characterized by three system components: source, sink, manager.

The manager is responsible for controlling the data path between the source and sink components and provides a unified interface to the multimedia object. This approach of multimedia object requires allocation, handling and deallocation of system resources during the lifetime of the object. It hides the distribution at the component level (interaction between the source and sink) for the price of heavy object model. The distribution at system level can be expressed by interactions between the multiple multimedia objects. GroupSPACE provides the means to define the structure of interactions between multimedia objects. This is called the control of GroupSPACE.

3.3 The Control

The most important part of the group applications is the control of the cooperation of partners. This feature can be considered from two points of view: the description and the prescription of the control.

The control of cooperation means how the completely unstructured collaborative task is transformed into a structured one having prescriptive rules (explicit controls) to guide communication between partners. Software development is one of the best examples of unstructured problems. In this type of activity the partners can not usually describe the steps, the details of the phases of the collaborative task in advance. There are routine cooperation patterns (like office procedures) which can be considered as having the most structured types of control. Between these extremities different levels of structured patterns of cooperation can be considered.

The description of control in real world groupwork belongs to the research areas of human-oriented sciences. The prescription of different levels of control is an engineering problem. There is always a trade-off between the completely prescribed control and the unstructured control. In the latter case, the well known and widely accepted social protocols usually substitute the prescriptions of control. In the literature, different paradigms are available to describe (or prescribe) control [16].

The approach of GroupSPACE provides a flexible control. This is the most challenging problem of the whole project. Initially there is no prescribed control in the space but meta-level controls (that is meta-level protocols) are predefined. This core set of control makes it possible for the users building the control on-the-fly, meanwhile the whole control of GroupSPACE is represented by multimedia objects and their interactions. These objects representing the control of GroupSPACE are located in the GroupSPACE itself. Therefore they can be manipulated in the known manner (direct manipulation). This unique feature makes the GroupSPACE architecture reflexive. The meta-level formation of GroupSPACE provides the most flexible approach in the area of groupware application design as a bigger set of groupware application design problems can be targeted by the same (meta-level) architecture. On the other hand this architecture clears the way for the self-modifiable groupware applications, where the control, the structure of collaboration depends on the actual content (semantics) of groupwork. This is really a very far and untouched area of group-computing.

In practice, specialists are going to program (build) the control of a particular groupware application within a particular field of problems. Their labours are based on the observations of anthropologists on groupwork patterns. Fortunately, the control structure of a system in operation is going to be stable for longer period, and the daily users do not tend to change it during work sessions frequently.

3.4 Direct Manipulation on Views

GroupSPACE gives direct-manipulation user interfaces (UI) for the human collaborative partners. Nowadays direct manipulation and/or graphical user interfaces are dominant actors in the world of computing. This popularity is based on some simple but powerful concepts [22]:

- continuous (graphical) representation of system objects on UI
- direct physical actions instead of commands of a language with complex syntax to initiate an operation
- rapid, incremental, reversible operations on objects
- immediately visible impact of operations on objects
- layered approach to learning that permits usage of UI with minimal a priori knowledge

Different direct-manipulation based user-interfaces differ from each other in the way the system objects are mapped into the user-interface objects. This mapping is crucial from usability point of view.

The GroupSPACE concept does not introduce a new user-interface metaphor besides the well-known UI objects (window, panel, button, menu) and methods. It follows the popular direct manipulation paradigm of graphical user interfaces. Objects are represented by icons. Operations can be invoked by clicking, pointing, drag-and-dropping.

Instead of new metaphors, GroupSPACE introduces the multiple modality views. An object can be regarded from different viewpoints. It can be represented by an icon, various graphical symbols, textual descriptions or the means by which end-user observes it. These modalities are equivalent in the sense that they all represent the same object but users of different categories[4] work on different modalities. For a system manager an object can be represented by graphical symbols as he/she can modify the control of GroupSPACE by direct manipulation on the graphical symbols representing the control elements of the architecture. Meanwhile, end-users can have another viewpoint from which an object looks like another graphical symbol or an icon. The multiple UI mapping of multimedia objects is one of the most characteristic feature of GroupSPACE.

Different views (viewpoints) of media objects and their relationships are defined at the level of meta-architecture of GroupSPACE. Switching between viewpoints for a particular user is controlled by the security architecture, as a part of the control architecture of the system.

4 Implementation Issues

GroupSPACE takes the advantage of the high-speed communication facilities of workstations and shares the traditional workspace among the participants of the collaborative task. In this way a shared workspace (called GroupSPACE) is formed. GroupSPACE is not built upon special new, unproven input/output devices. Traditional devices like screen, keyboard, pointing devices (mouse and/or pen) are going to be used for a long time yet. We think that capabilities of traditional workstation GUIs and IO devices have not been fully exploited up till now, from usability point of view. There is no doubt about the rapid development of new UI technologies, but this project is focused on another aspect of groupcomputing. As the ultimate aim of this project is the development of a prototype grouptool to prove our basic ideas, the maximum advantage of the media-rich software capabilities of NeXTSTEP systems and the attached efficient communication technology constitute the computational underpinnings of this project. The architecture of GroupSPACE is based on the paradigm of computational reflection.

A general approach to address the flexibility requirements against groupware application design is the setting up of a toolkit from which different custom-designed groupware applications can be built. A toolkit consists of a set of elementary components and structuring, compositional operations, that is the means how these can be amalgamated.

In the case of GroupSPACE, an analogue of toolkit, a meta-level architecture is implemented by a programmable replicated software architecture. As a consequence, there is no predefined architecture of GroupSPACE. The meta-level architecture represents the unmodifiable architecture of GroupSPACE, while all other structures of interactions are built from these elementary objects and compositional operations.

[4] E.g. system manager, end-user, discussion control designer etc.

The GroupSPACE concept based software prototype is going to be implemented in NeXTSTEP programming system, which is a complete object-oriented programming environment including Distributed Objects management.

As the sharing protocol is one of the essential features of the system, it is included in the meta-architecture. Implementation of sharing of an object is based on the clients-server paradigm. The object is represented by a fully operational master copy of the object (the server) while there are auxiliary copies (clients) that provide view services. The role of the clients is the transfer of the invocations operations and the local representation of state of the master copy. This implementation paradigm can be directly mapped into the Distributed Objects feature of the embedding NeXTSTEP system.

5 Conclusion

In this paper a framework for the design and implementation of groupware applications of repetitive-collaborative tasks of CSCW has been briefly presented. Collaborative teleservices (such as JVTOS - Joint Viewing and Teleoperation Service [23]) are under the intensive research and development. Aim of GroupSPACE goes beyond providing a new set of collaborative teleservices. It provides basic compositional glue that melts individual teleservices into a scenario orchestrated support of complex groupwork patterns. The formal description techniques of groupwork patterns have usually messenger role between groupware application designers and cognitive scientists dealing with human groupwork activities. In GroupSPACE they have more important role as formal descriptions of groupwork patterns directly control the software architecture.

The ongoing GroupSPACE project targets the research and development of a generic architecture prototype based on the paradigm of computational reflection as well. This architecture makes GroupSPACE unique. The simple sharing facility, the direct manipulation user interfaces and the multiple modality views of GroupSPACE may predict the seamless user acceptance of the prototype system.

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