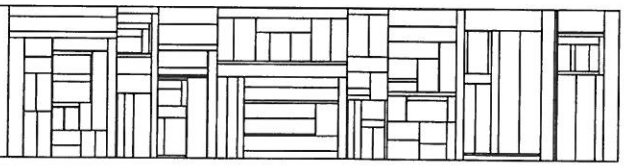
ISSN 0105-8517

A Framework for Computer Supported Cooperative Work

Pål Sørgaard

DAIMI PB – 253
March 1989
Revised Version

AARHUS UNIVERSITY
COMPUTER SCIENCE DEPARTMENT
Ny Munkegade 116 – DK 8000 Aarhus C – DENMARK
Telephone: + 45 6 12 71 88 *Telex: 64767 aausci dk*



Abstract

A conceptual framework for computer supported cooperative work is presented. A distinction is made between the context of the work, the use situation (which is a part of the context), and the computer system. The context of the work refers to the totality of the work: the kind of work, its organisation, etc. Cooperative work is seen as an aspect of the context of the work. The use situation is more delimited; it is the work situation(s) where the computer system actually is used.

The use relation is defined to be the relation between the context of the work, including the use situation, and the computer system. Computer supported cooperative work is defined as a quality of this relation. This quality is obtained when the computer system is used in such a way that the cooperative aspects of the work are supported. This definition denies that computer supported cooperative work should be seen as a property of the context of the work or of the computer system alone.

The use relation can be of many kinds. Three use relations: medium, shared material, and tool are of special interest to computer supported cooperative work.

Two applications of the framework are pointed at. One is its use in analysis when computer support for cooperative work is to be developed. The other is its application as a relevance criterion for research in computer supported cooperative work.

1 Introduction

The field of computer supported cooperative work is a new research field. At least two important sources of inspiration can be identified. One is the growing awareness of the misfit between classical information systems and the way work actually is performed [8, 27, 42, 46]. Another is the development of new kinds of multi-user computer systems, for example at Xerox PARC [41]. The framework presented here does not, however, try to give an account of the history of computer supported cooperative work.

There is no general agreement about the nature of cooperative work nor of computer supported cooperative work. Neither has there been much discussion about these issues. To the author this has resulted in uneasy feelings about this research field. Is there really a common topic or is the field just the latest fashion? The purpose with this paper is to create and contribute to discussions about these issues.

In the framework presented in this paper a distinction is made between the context of the work, the use situation, and the computer system. This distinction is made in order to make it possible to express that computer supported cooperative work is not only an issue of modern multi-user computer systems. One may, for example, talk about computer supported cooperative work although the use situation itself is entirely individual.

Inspired by the use of the computer as a tool [7, 10, 44] a more general term, the use relation, is defined. Tool is seen as one kind of use relation. Two other use relations of importance to computer supported cooperative work are medium and shared material. The main parts of the framework are illustrated in figure 1.

The paper proceeds as follows: In section 2 the use relation is discussed in more detail. Some examples of use relations with relevance to computer supported cooperative work are presented. In sections 3–5 the three main categories: the computer system, the use situation, and the context of the work, are discussed. Finally, in section 6, some possible applications of the framework are pointed at.

This paper is a part of the authors lic. scient. (Ph. D.) thesis. The other parts of the thesis are [34, 35, 36, 37, 38].

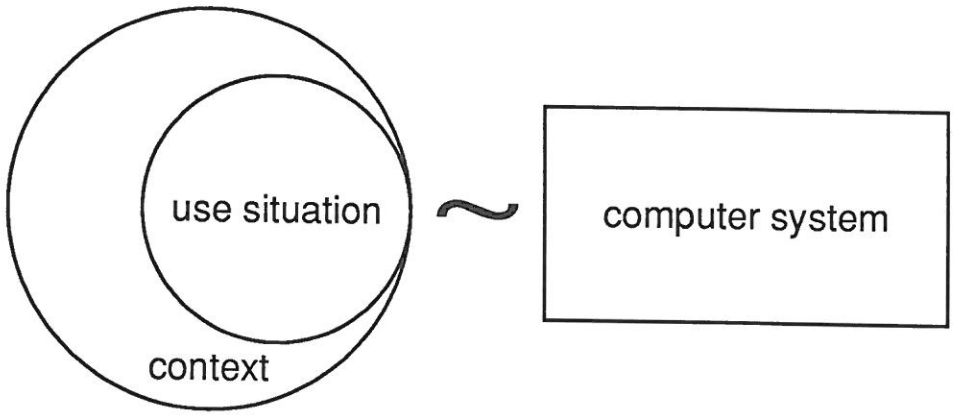


Figure 1: The use relation

2 The use relation

In this paper the *use relation* is defined as the relation between the context of the work and the use situation on one hand and the computer system on the other. This definition of the use relation is inspired by the tool perspective developed in the UTOPIA project [7, 10, 44]. In this perspective a computer system is not a tool in itself, its "toolness" lies in the way it is applied.

