COMIC

ESPRIT BASIC RESEARCH PROJECT 6225

An Integrated View of COMIC

Abstract

This deliverable considers the general nature of the COMIC project. It presents the different contributions brought to the project and the various integrated results which have emerged. The deliverable also reflects on the challenges of integration set out in the project from the outset and how this integration has manifest itself during the project.

Document ID	D5.4
Status	Accepted
Type	Deliverable
Version	1.0
Date	August 20, 1994
Editors	Lancaster University
Task	5.2
ISBN	1-86220-001-7

Project coordinator:
Tom Rodden
Computing Department
University of Lancaster
Lancaster LA1 4YR
United Kingdom
Phone: (+44) 1524 593 823
Fax: (+44) 1524 593 608
Email: tom@comp.lancs.ac.uk

The COMIC project comprises the following institutions:
Gesellschaft für Mathematik und Datenverarbeitung (GMD), Bonn, Germany
Risø National Laboratory, Roskilde, Denmark
Royal Institute of Technology (KTH), Stockholm, Sweden
Swedish Institute for Computer Science (SICS), Stockholm, Sweden
Universitat Politècnica de Catalunya (UPC), Barcelona, Spain
University of Amsterdam, Amsterdam, The Netherlands
University of Lancaster, Lancaster, United Kingdom (Coordinating Partner)
University of Manchester, Manchester, United Kingdom
University of Milano, Milano, Italy
University of Nottingham, Nottingham, United Kingdom
University of Oulu, Oulu, Finland

Editors of this report:

Tom Rodden
Department of Computing
Lancaster University
Lancaster LA1 4YR
United Kingdom
Phone: (+44) 1524 593 823
Fax: (+44) 1524 593 608
Email: tom@comp.lancs.ac.uk

Lancaster University, 1995
This report is available via anonymous FTP from ftp.comp.lancs.ac.uk.
Further information on COMIC available from http://www.comp.lancs.ac.uk/computing/research/cseg/comic/
ISBN: 1-86220-001-7

Table of Contents

An Integrated view of COMIC

Tom Rodden
Lancaster University

The COMIC Project

This deliverable aims to collect together the principle outcomes of the COMIC project, a three year initiative on Computer Supported Cooperative Work funded by the European Commission. The COMIC project began in September 1992 and ran until August 1995. During this time the project gathered together CSCW researchers from twelve institutions spread across nine European countries[1]. In line with the multi-disciplinary nature of CSCW these researchers came from many different backgrounds and traditions and each of them sought to contribute to the broad set of issues and problems that constitute CSCW.

To reflect the diversity and pluralism of the participants and the nature of the subject area itself the project from the outset interpreted and examined CSCW from a broad perspective. Much of the motivation for bringing together the different researchers involved in the project was to further define and crystallise the field of CSCW itself and what each of the different contributions brought to the subject area. These ambitions were reflected in the overall aims set at the outset of the project.

> "The overall objective of the COMIC project is to lay the foundation for the future development of CSCW systems. This requires both a greater understanding of the nature of cooperative work and an assessment of the usefulness and applicability of novel technologies, principles and techniques for subsequent generations of CSCW systems."

As this broad objective reflects, from the outset the intent of the project was to consider the fundamental nature of CSCW and the lessons needed to allow future developers of cooperative systems to construct systems that better support the nature of work. Potential contributions to these lessons could be drawn from existing theoretical perspectives on the nature of work and organisations, empirical studies of work, the design of information systems and the nature of software systems to name but a few. While seeking to bring these different areas of work together, the problems inherent in combining radically different views were also recognised at the outset. A strategic decision was taken that different views and perspectives would be brought together in the practical development of

---

1 In fact some of the individual researchers spread themselves across many European countries.

CSCW systems rather than attempting an abstract theoretical or methodological synthesis of techniques or approaches. The explicit recognition of pluralism was reflected in the decision to adopt a constructional philosophy to the project as stated in its initial description.

> "To encourage focused and directed multi-disciplinary research a constructional philosophy will be adopted throughout COMIC. The investigation of models and theories by social scientists will be directed toward the development of cooperative systems by computer scientists. This is intended to engage researchers from a collection of disciplines in common tasks in order to promote the transfer of knowledge across disciplines".

This chapter reflects the initial recognition that the need to promote directed progress on specific areas and topics of investigation had to be buttressed by a serious consideration of how the different disciplines could be brought together to address the issues. From the outset the COMIC project focused on a collection of well defined and bounded areas of work rather than a grand synthesis of approaches. In other words, rather than proposing some abstract integrative principles, points of integration between approaches and methods were allowed to emerge as a consequence of the research itself. In this deliverable we wish to outline the nature of the project in more detail and highlight the particular points of integration that have emerged during the project's lifetime.

The COMIC Consortium

The COMIC consortium has brought together researchers from a broad spectrum of research traditions. These traditions reflected both technical, organisational and human issues in the development of cooperative systems. To each member of the community of researchers constituting the COMIC project, both the nature of research and the product of research vary tremendously. For example, for those from a software development tradition the construction of a software artefact constitutes a research result. For those from a background based on organisational theory the refinement of a theory to model or explain different aspects of work represents a research result. An equally valid research result for those from an ethnographic tradition is a rich description of the work taking place within an organisation.

In this section we wish to briefly outline some of the research traditions and backgrounds that have contributed to the COMIC research project. The intent of examining these different traditions is to outline the particular perspectives the researchers brought to the project. In outline, the following areas contributed to the work of the COMIC project:

- *Ethnographic studies of work*. The tradition of ethnographic enquiry is well-established within sociology. It is an observational technique that uses a naturalistic perspective and seeks to understand settings as they naturally occur, rather than in artificial or experimental conditions, from the point of view of the people who inhabit those settings. While ethnographers have

historically concerned themselves with issues that might be described as quintessentially 'sociological', more recently they have been used as a means of informing the design of IT systems. The ability of ethnography to see activities as social actions embedded in a socially organised domain and accomplished in and through the day-to-day activities of participants is its principal appeal to the developers of cooperative systems.

- *Activity modelling*. Since its inception as a research area in its own right, CSCW has drawn researchers who wish to developed abstract models of cooperative activities and procedures. These researchers aim to support well-defined or procedural cooperative work as it is defined in organisational contexts. A number of alternative models of cooperation and activity have been postulated and a range of systems developed to support these models. Many of these systems have been widely used and critiqued within the CSCW community.
- *User Interface systems*. The development of high speed networks and the ability to construct applications that support and coordinate real time interaction across a community of users has feature prominently in cooperative systems. The development of user interface systems requires a consideration of the needs and demands of windowing systems, the layout and structure of the user interface and the nature of interaction. As CSCW has matured the consideration of what constitutes interaction has broadened to consider both augmented and virtual reality techniques.
- *Software and communication systems and architectures*. A significant part of the development of cooperative applications is the realisation of an appropriate communication infrastructure and software architecture. The development of this infrastructure and the relationship between the supporting architecture and properties of the application are crucial to the eventual realisation of the software for the cooperative system.

Much of the work of the COMIC project involved bringing these previously disparate trends and traditions together to foster communication and cooperation in the resolution of particular problems central to the future of CSCW systems development. From the outset, participants were in agreement that a single CSCW model, theory, or account was undesirable and probably counter-productive. A unitary paradigm would exclude disciplines with potentially valuable observations, critiques, models, and methods. Similarly, a prespecified set of target software would prevent the exploration and exploitation of innovative results arising within the project. In a research field as new as CSCW it is a mistake to impose unwanted and unhelpful restrictions on its development. Rather the intention was to bring the combined expertise of these researchers to bear on the problems that represented significant barriers to the future development of CSCW as a research community.

This characterisation of the results expected from the COMIC project is key to understanding the nature of integration across the project. Given that it was never the intention of the project to develop a single product or theory it is no surprise

that integration is not evident in the production of a single theory, concept or set of software. Rather, the project has produced a collection of contributions to the CSCW community. The set of contributions emerging from the project have attempted to clarify the problems and lay the ground work for a more thoroughgoing integration of CSCW approaches and techniques as these may emerge in the future. *Integration in the COMIC project takes place in practice through the production of a number of research results*. The concerted application of research methods and techniques from a disparate community of scholars on focused applications has seen the migration and integrated application of different research tradition and the integration of many different approaches and traditions in practice.

The project structure

The COMIC research results have emerged within a project structure intended to support the cooperative application of research approaches on a number of focused areas of research. The problems selected to constitute the detailed research agenda for the COMIC project were drawn from examples of real world cooperation and the problems this cooperation faces. The overall project structure exploited *four major themes*. These themes were selected to represent distinct but related theoretical issues central to CSCW systems development.

"• The organisational context of *interaction*
- *Interaction* in the development process
- Languages and notion of *interaction* in CSCW
- User *interaction* mechanisms for CSCW"

These themes were characterised as being

" • Sufficiently distinctive to be an identifiable area of research.
- Sufficiently meaningful for each of the different disciplines involved.
- A central topic for the development of future 'real world' CSCW systems."

The explicit intent of these themes was to meet the need for, and to focus, multi-disciplinary research by enabling close cooperation across a number of disciplines. The aim was that for each of the project themes, concepts and theories central to the development of future CSCW systems would be projected by social scientists within the project. This projection would be based on social theories and the experiences and observations of 'real world' cooperation. In tandem suitable computational mechanisms would be developed by the computer scientists to realise and exploit, using prototype systems, appropriate portions of these concepts and theories for inclusion in future CSCW systems (figure 1).

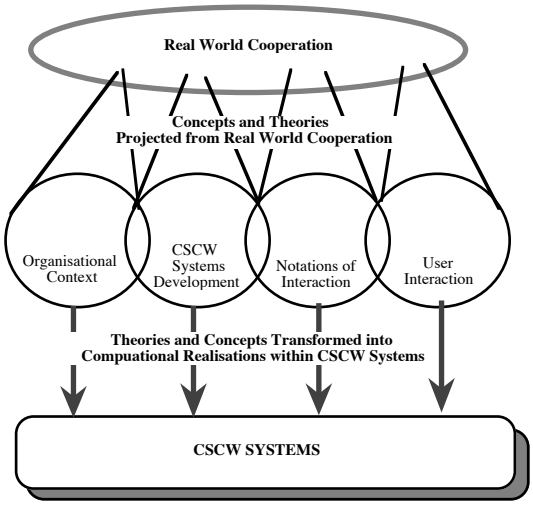

Figure 1 The role of the COMIC project themes

Although presenting the project as a set of separate themes this approach fostered integration through the research process. The process based integration used in the project replaced the more traditional 'product' as focus for cooperation and coordination. The integration that has occurred during the project has taken place between research groups in the project in the development of particular approaches and techniques within the strands. In addition, a number particular approaches and techniques have migrated across the strands with results from one area being directly applied in another. In the rest of this deliverable we wish to focus on accounts of the nature of integration demonstrated in the project and the ways in which this integration is manifest in the project.

Project Results

As said earlier, a research project as large and diverse as COMIC would be constrained by a search for a single 'result' or product. Many related lines of investigation were followed by the researchers involved. Each of the different parties contributing to the COMIC project was involved with different aspects of the project to differing degrees. The problems of presenting the results of the COMIC project are amplified by the overall productivity of the participants. This is perhaps best illustrated by the summary table of publications shown in figure 2.

	Internal	**External**		
Year	**Papers and Reports**	*Journal*	*Conference*	*Other*
1992-93	79	13	52	9
1993-94	75	9	56	19
1994-95	80	30	70	26
Totals	**234**	**52**	**178**	**54**

Figure 2: COMIC publications produced during the project

This extensive set of publications is also testimony of COMIC's contribution to the establishment of CSCW as a research community. Members of the project have supported the development of journals and conferences and the project has provided a considerable impetus to the formation of an identifiable European CSCW research programme.

Before presenting an abstract overview of the COMIC project we wish to consider in this section the actuality of the research as seen by the key participants in the project. Each of the following sections presents the key results of the project as seen from the perspective of different project sites. Some of these are social and some technical, some focus on methodological issues others on prototyping. However, each of these different perspectives on the COMIC project has equal validity and in line with the general acceptance and support of pluralism in the project they are presented here prior to the more general consideration of the project developed in future sections.

Lancaster University

The CSCW group at Lancaster consists of sociologists and computer scientists who have worked together on a number of projects. This collaboration has mainly been focused on developing ethnographic methods for the study of work settings and relating these to system development and design. In other words, a principal focus of the Lancaster team, in conjunction with colleagues at Manchester University, has been methodological and developing means of integrating and organising fieldwork results for the purposes of CSCW design.

The methodological aspects of the work of Lancaster have contributed to all parts of the project with studies of work being used to motivate large parts of the project and Lancaster contributing to all strands of the project. Studies of air traffic controllers, the police use of information technology, software engineering, banking services, and the technology centre of a large corporation have been brought to the COMIC project and used in the development of a framework for characterising the features of the 'real world' social organisation of work. Summary versions of these and other studies of work have been made available on WWW[2].

In addition, the Lancaster and Manchester teams have collaborated on the use of the Designer's Note Pad, a tool for supporting the integration of work studies into system design. The designers notepad has been developed at Lancaster and has been significantly amended as part of the COMIC project. The system exploits a viewpoint perspective for organising field study materials and embedding these within more graphical design tools. This has been supported by the development of a general framework for the analysis and presentation of fieldwork material.

---

2 http://www.comp.lancs.ac.uk/sociology/research/CSCW/COMIC.fs.index.html

The computational elements of Lancaster's involvement has focused on the construction of the shared object service and the development of cooperative virtual environments. This has involved the development of the shared object service and the supporting architecture, a prototype realisation of the SOS. The outlining of the shared interface service and the development of a toolkit that realised it. The construction of tools to develop virtual environment and the development of extension of the spatial model of interaction that makes it applicable in non-spatial domains.

The work of the project has also allowed for the exchange of researchers for significant periods of time. During the project, John Mariani from the computing department spent six months at GMD on the development of the awareness event mechanisms. This was complemented by a number of months spent at Nottingham developing the work on populated information terrains.

UPC

For UPC, this project has contributed to a greater understanding of many aspects of Large Scale cooperative arrangements coming from disciplines which are new to UPC. This work, initiated in the COST14 CO-TECH action, has helped to evolve our viewpoint on difficult problems of large scale computer based cooperative environments. It has helped us consider the problem from new and enlightening perspectives. This has materialised on contributions to conferences and workshops (ECSCW'93, ICDCS'94, Pirineos'94, JENC6, ECSCW'95) and on internal and external COMIC documents. The principal focus of our work has been the development of the Aleph system. Aleph has been strongly influenced by work in the organisational context of interaction, on languages and interaction, and on user interaction in CSCW.

The design of Aleph to support the organisational context of large scale cooperative arrangements has led to the realisation of an ethnographic study of I*EARN, an organisational learning network, in order to evaluate the applicability of Aleph to that environment. This work has opened a line of work to observe and design support systems for these emerging forms of organisation based more on the idea of "network learning organisations" rather than on "bureaucratic controlled workplaces".

Work on architecture for CSCW systems has contributed to the definition of the SOS/SIS architecture for cooperative systems. The concept of resource management and federation has been our main contribution. Resource Management has proven to be a useful functionality with its ability to take into account the organisational context of work (policies, actors, resources, responsibilities, etc.) and the articulation of distributed activities (organising and adapting the relationships between objects (OAW)). Federation of disjoint environments has also been an area of research and prototyping. The mechanisms for working in large inter-organisational environments is a promising topic of research on our fast emerging information society.

The requirements for interaction raised in strand 3 has lead to the refinement of the Aleph notation. This notation is based on the architecture for malleable and linkable mechanisms of interaction developed in this strand of work. It is an extensible notation with primitives for cooperative work developed from the Tcl interpreter.

Therefore, the Aleph system demonstrates how the Architecture for malleable and linkable Computational Mechanisms of Interaction, and the Architecture for Collaborative Shared Object Systems can be practically integrated and materialised in the Aleph demonstrator.

Stockholm (SICS and KTH)

The Stockholm group consists of computer scientists from SICS, Swedish Institute for Computer Science, and computer and behavioural scientists from IPLab, Interaction and Presentation Laboratory, at KTH, Royal Institute of Technology. The group as a whole has a tradition of work in distributed collaborative environments, computer networks, user centred design methods and object oriented design and construction of user interfaces and multimedia applications. During the whole of the COMIC project the group at SICS has stayed in very close contact with the corresponding COMIC research group at IPLAB/NADA department at the Royal Institute of Technology, Stockholm. In many cases so much so that it is hard to see where the SICS efforts stop and the IPLABs begins, so in COMIC terms this should be seen as a joint effort.

In COMIC the main contributions from Stockholm have been made to Strand 4, both to the shared virtual environments and to the shared objects work. In Strand 3 SICS has contributed with mechanisms for adaptable support for cooperative work with examples expressed in pi-calculus notation.

CoDesk, the Collaborative Desktop, is a shared, enhanced conventional 2D environment, mainly developed at the IPLab, KTH. The CoDesk environment is based on rooms, where tools, documents and other objects can be shared with other users present. In the development and evaluation of the CoDesk, its user interface and usability, user centred methods both from our own tradition and from Strand 2 have been used. Discussions on organisational issues in Strand 1 have also been fruitful for the CoDesk development.

The requirements for SOS, the Shared Object Server, have been developed in close cooperation with Lancaster, GMD and Barcelona, and informed by ethnographic studies undertaken by Lancaster and Manchester. At KTH some of the mechanisms have been implemented and evaluated in CoDesk and, more extensively, in MultiGossip, a package extending Smalltalk/Visual Works with powerful tools for making single-user applications distributed, multi-user and cooperative.

