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Abstract
The diffusion of groupware disciplines has determined the development of a wide range of co-operative applications with multimedia user interfaces. User interfaces have evolved from the point of view of the type of communication that they determine between user and computer. Traditionally, user interfaces involve three aspects: the system, the user and the way in which they interact. The goal of user-friendly design is to reach a level of interaction with the user that enables him/her to achieve communication with the computer in the most natural way. Similarly, group interface design aims to create a new means of communication among people. However, through this means modalities of interpersonal interaction differ from previous types of interaction (face to face, telephone, mass-media, etc...). In the design of a group interface it is necessary to determine and use different heuristics (linked to the study of organised activities, the work environment, etc...) and models relating to human behaviour in communication. Concepts such as roles and organisation, ignored in systems centred on interaction between individual user and computer, must become an integral part of the design of interfaces for groupware systems. This paper describes the design and prototype of CHAOS-I, the interface of the co-operative system CHAOS (Commitment Handling Active Office System), which handles a network of conversations and commitments for a group of people. CHAOS-I provides the user with three work environments: communication, commitments and the organisation of personnel. The design of CHAOS-I has been guided by a set of heuristic principles for group interfaces that take into account the roles, organisation, objects, awareness and personalisation of views. Finally, an initial evaluation of the interface will be given and the effectiveness of the applied guidelines and their generalisation to groupware interfaces will be discussed.
1 Introduction: interfaces for groupware

Groupware disciplines, or computer supported co-operative work, concern the use of computers to facilitate human interaction. Groupware supports the co-operative work done by a small community of people with common goals assuming responsibilities for doing particular tasks [Ban93]. Communication, collaboration and co-ordination of user activities must be integrated in the groupware software [Ell91]:

- communication
At present, computer mediated communication, such as electronic mail, is not completely integrated with other forms of communication. The asynchronous world of electronic mail exists separately from the synchronous world of telephone and face to face conversations. The integration of computer technology with telecommunications will enable the user to bridge the gap between these two synchronous and asynchronous worlds.

- collaboration
Collaboration, as well as communication, requires the sharing of information among people in suitable shared environments that make users aware of the actions of others in an explicit way. Unfortunately, current information systems (particularly database management systems) isolate each user from the others. While recent applications, such as databases, contribute to collaboration in a certain way (providing multiple access to shared objects), most of the tools offer only a perspective for the single user.

- co-ordination
Communication and collaboration can be more efficient if the activities of the group are co-ordinated. Co-ordination can be viewed as a real and indispensable activity when different people do different parts of the same work [Mal90].

Besides, in groupware applications, there are concepts that are ignored in systems centred on the interaction between single user and computer. These concepts relate to:

- tasks
Tasks must be considered in relation to structures of organised activities and structures of goals. People taking part in social situations cannot know how the whole structure is developing. Tasks are able to influence the interaction between members of the group. Tasks can be identified at various levels of complexity: at the basic level, they can be divided into single actions.

- roles
A role is a set of competencies and responsibilities, or a subset of tasks, assigned to a person and sometimes to a module of the system. In many work situations people act on the basis of one or more roles and interact with others behaving according to their perception of roles. The tasks of each person are linked directly with the roles that the person performs.
- objects
Almost always the work of the members of the group consists of the manipulation of objects which can be of a physical nature (documents, signatures...) or of a conceptual nature (messages, conversations, general information...).

- work environment
A work environment defines the scenario and possibilities of executing specific tasks, and it includes people, their roles and the objects involved in the tasks.

Interaction within a group can be described by the instantiation and combination of these four factors. Therefore they must become an integral part of the design of the interfaces of groupware systems [VdV94]. On the other hand, the diffusion of groupware has determined the development of a wide range of co-operative applications with multimedia user interfaces.

User interfaces have evolved from the point of view of the type of communication that they determine between users and the computer [Bas93]. At the beginning user interface was designed with a technologically-centred perspective: the user had to be familiar with a difficult language of commands, carried out exclusively to obtain efficiency. In the seventies the new idea of the centrality of the user in the design of systems (User Centred Design) began to spread. The whole design process has been guided by the study of the cognitive attitudes, preferences and professional habits of the user.