The use relation is an abstract concept. This is because it is used to denote a wide variety of phenomena. These range from the situation where a computer system is used as a perfect tool in total harmony with the working process to situations where the computer system is a major obstacle to getting the work done or where the system is used as a means for social control [22].

As already stated there is no generally accepted definition of cooperative work. One definition, proposed by this author, is [34]:

- People work together due to the nature of the task,
- they share goals and do not compete,
- the work is done in an informal, normally flat organisation,
- the work is relatively autonomous.

This defines cooperative work to be an ideal, or prototypical, kind of work. Cooperative work is one aspect of the context of the work. Other conflicting aspects may be present concurrently. The cooperative work may, for example, take place in a horizontally organised work unit which

is embedded in a hierarchical organisation. Cooperative work can be compared with group or clan organisation as described in the transaction cost theory [30, 38]. Using this definition of cooperative work, computer supported cooperative work can be defined as a quality of the use relation, namely that the computer system is used in a way which *supports* the cooperative aspects of the work. A specific reason for defining computer supported cooperative work as a quality of the use relation and not as a technical characteristic of a computer system is the observation that the impact of a computer system may vary from organisation to organisation [6, 29]. Thus a system which supports cooperative work in one context does not have to do so in another.

In the following three use relations of special interest to cooperative work will be discussed. These are medium, shared material, and tool.

Medium

Much research in computer supported cooperative work has focused on the use of the computer as a medium; examples are Winograd [45], Dunham et al. [9], and Goodman and Abel [15]. Madsen discusses the use of metaphors in design [23, 24]. Electronic mail is based on the use of ordinary mail as a metaphor. There are other computer based media that are based on the application of other metaphors. Examples of such metaphors are the telephone, blackboards, bulletin boards, and conferences.

There has been much empirical research on the use of electronic media [11, 12, 13, 39]. Quantitative research on the use of electronic mail does not necessarily address cooperative work, at least not as defined in this paper. By volume electronic mail is often dominated by distribution list messages, i.e. messages sent to symbolically named groups where the sender and receiver do not necessarily know each other. In one case Sproull and Kiesler have found that 86% of the messages read where group messages, most of these where sent to distribution lists [39]. The COM system provides computer conferences and electronic mail [31]. Palme reports that 92% of the messages read in COM where conference entries, the rest were letters [32]. In an analysis of the contents of electronic mail Eklundh concludes that the language used is different from other kinds of written communication [11]. Also when looking at who is communicating with whom, electronic mail exhibits special patterns. Eveland and

Bikson have documented a high volume of messages between people who are physically and organisationally close [12], i.e. between people who normally would not bother to write to each other. Personally the author uses electronic mail also to communicate with people he otherwise sees several times a day. This indicates that electronic mail cannot be seen as a replacement for ordinary mail. Electronic mail can be compared with a series of conventional media like ordinary mail, internal mail, answering machines, and tube mail.

The medium use relation is not restricted to the use of systems which explicitly support communication. The entry of data into a database can be interpreted as a communicative action [3]. Hellman argues that a reconstruction of a classical database system, where this implicit communication is made explicit and visible to the users, may solve some of the problems related to the use of information systems [17].

Shared material

Shared material is another kind of use relation which is central to computer supported cooperative work [36]. Material is the "thing" people work on, manipulate, move, etc. Many cues to the way work is performed can be attributed to the material. The development of typography, where the material has changed from metal types to photographic paper and further on to a computerised material is an example of this [7]. In cooperative work shared materials are important. One example is the way two persons carry a large piece of furniture. This example is perhaps hard to use directly in the design of an information system, but it may serve as a design metaphor.

When material is computerised many of its properties are lost or changed. A simple example is the coordination that comes automatically with the use of a manual file. A manual record can only be in one place at a time. This ensures that two persons who try to work on the same record will "automatically" be made aware of the collision. They will have to figure out how to proceed with the work.¡ They may decide that they can proceed independently, they may reschedule some activities to work on the record one at a time, or they may start working on the record together because their tasks are related. Thus the manual file provides the necessary cues to trigger cooperation when needed. The file does not, however, impose any specific way of doing the cooperation.

