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INTERACT97 Combined
Workshop on
CSCW in HCI-worldwide**

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Proceedings
of the
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July 15th, 1997
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Edited by

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Lars Oestreicher
John Grundy

Foreward

**Matthias Rauterberg
Lars Oestreicher
John Grundy**

Dear Workshop Participant

This is the proceedings for the INTERACT97 combined workshop on "CSCW in HCI-worldwide". The position papers in this proceedings are those selected from topics relating to HCI community development worldwide and to CSCW issues. Originally these were to be two separate INTERACT workshops, but were combined to ensure sufficient participation for a combined workshop to run.

The combined workshop has been split into two separate sessions to run in the morning of July 15th, Sydney, Australia. One to discuss issues relating to the position papers focusing on general CSCW systems, the other to the development of HCI communities in a worldwide context. The CSCW session uses as a case study a proposed groupware tool for facilitating the development of an HCI database with a worldwide geographical distribution. The HCI community session focuses on developing the content for such a database, in order for it to foster the continued development of HCI communities. The afternoon session of the combined workshop involves a joint discussion of the case study groupware tool, in terms of its content and likely groupware facilities.

The position papers have been grouped into those focusing on HCI communities and hence content issues for a groupware database, and those focusing on CSCW and groupware issues, and hence likely groupware support in the proposed HCI database/collaboration tools. We hope that you find the position papers in this proceedings offer a wide range of interesting reports of HCI community development worldwide, leading CSCW system research, and that a groupware tool supporting aspects of a worldwide HCI database can draw upon the varied work reported.

Best regards

Matthias, Lars and John
July, 1997

Contents

Topic	Page
Foreward	1
Contents	2
Part I: HCI worldwide	
CSCW in HCI – World Wide: A Swedish Perspective <i>Lars Oestreicher</i>	3
The Current Status of HCI in Japan and China <i>Xiangshi Ren</i>	6
Building an HCI Community in Brazil: Recent Efforts and Initiatives <i>Luiz Ernesto Merkle, Raquel Olivera Prates, Juliana Pereira Salles and Marcello Stein de Lima Sousa</i>	12
HCI in Russia <i>Anna Leonova and Ivan Burmistrov</i>	15
HCI in Singapore <i>Kee Yong Kim and Linda Herman</i>	17
Part II: Next Generation of CSCW Systems	
Large Scale Collaborative Information Visualisation using Virtual Environments <i>Dave Snowdon and Steve Benford</i>	19
Component-based Groupware: Issues and Experiences <i>John Grundy</i>	23
Collaboration Issues for Augmented Realities in an Outdoor Environment <i>Bruce Thomas and Susan Tyerman</i>	29
The WORLDS project: discovering patterns of collaboration <i>Tim Mansfield, Simon Kaplan and Geraldine Fitzpatrick</i>	34
Collaborative Design Studios <i>Barat Dhare</i>	39

CSCW in HCI - World Wide

A Swedish perspective

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This is a position paper for the workshop W2 at the INTERACT'97 conference in Sydney Australia. It addresses the problem of establishing HCI as a truly international discipline, with a certain focus on the use of groupware technologies. The statements in this paper should be regarded as the personal views of the author, and do not necessarily reflect the official view of my employer.

1 HCI in Sweden

Human-Computer Interaction (HCI) has in Sweden been an important discipline in software design/engineering at least since mid-1980s. Some of the work in the area has also considered the problems of using electronic media for exchanging information among people, e.g., through email (Palme, 1984; Severinson Eklundh, 1994; Severinson Eklundh, 1995) and conferencing systems.

Another important area of Swedish HCI is in the integration of general design aspects in HCI; there are more than one center that attempts to unify classic design and HCI, in some cases with a large emphasis on web-design, a not unimportant area for HCI research.

HCI is considered to be a largely interdisciplinary research area, with a large emphasis on the involvement of end-user representatives in software design (cf. the Scandinavian approach to participative design, Eason, 1988). In the department of Computing Science at Uppsala University cognitive psychology has been a base subject for students of software design since 1986, and a basic HCI course has been compulsory for software designers for several years. In many other universities in Sweden similar courses are given in software design education. HCI has the status of an academic subdiscipline, primarily to computing science, but also to psychology, design and philosophy. A national doctoral program in HCI is also currently being introduced.

In 1986 the Swedish interdisciplinary interest group for human-computer interaction (STIMDI) was founded, in order to promote and stimulate the exchange of information about research in human-computer interaction,

not only between researchers, but also between researchers and practitioners. The problem of increasing the exchange of results between academia and professionals has been a more or less continuous theme in panels and workshops on the local annual conferences held by the society. Still the general opinion seems to be that too little research knowledge is transferred from universities to practitioners, and conversely too little practical experience is shared between industry and university researchers.

Many of the cultural/social aspects of international HCI are prominent in a country with a small population (which is small also language-wise). With appr. 8 million Swedish-speaking citizens, the linguistic/cultural problems that arise from computers being primarily manufactured abroad are fairly obvious in many cases. There is still an American trash can on the Macintosh desk top, the ambulance and truck icons are American in style, and there are several similar examples that are easy to find.