However, current HCI interface design methods fail to fully incorporate the issues involved in current group interfaces. In a recent paper [Bow93], Bowers and Rodden argued that the concept of the single interface providing a focus for interaction with a computer system is no longer tenable and that richer conceptions of the inter-relationships between users and computers supporting their work are needed. They pointed out that, in a co-operative system, "the interface is publicly available as a resource for social action and interaction", so "the interface as simple abstract model of the real world becomes problematic".

According to Plaisant and Shneidermann's perspective [Pla94], the natural evolution of the user interfaces is towards "roles-centered" design which places more emphasis on user tasks rather than on documents. Substantially, the goal of these interfaces (called interfaces of the fourth generation) is to improve the support provided to people in handling their multiple roles in an organisation. Every person's role determines a specific set of people with whom he or she must collaborate, and a specific collection of tasks that he or she must execute. Group interfaces inherit the interaction styles and the technologies of the previous generations (such as command languages, direct manipulation and the hypertextual style oriented towards documents), and use them with the aim of improving performance and reducing distraction while working in a particular role; besides, they are designed to facilitate the shifting of attention from one role to another.

In order to ensure system usability and to design interfaces that reproduce user communication styles, designers make use of guidelines. These are produced both as the
result of research into the fields of cognitive psychology and human factors, and through the knowledge acquired by experts in the field of interface design and evaluation. The guidelines are the goals of a user interface design [May92] and consist of a set of recommendations expressed in a generic form, and adopted according to heuristics about user behaviour, or according to psycho-cognitive theories that provide a model of how information is elaborated in the human mind. The application of guidelines is not always straightforward. In fact, since they offer general goals, in a particular application, guidelines may generate conflicts because of their general nature.

Ellis, Gibbs e Rein [Ell91] have suggested some design principles restricted to the field of real-time groupware interfaces: WYSIWIS (What You See Is What I See), use of appropriate devices to keep the attention of the group, criteria for sharing screen space, alternative ways of using new interaction objects.

The aim of the design of a group interface is to create a new means of communication among people, in which the modalities of interpersonal interaction differ from the interactions previously developed (face to face, telephone, mass-media, etc...). This design perspective is based on the explicit assumption that, quite obviously, users want to communicate in as natural and easy a way as possible. In the design of a group interface it is therefore necessary to determine and use different heuristics (linked to the study of organised activities, of work environments, etc...) and models and theories relating to human behaviour in communication.

The design and prototype that we have implemented for the interface of a group system, and the heuristic guidelines that we have selected and applied during this design will be described. Finally, their effectiveness and generalisation to groupware interfaces will be discussed.

2 The design of CHAOS Interface

We have designed the interface for a co-operative system named CHAOS (Commitment Handling Active Office System), developed by the Department of Computer Science of Milan [Dec88],[Div93].

The system supports co-operative work within groups: it handles a network of conversations and commitments among a group of people and is characterised by the following aspects concerning two different dimensions of the language, the first pragmatic and the second semantic:

1. CHAOS is based on the theory of language/action [Aus62], [Sea69], [Sea75], that considers language as a social action. According to this perspective each message is essentially a language act that always belongs to a conversation [Flo81], [Win88]; while each conversation is a sequence of linguistic acts and represents the means through which the communication between people is organised.

2. CHAOS is concerned with the semantic dimension of language, that is how information is presented within a message. It forms communication messages using half-structured modules that are organised in such hierarchies that the more specific modules inherit the
structure from the more general ones. It defines a set of tools to gather and filter messages automatically [Mal87], [Mal92].

The goal of the CHAOS system is to handle the co-operation within three main areas of activity in an organisation:
- the communication,
- the management of the organisation,
- the management of the work commitments.

CHAOS-I 3.0 is the group interface of the CHAOS system that we have designed. We have developed a prototype of this interface in the X-Window™ environment, using the programming toolkit Tcl/Tk™ [Ous93].