This coordination "for free" is often lost in a database system where the emphasis has been put on giving the users independent access to the same data. Database systems often provide the illusion that each user has the whole database at his or her disposal. Current database technology solves many of the technical problems which arise when data are shared, but they fail to address the importance of coordination through shared material. Work on databases for computer aided design, for example Katz et al. [21], has, however, addressed many issues of relevance to computerised shared material. One of these issues is "long transactions", corresponding to what will happen when a database is to reflect the absence or presence of documents.

New design metaphors are needed for the construction of shared material. Some possible metaphors are shared working surfaces, spatial occupation of a house, a material mediating actions, a distinction between original and copies, or surfaces where people can leave messages or annotations.

In Colab at Xerox PARC several systems which can be described as shared material have been developed [41]. One of the metaphors used in Colab is WYSIWIS (What You See Is What I See), a metaphor based on a shared workspace. Experience has shown that it is difficult to use "pure" WYSIWIS. Some relaxations are proposed by Stefik et al. in [40]. Another example of computerised shared material is a shared calendar [16].

Tool

The use of the term tool in this paper has its origin in the way the term has been used in the UTOPIA project [7]. A computer system is not a tool in itself, but a system can in some cases be used as a tool. "A good tool is something which helps the skilled users focus their awareness on the materials and products of the work process, leaving only subsidiary awareness on the tool" [7, p. 262].

Tools are normally perceived as individual. "When viewing the use of computers from a tool perspective, one focuses on the individual use" [7, p. 261]. Tools are, in spite of this, of clear interest to computer supported cooperative work. This for at least four reasons: (1) The term use relation as defined in this paper is inspired by the discussion of the computer as a tool. Many parallels can be drawn from the discussion of the computer

as a tool to a discussion of other use relations, for example from the statement that the computer is not a tool in itself to similar statements about other use relations. (2) Tools are used to manipulate material, also shared material. In general there is a close relationship between tools and the materials they are used to manipulate [7, p. 262]. Any attempt to support shared material will have to face the issue of developing suitable tools to manipulate the material. (3) There are examples of shared tools. The two-handled saw is a classical example of a shared tool. The flight control system in an aeroplane is an example of a computerised shared tool. A flight control system can be a tool in the sense that the pilots direct their primary awareness towards the aeroplane. The system is a shared tool in the sense that it needs to be built into the system that there are two pilots controlling the aircraft. (4) Although a tool is purely individual its use may still support cooperative work. One example of this is the construction of prototypes. The construction of a prototype is often made exclusively by the system developers using professional tools, but the prototype is used together with the users in a cooperative development process [2].

3 The computer system

In this section some characteristics of the computer system that are of relevance to computer supported cooperative work will be discussed. These characteristics are the use model, the data sharing technique, and the accessibility of the system. Some additional characteristics can be found in table 1 at the end of the paper. Space does not allow all these characteristics to be discussed.

The term *use model* is adapted from Kammersgaard [20].[1] A use model is a user oriented conceptual model linking user interface and functionality together and relating them to the area of application [20, p. 3]. A use model is, in other words, a model of the system presented to the user. In relation to cooperative work it is relevant to distinguish between single-user use models and multi-user use models. Many database systems have a single-user use model although the system handles the complexities incurred by many simultaneous users. As pointed out in the

[1]Kammersgaard uses the term user model. Bødker et al. [7] use the term use model. Kammersgaard's paper is a critique of the concept of user's model as presented by Newman and Sproull [25]. Kammersgaard distinguishes between the user model and the user's mental model.

Knowledge and Work project at the University of Turku this leads to weak coordination and communication [17, 27, 29]. The organisational context of the work is hidden from the user. The distinction between single-user and multi-user use models does not have to coincide with a distinction between systems that can be used concurrently by several users or not. It was observed above that a multi-user system can have a single-user use model. Conversely: a system running on a single user personal computer may very well have a multi-user use model. Such a system could be used in the same way as a serially accessed manual file.

Some implementations of multi-user use models require high communication speeds, for example a user interface based on the WYSIWIS principle, where the users can follow each other's actions. Today such interfaces are only feasible in local area networks.

The ability to share data is central in computer supported cooperative work [16]. Several *data sharing techniques* are available. Some alternatives are manual distribution of floppy discs or magnetic tapes, explicit transmission from one user to another, and shared access to the same file.