Swedish HCI is also, at least to some extent, oriented towards the Anglo-American schools of HCI. Swedish culture is very quick at adopting style elements from other cultures, especially American culture. This is also possible to observe in the computer-user interfaces which, although the software companies attempt to remedy the situation through extensive guidelines there are still many cultural oddities that show through the glossy makeup.

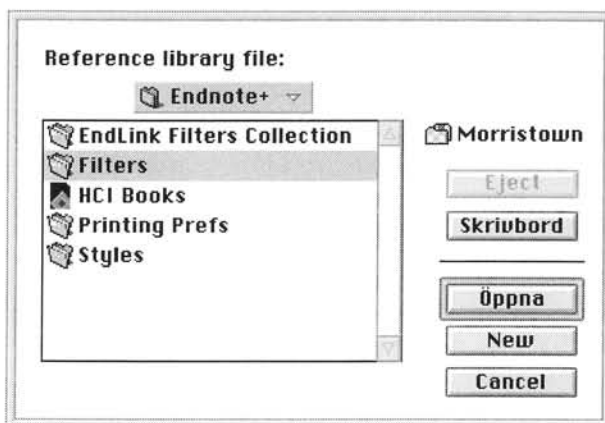
2 HCI World Wide – Today

I will, starting from the Swedish perspective, discuss my views on important problems with the current situation in HCI. Essentially, I would consider that one of the main problems will be addressed by this workshop, and by the current work being done in the IFIP TC.13, namely the spreading of knowledge, not only about research that is being done all over the world today, but also knowledge about what is *needed* in different parts of the world, with different cultures and social structures in different countries. I will discuss this from two different

perspectives: HCI problems stemming from general cultural differences and HCI in developing countries.

2.1 General Cultural Differences

One considerable problem concerning international HCI is the current, historical dominance of Anglo-Saxon research within the whole field of computer science, including HCI. This has resulted in many unnecessary HCI problems, both large and small, such as the difficulty of sending an e-mail containing the word "Smörgåsbord" from one Swedish computer to another without having it turn up as "Smlrg}sbord", or something even more unintelligible. Other similar problems are mixed language dialogues, where buttons may have both Swedish and English labels, or the text is Swedish, while the buttons are English (see example dialogue below; note the text on the middle button to the right of the dialogue – this very example was found while making the bibliography for this paper).



These kinds of problems are apparent and easy to spot in existing software, but still remain in software developed for different countries.

Another, possibly more severe problem is that in HCI, like in many other disciplines, strategies and methods are often promoted as being either right or wrong, although when detailed user-centred design is discussed, it is often stressed that solutions have to be based on the context. Is it certain that, just to give a fairly concrete example, *participative design* of software systems is really the one and only solution to bad software design, in all countries over the world? Should we assume that the STAR model is generally applicable all over the world? I would strongly suggest "no" as the proper answer to both questions.¹ There may be cultures where these paradigms will be less useful for some reason, and where other methods for software development need to be developed. Despite this there is a large tendency to regard methods as international, no matter which. I therefore see a large need for an increased discussion about how different cultural backgrounds will influence, not only the detailed design, but also the general process of user-centered software design.

¹ Note that I do *not* state that participative design or the STAR model are particularly bad examples, but rather that we cannot be sure about that they will cover every conceivable design situation, especially when the thods are transferred into different cultural settings.

2.2 Developing Countries

Apparent is also the even greater ignorance about the special needs in HCI from the development countries. Although most software today originates in the developed world, also for developing countries, there is very little mentioning in the textbook literature of special needs for people in the developing countries. Thus the HCI solutions that are, at best, appropriate for users in the developed countries will be used also for software that will be used by a completely different category of users with completely different backgrounds.

In development countries, education in computer science in general, and in HCI in particular, will for the foreseeable future be performed on low level technology as compared to in the developed countries. Using advanced multimedia, virtual reality and similar techniques for education will – in developing countries – in many cases be just something to wish for, and instead many students (and even researchers) will have to rely on what in the developed countries will be regarded as almost stone age technology.

On the other hand, the spreading of the HCI research results that is produced in , e.g., development countries is also of varying success, to say the least. Often interesting work is quite simply not known outside of the national borders.

Finally, we can see HCI as an emerging area in many countries, and therefore the international HCI community has a possibility and maybe a moral obligation to support the local HCI communities in purporting the area within software design. Thus HCI research in developing countries needs to be recognized to a higher degree.

3 CSCW as a Tool for HCI

The international character of HCI has already been mentioned and should be fairly obvious by now. However, it seems to be less recognized among practitioners. I will in this part address mostly problems with respect to the situation in developing countries, since the general problems of special cultural needs will be covered in the discussion. In my opinion one of the main problems within HCI is the communication aspect of software. This is reflected also in the HCI world-wide problem. We need better means of distributing knowledge about what is needed and not the least, what has been done already. There is a need for communication media/tools that will allow people world-wide to access each others HCI research and results. The use of CSCW tools for information promotion is already an interesting possibility to a large extent facilitated by the WWW.