The Swedish Institute of Computer Science (SICS) involvement in COMIC has very much concentrated on strand 4 and the development of distributed multi-user

virtual environments (i.e. VR- systems) and the research into spatial metaphors and the possible integration of those into such computer generated habitats.

At the start of the COMIC project SICS already had an early version of what today is known as the DIVE (Distributed Interactive Virtual Environment) VR system running together with some ideas and early work on spatial interaction models. At the first COMIC meetings it become apparent that more or less the same kinds of concepts were being explored by researchers at the University of Nottingham. Our concepts were pooled with those of Nottingham (and later with researchers from Univ. of Manchester and Lancaster) and the work to develop a more consistent model started together with actual implementations of concept demonstrators in existing VR systems.

SICS have had extensive and fruitful contacts with the other partners in the COMIC taking the form of extended site visits, joint authoring of research papers, exchange of actual application code and multiple site distributed VR experiments and so on. In particular we have collaborated with

- The University of Nottingham to develop the Spatial Model of Interaction, the development of distributed VR systems in general and the development of the DIVE system in particular.
- The University of Lancaster in order to integrate the spatial model with event models, in the development of the DIVE system and also in the exchange of ideas and background information in areas of ethnographic studies and CSCW design.
- GMD regarding the development of the DIVE system and virtual reality systems in general. Also some experimental implementation of support in the DIVE for the CORBA shared object system was done.
- The University of Manchester in the areas of the spatial model, reactive environments, embodiments in virtual spaces, the role and nature of agents in DCE's and the future evolution of inhabited electronic spaces in general.

For SICS the single most important contribution of COMIC has been the establishment in the research community (and, presently at least, to a lesser extent in the industry) of the concept of inhabited distributed virtual reality environments as a contender for future man-machine interfaces and as a collaboration and communication infrastructure.

Some of the major results and insights coming from our involvement in COMIC include:

- COMIC played a major role in the evolution of the DIVE system from a purely “technical” infrastructure into an environment intended to support richer activities and phenomena (casual awareness, opportunistic encounters etc.) that constitutes real world collaborative situations.
- The development of the spatial model of interaction.
- The identification of user embodiment issues as a major concern.
- The importance of being informed by ethnographic and social studies in the design of shared distributed computer generated spaces.

- The realization that virtual environments need to be populated, active and reactive and that this is more important than having a large number of beautiful but dead polygons put together in intricate ways.
- Being able to participate in and experiment with real world multi-site multi-user virtual reality setups.

GMD

The GMD project group joined the COMIC project with a background on organisational modelling with the X.500 Directory Service (Prinz and Pennelli, 1992), office procedure systems (Kreifelts, Hinrichs, et. al., 1991), and message based group communication (Fuchs et al., 1994). During the project we have focused our contributions in the area of organisations and shared object systems. A broad range of results were produced which are reflected in the COMIC deliverables and papers. However, beside these technical results which are documented by the working papers, deliverables and many publications, it is important to reflect on other aspects that were inherent to COMIC and that distinguish this project from many other projects we were involved in. Two of these are worth mentioning explicitly:

- From the beginning, the cooperation of researchers from different disciplines was a major aim in COMIC. This has led to many controversial, but always very stimulating and thought provoking discussions. The learning process involved will have a further influence on the construction and organisation of future CSCW projects at the participating sites including GMD.
- As a project COMIC brought together partners with complementary expertise and interests. This resulted in the formation of strong cooporative links between partners. The cooperation between GMD and Milan on the topic of W-TOSCA is on example that is illustrated by the Milan section in this deliverable. Further cooporative links between other partners are easy to find for example the joint work between Lancaster, UPC, KTH and GMD. This was strengthened further by Ludwin Fuchs from GMD visiting SICS for an extended period of three months. These cooporative links and research alliances will extend beyond the COMIC project and will provide the foundation for further research initiatives. Furthermore, the specific results from these cooporative links contributed to many of the currently internationally discussed CSCW research questions.

During the project, COMIC raised and initiated a set of new CSCW research ideas. Although this must be regarded as obvious for a research project it was the presence and attention of COMIC in the international CSCW community that led to an adoption of these topics by other researchers. In particular, it will has had a direct influence on two projects at GMD. From the spectrum of COMIC results

the following will be of particular importance for the POLITeam project (Navarro et al., 1995):

- The concepts and models on organisational modelling and its application by workflow systems (W-TOSCA) for the realisation of the electronic circulation folder component.
- The concepts of a shared object server for the realisation of a the common electronic desk.
- The social awareness considerations and technical awareness concepts for the information and notification service.
- The CSCW systems design research for the POLITeam system design and cooperation with the POLITeam application partners.

Furthermore, an internal project on VR and CSCW (Mathiassen and Sørensen, 1995) has been launched. Again, this was initiated as a result of our involvement in the research of the COMIC project and will further investigate the research issues that were initially raised by COMIC.

The University of Manchester

Manchester has participated across all of the COMIC project with the work on the systems development process being predominantly the product of close collaboration between Manchester and Lancaster[3].

Though not entirely so, Manchester's participation has mainly been in terms of its social science emphasis, with input relating to the issues of organisational modelling and the role of ethnographic studies in requirements capture, though it has also played a part in the development of VR environments. On the work on organisations, Manchester's specific contribution was with respect to the formulation of models of organisation, the exploration of the reasons for and the meaning of plurality in such modelling, and the initial development of a performative model of organisation. Manchester also contributed the results of its field studies of networking organisations. Manchester also provide a case study and some methodological suggestions on the development of the concept of Mechanisms of Interaction. In terms of the work on systems development the main developments were with regard to defining a (possible) role for fieldstudies in requirements capture. This involved the elaboration of an understanding of ethnography's nature and the problems involved in making the products of fieldwork accessible to designers through supporting/studying the development of the DNP. In terms of the work on spatial interaction and virtual environments Manchester has made significant input to the consideration of social issues. This work has involved an examination of previous work on the sociality of space and emerging work on artificial life and societies.

Manchester's principle achievements during the COMIC project have included:

---

3 Often referred to as "plucky strand 2"

- the formation of a clear and consistent position on the role of procedures, plans and rules in the organisation of action.
- the exploration of problems in the understanding of organisational structures through both 'performative' and 'ethnomethodological' conceptions.
- the development of a CSCW-relevant understanding of the problems of supporting complex patterns of work in 'real world' organisational contexts.
- the articulation of a distinctive position on the relationship between social science and design, both with respect to general theoretical issues and with respect to concrete design issues, particularly pertaining to the use of field studies.
- collaboration in the production of a framework for the analysis of the organisation of work.
- collaboration in the development of DNP as a tool to support ethnographic work for design purposes.
- the provision of a social foundation for the spatial model of interaction.
- the development of techniques and guidelines for the structure and layout of artificial environments.

The University of Milan

The University of Milan has worked in a number of areas of the COMIC project. Most notably it has worked in the development of new organisational concepts and on the realisation of computational mechanisms of interaction. Much of this work has been undertaken jointly with other sites. The work on Mechanisms of interaction and the relation between Milan and RISØ is outlined in the section provided by RISØ. In this section we shall focus on Milan's relationship with GMD.

Milan initiated in autumn 1992 its work on the organisational context of CSCW systems within COMIC on the basis of its experience in developing the integration of a workflow management system and a conversation handler (Woorks + UTUCS) in the ITHACA Esprit Project. The resulting work process(wp) model was an attempt to further exploit the language/action perspective (Win Flo) in order to take into account the critiques it had received by various CSCW scholars[4] and to enrich it with concepts and categories from other disciplines (including economics, industrial organisation, strategic management). A first experiment using the wp model in a real work setting was performed in the first few months of COMIC, developing a prototype application of Milan's Woorks+UTUCS environment within a BPR project in an Italian bank (Agostini, 94).

---

4 The many critisisms levelled against this approach included the normative definition of conversations, inadequate understanding of the pragmatic dimension of human communication. Interesed readers are referred to the debate between Suchman and Winograd and the associated commentaries in the CSCW journal.

Also at the beginning of COMIC, the GMD group working within the Strand 1, had worked in the CSCW field paying attention to the architectural aspects of CSCW systems on the basis of the X.500 standard, and was developing TOSCA, a system for the representation of knowledge about organisations and their resources which are relevant for communication and cooperation. The development of the TOSCA prototype provided an occasion to exploit some relevant requirements that effective systems should satisfy. These included the provision of organisational information and openness with respect to external resources, scalability and tailorability.

From the Milan perspective joint work started at Bonn, where a first seminar was dedicated to share the experiences and approaches of the participating partners and to define what they meant with "organisational context of cooperative work" and with "awareness of the organisational context" (COMIC-GMD 1.5). At the Bonn meeting it was decided to have a focused workshop on organisational context in Barcelona in May 1993.

The Barcelona workshop was very important in the joint work of Milan and GMD. GMD presented a paper on "Organisational Context and", that formulated in a very rich manner the lessons learned from the development of the prototype In particular, the relevance of the organisational context with respect to the issue of awareness, and the requirements for supporting it were clearly analysed.

At the same workshop the University of Milan presented a paper on the organisational context of work processes, in which the organisational context issues were discussed from the point of view of the wp model. Its main contribution was a clear formulation of the distinction between the "inner" (related to the history of the work process itself) and "outer" (related to features (roles, structures, procedures, etc..) defined outside of the work process) organisational context of a work process.

The outcomes of the discussion at Barcelona were added to by many other partners and made a significant contribution to deliverable D1.1. This meeting also had a deep influence on the work on organisations in the subsequent years. On the basis of the communication started at Barcelona, GMD and University of Milan began a collaboration that was based, on the one hand, on the assessment that was a good candidate to provide the basis for a system supporting the awareness of organisational context within work processes, and, on the other hand, on the assumption that the distinction between inner and outer context was useful to shape an organisational context awareness support system.

During 1994, the collaboration became more concrete, and ended up into the common development of an extension of, W-TOSCA, modelling the organisational context of work processes and in a joint paper in deliverable D1.2. In this deliverable a common conceptual framework was adopted to present two extensions of. The joint paper was later presented at COOP 1995 in Antibes and it is currently under publication in the CSCW Journal.

The experience of developing W-TOSCA has been very important for the University of Milan group. During 1993-4 the design of a newly conceived conversation handler was started. This became one of the main components of a new ambitious prototype, the Milano System, aiming at embedding the wp model in order to support cooperation within work processes. W- has been, in fact, adopted as the basis for developing the Organisational Handbook component of Milano, and the wp model adopted in it has served as the main guideline to design the integration between the workflow management model and the conversation handler of Milano. Similarly, the collaboration on the extensions of, has been widely influential at GMD within the Politeam project, guiding the way in which awareness of the organisational context could be supported in that project.

The University of Oulu

The Department of Information Processing Science at the University of Oulu was drawn into the COMIC project because of its expertise in system design and organisational change. Correspondingly, while the main emphasis within COMIC towards design has been at the microlevel, in the exploration of the potential of ethnographic studies on work to inform design, the role of the Oulu group has been to attempt to bridge the gap between this microlevel perspective and broader vistas of system design and work and organisational development. The work in Oulu has progressed at two interlinked levels: on one hand at a level of theories, concepts and methods; on the other hand at a level of particular applications as examples of the field and testbeds for ideas.

At the theoretical level, Oulu has been studying the relationship between systems and the transformation of work processes towards a "post-Fordist" work organisation, trying to find theories, concepts and frameworks that would enable a better understanding and description of the transformation process for design purposes. Based on this work and a critique of old methodologies of system design, the goal of methodological studies has been to find suitable concepts and methods to design support for non-prescribed, "emergent" work tasks and to combine ethnography with a systematic approach to change some work process. In these studies the cooperation with the University of Limerick has been especially lively and fruitful.

At the application level, Oulu has been studying both synchronous and asynchronous cases of cooperative work to get a better coverage of the field. Teleradiology — cooperative interpretation of X-ray images over a local network — has served as an example of synchronous cooperation (Kuutti & Karasti, forthcoming). The cooperating partner in the studies has been the radiological department in the Oulu university hospital. From asynchronous cooperation two different cases have been studied. An example of asynchronous communication with an emphasis on coordination has been an error management system for a programming team. This area has been studied in close contact with the Risø Research Center and their cooperation with Foss Electric (Tuikka, 1995). Another

example from asynchronous cooperation, but emphasising mutual understanding and sense-making has been an "organisational memory" system used by a team of labour protection inspectors (Kuutti & Virkkunen, 1995; Favorin & Kuutti, 1994). This area has been studied in a close cooperation with the Administrative Development Agency of Finland and Uusimaa Labour Protection District.

In terms of results Oulu has been able to meet its major targets and thus to contribute to the success of the whole project. Oulu has developed a set of propositions about the relationship between systems and changes in work processes and organisations and presented a set of concepts that can be used in understanding organisations as a shapeshifting network of locally-defined, self-reconstructing work activities embedded in broader cultures and traditions that influence them (Kuutti, forthcoming a; Kuutti, forthcoming b; Kuutti, forthcoming c; Virkkunen & Kuutti, forthcoming a; Virkkunen & Kuutti, forthcoming b; Bannon & Kuutti, 1995). It is found that for designing systems for such work activities a work process-oriented design approach is necessary, and current developments towards such approach are analyzed, criticized and remedies suggested (Kuutti, Virkkunen, & Young, 1995). An outline of a work design method where ethnographic studies can be embedded has been suggested (Kuutti & Pihlaja, 1994), and "scenarios" are found to be a potentially useful link between them and more formal parts of system design (Kuutti, 1995). Additionally, a tool to facilitate the construction of scenarios in participatory design situations has been developed (Tuikka & Kuutti, 1994).[5]

The University of Nottingham

Nottingham's major involvement in COMIC has concentrated on the spatial aspect of strand 4; that is, on developing novel interaction techniques for cooperative work in shared electronic spaces. At the start of the project, we had already completed some preliminary work on the use of rooms metaphors to structure environments and had proposed some rudimentary interaction mechanism including primitive definitions of focus and nimbus, although these names were actually defined later on. Meeting the researchers from SICS at the first ever plenary meeting was an eye opener for us; interactive cooperative virtual reality was a real technical possibility! From that point on, exploring this possibility became our driving goal.

The major contributions of COMIC in this area have been to raise the issue of *Collaborative Virtual Environments* in the first place and to conduct an initial exploration of the topic. It is also significant that, in an area rife with short term technological fixes and hype, COMIC has tried to develop some underlying theory. Furthermore, this theory has emerged from an interdisciplinary perspective, strongly influenced by the involvement of Manchester, Lancaster and

[5] Unfortunately, due to the delays involved in dealing with large user organisations for research purposes, the start of field testing, validitation and further development of the proposed set of concepts, tools and methods has been postponed until October 1995 and it can't thus contribute to the results of this project.

Sageforce. From our point of view, the major results arising from this work have been:

- one of the first serious treatments of space in cooperative systems, i.e. one that moves beyond the use of space as a metaphor for interface design to consider the construction of *inhabitable* and *navigable* electronic spaces.
- the development and refinement of the spatial model of interaction which provides a small, but powerful, set of mechanisms for managing communication in potentially densely populated spaces.
- the emergence of the concept of *Populated Information Terrains (PITS)* which populates information visualisations with multiple co-present users and so adds a further dimension to the notion of sharing data with other people.
- an exploration of user embodiment issues that has resulted in an initial framework of design issues and techniques.

We have also progressed a long way in terms of the practical development of Collaborative Virtual Environments. Indeed, by the end of the project we see the DIVE system being used by several partners to develop various CVE applications and also the use of the MASSIVE spatial model implementation to hold a series of wide area virtual meetings, including one spanning five sites in three countries.

Risø National Laboratory

The group at Risø has been — more or less evenly — involved in a range of distinct activities across the project:

- field studies of cooperative work in different work settings, especially studies of the use of symbolic artefacts for coordination purposes;
- critical examination of received software engineering approaches to requirements analysis from a perspective;
- development of a conceptual framework for the analysis of cooperative work;
- development of a conceptual foundation for constructing computational coordination mechanisms for systems;
- development of a notation for constructing computational coordination mechanisms or mechanisms of interaction;
- development of a language for modelling and defining interactions among multiple mechanisms in a wider organisational context;
- development of demonstrator prototypes of computational coordination mechanisms based on requirements derived from field studies.

In all this, the focal point of the Risø group's work has been the concept of coordination mechanisms. In developing this concept, the Risø group has been working very closely with the Milano group. The scope of this collaboration has

been unique in that it has bridged ethnographic field studies and the formal specification of a computational notation (and the other way as well!) — and has been an enjoyable experience.

While the focal point of the group's work has been the concept of coordination mechanisms, the development of this conception has been deeply inspired and influenced by the issues raised in other strands and by the conceptual frameworks developed to deal with these issues.

For example, the crucial role of mutual awareness among participants in cooperative work which has been highlighted and explored in ethnographic field studies (cf., e.g., Hughes et al., 1994, pp. 148 ff.) has been addressed as the focal issue in the work within strand 4. The architecture of the Shared Object Service is devised to provide effective support for mutual awareness among actors by making objects aware of the state of other objects (Trevor et al., 1994; Trevor et al., 1995). This approach, in turn, influenced the architecture of Ariadne, the notation for computational coordination mechanisms being developed in strand 3, in that the basic elements of the notation (the 'objects of articulation work') were conceived of as objects which could be 'aware' of other objects, so that — eventually — actors could be aware of activities occurring beyond their immediate sphere of work and have an overview of the state of affairs within the cooperative work arrangement at large (Simone et al., 1995).