Manual distribution and explicit transmission imply limits to how shared data can be used. These techniques do, however, make the act of sharing explicit. In this way shared use of data is kept visible to the users. Nurminen argues that in a purely "humanistic perspective" each worker should have his or her own system unit at disposal. "These units are interconnected, but there are no shared storing or processing functions" [28, p. 167].

Shared access to files can be implemented in different ways. The ultimate solution is centralised storing and processing of shared data. This is the typical solution in practical database systems. A slightly more loose sharing is implemented in the Network File System (NFS) provided by SUN [26]. NFS allows actual sharing of the same files in a network of workstations. This is achieved without severe losses in speed, but unique access to a file is no longer provided. The same file can be written from two different workstations at the same time. This is a consequence of the NFS protocol, where the file server does not maintain any information about the use of a file. This implies that facilities allowing shared manipulation of data must be explicitly constructed, typically using the remote procedure call protocol [26]. An alternative is turn-taking, either by agreement or by using a facility such as the Source Code Control System [33]. The Source Code Control System has been reimplemented

under NFS, using remote procedure calls to guarantee correct functionality. NFS does, however, work in the expected way as long as shared reading of the same file is sufficient.

In Colab shared data is, in some sense, simulated. The same data are replicated on the discs of the different workstations. An optimistic reservation strategy is used. This means that concurrent modification of the same data will not always be prevented, but it will be detected within seconds [41]. This strategy increases speed since the data are already in the workstation. It may also reduce network traffic since in some cases only control information about who is using the data and not the data itself needs to be transmitted.

Sometimes there is a clear match between a data sharing technique and a specific metaphor for shared material. This is the case with explicit transmission and a material which can be in only one place at a time. Work is needed, however, to develop metaphors and data sharing techniques which match and which utilise the capacity of current hardware.

The *accessibility of the system* is a factor which may strongly influence the use of the system. This author did not bother to learn how to use electronic mail before he got his own terminal. It would have helped, of course, if the mail system had been easier to learn; see Jørgensens critique of the user interface in UNIX mail [19]. It is obvious, however, that rapid dialogues, with many exchanges during a day, can only be realised when users are permanently logged on to the system on their own terminal or workstation. This is the kind of use of electronic mail which is most interesting to computer supported cooperative work since it may support tight cooperation and since it is only feasible with the use of computer technology.

Some other systems, for example meeting support systems, are designed to run on special equipment in special meeting rooms. Examples are Cognoter [14, 41] and the MIS Planning and Decision Laboratory [4]. Such systems will have to be easy to learn because the time the users are going to spend using them is limited.

The technical characteristics discussed here are very general and in no way sufficient. It has been pointed out by Bannon that apparently small changes to a system can significantly change its utility [5]. Examples of such changes in a mail system are notification of receipt and delivery of messages. It would be desirable to know more about these effects. Such knowledge cannot be entirely empirical, since it is an endless endeavour to

do empirical research on the effects of all possible changes to, for example, electronic mail systems.

The discussion in this section is quite technical at some points, although many technical characteristics worthy of discussion have been left out, see table 1. Technical detail is, however, relevant in this discussion since many interesting applications of computer supported cooperative work require quite specific and sometimes complicated technical solutions.

4 The use situation

The *use situation* is the well defined part of the context of the work where the system actually is being used. Nurminen et al. also point at the importance of the use situation [29]. In the context of computer supported cooperative work it is important to distinguish between the use situation and other aspects of the context of the work. One reason for this is that we may have individual use which still supports cooperative work, or we may for that matter have collective use which disrupts cooperation. The latter would be the case if the computer system were used as a kind of assembly line. A second reason for this distinction is that some important characteristics of the way a system is used cannot meaningfully be attached to the context of the work. One such characteristic is the distinction between synchronous and asynchronous use. A third reason is that there may be several different use situations in the same work. Finally there are some characteristics, like physical distance between the users, that may be different during use than otherwise. Some characteristics of the use situation will be discussed more in detail below. These are physical distance, synchronous versus asynchronous use, and open or closed sets of users. Some additional characteristics can be found in table 1.