Still we know little about how to use these tools in an efficient way to enhance research and education within HCI. In the world-wide perspective, the challenge will be even greater. CSCW is often discussed in terms of advanced technology solutions, but for this purpose there is a need also for low-cost alternatives. One such solution is of course the Internet publication facilities. However, also here development countries run the risk of being left behind through the rapid development of the technology. WWW-browsers also increase in size,

and require more and better hardware configurations, something which is not available in many places.

There is also a large need for group work solutions that require neither high bandwidths, nor large end-user configurations. For some future CSCW research should therefore also consider solutions which are based on less advanced technology. One especially interesting aspect of this is the use of "cheap virtual reality" systems, i.e., primarily text based environments, such as IRC, MUDs and MOOs for discussion and exchange of research and education in HCI. There are many aspects also on the usage of these low technology systems for group work, such as how groups form their internal cultures, that have still to find their solutions in research applications although some research has already been performed on these environments (cf., some standard work by Bruckman & Resnick, 1993; Cherny, 1995; Reid, 1991)

4 Concluding Discussion

I see the promotion of knowledge about research and results within the HCI area to be one of the most important aspects of how HCI shall be improved world wide. There should be some means for researchers around the world to become aware, both of needs and results in HCI research being done around the world. I also see the need for low-cost/low-level technology solutions. One important question to discuss here is how advanced the information sources can be made using only "outdated" technology. What is a minimum acceptable level of technology that can still be of use for the HCI community world wide? Can this kind of solution also be designed to be attractive to researchers and practitioners also from developing countries, i.e., is it possible to design the groupware solutions in such a way that the result will be regarded as beneficial for the major part of the HCI community.

The second part of the knowledge spreading also concerns what kind of information is needed in different countries. Considering that a kind of official knowledge center should be created, what kind of information should be maintained in this information hub? In my opinion the information hub should 1) be used to create a network of research contacts, 2) be an information source that helps people from different parts of the world to access each others research results. From the knowledge center a researcher should be able to find other researchers in different (or even the same) countries that do related work. It should also be possible to access information about methods, and methodologies that are in use or under development. Efforts in this directions are already being made, e.g., on the world wide web. However, so far these information sources are primarily uncoordinated, although they provide useful information. One important development would be to collect the best of these information sources under an official coordination center. making them easier to access.

Through this workshop, involving researchers from a wide range of countries it is my hope that (at least some of) these issues can be highlighted and combined into a first amendment of how "international" HCI can be promoted, especially through the use of internationally available CSCW technology.

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The Current Status of HCI in Japan and China

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ABSTRACT This position paper is in two parts. It addresses some areas involved in human-computer interaction in Japan and China. Part I provides an overview of human-computer interaction activities in some major professional societies and reviews their current status in Japan. It uses a concrete example from a special-interest group in Japan. It also reviews the current state of human-computer interaction publication and education in Japanese universities. Part II gives information on education and research activities related to human-computer interaction in China.

KEYWORDS HCI (Human-Compute Interaction), SIGHCI (Special-Interest Groups on HCI), SIGHI (Special-Interest Groups on Human Interface).

INTRODUCTION

This position paper is in two parts. It addresses some aspects of HCI in Japan and China.

Part I describes HCI research and studies in Japan. Earlier reports on the status of HCI or computer science in Japan have previously been published (Foley and etc., 1996; David and etc., 1993), and, although this position paper is not a systematic or complete survey, the following observations will augment and update these earlier reports. Part I provides an overview of HCI activities in some

major professional societies, especially information on special-interest groups on HCI (SIGHCI). A concrete example of the activities of a SIGHCI is included. HCI publications and education are also referred to.

Part II addresses some aspects of HCI in China. Though there was a report (Chen Y. and Fang M., 1995) summarizing software engineering in China, it didn't mention any HCI topic. I will introduce the current status of HCI education and research in China. Information on Chinese researchers working overseas is also noted.

PART I: HCI IN JAPAN

1. SOCIETIES AND SPECIAL — INTEREST GROUPS

1.1 Japanese Societies related to HCI

Academic research in HCI is quite prolific in Japan. Here are some of the main societies related to HCI. The information includes the date of establishment and the current membership (May 1997).

- Information Processing Society of Japan (IPSJ, established: 1960, current membership: 30000)
- Institute of Electronics, Information and Communication Engineers (IEICE, 1987, 40385)
- The Society of Instrument and Control Engineers (SICE, 1961, 10000)
- Japan Society for Software Science and Technology (JSSST, 1984, 1200)
- Japanese Society for Artificial Intelligence (JSAI, 1986, 4000)
- Japanese Cognitive Science Society (JCSS, 1983, 1300)

These societies hold annual meetings in Japan for their members.

1.2 SIG on HCI (SIGHCI)

Some societies have special-interest groups (SIG) on HCI. These SIGHCI hold technical meetings where the members present papers on their new research results without previous academic reviews. These societies mail written proceedings to all SIG members. Both SIG and general meetings are attended by interested parties from many associated areas.