Similarly, the issue of computational representations of organisational context addressed in strand 1 and the realisation that organisational context is 'open ended' and cannot be assumed to be defined and managed top-down from a omniscient centre (Pycock and Sharrock, 1994; Schmidt, 1994), made the Risø group re-analyze field study findings in order to examine whether organisational context, for the purpose of constructing computational representations of organisational context for applications, could be conceived of as a population of interacting coordination mechanisms (Schmidt et al., 1994). The conclusion of this study was that it did indeed make sense and furthermore a number of typical inoperation modes were identified. This result had important implications for the architecture of the Ariadne notation. Most notably, it was decided that not only should it be possible to link multiple coordination mechanisms by means of an 'interoperability language' embodying the modalities identified in the re-analysis of the field studies, but in order to achieve a high degree of malleability and mutual awareness the basic elements of the notation (the 'objects of articulation work') should be conceived of as software agents interacting through the very same interoperability language (Divitini et al., 1995).

For the Risø group, the next step in the work commenced within COMIC will be to take the concept of coordination mechanisms and the Ariadne notation and explore how it can be used for coordination purposes in time- and safety-critical work settings.

The University of Limerick

While the University has not been a formal contract partner in the COMIC project, through the Director of the Centre at the University, Liam Bannon, we have been involved in the project on a consultancy basis with Risø in Denmark, for a period of approximately 9 months over the lifetime of the project. Due to the consultancy nature of the contract, contributions have concentrated on setting out parameters of the research focus of COMIC, and assisting in the coordination of research activities in order to achieve the project objectives. In the first year, we were heavily involved in the work on organisations, and in developing an agreed framework for future research work, while contributing via reports and critiques in helping to sharpen the concept of "organisational context". As part of this process we helped edit deliverable D1.1, which provided a much stronger base for the work on organisational context than had previously existed in the field. The contributions of Manchester, Milano, GMD and Risø were critical here, and we believe that the foundational work done in this period concerning "organisation" will significantly affect research work in a variety of areas, well beyond the confines of.

Also in the first year a major part of the work on the design process involved the collation, analysis and synthesis of earlier work, with a view to defining future work within COMIC. We contributed with analysis of various design methodologies, in particular participatory approaches. Again, we believe that this work is a significant contribution to the research field in the area of design methods.

One final piece of work has been in the evaluation of certain computational mechanisms of interaction developed at Risø.

The work on COMIC has helped the Centre to maintain a close liaison with a wider community, and has significantly impacted the kinds of research questions that the UL Centre is currently researching, while we believe that we have managed to make a small but significant contribution to the COMIC effort at both a conceptual and pragmatic level in our work on concepts of organisation, process and practice on the one hand and in our evaluation work on the other.

The University of Amsterdam

Work at the University of Amsterdam has focused on developing concepts surrounding the notion of mechanisms of interaction and the work on spatial interaction. This has involved the development of a framework for analysing Social Mechanisms of Interaction and its application as a basis for the design and implementation of a tool (CPTOOL) for rapid construction of relatively small scale CSCW applications. This tool is described in Deliverable D3.4.

This work has been complement by work on the concept and applicability of the 'Populated Information terrains' developed in the COMIC project, and on the relation between the spatial model and populated information terrains. Generally,

information is not clustered in relatively homogeneous spaces, but is clusred depending on the retrieval and use of information. This general phenomenon can also be found in scientific information terrains. A clarification of this effect in terms of empirical patterns in the links between elements information units may clarify this dimension of infomation terrains. A series of studies of the structure of information in research communities has been undertaken to consider this issue.

At the beginning of 1994 a young researcher Jolanda Tromp joined the UvA team. Her work in COMIC has concerned mainly the evaluation of CSCW environments, in particular with respect to cognitive factors. A particular focus has been MASSIVE, developed in Nottingham. This was evaluated with an evaluation tool developed in Amsterdam.

MASSIVE was successfully evaluated in two stages, while it was respectively in use by nine participants at four different sites, and seven participants at three different sites. The first stage of the evaluation concerned itself with experienced users of MASSIVE. The second stage concerned itself with new users. This was done to be able to find possible learning effects. The opinions of the experienced users were compared to an earlier evaluation of MASSIVE to be able to find possible changes in opinion over time.

To get a better insight in the way MASSIVE is used visits were made to Nottingham. The provided a good insight in the program, and to plan the experiments. We were also present at the organization of a virtual COMIC meeting using MASSIVE -the first stage of the evaluation.

MASSIVE was also shown to the public in Amsterdam at the Science Fair, July 12th, 1995, using a Silicon Graphics Indigo, which was on loan to the department for the duration of the fair from Silicon Graphics. MASSIVE was received with interest.

Sageforce

Sageforce acted as consultant to Amsterdam for the duration of the project. From the stance of Sageforce a broad objective within the COMIC project was to develop and refine a set of precepts and design concepts originating in the work of the COST-11 Working Group (IV) on Design — e.g. Peripheral awareness, Implicit communication, Double level language, and Overview

A more specific objective was to test the scalability of these concepts (their applicability in large scale, and in organisational systems) and if possible, and where necessary, to develop additional precepts and design concepts.

Two important developments originated in the joint COMIC/EuroCODE workshop held in Aarhus in May ‘94.

First, an emphasis on the importance of assuming uneven and disparate infrastructures of communication. A host of technical problems in linking disparate systems are relatively well known. There are many additional social, organisational, and usability issues that have to be addressed, especially as the gap

between bottom and top end systems is constantly expanding. The ability to project 2D, or "flatland" versions of DIVE are a useful start in exploring these issues.

Second, the central nature of the "boundary object" concept in analysing, designing, and supporting communication and interaction between disparate communities. The boundary object concept is able to take the initial concepts (peripheral awareness, etc.) which originated in small scale ethnographic studies of work process, and facilitate their deployment in design on the organisational and inter-organisational planes.

In addition, preliminary conceptualisations have been developed for evaluating the "novelty" of systems and applications, and thus the level at which they can be developed using existing know-how, and the degree to which they will call for new research efforts.

These ideas "spun off" into analyses of Governmental Work Processes in the POLITeam Project in Germany, into new ongoing work with the EU to support the development of Europe wide linkages between local employment initiatives, and with the World Heath Organisation to support 3D projections of its distributed Mortality Database, the International Classification of Diseases.

The integrated project results

The remaining elements of this deliverable directly address the nature of integration by providing an overview of the integrated research results central to the project. These results are structured around a set of themes common across the project. These themes highlight the way in which each partner in the project has exploited results produced by others and provided techniques and approaches that have been taken up and exploited. The themes examined include:

- CSCW Systems Development and Design
- CSCW Prototypes and Trials
- CSCW Frameworks and Architectures
- Basic Problems and Concepts

In addition to these common themes the final chapter of this deliverable reviews the significant results anticipated at the outset of the project and outlines a selection of possible future research directions for CSCW.

CSCW Systems Development and Design

When we reflect at the original aims of the COMIC project it is clear that the systematic and effective development of CSCW systems was core to the project.

> "The overall objective of the COMIC project is to lay the foundation for the future development of systems. This requires both a greater understanding of the nature of cooperative work and an assessment of the usefulness and applicability of novel technologies, principles and techniques for subsequent generations of CSCW systems."
>
> (COMIC Technical Annexe, April 1992)

The consideration of CSCW systems development and design and the contributions emerging from the project represents the first of our points of common integration. The focus on the development process and how it is supported is quite natural for a project involving so many disciplines many of whom are discovering techniques to allow them to work with disciplines and traditions quite unfamiliar to them.

The Research Groupings

The project has been quite fortunate in that the close cooperation across the project and continued commitment to working together across disciplinary boundaries has resulted in significant progress in understanding systems development. The close cooperation across the project has resulted in a large number of joint documents and publications addressing the issues surrounding the development process. This integration is reflected in the map shown in figure 3 where the sites writing jointly are linked. Unsurprisingly in a project of the size of COMIC not all partners are involved and a number of distinct constellations of activity have emerged between different sites. In the case of systems development groupings of particular note include

GMD and Milano's joint work on organisational and workflow modelling indicates how different perspectives of cooperative work and organisations combine in supporting the development of cooperative systems. This work has taken place as part of a more general formulation of an organisational framework to support systems development.

RISØ and Milano have worked together in the systematic development of a the notion of mechanism of interaction. Mechanisms of interaction draw heavily on work across the project and provide future developers of cooperative systems with the core building blocks needed to develop cooperative systems.

Lancaster, Manchester, OULU, RISØ and Limerick have all considered the issues involved in systems development from different perspectives and the contribution to be made to systems development from different perspectives and backgrounds. Much of this work has been informed by empirical studies of work.

These different constellations of research have interacted to produce the integrated results detailed in this chapter. While these results have tended to be located within one of the strands of the project they have necessarily drawn heavily on work across the project.

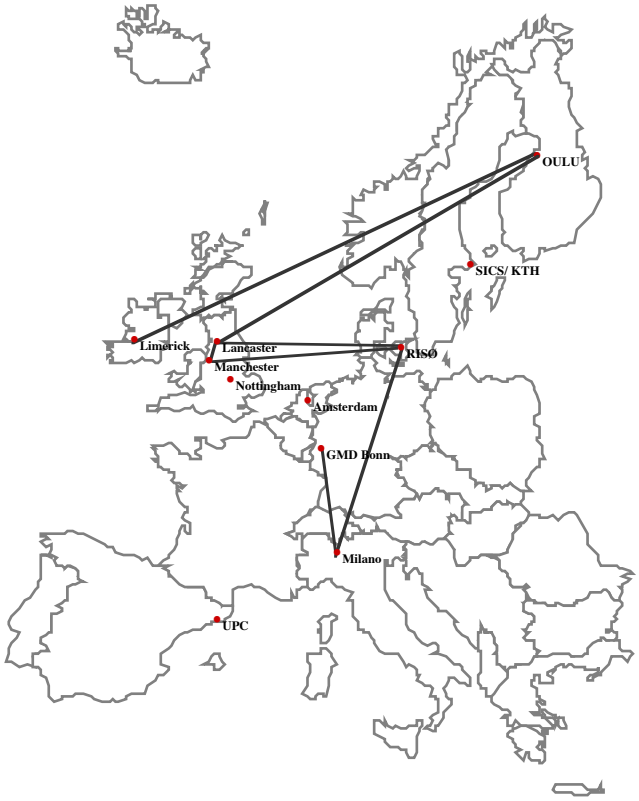

Figure 3: The research groupings involved in work on the development of cooperative systems.

The Integrated Results

Systems development requires a large number of issues to be addressed. These range from technical infrastructure issues to the organisational implications of realising cooperative systems. Many of the concerns central to systems development are shared across the project and are manifested in different aspects of the work of the project. In this chapter we wish to focus on those issues that are predominantly concerned with how we manage the systems development and design process.

The work yielding the results described in this section has taken place across a number of different strands of the project. Most notably, the work focusing on organisations has been reported as part of the work of strand 1, while the work on integrating studies of work has been reported in strand 2 and strand 3 has been used to report the work on mechanisms of interaction. This division reflects the manner in which the work has been reported rather than any strong division in the research leading to the work, or the way in which partners have communicated.

During the project a number of distinct concerns have formed that collectively represent a COMIC project position of cooperative systems development and design. These concerns have resulted in a series of project results intended to address these concerns. The set of general and related areas of result include:

- the development of a corpus of fieldwork materials and the identification of the emergent features of the social organisation of work;
- the investigation of techniques to support the involvement of ethnographic studies of work in the systems development process.
- the realisation of the notion of a mechanism of interaction as a means of constructing cooperative systems
- the development of assessment and evaluation techniques and the experiences of using these techniques.
- the construction of new techniques for considering the relationship between the structure of the organisation and the activity that takes place within it.

These different areas have been collectively addressed by sites across the project. However, it is worth re-emphasising, (in case these concerns are formulated as a distinct problem) that no single COMIC solution is offered by the project. Rather a collection of different research results that address the different issues in these complex problems are provided as a contribution to the formulation of a solution in practice.

The following sections briefly review a selection of some of the areas of research that have address these concerns. All of this research represents activities undertaken jointly across different sites in the project and the production of these results in themselves represents significant progress on the integration of the project.

Integrating ethnography in the design process

Given the background of the participants a particular concern for the COMIC project has been exploring and calibrating ethnography as a method for informing the design and development of systems. A pragmatic approach has been taken to many of the issues surrounding the role of sociology and ethnography in design. This allows us to situate ethnographic field studies of the social organisation of work in a design process that will necessarily involve the concerns of software engineering as well as giving more attention to issues that go beyond the technology.

As part of this objective a distinctive feature of the COMIC research has been to come to a better understanding of the ways in which ethnographic field studies can contribute to design and development outside the research laboratory. This has involved an attempt to specify, based on our experiences of using the approach across the project, the variety of roles that ethnographic fieldwork is capable of playing in the design process and, as part of this, the kind of information it is capable of providing during the various stages of that process.

We make no claim that ethnography is a panacea to the problems of system design. However, we do claim that it is capable of performing an important role, ~~in,~~ given that one of the essential motivations of CSCW is the need to examine the 'real world' social context into which systems will be placed. Three related themes form the core of our approach:

- understanding the nature of the social organisation of work;
- coming to terms with problems of representation and communication;
- exploiting the viewpoints notion.

These three themes lie at the core of a framework for the analysis and presentation of ethnographic work in systems development. We address the issues of structuring the results of the ethnographic studies of work in practical way by structuring the corpus of studies and by using the designer's notepad.

Mechanisms of Interaction

The COMIC project has developed the notion of a mechanism of interaction as part of the repertoire of tools to be used by future systems developers. The concept of mechanisms of interaction and the supporting infrastructure has been a particular focus of research for both RISØ and Milan. Mechanisms of interaction are conceptual building blocks that provide a means of supporting the distributed coordination inherent to large scale cooperative work. They are also intended to be applicable to requirements analysis, with a view to identifying likely candidates for computational mechanisms of interaction, as well as to the design of such computational mechanisms of interaction.

In developing a definition for mechanisms of interaction its proposers point out that since the allocation of functionality between human actor and artefact will change, perhaps radically, as a result of incorporating mechanisms of interaction in computer systems, the definition should not presume a specific allocation of functionality. To the contrary, it should span the entire range of allocation of functionality and hence of local control. They have therefore adopted the following definition:

> A mechanism of interaction can be defined as a protocol, encompassing a set of explicit conventions and prescribed procedures and supported by a symbolic artefact with a standardized format, that stipulates and mediates the articulation of distributed activities so as to reduce the complexity of articulating distributed activities of large cooperative ensembles. Similarly, a computational mechanism of interaction is defined as a computer artefact that incorporates aspects of the protocol of a mechanism of interaction so that changes to the state of the mecha-

> nism induced by one actor can be automatically conveyed by the artefact to other actors in an appropriate form as stipulated by the protocol. (Schmidt and Simone, 1994)

With this definition, social and computational mechanisms of interaction are not conceived of as different kinds of mechanisms. Instead all mechanisms of interaction are fundamentally and inexorably "social" mechanisms of interaction in that they are constituted by a set of procedures and conventions and supported by "a symbolic artefact with a standardized format". The adjective 'social' is therefore redundant. Accordingly, *computational* mechanisms of interaction are conceived of as a special category of mechanisms of interaction that is characterised by a specific allocation of functionality between human actors and artefact. In investigating mechanisms of interaction the COMIC project has initiated a general process of uncovering the generic mechanisms that will provide the basis for building future cooperative systems.

Describing Organisations and Activities

One of the driving forces in the COMIC project has been to bring together the technical and the social. In the case of CSCW systems development this fusion is most notable in terms of the in the descriptions of organisations and their activities. The work of COMIC over the last three years has extensively explored different descriptions of organisations and their utility to the production of CSCW systems. Even a superficial examination of organisational theory indicates that there is little agreement on the nature of organisations or the core concepts that allow for effective management of organisations and the activities they support.

The diversity evident in considerations of organisations has meant that the COMIC project has adopted a pluralistic approach to understanding organisations. For the project the problem is no longer finding a single approach or theory to describe organisational properties, rather we have outlined a framework to allow different equally valid approaches to organisations to have equal prominence and be drawn upon as resources by designers. This acceptance of multiplicity has emerged as an integrating theme within our approach to systems development and is also central to the use of viewpoints and the framework to support the presentation of studies in the development process.

Although the framework focuses on issues on multiplicity significant points of integration have emerged in practice during the development of this framework. One of the most notable of these is the joint development of a system that combines the organisational modelling approach of GMD with the workflow modelling of Milan. In doing so this prototype integrates previously disparate approaches to the representation of organisational activities. This integration has taken place in the wider context of the formulation of a broader organisational framework. Thus rather than form a grand theory of organisations for systems design the project has brought together those aspects of organisational theory that it makes sense to do so within a much broader and diverse broader context.

Techniques to support CSCW system development

Our focus on tools and techniques to support development has concentrated on a smaller number of sites. One reason for this more focused approach is the need to support the close cooperation required in informing the development and construction of tools. Two types of supporting tool have emerged. A tool to support the development process and a series of tools to support prototyping and development itself. In this section we shall focus on a the refinement of the DNP, a tool for representing field study materials in a form which is able to support design work. We have used the tool to exploit the notion of viewpoints as a series of vantage points from which to present field study materials.

