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Human-Computer Interaction Aspects of CSCW Systems

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Today's human-computer interaction debate mainly focus on interface design of single-user work places concerning individual workload, personal maladaptation, cognitive stress etc. Social organization of computerized work with people working together by using computer networks have hardly been considered systematically from an interface design viewpoint up to now. In most cases, design criteria from the „single-user world" are being transferred to groupware interfaces without any particular concern. But in CSCW systems users are not only dealing with interfaces but more important they are part of an interaction process. In CSCW systems users act, react, and interact with other users via computers. Therefore we have to design complex, dynamic human-computer-human interaction processes.

By developing CSCW systems designers have to leave the narrow viewpoint of „computers being a tool" to solve isolated tasks. They have to enlarge their perspective to the level of „computers being a medium" of cooperative task performance in a complex organizational setting. The knowledge which has been created and applied by researchers in the field of human-computer interaction (HCI) has mainly been derived from disciplines like cognitive science, perception psychology, or ergonomics. Investigating computerized group work and designing CSCW systems as well as embedding these systems into a distributed enterprise organization requires consideration of scientific fields such as social psychology, small group theory, communication sociology and media science.

Which knowledge can be transferred from the design of tool interfaces to that of media interaction? Which are the usability deficits of today's groupware, concerning application level, criteria level, and methodological level? Which are the deficits of current HCI approaches dealing with CSCW systems? The analysis of these questions will lead to some aspects of a group-oriented re-design of HCI to become HCHI (human-computer-human interaction).

1 Second Generation of Human-Computer Interaction

1.1 Single Work - Cooperative Work

Traditional computerized work is single work: One person is working with one computer[1]. The productivity gain results from the calculating, sorting, or retrieving power of the computer, not from its ability to mediate between people.

Accordingly, the discipline of human-computer interaction is dealing with single-user oriented design criteria up to now. If we take a look at current state of international standardization in the field of human-computer interaction this becomes quite obvious. ISO 9241, part 10, requires the application of the following ergonomic design criteria [2]:

1 *Suitability for the task*
User is being supported in effective and efficient completion of the task

2 *Self-descriptiveness*
Each dialogue step is immediately comprehensible or explained to the user

3 *Controllability*
User is able to maintain direction over the whole course of interaction

4 *Conformity with user expectations*
Dialogue corresponds to the user's task knowledge etc. and to conventions

5 *Error tolerance*
Despite errors, intended result may be achieved with no or minimal correction

6 *Suitability for individualization*
System allows for modification to the user's individual needs and skills

7 *Suitability for learning*
Dialogue provides support, and guidance to the user during learning phases

Each of these criteria aims at the interaction of a single user, considering his individual (cognitive) health and safety.

This view on single-user requirements is quite important but not at all sufficient. Since companies have realized that productivity gain of single-user applications is limited and even worse that the design of computerized work systems with a high degree of division of labor is often counter-productive companies more and more are taking holistic and cooperative aspects of work into consideration.

But unfortunately this insight up to now is not transferred to system development: Ergonomic design of cooperative work systems is done by simply adopting principles and methods from the age of single-user workplaces. The result is that this kind of groupware fails to achieve promised productivity gains and is often rejected by users because of its lack of expected humanization of work.

1.2 Groupware: Tool - Medium - System

The computer at a single workplace serves as a *tool* (or a machine) which supports (or replaces) human problem solving. In addition to this a computer used in a group serves as a *medium*. It combines single workplaces by transferring, saving, and delivering information to cooperation partners, by intelligent monitoring of communication between users, by providing space for shared work on documents etc.

Considering CSCW systems as software which supports „group work" we first have to define the essential characteristics of this kind of social organization before dealing with design criteria for groupware. From our point of view group work covers all kinds of collaboration which aim at joint solution of a common task. Group work is characterized by several dimensions, each varying on a wide scale:

◊ Subject of collaboration
- act on shared material (co-action)
- transfer information (communication)

◊ Competence for defining goals
- by group itself (intrinsic motivation)
- by a third party (external motivation)

◊ Competence for planning joint actions
- assigned to group (auto-planning)
- located externally (coordination)

[1] Even in central multi-user timesharing systems the operating system simulated a one-to-one relation between user and computer (virtual machine concept).

◊ Degree of (inter-)dependence[2]
  - voluntary interaction, loose connection (internal control)
  - forced interaction, close connection (external control)

◊ Kind of interaction
  - influencing the actions of a partner (bargaining as part of cooperation)
  - adjusting to the actions of a partner (acting according to rules)

◊ Degree of directness (awareness, space, time)
  - direct: present, face-to-face, synchronic
  - indirect: absent, distant, asynchronic

◊ Degree of social dynamic (concerning values and judgments)
  - consent, compromise
  - disagreement, conflict[3]

◊ Group stratification
  - flat organizational structure
  - hierarchical organizational structure

Considering especially the last two dimensions it should be obvious that design criteria for groupware can not be restricted to cognitive and perceptual aspects but have to deal with „dynamic social interfaces" in complex organizations. Even if groupware systems fulfill traditional HCI criteria quite well they nevertheless may be neither productive nor accepted by users if they lack to deal with socio-technical interface criteria.