In general, these groups are supported by big companies. For example, perhaps six large companies, including National/Panasonic, and Toshiba, are gold sponsor members of a SIG on HCI under the Society of Instrument and Control Engineers.

Many SIGs have established Web sites on the Internet, although most of these are in Japanese. Information about technical meetings, research labs, references and Web links can be found there.

The following are some SIGHCI. The information includes the year of establishment, frequency of meetings and membership. These are the main SIG currently functioning in Japan.

- SIG on Human Interface (SIGHI) in the Society of Instrument and Control Engineers (SICE).

Established: 1985

Meetings: five times a year

Number of members: 554

- SIG on Human Interface in the Information Processing Society of Japan (IPSJ).

Established: 1981

Meetings: six times a year

Number of members: 492

- Human Communication Group (HCG) in the Institute of Electronics, Information and Communication Engineers (IEICE).

Established: 1995

Meetings: once every two months.

Membership: 876

- SIG of Man-Machine Systems in Atomic Energy Society of Japan

Established: 1990

Meetings: six times a year.

Membership: about 120

- SIG of Human Interface Design in the Japanese Society for Artificial Intelligence (JSAI)

Established: ?

Meetings: five times a year.

Membership: 300

2. A CONCRETE EXAMPLE – SIGHI ACTIVITIES

2.1 SIGHI of The Society of Instrument and Control Engineers (SICE)

This group meets for mutual exchange between researchers, engineers and HCI users. Presentations, information exchange and new proposals are especially valued in the SIGHI.

Academic research is very active in the SIGHI. The Human Interface Symposium (HIS) has been held every year since 1985. In addition the HIS co-sponsors an international conference with the HCI International Conference every two years. The SIGHI regularly holds technical meetings to encourage deeper discussion on special issues. A revised membership system was adopted in 1986 which allows members to register directly in SIGHI and not necessarily via the parent organization - SICE.

2.2 Informal Meetings of the SIGHI

There are two SIGHI in SICE. The first, called "Informal Meeting on Usability & Evaluation Study", was established in 1994. The second, called "Informal Meetings on Pen Input Study" (IMPIS), was established in 1993. I would like to introduce the latter in more detail.

Research results are usually presented at formal technical meetings or academic presentations. However, ideas which deal with the real intention

and essence of a particular theory may also be presented in an informal exchange. Therefore, these informal meetings, such as IMPIS were planned and executed under the auspices of SIGHI. Since IMPIS was established in 1993 over twenty meetings have been held in two universities (Tokyo Denki University and Tokyo University of Agriculture & Technology) and industrial labs.

Most researchers attending IMPIS are from industrial labs and industrial corporations rather than from universities. Japanese corporations concentrate on development activities rather than basic research.

The IMPIS met ten times in 1994. The meetings were held in a different company labs (SII, NTT Human Interface Lab, WACOM, Cannon, OKI, RICHIO, SEIKO-EPUSON, HITACHI) and only one university (Tokyo Denki University). The total number of participants in 1994, the most successful year, was 247 persons over ten meetings. One of the reasons for the interest was that pen-input systems received special popular attention around 1994. Forty five people attended a presentation on the pen input interface presented by professor Lingjiang Liu from the Chinese Character Recognition Lab which is one of the labs in the Chinese Academy of Science (CAS). In China and Japan, a lot of people believe that if the problem of Chinese character recognition is solved a huge market will be opened up. The impact of each country's culture on all aspects of HCI should be considered if full market potential is to be achieved.

3. PUBLICATIONS AND EDUCATION

One indication of the interest in HCI is the publication in the Journal of Information Processing Society of Japan (IPSJ) of a number of related articles. In the past five years, there have been three Special Editions related to HCI focusing

on three different topics: User Interface Management Systems, Spoken Language Processing and Virtual Society. The total number of papers was seventeen. Moreover, there were four tutorial articles related to HCI dealing with the problems: Visual Interface, Designing of the Human Interface, HCI Survey and Computer Agent.

However, there is no official authoritative publication for HCI yet. There is, however, a transaction paper named "*Progress in Human Interface*" which is published twice a year by SIGHI of SICE.

It seems that subjects or curricula for HCI as a discipline are not yet established in Japanese universities. There are, however, a few individual subjects in the graduate schools of some universities. For example, there is a subject, "Human Interface", in the master's program in Tokyo Denki University.

I have given a talk "HCI and Pen-based Computers" at Tokyo Denki College on two occasions where I found that the students were interested in HCI even though they were not involved in HCI education.

HCI education has been valued in recent years and the demand for HCI teachers is increasing. HCI professionals have noted that there is a need for teachers of HCI in a number of universities.

PART II: HCI IN CHINA

1. EDUCATION AND INDUSTRIAL LABS

Since 1993, when I started my master's course, I have been paying attention to HCI issues not only in Japan, but also in China. When I studied in my Ph.D. years (April, 1993 - March, 1996), I

accompanied my supervisor, professor Shinji Moriya, to China on several occasions. We visited six universities located in major cities (see, *List 1* below) including two major universities – Tsinghua University and Beijing University. In addition, We also visited some industrial labs and companies including the Chinese Academy of Sciences (*List 2* below).