These concerns have been focused around the longer term objective of integrating field studies into the design process. The use of the tool has centred on research at Lancaster-but has also included a number of other sites. The practical use of the DNP has also outlined a series of shortcomings with the DNP-which have motivated the development and modification of the tool. (SEE D2.2; D2.4)

A Corpus of materials reflecting the social organisation of work

This element of the research has been primarily concerned with developing a series of case studies of work settings in a variety of field sites and, as a parallel endeavour, building up a corpus of fieldwork materials that are capable of serving as the basis of the development of a framework for the analysis of the social organisation of work. This corpus acts a resource across the project and is held electronically on the world wide web[6].

The studies held in the corpus were carried out at various times, conducted by various researchers and under varying auspices across the project. They are very much a 'contingent corpus' assembled out of developing interests in CSCW on the part of a number of researchers in the COMIC project and to this extent were created within a context where issues of design predominated. In other words, they are studies accumulated in close association with design issues even when these are not directly addressed. They are studies completed with the longer term aim of obtaining a better understanding of the varieties of 'real world, real time' work within their 'real world' organisational context as a basic requirement for the development of CSCW systems. In this respect, the collection represents the beginning of the development of a corpus of such materials which can be used to identify some of the main features of cooperative work in a variety of work settings.

This on-line corpus represents a publicly available resource for the community allowing the designers of cooperative systems to access previous studies as part of the process of informing their initial design.

---

6 Avaliable from http://www.comp.lancs.ac.uk/sociology/research/CSCW/COMIC.fs.index.html

An ethnographic handbook for CSCW

As we have said earlier in this Deliverable, the corpus of materials is seen as a resource for the development of a framework for the analysis and presentation of the social organisation of work. In order that the framework and the corpus of materials is accessible to the design community, a handbook was developed as a companion to the framework.

In some respects, the handbook represents the culmination of the methodological research of the project. It presents a distillation of the relevant research in COMIC and related projects using ethnographic fieldwork methods and constitutes an effort to formulate 'best practise' within design. The objective is not to try to turn system designers into ethnographers, but to provide an accessible way in which they can come to understand both the purpose of fieldwork and how its findings can be made relevant to design issues.

Assessment and Evaluation

Given the constructional approach to the project and the large number of prototype systems developed during its lifetime it is perhaps not surprising that significant results have emerged in the form of various assessments and evaluations. As the applications developed in COMIC matured over the project's lifetime they have, inevitably, been subject to assessment and testing. As part of that process we have investigated the issues surrounding evaluation and assessment in practice. This work has had two principle themes:

- The nature and role of evaluation and assessment in the development of interactive applications;
- The features of evaluation and assessment to which ethnographic fieldwork methods can contribute.

Work in both these areas has been reflected in a series of publications and in the application of the analysis framework to emerging tools to support work. These tools have been drawn from across the project to evaluate the different approaches to assessment used in the project.

Conclusions

In this chapter we have considered the set of integrated results that collectively address the problem of systems development. The complexity of this problem is such that it is unrealistic to expect a single solution to emerge from a research project. Rather, significant contributions have been made addressing the issues that constitute the problem of systems development. These different contributions collectively address significant portions of systems development and can be broadly categorised as theoretical and methodological contributions and contributions of best practice.

Theoretical contributions have emerged with the development of ~~a~~ mechanisms of interaction as a conceptual framework for structuring systems. Mechanisms of interaction offer a "building blocks" approach to systems where applications are constructed and modified by configuring a core set of mechanisms. The theoretical contribution of mechanisms of interaction has been complemented by a consideration of the relationship between models that reflect the structure of organisations and the nature of activities that take place within the organisation.

The theoretical contributions have been complemented by a consideration of the methodological issues in involving studies of work in systems development. A variety of approaches has been examined in practice and the experiences of these different arrangements documented. The central role of communication and the tension between the different representations used to express ethnographic studies and systems design has been highlighted and investigated through the application of a hypertext based design tool.

These theoretical and methodological issues have been complemented by a pragmatic consideration of best practice in systems design. This best practice has been reflected in the development of an ethnography handbook that reflects the nature of ethnography, how it may be used in systems development and different issues involved in its inclusion in the systems development process.

Collectively these different areas of research represent a thematic and integrated effort to address the fundamental problems at the core of systems development. While not proffering a single solution the results that have emerged from the project offer considerable guidance in uncovering the most appropriate path within a given context for developing systems. This broad approach directly addresses the problem identified by the project in the COMIC technical annexe

> " systems lack the foundation provided by well founded theories of cooperative work and the development of techniques based upon these theories"
>
> (COMIC Technical Annexe, April 1992)

We believe that the project has collectively contributed to the formation of these foundations by integrating contributions drawn from disparate disciplines, different sites and complementary areas of work.

CSCW Prototypes and Trials

A central feature of the work of the COMIC project over the last few years has been the development and testing of prototype systems. The constriction of software systems has always provided a focus for the work of the project. The ability to allow prototypes to act as points of integration for the social and the technical was recognised at the start of the project.

> "To encourage focused and directed multi-disciplinary research a constructional philosophy will be adopted throughout COMIC. The investigation of models and theories by social scientists will be directed toward the development of cooperative systems by computer scientists."
>
> (COMIC Technical Annexe, April 1992)

In addition to acting as a site of integration in their own right the prototyping activities across the project provide a significant set of integrated results. They provide demonstrators of concepts in a manner that encourages their use in future systems and products.. To promote the role of the concept demonstrators and prototypes the project has also undertaken a number of demonstration activities. The sites of demonstrations have included:-

- Three days of the ITEC exhibition Brussels - 6-8 June 1994.
- G7 meeting in Brussels, February 1995.
- CeBIT computer fair, Hannover, March 1995.
- ECSCW´93, Milan, Italy, 13th-17th September 19
- CSCW'94, Chapel Hill, North Carolina, October 1994.
- ECSCW'95, Stockholm, September 1995.
- HCI'93, Loughborough, September 1993.
- As part of the ESPRIT stand at InterCHI'93, Amsterdam, April, 1993.
- CHI'94, Boston, 24-28th April 1994.
- CHI'95, Denver, April 1995.
- ERCIM'94, Stockholm, 1st-3rd June 1994.
- Participative Design Conference (PDC'94), Chapel Hill, North Carolina, October 1994.

This collection of events represent the most prominent international conferences on CSCW and HCI held during the lifetime of the project. These academic conferences have been complemented by industrial trade shows and fairs. The intent of these demonstrations is to make the research results of the project more accessible to a broad community and ultimately to increase the potential for exploitation. In this chapter we wish to collectively review the

prototype systems and trials that have emerged from the project and the various forms of integration the development of these systems has fostered.

The Research Groupings

All of the prototype systems presented in this chapter represent the joint endeavours of institutions across the COMIC project. A series of links between institutions has emerged as joint concepts have been designed and used, code has been exchanged or jointly written and information from different disciplines has been transferred. The extent of this integration is reflected in the map shown in figure NN where the sites jointly involved in prototyping activities are linked. As in the case of systems development research not all partners are equally involved. In the case of prototype development, groupings of particular note include

Nottingham, SICS, GMD, Lancaster and Manchester have all been involved in the development of work based around coopertaive virtual environments. This has resulted in a series of prototype systems and the development of a model to describe and manage interaction in shared virtual spaces.

GMD, KTH have been involved in the development of shared desktop systems and have migrated many of the research results between prototypes at KTH and GMD.

UPC, Lancaster, SICS, KTH, GMD have all been involved in the specification and development of a shared object and a shared interface service. These services have been realised in a series of related prototypes which illustrate this process of joint development.

RISØ, Milan and OULU have all been involved in the construction of software supporting different forms of coordination for cooperative workers. This work has taken the conceptual results surrounding mechanisms of interaction, the shared object service and organisational issues to formulate a series of prototypes.

UPC, GMD and Milano have all worked together to produce a series of prototypes building upon each other work and the general work of the project. Many of these prototypes instantiate notions central to different organisational and activity models.

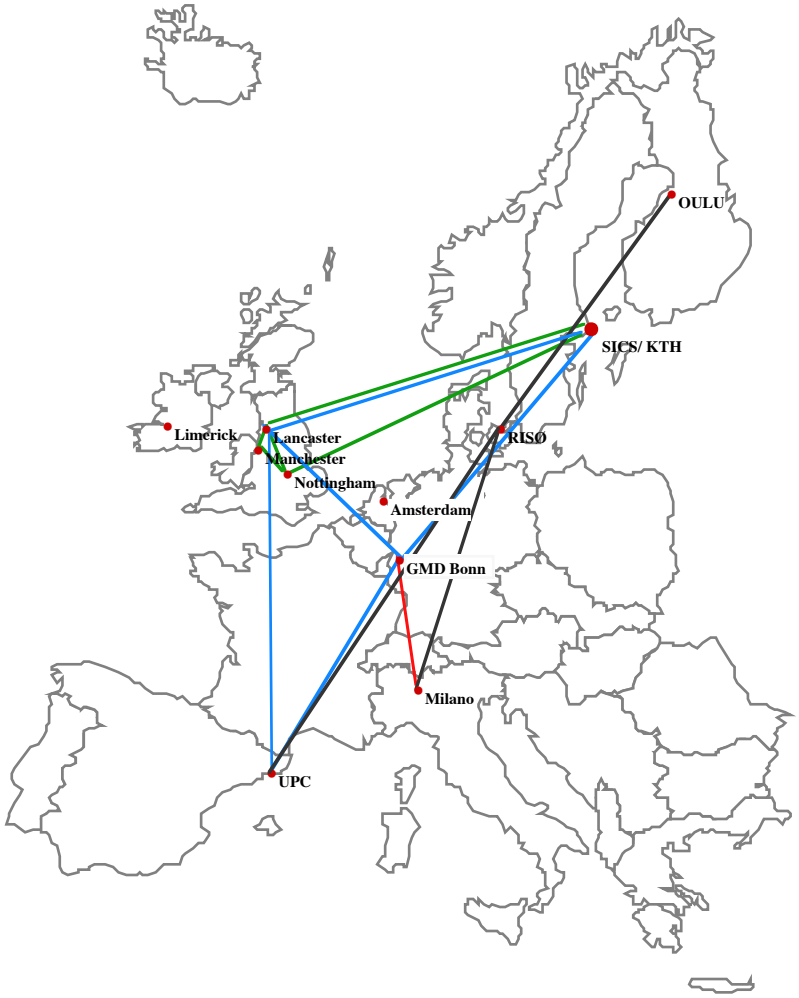

Figure 4: The research groupings involved in work on the development of cooperative systems.

As in the case of system development these grouping have interacted to produce a set of integrated results detailed in this chapter. The size and scale of the project is such that it not possible to discuss all of the prototypes and trials developed. In this section we wish to focus on an illustrative selection of prototypes. A more complete listing of the prototypes, the principle developers and the contributing organisations is given in figure 5[7]

7 Note this selection focuses on significant prototypes reported to reviewers. It is not exhaustive and a number of smaller scale prototypes have been developed as part of the investigation of the project.

Prototype	Description	Principle Developer	Supporting Organisation
Aleph	An organisational resource trader	UPC	RISØ, Lancaster, GMD, KTH, Milano
Ariadne	A MOI platform	Milano	RISØ, OULU
BRaHS	An MOI bug report system	RISØ	Milano, OULU
C-MOI	An MOI toolkit	OULU	RISØ, Milano
CoDesk	A shared Desktop system	KTH	GMD
COLA	An activity model based on the SOS	Lancaster	RISØ, Milan, Manchester
Cyberconferenc e	A dive conferencing system	SICS	Nottingham, Manchester, Lancaster
DNP	A system to support presentation of ethnographic material	Lancaster	Manchester, RISØ, OULU
GroupDesk	A shared desktop systems	GMD	KTH
I*EARN	Wide area network support for an electronic organisation	UPC	GMD, RISØ, OULU, Milano, Manchester
Massive	A realisation of the spatial model	Nottingham	SICS, Manchester, Lancaster
MEAD	A SOS based UI builder	Lancaster	GMD, UPC, KTH
Mr Nimbus	A realisation of the spatial model	SICS	Nottingham, Manchester
MultiGossip	A shared interface/object service toolkit	KTH	GMD, Lancaster, UPC
PITS Office	An integrated PIT and world flythrough	Nottingham, Lancaster	SICS, Manchester
QPIT	A benediktin Populated Information Terrain	Lancaster	Nottingham, SICS, Manchester
SOL	A realisation of the shared interface service	Lancaster	GMD, KTH, UPC
SOS	A realisation of the shared object service	Lancaster	GMD, KTH, UPC
The Milano System	A next generation workflow system	Milan	RISØ, Lancaster, GMD
	An organisational modelling tool	GMD	Milano, Manchester, Limerick
VR-MOG	Virtual organisation builder	Lancaster	Nottingham, Manchester, SICS
VR-VIBE	A statistical Populated Information Terrain	Nottingham	Lancaster, SICS, Manchester
W-	A merger of an organisational and activity model system	GMD, Milan	Limerick, Oulu

Figure 5 : A selection of the prototypes developed during the COMIC project.

The Integrated Results

In this section we wish to focus on a small set of the prototype systems developed during the project and the associated trials of this software. One of the problems

in describing the prototyping activities of the project is selecting an appropriate set of prototypes. This problem is very much of the projects own making in that a sufficiently large number of software systems were developed during the project that reporting them all is a serious challenge. In this section we have chosen to focus on three principle areas of software prototyping

- Support for shared interaction
- Support for coordination users activities
- Support for presenting information

These three different areas of support are central to most cooperative systems and a series of COMIC prototypes have addressed each of these areas of research. The development of software systems which demonstrate the core concepts have also allowed many of these systems to be assessed and used in practice.

Support for shared interaction

The notion of shared interaction was chosen from the outset as a specific focus for the work of the project from the outset and merited a theme of work in its own right. The need for this focus was motivated by perceived shortcomings in the user interface techniques predominant within HCI at the outset of the project.

> "CSCW requires the development and extension of existing user interface techniques to support the work of groups. A number of approaches have already being investigated which have focused on augmenting existing single user techniques. In contrast, COMIC will investigate the development of novel user interface techniques derived from social theories of interaction and how these can be incorporated in computational mechanisms."
>
> (COMIC Technical Annexe, April 1992)

Two distinct approaches to cooperative interaction were adopted across the project. One of these approaches focused on managing the cooperative interaction via the sharing of electronic artefacts. This was complemented by a consideration of the cooperative interaction which occurs in the spaces surrounding shared artefacts. This area of research has seen considerable prototyping and a significant number of prototypes have emerged from both these considerations of cooperative interaction.

The consideration of cooperative interaction in terms of shared artefacts has been driven by the collective outline of two services. The COMIC shared object service outlines the facilities needed to allow the cooperative sharing of information while the Shared Interface Service details the features needed to promote shared user interaction. A number of prototypes have been developed by COMIC partners that realise many of the features of these services. These prototypes have been developed in the context of standard platforms for both distributed systems and user interfaces. The different prototypes and their relation to shared object service and shared interface service they demonstrated are shown

in Figure 6. Interested readers are referred to a more detailed description of the shared object service and the prototypes in deliverable D4.2.

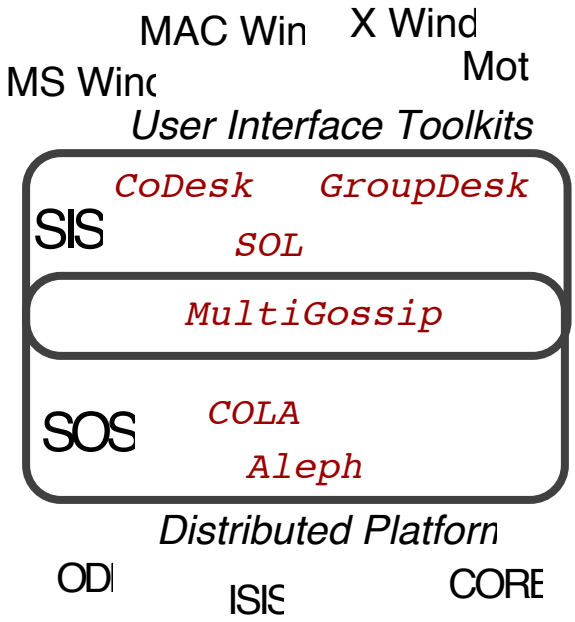

Figure 6: The prototype demonstrators and their relation to the shared object and interface service.

The work on the shared interface service and shared object service was complemented by a consideration of the nature of cooperative interaction surrounding the use of shared artefacts in the real world. This work has exploited novel interaction techniques by focusing on the use of distributed multi-user virtual reality environments. This work has been the collective endeavour of a number of sites in the project who have worked closely together to realise a range of applications. These environment allow the construction of a cooperative space which may contained shared objects and tools that can be simultaneous "populated" by geographically remote users. These shared spaces allow users to interact in three dimensions within an artificial environment and to exploit the virtual space to orient their actions. The resultant spatial approach to interaction has been demonstrated in a series of prototypes and a has been the focus of considerable assessment activities. For example, a series of virtual project meeting have been held including a VR COMIC meeting involving Lancaster, Nottingham, SICS, KTH and GMD. The network topology for this meeting and a view of the meeting from one of the participants perspectives is shown in figure 7 and 8.