The importance of *physical distance* in the use situation has been pointed out by the people behind Colab [14]. Users of Colab are in the same room, hence they have other means of communication like voice and gestures at their disposal. There ought to be a tremendous difference between a system supporting a face-to-face meeting and a system that tries to create a meeting-like situation between people in different locations since the latter must provide facilities for all sorts of interaction needed whereas the former provides some facilities useful to a group

which has many other means of interaction. The following quote from Eleanor Wynn illustrates this point [46, p. 13]:

> "... the face-to-face situation is one in which the interactants relate to each other as individuals whom they incorporate into their experience in a total social way, not just in terms of the immediate utilitarian task or "topic" at hand. An emergent property of such a phenomenon is that material which is *associated* with the task but not directly necessary for the very performance at hand is brought to play. In other words, the interaction becomes an occasion for many interpersonal and cognitive possibilities, not just one."

Bannon claims that one of the most common distinctions between communication facilities is between *synchronous* and *asynchronous* facilities [5]. Here this distinction is applied to the use situation since some systems may be used in both ways. The synchronous facility of sending messages to somebody else's screen may also support asynchronous communication: the receiver may be absent when the message is received, and does not react until he or she comes back. Electronic mail is an asynchronous facility, but if the arrival of mail is appropriately signaled, electronic mail can be used in an almost synchronous way. Bannon points out, however, that computer support for pure synchronous communication is not too interesting since this can be much better supported by the use of telephones.

The distinction between asynchronous and synchronous use situations may also be applied to sharing of material. Asynchronous use of shared material is fairly easy to support, this corresponds to turn taking or explicit passing of data between users. Synchronous use of the same data, while maintaining a multi-user use model, is much harder to provide. See the discussion of data sharing in Colab in section 3.

The last distinction discussed is between *open* and *closed sets of users.* Closed sets of users can be found in ordinary electronic mail and in closed computer conferences. Open sets of users are typical in network news and in open conferences. The COM system allows open as well as closed conferences [31]. Mailing lists or mail groups are often used as closed groups, but as the groups get large, refer to each other, etc., the mail groups effectively become open. An open set of users implies that care should be taken with respect to wording of messages: (quotation from

letter on use of the USENET)

> **Never Forget that the Person on the Other Side is Human**
> Because your interaction with the network is through a computer it is easy to forget that there are people "out there". Situations arise where emotions erupt into a verbal free-for-all that can lead to hurt feelings.
>
> Please remember that people all over the world are reading your words. Do not attack people if you cannot persuade them with your presentation of the facts. Screaming, cursing, and abusing others only serves to make people think less of you and less willing to help you when you need it.

The distinction between open and closed sets of users also applies to the use of shared material. In a closed group it may be feasible to allow sharing of data without using complicated privilege mechanisms.

5 The context of the work

The *context of the work* refers (in a sociological sense [18]) to the totality of the work. The characteristics of the context of the work discussed in this section is a very small selection of the aspects of the context of the work one might pay attention to. Care should be taken not to reduce the issue of understanding a totality to an issue of selecting the right characteristics to pay attention to. This does not imply, however, that it is wrong to identify some important characteristics. A set of important characteristics may serve as a starting point in an attempt to achieve understanding of a totality. Furthermore, in this paper the identification of some characteristics serves the purpose of presenting the idea of the context of the work to the reader. The characteristics discussed will be the nature of the work, the physical distance between the workers, the size of the group, and the kind of work in question. Again some additional characteristics can be found in table 1.

As stated earlier in this paper cooperative work is a characteristic of the context of the work, not of the use situation. The *nature of the work* can be ambiguous. There may be cooperative aspects of the work, but these may be in conflict with the surrounding organisation. A system development project may, for example, be characterised by cooperative

work between the system developers themselves and perhaps also between the system developers and the users. The project may be a part of a larger organisation where more formal organisation dominate. It is also so that few relations are purely cooperative. There may be occasional conflicts in a group which otherwise is characterised by cooperative work. The idea of seeing cooperative work as an aspect of the work is in clear parallel to the characterisation of organisations as groups, bureaucracies and markets in the transaction cost theory [30, 38]. One definition of cooperative work was given in section 2 of this paper.

Close *physical distance* is important in group work. This has been pointed at by Wynn [46] and Suchman and Wynn [42]. Wynn focuses on the "ongoing interactions that are continually in the background in the office". These help to "maintain an interpretive framework that makes sense of utterances and situations" [46, p. 11]. Wynn argues that this kind of communication cannot easily be performed in other situations than face-to-face communication. In the context of computer supported cooperative work this implies that we ought to consider support for communication as a *supplement* to the existing means of communication, and not as a means to achieve cooperation between people who are not physically close.