List 1: Universities visited (location, month visited, year):

- Yunnan Polytechnic University (Yunnan, October, 1994)
- Beijing University (Beijing, June, 1994)
- Tsinghua University (Beijing, June, 1994)
- Beijing Technology University (Beijing, June, 1994)
- Jilin University of Technology (Changchun, October, 1995)
- Dongbei University (Shenyang, November, 1995)

List 2: Industrial labs and companies visited in Beijing (year visited):

- Institute of Automation, Chinese Academy of Sciences (1994, 1997)
- Hanwang 99 Co. Ltd. (1994, 1997)
- Peking University Founder R&D Center (1994, 1997)
- Beijing Founder Electronics Co. Ltd.(1997)
- National Research Center for Intelligent Computing Systems (1997)
- Dawning Information Industry Co. Ltd.(1997)
- Institute of Software, Chinese Academy of Sciences (1997)
- Chinese Daheng Group (1997)
- Lianxiang Group (1997)

We found that HCI education and research is not yet systematically established in Chinese universities, however, most people have become interested in our presentations related to HCI and pen-input systems. I have recently heard that some universities and labs in China have established HCI labs – e.g. Tsinghua University, one of the most respected universities. When I went back to China last summer, the book "Being Digital", written by MIT Media Laboratory professor Nicholas Negroponte and published by MIT, was very popular. It had been translated into Chinese. This book describes the new media of HCI.

As a result of my visit to Beijing in May, I feel that the HCI industry is developing along with the Chinese economy. Many industrial labs have established companies to sell the products developed from their research. They are attempting to make products which are adapted to user needs. The Institute of Automation of the ACS (IAACS) has been focusing on research in Chinese character recognition over ten years as a national plan. The Hanwang 99 Co. Ltd. has combined with the IAACS.

After eight years of development, Founder (see *List 2* above) has become an international company with diversified industries. The world - famous Peking University Founder Electronic Publishing System for Chinese Characters has been improved and developed during its long period of application in order to meet demands from various users. Consequently it has maintained a market share of 80% in the domestic and overseas Chinese language industry and the newspaper industry. There is a HCI lab in the Institute of Software of the Chinese Academy of Sciences. The area of research they are interested in is CAD and Chinese Speech Recognition. I noted that Speech Recognition research is aimed at inputting rapidly when using other systems. Dawning Information Industry Co. Ltd., jointly sponsored by the National Research Center for Intelligent

Computing Systems and other such companies, was founded in 1995. Multimedia Servers, the NI-OCR Chinese Character Recognition System, the NCI Press Desk-top Publishing System and the Notes Based OA System are products of the Dawning family. This company also has close ties with many companies throughout the world such as Motorola, IBM and many others. As a consequence, the Motorola-NCIC Joint R&D Laboratory was founded in 1996. JDL's main research directions regarding HCI include:

- Natural man-machine interface technologies
- Speaker-independent continuous speech recognition, and fast learning technologies
- High-performance multi-media systems
- Wireless communication systems

In contrast to western trends, the Japanese and Chinese pay special attention to the pen-based interface. Here, many people want to use pen-based computers instead of keyboard-based computers. For this and other reasons I believe that HCI issues are strongly influenced by national cultures.

2. CHINESE RESEARCHERS OVERSEAS

There are not many Chinese HCI researchers in Japan. I am a member of the Chinese Academy of Science and Engineering in Japan (CASEJ) which was established in March, 1996. There are approximately 130 members who mostly engage in teaching and research activities in various universities in Japan. I have noted that only a few people are working on HCI or research related to HCI.

I did, however, meet a few Chinese researchers at various international conferences, such as, the

CHI and HCI international conferences. It seems that there are a few Chinese HCI researchers around the world.

CONCLUSION (PART I and II)

This position paper has made the following observations:

- In Japan, academic research is very active. There is a significant number of SIGHCI which are characterized by the Japanese style. These groups hold informal meetings.
- HCI education has not yet been established as a discipline in Japanese universities and there is no representative authoritative publication yet, though various articles have been published.
- HCI education and research are not established firmly in China, although the situation is changing. HCI research and activities introduced in this position paper are performed by only a few of the most advanced labs.
- The research status and trends of HCI in a country are deeply related to that country's culture. In Asian, most ordinary people tend to use pen-based computers rather than keyboard-based computers.

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Design in the Japanese Society for Artificial Intelligence) provided information about their societies. My travel for the conference expenses was heavily subsidized by the International Information Science Foundation.

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SHORT BIOGRAPHY

Xiangshi Ren is an assistant in the Department of Information and Communication Engineering at the Tokyo Denki University. His research interests include all aspects of human-computer interaction (HCI). He is currently focusing on usability, particularly of the pen-input interface, with a view to facilitating human-computer communication. He has recently become interested in the database field.