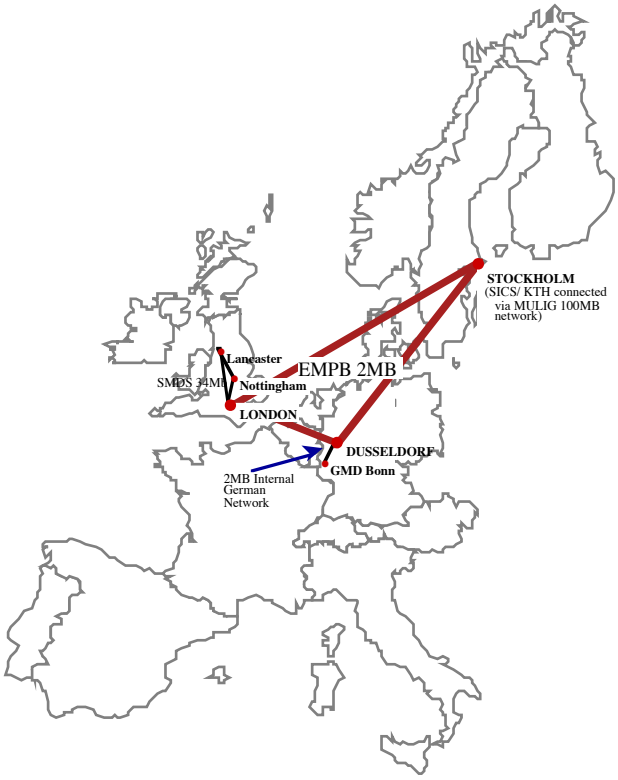

Figure 7: The Network Topology for the COMIC VR Meeting.

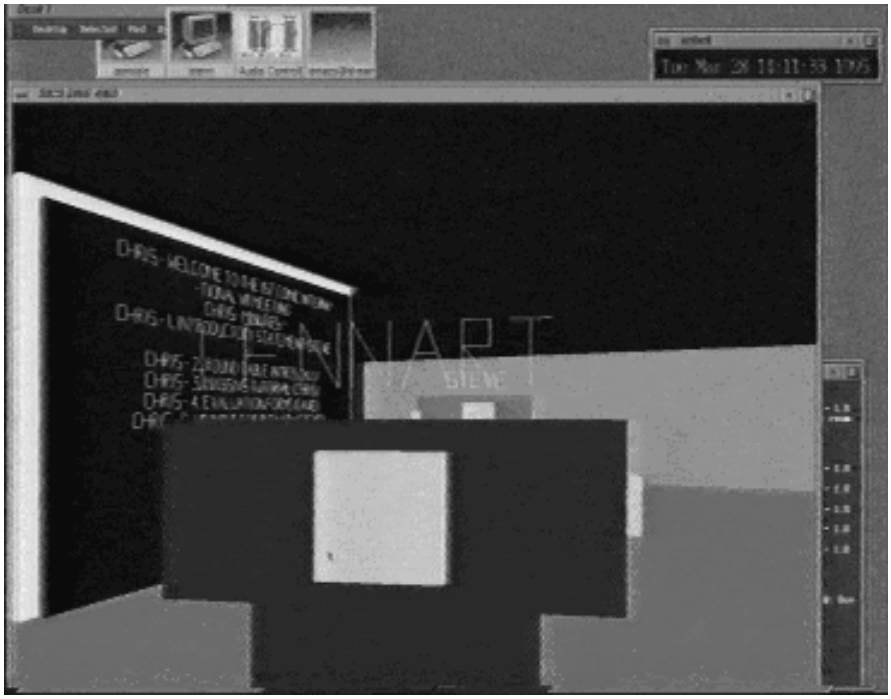

Figure 8: During the COMIC Virtual Reality meeting Lennart(in SICS, Sweden) and Steve(in Nottingham, UK) meet to discuss the meeting agenda which is displayed on the shared blackboard in the background.

Support for coordination of users activities

One of the driving forces in the COMIC project was the notion of scale and scaleability. The spatial model of interaction and the use of the shared interface and object service directly address the issues of scale at mechanistic level and are designed to support interaction across growing user communities. The spatial model and the shared object service also provide facilities to allow users to manage the dynamic aspects of interaction in potentially large groups.

Both the spatial model and the shared object approach to interaction focus on dynamic, spontaneous forms of interaction where the nature and form of interaction taking place is difficult to predict in advance and the application domains do not require significant restriction or policies to be imposed. However, this form of interaction represents only a selection of the many forms of cooperative interaction that occurs. An equally valid form of interaction takes place within more structured domains where the cooperative interaction is more closely managed and controlled. In fact, it could be argued that in large scale cooperative situations this form of managed interaction is more likely to be the norm.

This latter form of cooperative provides the motivation for a series of prototypes to emerge across the project. Many of these adopt either the notion of an activity or workflow model or the model of a mechanism of interaction. The prototype systems have also build upon the more general work on flexible interaction with the spatial model and the SOS. Prototypes of note include

- The development of Ariadne developed by RISØ and Milano as a demonstrator of the work on mechanisms of interaction applied to activity model.
- The construction of the Milano system to incorporate observations from Manchester on the need for alternative perspectives and the importing of graph theory work on the spatial model of interaction.
- The development of an demonstrator by GMD and Milano called W- which combines the work on activity modelling at Milan with a system to act as an organisational directory at GMD.
- The development and use of the SOS as a Mechanisms of interaction through the construction of the Aleph and COLA systems.

These prototypes combine the previously disparate approaches of different institutions to offer potential solutions to the situation where cooperative interaction needs to be structured and managed. The significant contribution here is the bringing together of positions from a variety of different traditions to consider the manner in which procedures and plans can be applied and supported in practice. Again rather than offer a single COMIC solution to the problem of distributed coordination a range of practical investigations have been undertaken which allow future users of COMIC results to select the most appropriate set of coordination devices for a particular situation.

Support for presenting information

Our final set of prototype systems focus on the different ways in which shared information is presented to users. It is difficult to understate the role of shared information in cooperative systems. It provides a common context for interaction and acts as a resource for the community of users involved in a cooperative endeavour. This importance was identified at the outset of the COMIC project

> "Cooperative work may be conducted with or without direct person-to-person communication. In real-world settings workers often cooperate by adding to, modifying, linking, searching, and retrieving items from a common information space, or by operating sequentially on 'shared objects'. The need to explicate the nature of shared information and how it can be supported by system architectures represents an important objective of current CSCW research.
>
> Information is always generated within a specific conceptual framework, which might include a particular expertise, a specific set of skills, domain knowledge, etc. which need to be communicated effectively to cooperating agents who have to act on information conveyed to them. Accordingly, in addition to task information, a common information space should provide contextual knowledge. This is a major design challenge both in terms of what should be represented and how this is represented within a computer system."
>
> (COMIC Technical Annexe, April 1992)

The use of shared information features strongly in the COMIC project and a range of prototypes adopt sharing as a general structuring metaphor. In this section we wish to particularly consider the range of different prototypes that have addressed the issue of presenting shared information to users. In particular, we wish to focus on the use of shared information as a resource to represent the organisation and as a means of communication across disciplines.

These two alternate approaches to the presentation of information presented in this section can be considered as representing two ends of a spectrum of structured information. Our first approach relies on a predifined schematic structure to represent the resources and procedures within an organisation. In contrast, the designers notepad is intended to support the structuring of information and provides facilities to allow relationships to be recorded and for structure to emerge as systems are designed.

The TOSCA and W-TOSCA systems both take as their starting point an object oriented model of an organisation. As a result of discussions with social scientists during the COMIC project this model has been relaxed from its orginial conception. The TOSCA system provides an organisational browser that allows user to locate resources and expertise within an organisation. The main aim of the TOSCA system is to provide both CSCW applications and users with organisational information. At this scope the system offers appropriate hierarchies of objects and relationships, designed to describe the structural components of an organisation. Moreover it is possible to enrich these pre-defined hierarchies with specific ones, if needed.

The structure of TOSCA is flexible and general enough to play the role of an organisational handbook for the institutions involved within a work process. In

this way,TOSCA can form the basis for a model of the organisational context of a work process. This further joint development by GMD and Milan of called W-TOSCA(Work processes in TOSCA) provides its users with the work process view upon an organisation. In other words W-TOSCA augments the static information of TOSCA with dynamic information concerning work processes. The system allows users to access much of this contextual information and its structure through a graphical browser(figure 9).

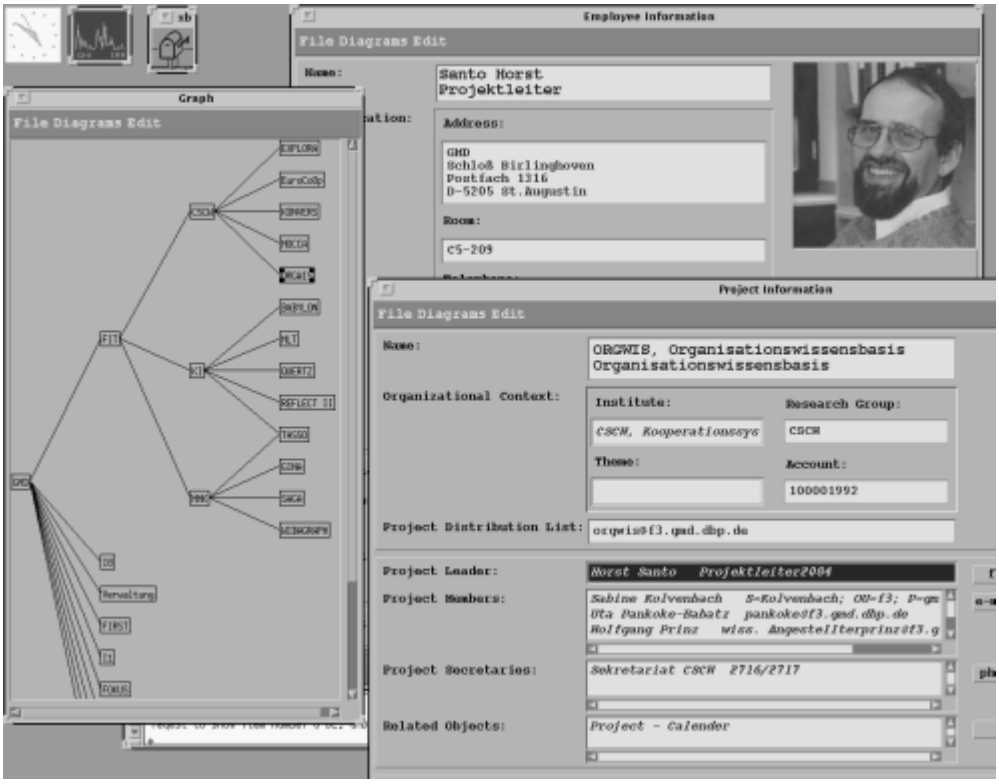

Figure 9: The TOSCA Windows displaying partial information about a project, an employee and a graph that displays the organigram for the project and its supervising institute.

Alternative perspectives of organisations have been developed that represent the structure of an organisation in a range of technologies including virtual reality. These approaches present to user both the abstract organisational structure in the form of graphs and the virtual facsimiles of actual spaces within the organisation. A number of tools have been constructed to allow these worlds to be defined and shared remotely and to access contextual information through these definitions. For example, the virtual world shown in figure 10 shows the presence of a user logged onto the network and details of the user stored in his world wide web page.

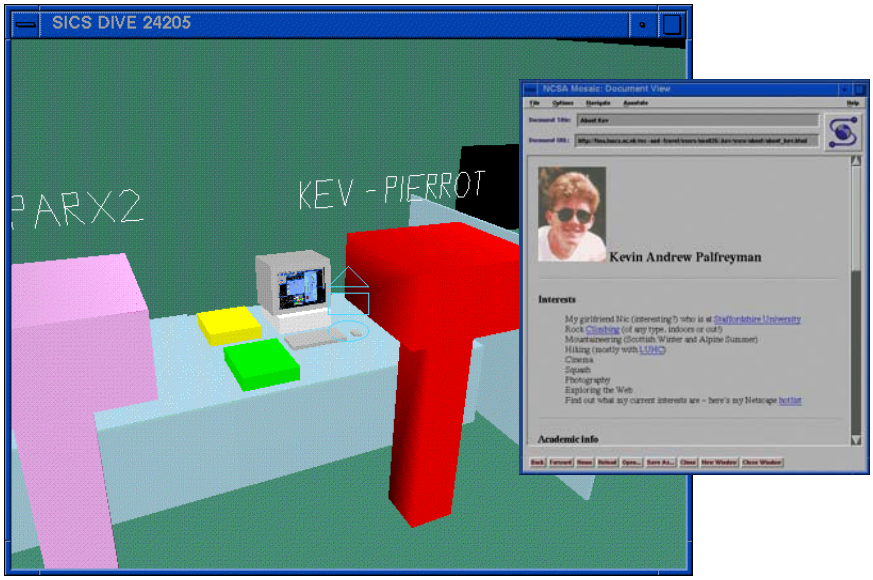

Figure 10: Showing the presence of users in the organisation and accessing details of the user.

The presentation of organisational information focuses on presenting the nature and structure of the organisation and the inter-relationship between users and resources in the organisation. In contrast to presenting this structured information the work of the Designers Notepad has concentrated on sharing information as a structure collectively evolves. The system has been constructed in the context of supporting the communication between field workers and systems designers. The core of the system is a graphical tool enabling the very rapid generation, organisation and refinement of box-and-link diagrams with a hypertext-like features (figure 11). Given its role in supporting the development of structure it is important that the DNP does not embody any particular methodology or technique.

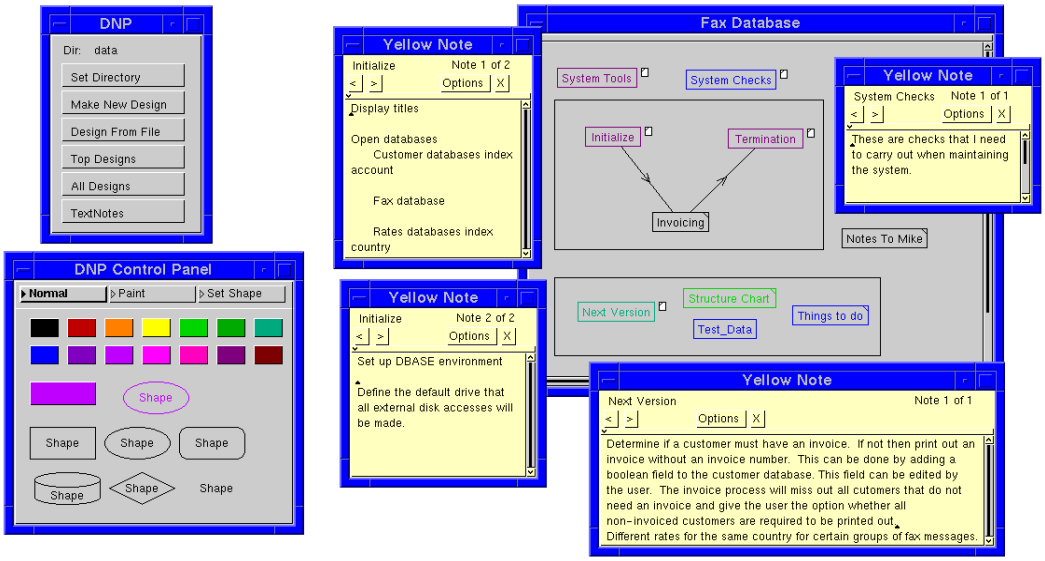

Figure 11: A typical DNP interface

The bulk of the development work has been concerned with refining the interface to make it easy to learn and use and, most importantly, easy to change and experiment with the evolving structures. An essential prerequisite for the acceptability of the tool is that it avoids problems of prior commitment: unnecessarily forcing the user to decide too early on what the form of the idea should be, by requiring a certain typing or structure to be adhered to. If the elements are easy to revise, the user need not worry about their initial form; it can be refined later on. The development process has been one of rapid prototyping coupled with ongoing formative evaluation studies of the use of the system by students from various backgrounds working on authentic tasks (tasks that they had to do anyway). The studies produced an evolving set of requirements for the system. The flexibility of the tool has resulted in it being used to support the structuring of designs, the writing of essays and browsing of information spaces. In the case of COMIC this flexibility has been increased by exploring facilities to allow multiple perspectives on information to be represented.

Conclusions

The work of the COMIC project has focused on the bringing together of the social and the technical in practice. This has been driven by the design, development installation and use of a wide range of prototypes. These prototypes represent the result of cross-site investigation and research. Many of them realise jointly produced concepts and ideas while others have been significantly amended as a result of the research of other COMIC partners.

In this section we have presented only a brief review of some of the prototypes produced across the project. These prototypes and the associated trials bring together a range of different research concepts to show how they can be used in practice. Many of these prototypes represent the integration of traditions and approaches that prior to COMIC where seen as disparate and unrelated. Many others incorporate the research results uncovered during the project from different research traditions and backgrounds. This is in line with original intent of developing systems:

> "The investigation of models and theories by social scientists will be directed toward the development of cooperative systems by computer scientists. This is intended to engage researchers from a collection of disciplines in common tasks in order to promote the transfer of knowledge across disciplines. "
>
> (COMIC Technical Annexe, April 1992)

CSCW Frameworks and Architectures

In addition to the methodological progress and the development of prototypes the development of frameworks has been used as a means of integration across the COMIC project. These frameworks have allowed common results to be related and placed in an integrated structure for future use. The breath of activities involved in the COMIC project means that rather than a single over-arching framework for CSCW, a number of distinct frameworks have emerged reflecting different issues central to the development of cooperative systems. In this chapter we wish to consider the different ways that frameworks and architectures have been used in the COMIC project.