It is not sufficient to look at the computer as a tool and it is also not sufficient to add the media perspective. Embedding both into the given organizational framework leads us to a system perspective of human-computer interaction. We therefore can say that the „tool ergonomics" together with a „media ergonomics" has to be enhanced to a „systems ergonomics".

1.3 Deficit classification

Confronting group work characteristics (listed in chapter 1.2) by traditional HCI criteria (listed in chapter 1.1) shows crucial deficits and design pitfalls. We can identify three kinds of deficits by putting the following questions:

◊ Which deficits occur when trying to *apply* HCI criteria to CSCW systems? (application deficits)

◊ Which deficits are due to insufficient HCI *criteria* when adopted in CSCW system design? (criteria deficits)

◊ Which deficits in CSCW systems result from inappropriate *design methods*? (methodological deficits)

These deficits sometimes are caused by insufficient HCI knowledge of groupware designers but in most cases they are deficits in *design principles* calling for a „second generation HCI", specially suitable for CSCW design: The new discipline of Human-computer-human interaction.

2 HCI deficits of CSCW

2.1 Application deficits

First we want to examine if CSCW systems fulfill traditional HCI criteria. The question is if these criteria derived from single-user applications can also cope with the needs of collaborating and communicating users in a groupware environment. With respect to limited space we will discuss only some of those criteria to illustrate the problem (terms in *italic fonts*, see chapter 1.1).

Suitability for the task refers to a work which changes the content of a given information. This criterion is applicable in the case of co-action on shared material (subject of collaboration, terms in helvetica font, see chapter 1.2) but it does not fit very well if communication is considered.

Controllability requires among other things that the speed of interaction should be under the control of the user. This is with respect to the degree of directness only possible in asynchronous collaboration. In synchronous communication speed depends on users' mutual agreement (co-control, suitability for bargaining).

The same criteria also demands for the implementation of reverse functions (undo). This is very useful in single-user environ-

[2] For an in-depth consideration of the concept of „interdependence" cf. Markus/Connolly [8].

[3] The often ignored fact that cooperation is always combined with possible conflict in social groups is quite well elaborated in Easterbrook [1].

ments to reduce stress caused by errors. In collaboration processes which are mostly characterized by exchange of material or information fulfilling this criterion becomes quite difficult, especially in synchronous communication. But it may also not be possible in asynchronous communication: Think about the difficulty of undoing the delivery of an email if recipients already got (and opened) the mail file.

Suitability for individualization is extremely helpful to adopt a program to an individual user. But the application of this criterion is quite limited in shared work and communication spaces because of existing interdependence. The input/output interface of a CSCW system (e.g. the appearance of an email client) may be adaptable to an individual's needs. But if we think about interface levels of higher semantics[4] we need as information theory tells us a common alphabet, in this case common dialogue and tool application rules, to enable "cooperative connectivity".
An example may illustrate this fact: In videoconferencing a uniform application program is needed on a semantic level to present shared material in a specific task context to all participants, regardless of their personal and situational background. On a pragmatic interface level, where social-psychological aspects of conferencing are taken into account, e.g. by supporting gesture expression, gaze awareness etc., individual adaptability is even more restricted.

A first hypothesis about the relation between workgroup dimensions and traditional *HCI criteria* can be stated as follows: The higher the degrees of interdependence, directness, and dynamic in a group situation are the less suitable are traditional HCI criteria for design and evaluation of CSCW systems. E.g., the use of a shared database by a work group to retrieve facts and figures represents a type of cooperation with a low degree of interdependence between group members, a low degree of directness concerning awareness, presence and synchrony, and a low degree of dynamics as no judgment is needed[5]. Most of occurring HCI problems of this shared database can be solved by adopting above mentioned ISO criteria. But because this example does not show the typical case of groupware the stated hypothesis indicates a crucial lack of group-oriented criteria in traditional HCI being the focus of next chapter.

Summing up we can say that traditional HCI criteria aim at asymmetric *human-computer* relations whereas the design of groupware requires criteria for symmetric *human-human* relations mediated by computers.