He was born in China and has been in Japan for ten years. He obtained his BS (1991), MS (1993) and Ph.D. (1996) degrees in Information and Communication Engineering from Tokyo Denki University. He is a member of IPSJ (Information Processing Society of Japan), IEICE (Institute of Electronics, Information and Communication Engineers) and SIGHI of SICE (The Society of Instrument and Control Engineers).

Building an HCI Community in Brazil: Recent Efforts and Initiatives

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ABSTRACT In this article we report the state-of-the-art of the HCI field in Brazil. We start with a brief history of the access of institutions and individuals to technology. After that we present some of the efforts done in academia in the 90's to establish the HCI field and to organize the HCI community. We briefly describe the personal profile of the participants of this community and how the field stands in relation to the Brazilian industry and government. Finally we expose our view on how to pursue our goals in the near future.

The information here presented reflects mainly the work and experiences done by the participants of a recently established HCI group of interest, whose main interactive medium is the internet. This group has emerged in the academic milieu and has strong links with computer science departments.

KEYWORDS Brazil, HCI, HCI community, university, industry

1. Introduction

The history of computing technology in Brazil can be abstracted as having three phases. The decades of the 60's and 70's were dominated by mainframes. Only big corporations or governmental institutions were able to afford the costs of such technology.

The 80's were characterized by market restrictions established in order to "protect" the national computer in-

dustry. At that time, personal computers should be produced in Brazil, and could not be imported by law. Due to high costs associated with high taxes, the access to personal computers were very restricted, the technology used was generally obsolete and was restricted to PC like machines.

In the beginning of the 90's the market restrictions were opened. As a result most hardware industries were not

able to compete and closed. Now academic institutions are allowed to buy equipment paying little or no taxes.

It was not until the 90's that the first studies in HCI emerged in Brazil. At that time there were no HCI researchs and projects being done, therefore these first studies were originated in other projects that had come across some interesting interface issues. Only then did some people start focusing their research in HCI. Most of the research was still done on problems applied to other areas, and most articles were published in conferences such as the Brazilian Symposium of Computer Graphics and Image Processing, the Brazilian Symposium of Software Engineering or the Brazilian Symposium of Artificial Intelligence.

In the last few years the number of researchers in HCI in Brazil has grown and the focus of their studies have spread. Many universities now have HCI graduate programs and undergraduate courses. In some of these universities, research groups have started to consolidate around professors that have been working in the field.

There is still very little contact among HCI groups and researchers. Although some of these researchers have presented tutorials and talks in some conferences sponsored by the Brazilian Computer Society, there are no HCI conferences or activities in which researchers can exchange and discuss ideas or publish. It was not until 1996 that the first efforts towards creating an active HCI community appeared in Brazil and only this year (1997) these efforts are starting to produce results.

2. State-of-the-art

In 1996 some Brazilian researchers met at CHI'96 and they realized that HCI groups in Brazil did not know each other nor the researchs that were being done. After some organizational efforts within computer science forums, a list of people working with HCI in the country was created. People then started to discuss the next steps to further organize the group and to form a community. As a result, in the beginning of 1997 a Brazilian HCI discussion list was created (ihc-l@furb.rct-sc.br) and so was a WWW site (<http://www.inf.furb.rct-sc.br/ihc/>) that contains information about the Brazilian researchers and interesting HCI pointers. These results have already proven themselves valuable. They have allowed researchers and professionals to learn more about each other, to discuss topics of interest and to plan the next steps in structuring

the emergent community.

We next present an initial profile of the Brazilian community. In order to try to establish this profile an informal survey was done using the above mentioned interest list. It's worth pointing out that this data only reflects a small part of the community, since the list has 52 participants and about 23 answered the survey. Other sources of information such as data previously collected and our own experience were also used.

Most of the community participants work in academia and have a background in computer science or engineering. However, there are a few people with background in other areas such as linguistic and education. Almost all participants work in software development, a few teach at the graduate level, but the majority is still doing their graduate studies in Brazil. Most of these graduate students are already employed by universities and will probably continue research in the field. Moreover, the number of HCI students is increasing, which is an indicator of the growth of the field as a whole.

In the table below we show the main research institutions ordered according to the number of participants in the HCI-List. The table only shows those institutions that have more than one participant in the list. There are individual researchers from 12 other institutions in the list.

- 11/52 State University of Campinas (UNICAMP)
- 8/52 Catholic University of Rio de Janeiro (PUC-Rio)
- 6/52 Federal Center of Education and Technology of Paraná (CEFET-PR)
- 3/52 Federal University of Rio Grande do Sul (UFRGS)
- 3/52 Federal University of Santa Catarina (UFSC)
- 3/52 Federal University of Minas Gerais (UFMG)
- 3/52 Brazilian Telecommunication Company (Telebrás)
- 2/52 State University of São Paulo (USP São Carlos)

It is worth pointing out that PUC-Rio has about half of the HCI Ph.D. students in Brazil. The remaining half is spread throughout the country. The number of participants linked to the industry is still modest (9/52), but as joint projects between universities and industries pay more attention to the interface design and issues involved, we hope to see that number grow.