CHAOS-I is an improvement of previous versions [Sim92], not only because we have used the interaction style of direct manipulation, but also because we have applied a set of heuristic guidelines for group interfaces (discussed in section 3) and the principles for a user-friendly design [May92], [App92]: use of metaphors, see-and-point, consistency, visibility, user control, feedback, robustness, recognise-rather-than-recall, reversibility and aesthetic integrity. Moreover, we have re-designed the entire architecture of menus and documents and we’ve planned a structure of three different working environments for the user.

CHAOS-I is inspired by the metaphor of the office. It provides the user with three work environments (Figures 1, 2): communication, commitments and the organisation of personnel.

The use of this metaphor fulfils a double role:
- to represent the elements and aspects of the application relying on the knowledge that people have of the world around them;
- to communicate a model of the program to the user.

Each work environment is characterised by a collection of objects and a collection of actions. To reduce mnemonic user effort (according to the guideline of “recognise-rather-than-recall”), we have structured the system in a stable and coherent way, that is with a limited number of types of objects and with standard actions.

### 2.1 The objects

The objects contained in the interface are identified using icons representing the metaphor from which they are inspired (Figure 3). There are two types of object:

1. objects with particular functions, such as folders, agendas and tools signalling the presence of a letter or talk request coming from other people;

2. documents.

The documents are divided into three groups:
a. documents for managing messages
This group of documents contains the documents used for managing messages. In such a

group there are:
- conversations
A conversation is a collection of letters and talks relating to a single theme. It is a

particular type of document because it contains the possibility of opening a new letter or a

new talk. For this reason conversations are represented by an icon underlining their

composite structure.
- letters and talks
Letters and talks always belong to a conversation and cannot be controlled independently

from it. Therefore, they are not represented by the style used for standard documents, but

by icons stressing their link with conversations.

Figure 4 presents a copy of the computer screen showing how a conversation appears and

the creation of a new talk associated with it.

b. generic documents
This second group of documents contains the generic documents, consisting of

unstructured text or/and a collection of fields;

c. specific CHAOS documents
We have defined many types of specific document (Figure 3):
- in the organisation environment there are:
  - activities
  - disciplines
  - people
- in the commitments environments there are:
  - commit types
  - agenda
- in the communication environment there are:
  - rules for handling conversations

Figure 5 shows an example of a document of the "activity" type.

As can be noted, the textual language of the interface is supported by a coherent graphical

language: the icons refer not only to the object type, but also to the particular behaviour of

the object. In this context we have applied the principle of aesthetic integrity, according to

which information must be well organised and consistent with visual design; well-chosen

graphics are considered fundamental for an efficient interaction between user and

computer.

2.2 The actions
The actions define what it is possible to perform on an interface object. They belong to the

menus of the interface, which are enclosed in the main menu bar of CHAOS-I (Figure 6).

In CHAOS-I we have extensively used menus, according to the guidelines of see-and-

point and of visibility. According to the guideline of see-and-point the interface must show
users what they can do in such a way that all the operations the user can execute are represented as alternatives on the screen; on the other hand the visibility guideline, also known as the principle of WYSIWYG (What You See Is What You Get), consists in making the important parts visible at all times, both on the executive level, so that the user knows how he or she can do it, and on the evaluation level, so that they can understand what effects their action will have.

3 Guidelines for group interface design
In our work we have defined a set of five principles that can characterise the design of group interfaces.

3.1 Shared objects
This principle refers to the concept of shared object.
An element of the system that can be seen or manipulated by many users is called a shared object. These objects are shared resources whose access must be controlled for many reasons: privacy, security in order to avoid potential conflict between users,... [Bri94].
From the point of view of the user interface, this control can be presented as follows:
- to represent the information associated with a shared context, indicating the collection of users that can manipulate the objects and the collection of users that can only see these objects;
- to define suitable ways of representing the objects according to the access type (in reading or in writing) a user has to the shared object. This implies that, for example, the content of folders or of document menus is visualised in different ways according to whether the user has opened them in the reading or in the writing mode;
- to activate error messages when the user tries to violate the rights of writing or when conflicts on shared objects arise.

In CHAOS-I each document and each folder is associated with a window containing related information:
- the name of the object;
- the people who can modify it;
- the people who can see it but cannot modify it;
- a personal comment that describes the object.