The different frameworks and architectures to emerge during the COMIC project serve particular purposes in the development design and use of cooperative systems. They also reflect different disciplines and orientations and are intended to serve different putposes. All of the frameworks and architectures are the result of joint research between COMIC partners. Frameworks of note include:

- The development of a framework to allow different representations of organisations to be related. This framework results from a collective consideration of the nature of organisations and rethinks the actual intent and purpose of frameworks in the development of cooperative systems.
- The conceptual framework surrounding mechanisms of interaction and its supporting architecture. This framework was developed by RISØ and Milan and is intended to allow a bridge between identified social mechanisms of interaction and the computational equivalents developed to support the work of groups.
- The development of an architecture to support a shared objects. This architecture presents a reference framework to guide the developers of future cooperative systems and represents principles agreed after considerable debate across the project.
- The construction of a framework for presenting ethnogrpahic fieldwork has emerged as part of the investigation into supporting the development of cooperative systems by multi-disciplinary teams. This framework supports communication between fieldworker and designer by offering an approach to structuring this information sensitive to the needs of developers.

A number of other frameworks have emerged across the project many of these have been applied as part of the project work. Each of these different frameworks represent significant points of integration for the project. Rather than describe these in detail this chapter focus on illustrating two particular forms of framework usage in the project. The technical use of architectures is illustrated by considering the development of the shared object service architecture. This is

complemented by a consideration of the framework to develop from a consideration of organisations. Finally, the relationship between these different forms of framework is considered in terms of the development of Mechanisms of Interaction.

The Research Groupings

The frameworks developed during the COMIC project represent significnat links between institutions involved in the COMIC project. As in the case of systems development and prototype construction a subset of partners have been involved in the development of the frameworks illustrated here. The extent of this integration is reflected in the map in figure NN where the sites jointly involved in framework development are linked. The groupings illustrated include

Manchester, Lancaster, UPC, Limerick, Milano, OULU and GMD have all worked together to develop a framework to allow different organisational and activity models to coexist. This framework also identifies a particular role for frameworks in organisational development.

RISØ, Milan and OULU have all been involved in the construction of the conceptual framework and architecture supporting the development of cooperative mechanisms of interaction.

UPC, Lancaster, SICS, KTH, GMD have collectively deevloped the SOS/SIS architecture underpinning the shared object and interface services. This architecture represents an abstraction over existing standard distributed systems platforms.

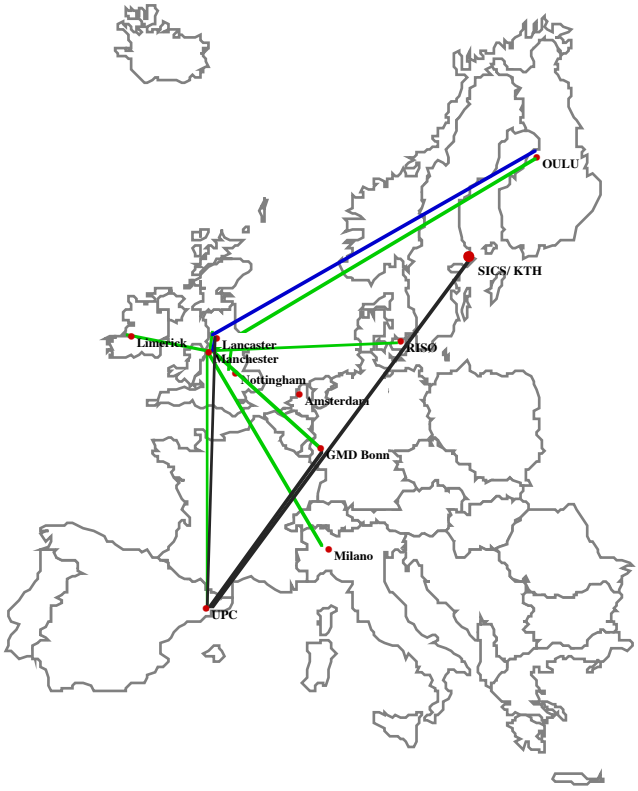

Figure 12: The different COMIC framework research groupings.

The Integrated Results

In this section we wish to focus the development of frameworks and architectures across the project. The community exploits frameworks and architectures in a number of way, ranging from conceptual devices for analysis to the recording the structure of technical artefacts. This diversity is reflected in the results of the COMIC project through the establishment of a series of frameworks each serving different purposes.

Rather than exhaustively consider all of these frameworks and architectures we have chosen to focus on two principle frameworks.

- A conceptual framework to understand organisations.
- The supporting architecture for the shared object service.

These represent both a conceptual framework and a technical architecture. Other frameworks have been exploited and used in the project. However, these two are indicative of the collective and integrated development of frameworks in the project. Other frameworks to be developed during the project include

- The spatial model of interaction and the associated frameworks of interaction developed jointly between Nottingham, SICS, Lancaster and Manchester.

- An analysis and presentation framework for fieldstudies developed jointly between Manchester, Lancaster and OULU
- The framework and architecture for Mechanisms of interaction developed collectively by RISØ, Milan, UPC and OULU. The framework in turn incorporates the architecture of the SOS as part of its structure.

A conceptual framework to understand organisations

The development of a conceptual framework to understand organisations forced the COMIC project to ask serious questions about the nature and role of frameworks. The multiplicity of accounts of the nature of organisations that can be found in the research literature dominated the development of a conceptual framework. Whether one looks to administrative science, sociology, computer science, organisational theory, organisational psychology or wherever, the sheer variation that can be found in descriptions of 'the organisation' is notable. It is essential that any framework reflects the multiplicity evident in organisation theory.

A number of responses are possible to recognise this multiplicity within a framework. One could attempt a 'grand synthesis' of all organisational theories or one could - in spite of the evidence of all contemporary thinking on organisations - try to hold on to just one theory. Both of these forms of theoretical integration are in direct opposition to the philosophy of integration in practice adopted across the COMIC project.

An open acceptance of pluralism caused us to rethink radically what a 'conceptual framework' for organisations might consist of. Indeed, one traditional way to understand the phrase 'conceptual framework' is precisely as a grand synthesis of theories, where all theories are given their place within an overarching edifice that might distinguish basic components or dimensions and see particular theories as 'occupying the slots'. Given the dilemma in organisation theory this is no longer a useful consideration of a conceptual framework.

The understanding of a 'conceptual framework' used by the project is to consider it as '*a means to effectively organise our thoughts*' and not a grand theory or abstract formalism. This understanding represents in itself an agreement between the conceptual work on organisations and the work on novel and critical approaches to understanding theories and formalisms in our consideration of Mechanisms of Interaction. What we have decided to offer is a conceptual framework which does not consist of an overarching abstract but of a set of ordered reflections on the nature of organisations and their support with technology. These reflections are ordered into three parts:

Part 1: Orientations

In offering accounts of the nature of organisations, one must reflect upon the status of these accounts. How are they to be taken? What is their purpose? How

are they to be used? Traditionally, organisation theory has regarded its task to produce accurate representations of the object studied. However, accounts of organisation are themselves reflexively tied to the work of organising itself. It is not just organisation theorists who produce, work with and deploy accounts of organisations: organisation members themselves do just that too. It is important to reflect on how representations, models, organisational theories are practically utilised by those who have need to and to orientate to this usage in practice. Taking an orientation of this sort is - we would argue - the necessary antidote to pessimistically seeing the currently pluralistic state of organisation theory and related disciplines as constituting mere disarray.

Part 2: Metaphors and theories

A consistent theme of the project has been an acceptance of pluralism and a resistance to a belief that a single theory will suffice for the purposes of CSCW research. Pluralism is certainly the current state of those disciplines that take organisations as their object of study. Our work has been no exception. A number of substantive theoretical accounts of organisations have been explored and this Part gives details of our work in this direction. This pluralism needs to be very carefully understood and its utility assessed in practice. We are *not* offering a relativistic view in which any and all approaches to organisation are worthwhile. Rather the different metaphors need to be assessed for their applicability under a particular orientation.

This turn to pluralism as part of the framework is consistent with the practical orientation of the ethnographic, ethnomethodological approaches to organisations and represents an integration with the COMIC work on ethnography and design.

Part 3: Mechanisms and Models

The third part of our framework concerns mechanisms and models. This approach has been greatly influenced by the work conducted in Strand 3 which has attempted to offer an organisationally and sociologically grounded understanding of what a mechanism/model might be. We wish to understand mechanisms and models in terms of how they themselves support cooperative work and the coordination of different resources and practices. In our view, there is not necessarily a difference in conceptual kind between mechanisms and models on the one hand and theories and metaphors on the other. Rather, we see mechanisms and models as relatively more 'formalised' and supporting representations that are relatively more visible, manipulable, transportable, combinable and computable.

The three parts of this framework support designers and analysts in articulating an understanding of their thoughts on organisations. Rather than offer a set of *a priori* constructs into which any organisation must fit we offer a means of organisation important aspects of our thinking on organisations. The framework enables its users to make explicit the orientation they have to organisations, the

metaphors and theories being applied and the mechanisms and models realising these theories.

The supporting architecture for the SOS

In contrast to the development of a conceptual framework for understanding the nature of organisation the development of a sofware architecture for the shared object service seeks to introduce a generic structure for CSCW applications. The Shared Object Service (SOS) is a distributed service platform developed during the project that provides access to objects and is intended to enable the effective development and management of systems for the support of cooperative work. The object oriented approach has proven to be appropriate in order to achieve systems that are easily extensible. The object server concept has the additional advantage of being easily portable across platforms, since object interoperation takes place via platform independent object interfaces. Implementation details as well as the location of objects are hidden; objects and services may be used on a local machine in the same way as distributed over a wide area network.

Objects form the basic components that constitute the SOS. They consist of an interface that offers a set of methods (services) and an implementation which is hidden from clients using them. An object may be persistent, i.e. it continues to exist in the SOS after a client has used it, or it may be transient, in which case it is only temporary created for some specific needs of the client and automatically deleted afterwards.

The notion of objects in the SOS is very general. There is no formal distinction between transient objects that live only to perform some task, similar to the notion of data structures in programming languages, and persistent objects that keep their internal state until the next invocation; the same holds for whole applications and programs. All these entities are simply objects in the user's view[8].

SOS Service Layers

The supporting SOS architecture consists of three layers. The lowest layer provides the basic access and management facilities that are implemented by the service. A second layer of core services allows applications to use the mechanisms that enable specific support for cooperative applications. An extensible set of common services forms the upper layer and implements the general-purpose utilities for administration and user tailoring in the SOS. This is shown in figure13(over).

8 We will however distinguish applications developed in the framework of the SOS from regular service objects provided by the SOS although they are objects in their own right.

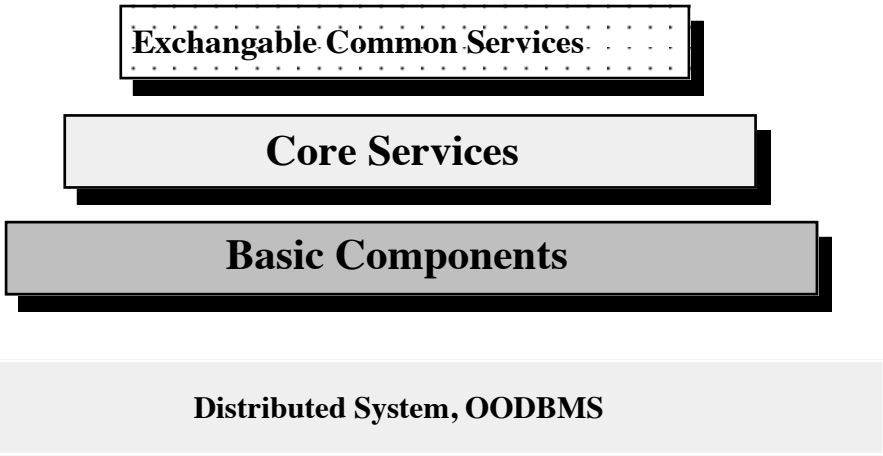

Figure 13: The layer view of the SOS

The layered approach gives application developers a way to structure the functionality of systems. However the distinction of the three layers should not be confused with a hierarchical (client-server) model: there is no limitation restricting access of objects in a given layer to the layers below. Additionally, they may interoperate directly with the underlying distributed platform. As an example, consider an event information service specific to a certain work domain being built on top of the SOS as an additional common service. The implementation of this service would make use of the basic components, e.g. define its own event types as subclasses of existing events or use object adapters and associations to implement additional object relationships and event distribution policies. The service may then use the event manager from the core services layer to handle the event distribution and notification.

Objects generally may be clients and servers simultaneously. The classification of services into three groups is solely intended to make the presentation more understandable by categorising the objects according to their level of granularity. New objects may be created based upon already existing objects. In this way the basis of services becomes broader as new objects are introduced; systems extensions do not have to be designed from scratch. A detailed description of the services provided and their position in the architecture is provide in chapter 16 of deliverable D4.2.

Conclusions

The COMIC project has developed a range of different frameworks. These frameworks are the product of cross-site investigation and research and integrate a number of different academic positions. They framework range from conceptual devices to support understanding to architecture to represent the generic structure of software systems. In this section we have only presented a brief review of a

conceptual framework for organisations and an architecture for the shared object service as example of each of these.

The different frameworks developed across the project reflect the broad scope of the CSCW research and the set of issues that need to be considered. This diversity is directly reflected in our interpretation of the role of conceptual frameworks. However, as in the case of CSCW as a research community this flexibility and diversity is balanced by a need to develop generic structures which represent abstracts of existing specific applications. The set of frameworks developed during the course of the COMIC project each contribute to the need for a greater understanding of the nature of cooperative work and the technologies to support this work.

Basic CSCW Problems and Concepts

As a basic research project one of the initial expectations and principle motivations for COMIC was to uncover basic CSCW concepts important to the future of the discipline. This was initially expressed in the overall aims of the COMIC project

> "...future CSCW developers will need to construct effective and well founded cooperative systems. This basic research project examines the fundamental research questions which need to be solved to improve future CSCW systems development."
>
> (COMIC Technical Annexe, April 1992)

The examination of these fundamental research questions lies at the core of the project and the collective work of the consortium. A set of key concepts has emerged across the project during the last three years. These problems and concepts have been manifest in a variety of different ways and in a number of contexts. This chapter seeks to reflect on some of the more prominent basic research problems and issues collectively addressed by the project. These basic problems and the research that addresses them represent a significant points of integration for the directed work of the project. It is worth stressing that the themes presented here are intended to be illustrative of the general contribution of the project rather than an exhaustive survey of the themes and topics tackled by the project.

CSCW: Old problem or New?

Despite its recent appearance as an identifiable research area in its own right many of the issues at the core of CSCW are fundamental to the development of information systems. This comes as no real surprise when one considers that the work information systems aim to support is like most work, essentially social. This merging of the social and the technical lies at the heart of CSCW and is often used as a means to characterise the field. However, it would be misleading to say that the problems involved are unique to the CSCW community or have been discovered by those involved in CSCW.

In addition, to the explicit involvement of the social in the development of computer systems. One of the dominant themes of COMIC has been to relate the work of the CSCW community to related research communities. This has involved both the integration of research results from other communities to the research agenda of COMIC and CSCW and the dissemination of project results to other communities. The areas of research involved in this general process of assimilation include the following

The HCI community

The COMIC project has contributed directly to the work of the HCI community. This contribution has addressed conceptual issues such as the nature of the interface and existing notions of user and tasks. The project has also contributed to consideration of design and design rationale. In addition, many of the prototypes constructed during the project have extended user interface architectures.

ODP and distributed systems

The development of the architectures and platforms in COMIC have built upon the results of existing distributed systems and augmented existing consideration of distribution. In addition, the work of the project has contributed to the thinking of the ODP community on the nature of enterprises and electronic organisations.

Organisation Theory, Management Audiences and the IS Literature

The work of the project on the nature of organisations the need for diversity and the development of different approaches to requirements capture have all taken place within the context of existing work on information and organisational systems.

Software and Requirements Engineering

Many areas of the project have used problems drawn from the domain of software engineering as examples of cooperation and coordination. Many of the studies reflect on the software process and work of the project contribute to amending the software development and requirements process.

The project has published in key conferences and journals in these areas and added to the work of these and other communities including the virtual reality, artificial intelligence and agent based systems. In doing so the project has contributed to a more general acceptance of the area of CSCW and the issues involved in the development of systems to support the work of groups.

Awareness

The notion of awareness has been a common theme in the COMIC project and more generally across the CSCW community. The need to make the activity of others available and to increase users awareness of others is often cited as a motivation for systems and prototypes in CSCW. Unsurprisingly the concept of awareness was apparent in many areas of research in the COMIC project. This includes the development of prototypes concepts and theories. Areas of particular note in the project include:-

An event model

The use of events to distribute actions across the shared object service, the codesk and groupdesk systems and the TOSCA organisational system all

demonstrate the how a simple mechanism can be used to make actions available to a group of users.

Awareness and the propagation of changes

The notion of awareness as the propagation of action is a theme shared with the development of organisational models and the concepts of linkability of mechanisms of interaction.

Modelling modes of awareness in virtual spaces

Perhaps the most prominent example of the use of awareness in the COMIC project is the development of a spatial model of interaction and awareness as part of the work on the construction and use of distributed virtual environments. The use of awareness in these spaces has some analogies with the consideration of awareness in mediaspace.