Many Brazilian companies have partnerships with universities for the development of software (i.e. Federal University of Minas Gerais/Telecommunications company of Minas Gerais, Pontifical Catholic University of Rio de Janeiro/Brazilian Oil Company, etc). Although these projects are in areas such as optimization, database or engineering, the search for high-level quality and consistency among different applications has required the involvement of HCI researchers.

It seems to us that people are starting to realize the importance of the interface and the interaction in computer and information systems. HCI researchers and people working in joint projects with the universities seem to be in great part responsible for that. For instance, the Federal University of Santa Catarina in a joint effort with the National Service of Industrial Learning has created an usability laboratory, called LabiUtil, whose main purpose is to give companies advice in interface development and evaluation. Moreover, both universities and companies already offer training courses and consultancy in HCI.

At the governmental level there are several programs related to human resources and technology development in which an HCI expert could contribute. At the present moment, there are several governmental programs to support and stimulate software research and development. In software development, certain programs such as SOFTEX and PROTEM aim at bringing growth to the area associated with software quality. One of their goals is that the companies in the program receive the ISO 9000 certificate. Other supporting programs are in educational technology (PROINF) and in continuing education (TV Escola). It is clear for us that HCI issues are fundamental to the success of these governmental initiatives. Most of these programs do not require the participation of an HCI professional, but we hope that they soon will.

3. The Future

In Brazil, the HCI research is quite recent and still has a long way to go. Our current concern is to consolidate the HCI field and the community in our country. In order to do that we plan to use all the experience and help we can get from national and international organizations, such as the Brazilian Computer Society, IFIP, SIGCHI, etc.

We would like to have activities in which our community could exchange ideas and research conclusions at a national level. To achieve that, we have established as a

first step the organization of one or more HCI workshops in already established computer science Brazilian conferences. Then we would work towards turning them into a Brazilian HCI conference. These activities would aim at not only consolidating the HCI community, but also getting the recognition of the field by other researchers and professionals, both at the university and industry. Once HCI becomes an established and recognized field in Brazil, the next step would probably be to have HCI courses become part of the Brazilian standard curriculum of computer science and engineering courses.

World-widely HCI is traditionally interdisciplinary. In Brazil most research and work in the area is done by people related to computer science. Some of these people have different backgrounds and study on their own disciplines related to human sciences. However, we think it necessary to have a bigger involvement with other areas. This would include not only more cooperative work among researchers and professionals from other areas and current participants of our community, but also the inclusion of more human sciences related courses in the HCI programs.

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HCI in Russia

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The study of interaction between human and computers is relatively well-developed in Russia, though mostly from the perspective of Engineering Psychology and Ergonomics. For a long period of time the use of computers was typical only for industrial job. A research support for the topic is provided in the studies of the first Russian HCI Laboratory, working at the Faculty of Psychology, Moscow State University, since 1994. The laboratory currently is involved in the following lines of research:

- Changes in professional activities due to a computerization of workplaces and its effects on well being and mental health of employees. An ambivalent nature of such effects, that improve characteristics of task performance but increase mental strain.
- Influencies of 'everyday' work stressors -- interruptions, short breakdowns, etc. -- on performance of computer aided mental tasks. An experimental model for investigation of typical forms of computerized jobs (clerical work, office managers, secret
- On-line support of computerized task performance by means of flexible human-computer interface. An interactive support of dynamic problem solving processes was realized in advanced development of script approach to design of human-computer interface
- Multimedia programs for stress management and self-regulation training at computerized workplaces. A psychological methodology of enhancing individual capacities to cope with job/mental overloads and stress reactions by the means of self-regulation. The mentioned lines of investigations can be considered in a wider perspective of Russian and International traditions of empirical HCI research. It could be one of the topics for a discussion at WS "HCI World Wide".

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HCI in Singapore

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The focus of HCI has, in the past, followed closely developments in the IT industry. For instance, the initial focus of HCI was on supporting the development of personal applications, e.g. development of interaction models to support display design, etc. This initial focus was followed by wider consideration of organisational issues, e.g. when developing CSCW applications, etc. In this respect, socio-technical systems approaches and participative design techniques were developed to realise in full, the benefits of IT introduction. Now, with the emergence of a global market, the explosion of the WWW, and the advent of the information superhighway, the scope of HCI needs to be extended far beyond the user-centered design paradigm to span international and cross-cultural boundaries. This need should be investigated as it has been reported that HCI evaluation techniques developed in the West need to be tailored for application in the East, if reliable results are to be ensured. It is hoped that the workshop would help to highlight the HCI research agenda required to address political, sociological, economic and cross-cultural implications for design.

Biographies

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Large Scale Collaborative Information visualisation using Virtual Environments

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1. INTRODUCTION

The goal of this work is to support potentially large numbers of users collaboratively working with abstract information. This paper will use collaborative visualisation of the World Wide Web as an example application. We chose the Web since it provides a large amount of source data, it has a large number of users and many people are familiar with the problems of navigating through the web.