The needs and possibilities for computer support depend on the *size of the group*. Certain data sharing techniques will become impractical when the group becomes too large. Ciborra argues that an information system compatible with the idiosyncrasies of a group may make group organisation (as different from bureaucratic organisation) feasible in larger groups than before.

Finally *the work in question* is central when computer support is to be developed [10]. The effects of specific facilities in the computer support may depend on the work being performed. One example is the introduction of tailorability [43], i.e. the ability to modify and extend an existing system by programming. In system development tailorability may ease the use of prototypes. This may make the use of prototypes feasible in the support of analysis and design [1], with the implication that programming skills are necessary in these system development activities. We may as a result observe a reduced relevance of the traditional division of work between analysts and programmers [37]. Such a shift may be in favour of the cooperative aspects of system development. In other kinds of work tailorability may lead to a deteriorated situation for those who are not

interested in or apt to programming. Those workers may have to rely on other people, perhaps their supervisors, to do the necessary tailoring. This may reduce their autonomy and increase the control by the supervisors, all in all not a development in favour of cooperative work. This is another demonstration of the observation that the effects of introducing new technology are not deterministic [6, 29].

6 Applications of the framework

In this section two possible applications of the framework will be discussed. The first is to use the framework to support analysis when computer support for cooperative work is to be developed. The second application is to use the framework as a relevance criterion for research in computer supported cooperative work.

In system development the analysis function is directed towards the user organisation, the technical possibilities, and the available design proposals. The aim of analysis is to achieve an understanding of these issues. Analysis and design are mutually dependent and should therefore be performed concurrently. Prototypes can be useful in system development, for example in supporting the interplay between analysis and design [1]. This does not imply that other approaches to analysis are obsolete or superfluous. The aim in computer supported cooperative work is to develop computer systems that support specific aspects of the user organisation. This requires an understanding of the user organisation and of the technical possibilities. The framework presented in this paper can be an aid in an analysis activity where the aim is to achieve such an understanding. This paper has only treated some of the relevant characteristics of the context of the work, the use situation, and the computer system. In table 1 an extended list of characteristics is provided.

It has been argued in this paper that computer supported cooperative work should be defined as a quality of the use relation. Research in computer supported cooperative work ought to reflect this. Technically oriented research in this field ought to be motivated by the applicability of the technical innovations in cooperative work. Empirically oriented research ought to focus on aspects of cooperative work that are or might be affected by the use of computers. Together this might pave the way for an improved interchange of ideas and results between technically and

The computer system:

- use model
- data sharing technique
- accessibility of the system
- are all users equal to the system or not?
- accounting, charging, and logging
- communication speed
- delay times
- reliability

The use situation:

- physical distance
- synchronous or asynchronous use
- open or closed set of users
- number of users
- time span and frequency of use

The context of the work:

- nature of the work (cooperative work or not)
- physical distance
- size of group
- kind of work performed
- cultural and social closeness between users
- homogeneousity of users in the organisation
- surrounding organisation
- what profession(s)
- time span of typical work tasks

Table 1: List of characteristics

empirically oriented research.

Acknowledgements

I am grateful to Joan Greenbaum for her constructive comments.

References

[1] Niels Erik Andersen, Finn Kensing, Monika Lassen, Jette Lundin, Lars Mathiassen, Andreas Munk-Madsen, and Pål Sørgaard. *Professionel systemudvikling.* Teknisk Forlag, København, 1986.

[2] Ole Bach Andersen, Erik Bjerre, and Jan Mark. *Udvikling og brug af fælles materialer — et aspekt af bruger/udvikler samarbejdet i design.* Master's thesis, Computer Science Department, Aarhus University, Århus, April 1988.

[3] Peter Bøgh Andersen. Semiotics and informatics: computers as media. In Ingwersen, Rajtery, and Mark Pejtersen, editors, *Information technology and information use*, Taylor Graham, 1986.

[4] Lynda M. Applegate, Benn R. Konsynski, and J. F. Nunamaker. A group decision support system for idea generation and issue analysis in organization planning. In *Proceedings from the Conference on Computer Supported Cooperative Work*, MCC Software Technology Program, Austin, Texas, December 1986.

[5] Liam J. Bannon. *Extending the design boundaries of human-computer interaction.* ICS Report 8505, Institute for Cognitive Science, University of California, San Diego, La Jolla, California, May 1985.

[6] Jeanette Blomberg. The variable impact of computer technologies in the organization of work activities. In *Proceedings from the Conference on Computer Supported Cooperative Work*, MCC Software Technology Program, Austin, Texas, December 1986.