2.2 Criteria deficits

Concerning the above mentioned dimensions of group work it becomes obvious that the crucial characteristics of groups up to now are no subject of HCI in groupware design. Some of the deficits in criteria are associated with:

A/synchrony
Let us consider the case of email: Which design rules deal with reduction of workload induced by forced interruption of mental processes in asynchronous task performance using email, e. g. in the case of co-authoring. On the other hand, email is rather quick compared with traditional mail. Therefore senders expect a quick reply (even if this is not necessary in most cases) and users vice versa feel pressed to answer quickly which causes mental stress. Email sometimes is so quick that user get the impression of "talk" rather than of "mail" and behave like in talks. Therefore utterances often are more informal, implicit and vague causing misunderstandings in several cases. But the medium offers (in contrast to non-verbal cues in real talk situations) no means to ease the burden of explicit formulation or at least to quickly solve those misunderstandings.

Social and cultural context
This deficit described as loss of social context cues (body language, speech intonation, status symbols etc.) is well known in CSCW design. But besides a lot of sophisti-

[4] e.g. dialogue and tool level, according to IFIF interface model.

[5] For a deeper analysis of the influence of "judgment" on the acceptence of groupware tools see Harper and Sellen, [5].

cated trials to simulate the real situation by designing „seamless environments" („design realism") there are no rules how to

- ◊ mentally compensate lack of context or
- ◊ systematically use „lack of social order" for creative and non-hierarchic discussion or
- ◊ at least inform users about a given social situation.

A specific aspect of social context is cultural context (work group culture, company culture, national culture) which is not „constructed" like organizational context may be but is deeply rooted in tradition. Groupware often implies cultural values, designers do not have explicitly built in, and software sales people do not recognize[6].

There are at least two other criteria deficits which can only be mention here:

Control versus privacy

Groupware often provides a lot of process monitoring facilities, e. g. in workflow systems, which create comprehensive user profiles. This raises the question of a lack in appropriate privacy design rules.

Social dynamics

Current groupware in most cases assumes harmony in cooperation processes, common goals of participants etc. But real life cooperation as well as computer-mediated collaboration is influenced by contradictions and conflicts which are normally not looked at in our algorithmic view on functional requirements. So there is a need for rules concerning exception handling as well as conflict resolution.

2.3 Methodological deficits

The analysis of single work places and the design of single user software normally use "low level methods". Analysis of perceptual and sensorimotor requirements of e. g. a text processing task can be done by applying GOMS model and task action grammar on "keystroke level" [7].

Also on a psychological level nearly all known methods focus on single work places. Methods like „video confrontation" or „thinking aloud" when adopted to CSCW systems analysis are only covering the individual part of these experiments.

Even on the highest methodological level of HCI, i.e. user participation in system design, as assumption often is claimed that users of a specific software have similar interests and form a rather homogenous community. In groupware systems normally there are quite different participants, some of which are doing the work others have the benefit from. Grudin described this effect in an early study of electronic calendar systems [3].

An experimental design in a usability lab is suitable to control variables of local system use to a far extend whereas complex group situations in distributed sites require application of social psychology and anthropology methods performing time-consuming field studies. Moreover single-user applications are „more visible" and more intuitively understandable compared with distributed group applications which are more „virtual". User feedback and test performance are quite difficult in such virtual environments [4].

Last but not least, which mental models of cooperation media designers think users have in mind? First of all, are there appropriated models at hand for special net topologies, distributed data storage, peer-to-peer or client-server architectures etc. ? And which metaphors do designers use? Of course the post metaphor for email but also the "conveyor belt metaphor" for workflow systems? Methodological research is quite necessary in this field.

3 Group-oriented criteria in designing CSCW systems

First we could think about re-formulation of given HCI criteria so that they will become applicable for groupware design: Suitability for the task e. g. would be transferred to

[6] A nice example is Lotus Notes: American consultants report difficulties in marketing Notes in Japan [9] complaining that Japanese work groups have an unappropriate structure compared with US. But instead of offering built-in cultural adjustment facilities to Japanese companies consultants try to sell US company culture, frozen in their groupware.

suitability for sharing tasks (focusing at the process rather than on the subject). In analogy to the given ISO criterion there will be the demand that the cooperation process should not be impaired by properties of the technical medium, e. g. by connection setup handling. Similar re-formulation could be done with some of the other ISO criteria.

More important, a set of additional HCI criteria which specifically meet to needs of cooperation systems have to be formulated:

- ◊ rules to improve *transparency* and *awareness* of the properties of shared media and spaces and of other participants therein, e. g. in conferencing or co-authoring systems
- ◊ rules for supporting *bargaining* processes between users about participation conditions, system characteristics, as far as joint parameters are needed (e.g. about monitoring, bandwith, data access, supported equipment)
- ◊ rules for balancing individuals' and groups' *adaptability* facilities
- ◊ rules for providing *adequate information flow* (avoiding information flooding as well as shortage)
- ◊ rules for group learning processes

The transition from single-user HCI to group-oriented HCHI is still at its beginning. Interdisciplinary cooperation in research is needed to cope with interaction problems of computer-supported cooperation in practice.

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