Each document is represented in two different ways, depending on the type of access:
- reading access
The document, for instance a conversation, is represented as a whole block, not allowing the user to modify its textual content. This does not prevent the user from opening new letters or new talks in the conversation, or from introducing new commitments in the agenda.
- writing access
The document is represented as a collections of fields and the user can cancel or introduce text only on some of them. These fields are not only visualised by the user in a different way from other users, but they also have associated menus containing the values that the
user can introduce. The collection of fields that the user can modify and the values that he or she can introduce depend on the user’s role.

If the document is the agenda, not all the commitments that it contains can be modified; for example the user cannot modify the ones fixed by his managers without their consent. Consequently, also the documents contained in the agenda relating to the commitments must be represented in a different way, depending on whether they are being modified or not.

3.2 Personalisation of views

This principle uses the concept of shared context. A shared context is a collection of objects such that the objects and the actions performed on them are visible to a series of users. Examples include documents of a co-authoring system and a blackboard of electronic rooms.

A view is a visual or multimedia representation of some portion of a shared context. Different views can contain the same information, although this is presented in a different way. For example, an array of numbers can be represented as a table or a graph. Alternatively, they can use the same representation but refer to a different portion of a shared context.

In the interfaces for groupware views must be customised [Bri94]. The personalisation can be either automatic, that is done by the system according to the role of the user, or determined by the user himself, or a combination of the two. In some cases users can impose what another user can see and how they can see it, according to his/her role. It must be observed that if not all users have the same views, some mechanisms of awareness and some shared experiences will be limited.

In CHAOS-I the principle of personalisation of views has been applied in the following way:

- the user can decide to cancel the shared objects which he/she only has the right to read without influencing the views of other users. In the same way, he/she can organise the shared objects in personal folders without influencing the organisation of information owned by others users;
- the user can decide to visualise commit types, activities or disciplines in a hierarchical order or in an alphabetical order, without influencing the vision of other users;

3.3 Awareness

Awareness is the understanding that a user has of the activities of others and that determines the context of his/her activity. This context is used to ensure that individual contributions are relevant to the activity of the group and to evaluate individual actions according to the goals of the group. Awareness then carries out an important function in the co-ordination of co-operative work.

It is important to realise that the context in which each member of the group works consists of the objects of co-operation, and of the way in which these objects are produced. Therefore, not only the content of these individual contributions, but also their type, that is, their meaning in the context of the group goals, should be considered.
Only providing awareness of the aspects of the work of other group members can users co-ordinate their activities in a more efficient way [Bel92]. Therefore, it is suitable:
- to provide direct mechanisms (such as electronic mail or talks) by which the members of the team inform each other of their activities;
- to define suitable error messages that inform users of conflicts in the activities that they have created;
- to represent a hierarchy of group activities pointing to the goals, the people and the operative situations that characterise each activity.

The user of the CHAOS system is provided with tools informing him of the activities of the organisation:
- in the organisational environment a folder has been defined for the activities of the organisation. This folder contains all the documents describing the activities carried out;
- in the communicational environment it is possible to have conversations with other members of the organisation. In these conversations the activities that a person performs or the state of the activities done by other people influencing that person can be discussed.

3.4 Roles
Groupware must support people in handling their many and different roles (for example an individual can at the same time be an employee, a student and a teacher).
From the point of view of group interfaces each role must be represented by information describing its various rights, privileges, duties, responsibilities, tasks and the involved people; this information is defined by the user or his/her manager.
The interface must represent the information according to the role which the user is performing, so as to put at her disposal the most important information relative to the goals, tasks and individuals connected to this role, and to secondly give him/her the information relative to the other roles of the user.

In CHAOS-I it is possible to assign many different roles to the same person. The roles owned by each person in his many activities are defined in the document associated with him/her.
Each user, according to the role performed for a certain activity, can affect the behaviour of the other user through conversational roles. To define the conversational roles we have designed a suitable editor that can be invoked by selecting the option Conversation Roles Editor from the People menu in the menu bar. Using this editor it is possible to cancel, modify or create rules influencing the behaviour of a set of people involved in a set of activities. Both these sets are automatically determined by the system according to the roles of the user in the activities of the organisation.