[7] Susanne Bødker, Pelle Ehn, John Kammersgaard, Morten Kyng, and Yngve Sundblad. A UTOPIAN experience: on design of powerful computer-based tools for skilled graphic workers. In Gro Bjerknes,

Pelle Ehn, and Morten Kyng, editors, *Computers and Democracy - A Scandinavian Challenge*, pages 251–278, Avebury, Aldershot, England, 1987.

[8] Claudio U. Ciborra. Markets, bureaucracies and groups in the information society: an institutional appraisal of the impacts of information technology. *Information Economics and Policy*, 1(2):145–160, 1983.

[9] Robert Dunham, Bonnie M. Johnson, Grady McGonagill, Margarethe Olson, and Geraldine M. Weaver. Using a computer based tool to support collaboration: a field experiment. In *Proceedings from the Conference on Computer Supported Cooperative Work*, MCC Software Technology Program, Austin, Texas, December 1986.

[10] Pelle Ehn and Morten Kyng. A tool perspective on design of interactive computer support for skilled workers. In M. Sääksjärvi, editor, *Report of the Seventh Scandinavian Research Seminar on Systemeering*, Helsinki, 1984. Also available as PB 190, Computer Science Department, Aarhus University, Århus, January 1985.

[11] Kerstin Severinson Eklundh. *Dialogue Processes in Computer-Mediated Communication.* Volume 6 of *Linköping Studies in Arts and Science*, Liber, Malmö, 1986. Ph.D. thesis.

[12] John D. Eveland and Tora Bikson. Evolving electronic communication networks: an empirical assessment. *Office: Technology and People*, 3(2):103–128, August 1987.

[13] Martha S. Feldman. Electronic mail and weak ties in organizations. *Office: Technology and People*, 3(2):83–101, August 1987.

[14] Gregg Foster and Mark Stefik. Cognoter, theory and practice of a colab-orative tool. In *Proceedings from the Conference on Computer Supported Cooperative Work*, MCC Software Technology Program, Austin, Texas, December 1986.

[15] George O. Goodman and Mark J. Abel. Communication and collaboration: facilitating cooperative work through communication. *Office: Technology and People*, 3(2):129–145, August 1987.

[16] Irene Greif and Sunil Sarin. Data sharing in group work. *ACM Transactions on Office Information Systems*, 5(2):187–211, April 1987.

[17] Riitta Hellman. A fictitious HIS-reconstruct of an information system (a case study). In Pertti Järvinen, editor, *The Report of the 10th IRIS (Information Research seminar In Scandinavia) Seminar*, pages 205–219, University of Tampere, Tampere, 1987.

[18] Joachim Israel. *The Language of Dialectics and the Dialectics of Language.* Munksgaard, Copenhagen, 1979.

[19] Anker Helms Jørgensen. The trouble with UNIX: initial learning and experts' strategies. In H.-J. Bullinger and B. Shackel, editors, *Human Computer Interaction — INTERACT'87*, pages 847–854, North-Holland, Amsterdam, 1987.

[20] John Kammersgaard. *On Models and their Role in the Use of Computers.* PB 202, Computer Science Department, Aarhus University, Århus, December 1985.

[21] R. H. Katz, M. Anwarrudin, and E. Chang. A version server for computer-aided design data. In *23rd Design Automation Conference*, pages 27–33, ACM/IEEE, 1986.

[22] Rob Kling and Suzanne Iacono. Computing as an occasion for social control. *Journal of Social Issues*, 40(3):77–96, 1984.

[23] Kim Halskov Madsen. Breakthrough by breakdown. In Heinz K. Klein and Kuldeep Kumar, editors, *Proceedings of the IFIP WG8.2 Working Conference on Information Systems Development for Human Progress in Organisation, Atlanta, 29–31 May 1987*, North-Holland, Amsterdam, 1988 (forthcoming). Also available as PB 243, Computer Science Department, Aarhus University, Århus, March 1988.

[24] Kim Halskov Madsen. *Sprogbrug og Design — sammenfattende redegørelse.* PB 245, Computer Science Department, Aarhus University, Århus, November 1987.

[25] William M. Newman and Robert F. Sproull. *Principles of Interactive Computer Graphics.* McGraw-Hill, 1986. 2. edition.

[26] *Networking on the SUN Workstation.* SUN Microsystems, Mountain View, California, February 1986.