Awareness metrics and measures

The work of awareness was further augmented by the development of a hybrid form of the spatial model that considered the application of notions of proximity and awareness across collections of related objects. This involved both a development of the spatial model for shared graph structures and the construction of metrics for measuring awareness in information sharing systems.

Awareness and workflow models

The derived form of the spatial model applied to graphs has been extended as part of the development of the Milano system to augment existing notions of workflow with an notion of awareness drawn from the spatial model.

The different forms of awareness explored in the COMIC project investigates different aspects of a phenomena common to cooperative settings in the real world. Each of these different areas of work illustrate the different ways in which this important phenomena may become electronically manifest.

Multiplicity and Heterogeneity

An important theme common across the COMIC project is an accceptance of complexity and heterogeneity in the real world and the ability to handle this in the development of cooperative systems. This acceptance and accomodation of hetrogeneity is perhaps most evident in the development of a conceptual framework which accepts multiple versions of organization.

Multiplicity and heterogeneity is also prominent in the work on systems development and the acceptance of multiple inputs and constrains on the the design of cooperative systems. This multipicity is accepted and supported through the realisation of an analysis framework for fieldstudies and the application of viewpoints as a means of presenting the results of fieldwork in the development process.

The acceptance of multiplicity reflects a project wide acceptance that simple solutions are unlikely to exist to the complex problems of the real world. This complexity is also reflected in the development of facilities to allow increasingly complex mechanisms to be constructed from basic building blocks both in terms of the use of shared objects and the development of complex mechanisms of interaction.

Space and Spatial Considerations

One feature of the work of the COMIC project that exploits novel technolgy is the explotation of space and the consideration of spatial models as a means of understanding cooperative interaction. VR technology and the devlopment and use of collaborative virtual environments has been used as a means of exploring and developing the COMIC spatial model. This use of space has also been manifest across the project in a number of forms.

Organisational spaces
: The use of organizational and social space has been explored through the construction of a range of differenet spatial environments reflecting different organisational structures.

Boundaries
: The use of boundaries to define the structure of space has feaured in the development of cooperative virtual environments. Boundaries have also featured strongly in the development of concepts to describe and define organisational structures. For example, the use of inner and outer organisational organisational context boundaries in the work of GMD and Milan. Similar boundaries are manifest in the construction and visualisation of virtual organisations and virtual cities such as those detailed in D4.3.

The spatial model and shared objects
: The spatial model has also been used to augment systems which do not normally have spatial cues. For example, shared object systems and databases. Two broad approaches exist to add spatial cues to shared object systems by visualising objects within virtual spaces or developing equivalences spatial metrics for shared object systems. Both of these approaches have been developed as part of the COMIC project.

Notations in Theory, Notations in Practice...

The use of notations and plans to coordinate the action and activity of users has feature prominently with the CSCW community. In fact, the role and nature of plans has represented a considerable area of debate across the community. Understanding the cooperative use of these plans in practice has been a dominant theme of the work of the COMIC project.

Understanding the use of plans has involved reflecting on the representation and the representing practices in organisations, the design and development process and the protocols defining mechanisms of interaction. The issue for the the COMIC project has been to understand the use of notations in practice and to develop facilities to support the practical use of notations.

This exploration has involved a consideration of notations in business modelling and business process re-engineering , the use of notations to represent designs and the resuls of fieldstudies and the use of notations to coordinate distributed action. This use of notation has been supported by the exploration and development of a formal framework to support the specification and development of generic mechanisms of interaction. The focus of the formal work has been on the use notations in cooperative work itself and how to define their manipulation, visibility and transformability.

Demonstrating Scaleability

A central challenge of the COMIC project has been the acceptance of scale and the need to support scaleability in the development of future cooperative systems. This scale has been examined in the COMIC project in terms of scale and structure within organizations and inter-organizational relations and the role of organizations as firms in (inter)national economies

Scale has also motivated the developmentof more systematic facilties for incorporating studies of work into the development process and the application of tool support to add communication. Scale has also presented a methodological challenge for ethnographic studies. The challange of scale has been addressed by the development of novel arrangements for undertaking ethnographic studies including the development of quick and dirt and evaluative ethnogrpaphic studies.

Similarly, scale has motivated the structure of many of the mechanism developed in the project and the investigation of facilities to configure and link different mechanisms to allow the management of complexity. This scaling up is also reflected in the continued development of the shated object service and the work on distributed cooperative virtual environments.

A summary of key approaches

This chapter has considered the development of common concepts, themes and problems across the project. These common themes provide a focus for common endeavour and integrated activity across the project. They have also resulted in the development of promoting of some key concepts which can be described as COMIC research approaches. These include:

- A consideration of articulation work to make public cooperaitve work
- A lightweight defintion and represtation of cooperaitve activities
- An acceptance and recognition of the preformative nature of organizations.
- An acceptance of design as a workaday activity.
- An exploration of shared objects and common artifacts to support coopertive work.
- The application of viewpoints to represent multiplicity
- The calibration of ethnography as part of the systems development process
- The development of a spatial model of interaction and the transfer of this model to non-spatial domains.
- The development of mechanisms of interaction to support distributed coordination across communities of users.
- The development of notions of virtual organizations
- The representation of organisations in differnet forms including: activity, networks of work processes, cooperative work arrangements

This list of approaches is not intended to be exhaustive or complete rather it is illustrative of the diversity of approach evident in a project of the size of COMIC. However, these approaches have tended to be complementary to broad aims of the project and reflect the nature of the CSCW community and the project.

Predicted Results and Future work

A series of result and potentials for exploitation from these results were highlighted prior to starting the COMIC project in the technical annexe. In this final chapter we wish to briefly review these predictions in terms of the progress of the project and identify areas of potential future research. The predicted results used in this chapter are drawn directly from the original COMIC technical annexe developed in April 1992.

The Predicted Results

The results predicted for the COMIC project and the potential exploitation possibilities were introduced in the technical annexe as

> "The various COMIC results areas highlighted have different exploitation potentials and are contributed to by different project goals. The exploitation potential associated with each result area can be characterised as:
>
> > *Short Term Exploitation* during the lifetime of the COMIC project with the results of direct benefit to the research community.
> >
> > *Medium Term Exploitation* subsequent to the completion of the COMIC project. Exploitation of these results will largely require further research and development.
> >
> > *Long Term Exploitation* is the potential future methods and practises to which the results of the COMIC project may ultimately contribute.
>
> Each of the different COMIC result areas have different exploitation possibilities in the short, medium and long term, these are summarised in the set of tables below"
>
> (COMIC Technical Annexe, April 1992)

These results and their associated exploitation tables provide the basis for our review of the COMIC project results in this section and the identification of future work in the following section.

The Nature of Groups

Result Topic	The nature of groups	
Exploitation Potentials		
SHORT	*MEDIUM*	*LONG*
A characterisation of the appropriate features of groups and how these may impact CSCW systems	Techniques and theories to understand the nature of groups and how this reflects in CSCW systems	A theoretical framework which allows the structure of groups and their inter-relationship with CSCW systems to be described in future system analysis methods.

The nature of groups and organisation has been explored extensively across the project. A number of particular characterisation of groups have been developed

and published in the HCI and CSCW literature(Kuutti, 1994; Prinz et al., 1994; Shapiro, 1994). Many of these characterisations have developed from empirical studies of work and adopt considerations of the flexibility and dynamic nature of groups. A number of prototypes have been developed to support flexible and dynamic groups in CSCW(Trevor et al., 1993; Agostini et al., 1995; Fuchs et al., 1995). The development and use of these systems have been complemented by the development of conceptual frameworks and analysis and presentation techniques.

The setting of CSCW systems

Result Topic	The setting of CSCW systems	
Exploitation Potentials		
SHORT	*MEDIUM*	*LONG*
An understanding of the impact of organisational settings on the structure of CSCW systems	Modelling techniques to allow important features of the setting of CSCW systems to be captured	A set of theoretical concepts and modelling facilities which allow organisational and social settings to be characterised and related to CSCW systems by future IT analysts..

The consideration of organisations and their relationship to systems has been supported by a large number of studies outlining the relationship between organisations and technology (Divitini et al., 1993; Andersen and Hansen, 1994; Hewitt and Schmidt, 1994; De Michelis, 1995; Sharrock, 1995). These studies have seen the development of a conceptual framework to understand organisations and to support the multiplicity inherent in modern considerations of organisations. A number of these concepts and the support for multiplicity have been used in the development of cooperative systems and used to support the inclusion of fieldstudies into the development of studies of work.

Requirements capture for CSCW

Result Topic	Requirements capture for CSCW	
Exploitation Potentials		
SHORT	*MEDIUM*	*LONG*
The applicability of existing requirements techniques and the relationship to observational methods.	Tools and techniques to support the analysis of observational information to develop requirements	A requirements method which supports the capture and development of system requirements and IT products to support these methods.

The relationship between observational fieldstudies and existing approaches to the development of IT systems has been examined during the project and a series of publications produced which examine this in relation to other communities(Visala, 1993; Hughes et al., 1994b; King et al., 1994; Sharrock and Button, 1995) . This work has been complemented by a consideration of the development process and the construction of tool support to aid communication between fieldworkers and systems developers(Bowers and Pycock, 1994; Hughes et al., 1994a; Hughes et al., 1995a; Sommerville and Rodden, 1995). This

communication has more recently been the application of a more systematic approach to the development of requirements based on an analytic framework(Hughes et al., 1995a)and associated methodological changes to the development process.

Result Topic	System development models	
Exploitation Potentials		
SHORT	*MEDIUM*	*LONG*
An assessment of appropriate strategies for the development of systems	A set of guide-lines and models to support system developers	A development framework which allows the contributing disciplines within to be related and tools to support this development process.

The constructional approach of the COMIC project has allowed the consortium as a whole to reflect on the nature of systems development and the relation to CSCW(Shapiro, 1993; Bentley et al., 1994a; De Michelis, 1995; Hughes et al., 1995b; Schmidt and Simone, 1995). This reflection has resulted in the development of general guidelines for the construction of cooperative systems and the incorporation of studies of work. This has been complemented by the development of frameworks which accept multiplicity and allow a series of different inputs to the development process. Most recently this has involved the incorporation of both ethnographic and cybernetic fieldwork into the systems development process (see Deliverable D2.3).

User interaction for CSCW

Result Topic	User interaction for CSCW	
Exploitation Potentials		
SHORT	*MEDIUM*	*LONG*
Understanding of the form and role of interaction within CSCW systems	Concepts and metaphors to support co-operative interaction within CSCW systems	Computational interfaces which encapsulate appropriate metaphors to support co-operation for inclusion in future CSCW products.

Perhaps the most prominent set of applications to emerge from COMIC have focused on the nature of shared interaction and how this is supported. These prototypes adopt either a model of interaction that focuses on shared objects or a spatial consideration of cooperative interaction(Benford et al., 1994; Benford and Fahlén, 1994; Benford and Mariani, 1994; Bentley et al., 1994b; Smith and Rodden, 1995; Tollmar and Sundblad, 1995). The developed models and metaphors have been informed from a consideration of the nature of interaction and where possible from extensive studies of the nature of interaction in the real world. The extensive range of computational interfaces which encapsulate the developed metaphors have been used and assessed during the project (see

Deliverables D4.2 and D4.3). Many of these interfaces have been fed into other projects and are been further investigated in different domains.

Computational Architectures for CSCW

Result Topic	Computational Architectures for CSCW	
Exploitation Potentials		
SHORT	*MEDIUM*	*LONG*
Identification of appropriate computational elements within systems	The development of computational models to reflect the salient features of co-operation within systems	A set of computational models for systems, the architectures to support these and their realisation within support platforms.

From the outset of the project we have considered applications in terms of their overall impact to the supporting technology(Schmidt and Rodden, 1994; Rodriguez and Navarro, 1996). Part of this consideration has seen us identify supporting architectures for the concepts and metaphors developed during the project. The developed computational models have been realised in terms of generic services which relate the work of the project to on-going initiatives and trends in computer systems. The computational models to emerge across the project have been demonstrated through a series of specific prototypes which are in turn related to more abstract architectural considerations. A number of infrastructure facilities have been developed as part of this work(See deliverable D4.2).

The results briefly reviewed above are obviously not the only results of the project nor are they necessarily the most significant results of the project. The overall assessment of the importance and utility of the project results rest with the community and the software industry. Ultimately they will decide the utility and importance of the project results in respect to each other as they are taken up and further developed. Initial indications suggest considerable interest in the project from both academic and industrial backgrounds and this allows us to feel confident about the overall prediction made when the results in this section were initially outlined.

> "A major aim of the COMIC project is to develop a basis on which systems can be designed which are able to support, and survive in, real-world cooperative environments. The results highlighted in the previous section will inform and support the developers of future systems. "
>
> (COMIC Technical Annexe, April 1992)

Future work

The COMIC project has undertaken a significant and extensive program of research in CSCW. This research programme has been undertaken during the development of a research community and the project has actively contributed to the development of this research community and the research agenda associated with it. In this final section of the deliverable we wish to very briefly outline some

aspects of current research in CSCW that have been influence or emerge from the COMIC project. As in the case of research results this listing is intended to be illustrative rather than exhaustive and to highlight only some of the research issues of importance to the community.

Evaluation and assessment techniques for cooperative systems

The first generation of coordination and cooperation technologies are now in use and open to assessment and it is pertinent to raise questions as to how they may be evaluated and assessed. Systems readily available include groupware products such as Lotus Note and Linkworks, and a series of systems developed on top of the Internet. The development of appropriate assessment techniques is a central concern in extending existing notions of systems design to incorporate the needs of the business process. Many of the initial issues have been addressed within the COMIC project in the assessment of the prototype systems developed during the project.

Distribution mechanisms for CSCW

Current coordination mechanisms in the form of groupware and workflow management systems typically assume an omniscient agent that is able to specify all objects and relationships within the system. There is no technological support for interoperability among multiple coordination systems designed and maintained in a distributed manner in a wider inter-organisational domain. However, one of the problems of much of current technologies is that they lack the mechanisms to support a 'bottom up' or distributed design that is able to adapt to evolution of work arrangements. Initial versions of these alternative arrangements have been explored during the lifetime of the project (for example, the aleph work reported in D3.4). These different mechanisms and platforms are now sufficiently mature that they are ready to assessed within real world industrial contexts.

A reference model for cooperative systems

Little consideration is currently being given in industry to the provision of general services to support cooperative applications. Without these services the widespread acceptance of cooperative applications will be inhibited by an impedance between the needs of future cooperative applications and the facilities provided by supporting software. The development of a general reference model for cooperative software that builds upon extensive experience of studies of work will provide a significant input for future standards bodies. This reference model should identify and outline generic facilities and structures for cooperative systems realisable across a range of architectures. Initial versions of this form of reference architecture have been developed in the COMIC project through the construction of the shared object service, the development of the architecture to

support mechanisms of interaction and the shared interface service. The development of a reference model would involve :

- The development of appropriate network services for CSCW.
- The development of appropriate mechanisms and techniques to augment existing platforms.
- An assessment of relevant standards and the input of novel techniques to meet the needs of future cooperative products.
- An understanding of the relation between communication services and interaction facilities.
- The development of architectures to support cooperation across a range of infrastructures offering different qualities of service.
- New models for constructing distributed cooperative multimedia systems and mediating cooperation.

Dynamic models of organisations

One of the major problems is developing satisfactory models of organisations that are capable of adequately representing the increased complexity of coordination processes. Traditional organisational models, such as charts of management hierarchies or functional units, have been paper based two dimensional representations. Many process modelling notations have similarly adopted a 2-D diagrammatic format. These tend to be static and ill-adapted to the rapidly changing environments of enterprises. They also fail to adequately reflect the diverse set of opinions that exist within organisations. The development of a conceptual framework for representing the multiplicity evident in organisations and the realisation of more dynamic computational models suggest that future organisational models make be constructed that better meet the needs of the organisation rather than the supporting software.

Organisational management techniques

One of the main issues in CSCW is understanding the relationship of the models of work and coordination to the actual domain of work. This is particularly important in the case of developing strategies to manage technology within organisations. A central problem is to ascertain how much and what kind of knowledge of the domain is essential to adequate modelling for these purposes. The COMIC project has focused on informing models of organisation through studies of actual work and coordination activities. The further development of these models and the approaches surrounding them will be important to the commercial acceptance of cooperative applications.

Multimedia Interaction and awareness techniques

The growth in cooperative products over the last few years has been mirrored by the increased prominence of multimedia applications. For example, the spread of multimedia information systems such as the World Wide Web over networks such as the Internet. However, although existing multimedia information systems provide a powerful infrastructure for publishing and retrieving information, their design has generally not considered the nature of cooperative working between their users. Indeed, users are typically reduced to the status of external observers, peering at information through the screen of a computer, unaware of each others' actions. In addition, current interfaces to such systems are based on WIMP technology and have generally not considered the possibilities for enhanced browsing and navigation offered by recent developments in interactive 3D graphics and 3D information visualisation. The continued growth in graphics capabilities and the maturing of desktop VR systems and products have made this form of technology more widely available and accessible.