3.5 The organisation
In groupware no user can function in isolation, because many users must by definition exist, otherwise groupware would not be suitable. Each user must be connected and integrated in the organisation, while satisfying his/her requirements of privacy; they may
wish to perform private actions and to own personal objects that are not handled by the organisation they belong to. From the point of view of the user interface this condition can be translated by representing the hierarchy of the activities, people and roles in the whole organisation to which the user belongs, that is by providing a complete vision of the organisation without limiting it to the domains covered by the roles that he/she owns. In this way user awareness is enhanced.

CHAOS-I contains an environment dedicated exclusively to the representation of the organisation. In such an environment folders containing information relating to the following can be found:

- the activities of the organisation
  If the organisation is a school, the activities could include the management of courses, administration, handling of the library, while in the case of a firm they include different fields in which the firm is concerned: production, administration, sales, etc.;
- the disciplines connected to the activities
  If the organisation is a school, they include subject which are taught in courses, while if it is a firm they include necessary knowledge of the different concerns of the firm;
- the people that belong to the organisation
  For each person roles that he/she performs are indicated in the activities of the organisation, the disciplines for which he/she is considered an expert or that he/she manages and the conversational rules limiting his/her behaviour.

4 Interface evaluation and future developments

Evaluating computer applications is always difficult, but it is more so for groupware than for single-user applications. Because we have only developed a prototype of the interface for the CHAOS system, we have executed only simple tests of the comprehensiveness, usefulness and friendliness of the interface. Some Computer Science students, who had never seen the CHAOS system before, tried to use the interface without help. Some common teaching situations, such as organising a seminar, interacting with the professor and assistants in order to prepare a thesis, or planning a test, were simulated. Students were requested to perform some roles, taking the role of the professor, for instance, they had to decide a hierarchy of tasks, involving different interlocutors (e.g. the administration, the students, the assistants) and to simulate the accomplishment of these tasks through the use of the agenda and conversations: the preparation of the final exam included preparation and agreements with the assistants, booking and correction of the exam. We asked them, during the experiments, if the objects, the menus and the general structure of the interface were readily understood. These initial experiments showed that the interface is easy and pleasant to use. We think that this is due to:

- the use of a toolkit (Tcl/Tk) for the development of graphical user interfaces. Toolkits for the development of GUIs incorporate studies by experts on HCI and allow programmers to easily apply the results of these studies to their interfaces;
- the application of guidelines for developing friendly graphical user interfaces, also based on the experience of very well-known graphical environments, such as Apple Macintosh or Windows. Moreover, we have considered some new principles and applied them to the design of a group interface.

The guidelines for group interfaces we have highlighted during the design of the CHAOS system are heuristic. However, they should ideally be supported by theories of human behaviour in communication, that could better explain their value and the scope of their application. However, we should take into account that, this time, communication is being mediated by a new type of medium, and that the mean of "ease-to-use" becomes problematic. Hiltz and Turoff [Tur93] have provided interesting points on the changes in behaviour of users experiencing computer mediated communication. The authors believe that theories like "situationism" by Goffmann [Gof59] or the analysis by J.Meyrowitz on the impact of electronic media on social behaviour [Mey85], could highlight and support suitable metaphors for the design of co-operative interfaces. For example, Goffmann's metaphor of human communication governed by mechanisms of "stage and backstage", can justify the need of our "awareness" principle, and suggest how awareness could be designed in an interface. This however, is a subject for further investigations.

There are at least two reasons why the attention to usability for group interfaces, requiring new definitions, guidelines and methodologies for design, is crucial:
- the trend towards more and more "virtual" working environments and organisation places distributed over great distances.
- the challenge created by the construction of information super-highways, in which a growing number of people access a growing quantity of information and other human interlocutors.

In the design of co-operative systems, the need for a focus on usability issues and basic standards concerning the complexity of interfaces is essential, in order to support co-operation among users and to reduce learning times and error rates. In this paper we described the development of CHAOS-I, the interface of the co-operative system CHAOS. We showed how the application of a set of heuristic principles, taking into account the roles, organisation, objects, awareness and personalisation of views, was essential to the design of the group interface.

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