[27] Jukka Niemelä. Informal organization, coordination of work and the use situation of ISs. In Pertti Järvinen, editor, *The Report of the 10th IRIS (Information Research seminar In Scandinavia) Seminar*, pages 535–553, University of Tampere, Tampere, 1987.

[28] Markku I. Nurminen. Different perspectives: what are they and how can they be used? In Patrick Docherty, Klaus Fuchs-Kittowski, Paul Kolm, and Lars Mathiassen, editors, *System Design for Human Development and Productivity: Participation and Beyond*, pages 163–175, North-Holland, Amsterdam, 1987.

[29] Markku I. Nurminen, Riitta Kalmi, Pirkko Karhu, and Jukka Niemelä. Use or development of information systems: which is more fundamental? In Patrick Docherty, Klaus Fuchs-Kittowski, Paul Kolm, and Lars Mathiassen, editors, *System Design for Human Development and Productivity: Participation and Beyond*, pages 187–196, North-Holland, Amsterdam, 1987.

[30] William G. Ouchi. Markets, bureaucracies, and clans. *Administrative Science Quaterly*, 25:129–141, March 1980.

[31] Jacob Palme and Eva Albertson. *COM Teleconferencing system — Advanced manual.* QZ Computer Centre, Stockholm, September 1983.

[32] Jakob Palme. Experience with the COM computer conference system. In Brian Shackel, editor, *Human-Computer Interaction — INTERACT'84*, pages 937–939, North-Holland, Amsterdam, 1985.

[33] Marc J. Rochkind. The source code control system. *IEEE Transactions on Software Engineering*, SE-1(4):363–370, December 1975.

[34] Pål Sørgaard. A cooperative work perspective on use and development of computer artifacts. In Pertti Järvinen, editor, *The Report of the 10th IRIS (Information Research seminar In Scandinavia) Seminar*, pages 719–734, University of Tampere, Tampere, 1987. Also available as PB 234, Computer Science Department, Aarhus University, Århus, November 1987.

[35] Pål Sørgaard. *A Discussion of Computer Supported Cooperative Work: Overview Paper.* PB 254, Computer Science Department, Aarhus University, Århus, May 1988.

[36] Pål Sørgaard. Object oriented programming and computerised shared material. In Stein Gjessing and Kristen Nygaard, editors, *ECOOP '88 European Conference on Object-Oriented Programming, Oslo, Norway, August 1988, Proceedings*, pages 319–334, Lecture Notes in Computer Science 322, Springer Verlag, Heidelberg, 1988. Also available as PB 247, Computer Science Department, Aarhus University, Århus, May 1988.

[37] Pål Sørgaard. *Programming Environments and System Development Environments.* PB 252, Computer Science Department, Aarhus University, Århus, May 1988.

[38] Pål Sørgaard. *Transaction supporting systems and organisational change.* PB 248, Computer Science Department, Aarhus University, Århus, May 1988.

[39] Lee Sproull and Sara Kiesler. Reducing social context cues: electronic mail in organizational communication. *Management Science*, 32(11):1492–1512, November 1986.

[40] Mark Stefik, Daniel G. Bobrow, Gregg Foster, Stan Lanning, and Deborah Tatar. WYSIWIS revised: early experiences with multiuser interfaces. *ACM Transactions on Office Information Systems*, 5(2):147–167, April 1987.

[41] Mark Stefik, Gregg Foster, Daniel G. Bobrow, Kenneth Kahn, Stan Lanning, and Lucy Suchman. Beyond the chalkboard: computer support for collaboration and problem solving in meetings. *Communications of the ACM*, 30(1):32–47, January 1987.

[42] Lucy Suchman and Eleanor H. Wynn. Procedures and problems in the office. *Office: Technology and People*, 2(2):133–154, January 1984.

[43] Randall H. Trigg, Thomas P. Moran, and Frank G. Halasz. Adaptability and tailorability in notecards. In H.-J. Bullinger and B. Shackel, editors, *Human Computer Interaction — INTERACT'87*, pages 723–728, North-Holland, Amsterdam, 1987.

[44] The UTOPIA project group. *An Alternative in Text and Images.* GRAFITTI 7, Swedish Center for Working Life, Stockholm, 1985.

[45] Terry Winograd. A language/action perspective on the design of cooperative work. In *Proceedings from the Conference on Computer Supported Cooperative Work*, MCC Software Technology Program, Austin, Texas, December 1986.

[46] Eleanor H. Wynn. *Office Coversation as an Information Medium.* PhD thesis, Department of Anthropology, University of California, Berkeley, May 1979.