A particular concern is the current separation between multimedia information infrastructures and the cooperative use of information. Results of the COMIC project suggest that information is most of most use when combined with an ability for people to communicate and cooperate with one another. Our research to date suggests that the notion of mutual awareness, both directed and peripheral, is critically important in many cooperative situations. In turn, awareness may require sufficiently rich user embodiment within the application. Support for cooperation also involves consideration of how information is shared, covering issues such as synchronisation, history, version control and the importance of providing different views on information as a function of a user's actions, interests or purposes. This research theme builds on the COMIC work on Collaborative Virtual Environments and Populated Information Terrains (PITS) which have demonstrated how a combination of virtual reality and distributed systems technologies can be used to constructed powerful shared virtual spaces for visualising and sharing a variety of different kinds of information. This work would also involve

- Techniques to manage multi-user interaction in distributed interactive applications.
- The development of presentation mechanisms to support highly variable interaction technologies.
- Development of new cooperative multimedia interfaces and techniques for disparate groups.
- The use of different wide area networks techniques to support heterogeneous user interfaces.

Summary

In this final chapter of the deliverable we have briefly revisited the results anticipated of the project at its outset and the exploitation opportunities identified. During the project all of these results have been achieved and many of the longer term exploitation opportunities have been initiated. This look at the past has been balanced by a consideration of the future opportunities identified by the research project.

It is difficult to summarise a project as large as COMIC addressing issues as diverse as those in CSCW. What is clear is that we have achieved the results initially anticipated at the outset of the project. In addition, we have investigated a much wider remit of problems than we had anticipated and the results of the project have contributed to many research communities other than CSCW. This focus on research has been complemented by energetic dissemination of results which has given the COMIC project a strong international profile and significantly increase the world-wide standing of European research.

References

Agostini, Alessandra , Giorgio De Michelis, M. Antonietta Grasso, Wolfgang Prinz, and Anja Syri (1995): Contexts, work processes and workspaces *Proceedings of the International Workshop on the Design of Cooperative Systems Antibes-Juan-les-Pins, January 25-27, 1995*. Sophia Antipolis: INRIA, pp. 219-238.

Pankoke-Babatz, U., ed. *Computer Based Group Communication: the AMIGO Activity Model*, Information Technology Series, 1989, Ellis Horwood, Chichester. 320 pages.

Andersen, Hans H. K. and Poul H. K. Hansen (1994). In P. T. Kidd and W. Karwowski (eds.): *Advances in Agile Manufacturing: Integrating Technology, Organization and People. Fourth International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation, Manchester, England*. IOS Press, pp. 105-108.

Bannon, L. & Kuutti, K. (1995). Hunting the Snark? The Case for & against Organizational Memory. University of Lancaster. Report No. COMIC-Riso-Oulu-1-1.

Benford, Steve and John Mariani (1994). *User Interfaces to Databases, Ambleside, UK*. Available from Computing Dept., Lancaster University, UK.

Benford, Steve and Lennart Fahlén (1994). In B. Pehrson and E. Skarbäck (eds.): *6th ERCIM Workshops, Stockholm, Sweden*. Available from SICS, Stockholm, Sweden, pp. 225-232.

Benford, Steve, John Bowers, Lennart E Fahlén, and Tom Rodden (1994). In B. Pehrson and E. Skarbäck (eds.): *6th ERCIM Workshops, Stockholm, Sweden*. Available from SICS, Stockholm, Sweden, pp. 15-28.

Bentley, R., T. Rodden, I. Sommerville, and P. Sawyer (1994b): Architectural support for cooperative multi user interfaces. *IEEE Computer*, vol. 27, no. 5, pp. 37-48.

Bentley, R., T. Rodden, P. Sawyer, and I. Sommerville (1994a): Cooperative Systems Design. *The Computer Journal*, vol. 37, no. 5, pp. 357-366.

Bowers, John and James Pycock (1994). In B. Adelson, S. Dumais, and J. Olson (eds.): *CHI '94, Boston, USA*. ACM Press, pp. 299-305.

Broll, W. and D. England, "Bringing Worlds Together: Adding Multi-User Support to VRML", in *Proc. of VRML '95 Symposium,* San Diego, 1995, pp.

Broll, W. and D. England, "Bringing Worlds Together: Adding Multi-User Support to VRML", in *Proc. of VRML '95 Symposium,* San Diego, 1995, pp.

De Michelis, Giorgio (1995): Work Processes, Organizational Structures and Cooperation Supports: Managing Complexity *Proceedings of the 5th IFAC Symposium on Automated Systems Based on Human Skill - Joint Design of Technology and Organisation, September 26-28, 1995, Berlin*. - (Forthcoming).

Divitini, M., G. Omodei Sale, A. Pozzoli, and C. Simone (1993). In S. Kaplan (ed.): *COOCS '93 Conference on Organizational Computing Systems, Milpitas, California, USA*. ACM, pp. 178-183.

Divitini, Monica, Carla Simone, Kjeld Schmidt, and Peter Carstensen (1995): *A multi-agent approach to the design of coordination mechanisms*WPCS-95-5, Roskilde University, DK-4000 Roskilde, Denmark.

Favorin, M. & Kuutti, K. (1994). To support learning at work by making work visible through information technology: An Activity theory approach. In Levonen, J. J. et al. (eds.). Proceedings of Workshop on Complex Learning in Computer Environments. Joensuu: Joensuu University.

Fuchs, L., U. Pankoke-Babatz, and W. Prinz (1995). In Schmidt, Sundblad, and Marmolin (eds.): *ECSCW 95, Stockholm, Sweden*.

Fuchs, Ludwin, Uta Pankoke-Babatz, and Wolfgang Prinz (1994). *D-CSCW ´94 - Einführung von CSCW-Systemen in Organisationen, Marburg*, pp. (forthcoming).

Hewitt, Betty and Kjeld Schmidt (1994). In P. Kidd and W. Karwowski (eds.): *Advances in Agile Manufacturing. Integrating Technology, Organization and People. — Fourth International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation,, Manchester, England*. IOS Press, pp. 118-121.

Hughes, J., J. O'Brien, M. Rouncefield, T. Rodden, and I. Sommerville (1995a). *RE'95*. IEEE Press.

Hughes, J.A, D Randall, and D Shapiro (1994a): Steps toward a partnership: ethnography and system design. In M. Jirotka and J. Goguen (eds.): *Requirements Engineering: Social and Technical Issues*. London: Academic Press.

Hughes, J.A, D Randall, and D Shapiro (1994b): Systems development - the fourth dimension: perspectives on the social organisation of work. In P. Quintas (ed.): *Social Dimensions of Systems Engineering: People, Process, Policies and Software Development*. Hemel Hempstead: Ellis Horwood, pp. 197-214.

Hughes, J.A., V. King, T. Rodden, and C. Anderson (1995b): The role of ethnography in interactive systems design. *ACM Interactions*, vol. 2, no. 2, pp. 56-65.

Hughes, John A., Wes Sharrock, Tom Rodden, Jon O'Brien, Mark Rouncefield, and Dave Calvey (eds.) (1994): *Field Studies and CSCW*. Lancaster, UK: Computing Department, Lancaster University. - [COMIC Deliverable 2.2. Available via anonymous FTP from ftp.comp.lancs.ac.uk].

King, V, J Hughes, T Rodden, and I Sommerville (1994). In B. C. Warboys (ed.): *EWSPT 94, 3rd European Conference on Software Process Technology, Villard de Lans, France*. Springer Verlag, pp. 59-64.

Klöckner, K., P. Mambrey, M. Sohlenkamp, *et al*., "POLITeam: Bridging the Gap between Bonn and Berlin for and with the Users", in *Proc. of ECSCW '95,* Stockholm, Kluwer, 1995, pp. Pankoke-Babatz, U., ed. *Computer Based Group Communication: the AMIGO Activity Model*, Information Technology Series, 1989, Ellis Horwood, Chichester. 320 pages.

Klöckner, K., P. Mambrey, M. Sohlenkamp, *et al*., "POLITeam: Bridging the Gap between Bonn and Berlin for and with the Users", in *Proc. of ECSCW '95,* Stockholm, Kluwer, 1995, pp.

Kreifelts, T., E. Hinrichs, K.-H. Klein, P. Seuffert and G. Woetzel, "Experiences with the DOMINO Office Procedure System", in *Proc. of Second European Conference on Computer-Supported Cooperative Work,* Amsterdam, Netherlands, Kluwer Academic Publishers, 1991, pp. 117-130

Kreifelts, T., E. Hinrichs, K.-H. Klein, P. Seuffert and G. Woetzel, "Experiences with the DOMINO Office Procedure System", in *Proc. of Second European Conference on Computer-Supported Cooperative Work,* Amsterdam, Netherlands, Kluwer Academic Publishers, 1991, pp. 117-130

Kuutti, K. & Karasti, H. (forthcoming). Supporting shared interpretation of a space of representations: A case of radiological conferences. In 1st Conference on Cognitive Technology. Hong Kong, 24-27 August 1995.

Kuutti, K. & Pihlaja, J. (1994). From ethnographic fieldwork towards change and development of work — experiences from Developmental Work Research projects. Lancaster University. Report No. COMIC-Oulu-2-8.

Kuutti, K. & Virkkunen, J. (1995). Organizational Memory and Learning Network Organization: The Case of Finnish Labour Protection Inspectors. In Nunamaker, J. F. & Sprague, R. H. (eds.). Proceedings of the 28th Annual Hawaii International Conference on System Sciences-1995 (HICSS-28). Vol. IV. Los Alamitos: IEEE Computer Press. pp. 313-322.

Kuutti, K. (1995). Work processes: scenarios as a preliminary vocabulary. In Carroll, J. (ed.). Scenario-based Design. Envisioning Work and Technology in System Design. New York: Wiley. pp. 19-36.

Kuutti, K. (forthcoming b). Coping with Active Subjects: The Emergence of CSCW from IS and HCI traditions. In Tauber, M. T., R. & Shapiro, D. (ed.). Design of CSCW. Proceedings of the 13th Schärding workshop. Frankfurt: Springer.

Kuutti, K. (forthcoming c). Debates in IS and CSCW Research: Anticipating System Design for Post-Fordist Work. In IFIP WG 8.2 working conference "Information Technology and Changes in Organisational Work". December 7-9, 1995, Cambridge, UK.

Kuutti, K., Virkkunen, J. & Young, K. (1995). "Activity" instead of "process"? Questioning the unit of analysis in BPR. University of Lancaster. Report No. COMIC-Oulu-1-4.

Kuutti, Kari (1994): Coping with active subjects - the emergence of CSCW from IS and HCI traditions. In D. Shapiro, M. Tauber, and R. Traunmüller (eds.): *The Design of Computer-Supported Cooperative Work and Groupware Systems*. Amsterdam: Elsevier Science, pp. (forthcoming).

Mathiassen, Lars and Carsten Sørensen (1995). In B. Dahlbom, F. Kämerer, F. Ljungberg, J. Stage, and C. Sørensen (eds.): *Proceedings of the 18th Information systems Research seminar In Scandinavia, Gjern, Denmark, August 11–13*. Institute for Informatics, Gothenburg University, Gothenburg, Sweden, pp. 479–492.

Navarro, Leandro, Gerard Rodriguez, and Artur Serra (1995). In J. Barberá and J. P. A. Kiers (eds.): *Joint European Networking Conference, Tel Aviv*. Freund Publishing House, vol. 1, pp. 6.

Prinz, W. and P. Pennelli, “Relevance of the X.500 Directory to CSCW Applications”, in *Groupware: Software for computer supported cooperative work,* D. Marca and G. Bock (eds.), IEEE Computer Society Press, 1992, pp. 209-225.

Prinz, W. and P. Pennelli, "Relevance of the X.500 Directory to CSCW Applications", in *Groupware: Software for computer supported cooperative work,* D. Marca and G. Bock (eds.), IEEE Computer Society Press, 1992, pp. 209-225.

Prinz, Wolfgang, Tom Rodden, Anja Syri, and Jonathan Trevor (1994): Modelling Cooperative Work Settings with Active Workspaces. In D. Shapiro, M. Tauber, and R. Traunmüller (eds.): *The Design of Computer-Supported Cooperative Work and Groupware Systems*. Amsterdam: Elsevier Science, pp. (forthcoming).

Pycock, James and Wes Sharrock (1994): Two comments on MOIs. In K. Schmidt (ed.): *Social Mechanisms of Interaction*. Lancaster, UK: Computing Department, Lancaster University, pp. 149-157. - [COMIC Deliverable 3.2. Available via anonymous FTP from ftp.comp.lancs.ac.uk].

Rodriguez, Gerard and Leandro Navarro (1996). *IFIP/IEEE International conference on distributed platforms, Dresden, Germany*. Chapman-Hall, vol. 1, pp. 15. - Submitted for review, acceptance not reported.

Schmidt, Kjeld (1994): The Organization of Cooperative Work — Beyond the ‘Leviathan’ Conception of the Organization of Cooperative Work. In T. Malone (ed.): *CSCW ’94. Proceedings of the Conference on Computer-Supported Cooperative Work, Chapel Hill, North Carolina, October 24-26, 1994*. New York, N.Y.: ACM Press, pp. 101-112.

Schmidt, Kjeld and Carla Simone (1995). *COOP ’95. International Workshop on the Design of Cooperative Systems, Antibes-Juan-les-Pins, France, 25-27 January 1995*. INRIA Sophia Antipolis, France, pp. 56-75.

Schmidt, Kjeld and Tom Rodden (1994): Putting it all together: requirements for a CSCW platform. In D. Shapiro, M. Tauber, and R. Traunmüller (eds.): *The Design of Computer-Supported Cooperative Work and Groupware Systems*. Amsterdam: Elsevier Science, pp. (forthcoming).

Schmidt, Kjeld, Hans H. K. Andersen, Peter Carstensen, and Carsten Sørensen (1994): Linkable Mechanisms of Interaction as a Representation of Organizational Context. In J. Bowers (ed.): *A Conceptual Framework for Describing Organisations*. Lancaster, UK: Computing Department, Lancaster University. - [COMIC Deliverable 1.2. Available via anonymous FTP from ftp.comp.lancs.ac.uk].

Shapiro, D (1993). In J. P. Bansler, K. Bødker, F. Kensing, J. Norberg, and J. Pries-Heje (eds.): *IRIS 16: Information Systems Research in Scandinavia, Copenhagen, Denmark*. Available from University of Copenhagen, Department of Computer Science, Universitetsparken 1, DK-2100 Copenhagen O, Denmark, pp. 15-27.

Shapiro, D (1994): Ferrets in a sack? Ethnographic studies and task analysis in CSCW. In D. Shapiro, M. Tauber, and R. Traunmüller (eds.): *The Design of Computer-Supported Cooperative Work and Groupware Systems*. Amsterdam: Elsevier Science, pp. (forthcoming).

Sharrock, Wes (1995): Organisational articulation of the design space. In T. Moran and J. Carroll (eds.): *Design Rationale*Lawrence Erlbaum.

Sharrock, Wes and Graham Button (1995): Practices for ordering software development. In A. Firth (ed.): *The Discourse of Negotiation*Pergammon Press.

Simone, Carla, Monica Divitini, and Kjeld Schmidt (1995). *COOCS '95. Conference on Organizational Computing Systems, Milpitas, California, August 13-16, 1995*.

Smith, G. and T. Rodden (1995): SOL: A shared object toolkit for cooperative interfaces. *International Journal of Human Computer Studies*, vol. 42, pp. 207-234.

Sommerville, Ian and Tom Rodden (1995): Requirements engineering for cooperative systems. *Collaborative Computing Journal*, vol. (In press).

Tollmar, K. and Y. Sundblad (1995): The Design and the Building of the Graphic User Interface for the Collaborative Desktop. *Computers and Graphics*, vol. 19, no. 2, pp. 179-188.

Trevor, J., T. Rodden, and G. Blair (1993). In S. Kaplan (ed.): *ECSCW'93, Milan, Italy*. Kluwer.

Trevor, Jonathan, Tom Rodden, and Gordon Blair (1995): COLA: A Lightweight Platform for CSCW. *Computer Supported Cooperative Work (CSCW). An International Journal*, vol. 3, no. 2.

Trevor, Jonathan, Tom Rodden, and John Mariani (1994): The Use of Adapters to Support Cooperative Sharing. In T. Malone (ed.): *CSCW '94. Proceedings of the Conference on Computer-Supported Cooperative Work, Chapel Hill, North Carolina, October 24-26, 1994*. New York, N.Y.: ACM Press, pp. 219-230.

Tuikka, T. & Kuutti, K. (1994). MOI-tool: A HyperCard-based Tool for Creating Demonstrations of Cooperative Systems. In Trigg, R. et al. (eds.). PDC'94: Proceedings of the Participatory Design Conference. Palo Alto: CPSR. pp. 133.

Tuikka, T. (1995). Reliability through Cooperative Work in Software Testing. In Lee et al. (eds.). Software Quality and Productivity. Theory, Practice and Training. London: Chapman Hall. pp. 336-344.

Virkkunen, J. & Kuutti, K. (forthcoming a). Expansive learning in a knowledge organization — a case study of a Finnish labor protection organization. In Blackler, F. (ed.). Knowledge Work, Organizations and Expertice: European Perspectives. London: Routledge.

Virkkunen, J. & Kuutti, K. (forthcoming b). Understanding organizational learning by focusing on "activity systems". Jrnl Change Management.

Visala, Seppo (1993): *An exploration into the rationality of argumentation in information systems research and development*. University of Oulu. Kuutti, K. (forthcoming a). Activity Theory as a potential framework for human-computer interaction research. In Nardi, B. (ed.). Context and Consciousness: Activity Theory and Human Computer Interaction, :,. Cambridge: MIT Press.