Our goal is to present new techniques for accessing, exploring and collaborating via the World Wide Web. Between them, they demonstrate new approaches to browsing and searching and, perhaps more importantly, seek to transform the Web into an environment where users are naturally aware of one another's presence and are easily able to communicate with one another. Our approach utilises Collaborative Virtual Environment (CVE) technology (i.e. multi-user, distributed virtual reality) in order to provide navigable 3-D graphical, textual, audio and video representations of the structure of the Web and also of its users. Put another way, we aim to transform the Web from being a series of discrete locations which can be visited one at a time into being a landscape of many related locations which is visibly populated by its users.

In the remainder of this paper we describe WWW3D, a prototype 3D web browser that addresses some of these issues and then describe enhancements that we are in

the process of implementing to achieve our goals of a populated web.

2. WWW3D

WWW3D is a novel browser, implemented in DIVE [Hagsand'96], that provides a single 3D display which integrates the display of the web documents themselves, the structure of the part of the web that the user has browsed and history information showing the links the user has followed in the recent past. In addition to this WWW3D supports multiple concurrent users who are visible to each other and who may either be browsing the same or different sets of web documents.

WWW3D uses the information contained in HTML documents to produce a representation of the document in 3D space. A web document is represented as a sphere which is labeled with the document's title. The contents of the document is placed around the inside surface of the sphere. Displaying large amounts of text in a satisfactory way is difficult in current VR systems so textual information is currently represented by icons that can be unfolded to reveal the entire text. This information is visible when a user enters a sphere.

When the user selects a link icon, WWW3D creates a new sphere representing the target document and places it near the document from which the user selected the link. In order to indicate the structure of

the portion of the Web that the user has explored WWW3D draws arrows between the spheres representing linked documents. If the documents are resident on the same Web server then the arrow is drawn in blue, otherwise it is drawn in green thereby helping to provide additional information on the structure of the documents that the user has explored. In addition to this, the brightness of the arrow is dependent on the time since the user last followed that link thereby providing the user with a visual representation of their browsing history. If WWW3D fails to fetch a document then a small red arrow is attached to the source document to represent the "broken" link.

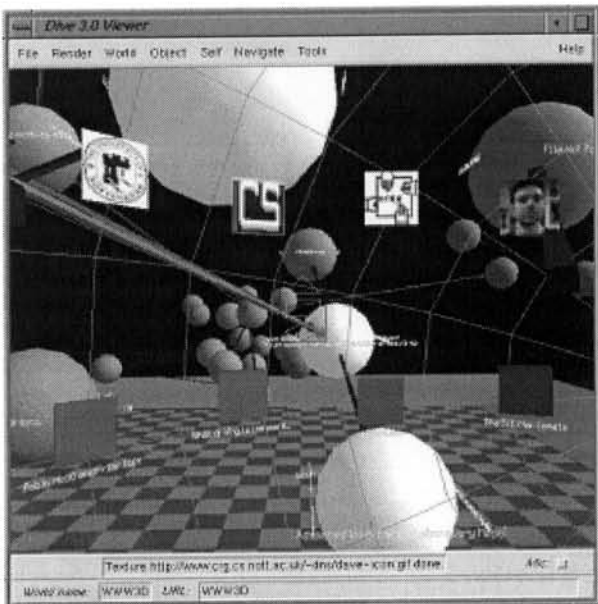


Figure1. A WWW3D representation of a web document seen from the inside. Our

Multiple web pages can be fetched simultaneously. This is essential if multiple users are to be able to browse independently. Users are also free to navigate through the space, browse other documents and talk to each other while waiting for a document to be retrieved.

As WWW3D parses a newly retrieved document, it checks for links to documents that users have already explored and draws arrows to represent them. This means that at any given moment the complete set of links between documents is displayed without users

having to follow every link. This is intended to aid users by indicating links between documents that they might have been unaware of. This also has the result that several users can be browsing different parts of the web and yet any links between the sets of documents they are exploring will be displayed. This might be useful since users will then have a visual representation of possible common interests.

To produce an acceptable layout of the set of linked documents an incremental version of the Force Directed Placement (FDP) [Fruchterman'91] algorithm is used. Links between documents act like spring forces which result in linked documents being moved closer together. Documents exert repulsive forces on one another which prevents documents being placed closer together than a user-specified minimum separation.

3. IMPROVING SCALABILITY

A current problem with WWW3D is that although it makes extensive use of Level-of-Detail operations for individual nodes, it will still eventually reach a point where the world becomes too complex to be rendered on even top of the range hardware.

We are attempting to avoid this by clustering the visualization and representing clusters of nodes as single artifacts that are only expanded into individual artifacts when the user becomes sufficiently aware of them. If clusters can be composed hierarchically, then the application will be far more scalable since arbitrarily complex clusters of nodes can be represented as single artifacts providing they are below a specified awareness threshold.

MASSIVE 2 [Benford'97] allows a virtual world to be decomposed into regions each of which may have its own associated IP-multicast group. These regions can be constructed so that only members of a region are sent state information about other members of the region. Therefore by re-implementing WWW3D in MASSIVE2 and representing clusters of nodes as MASSIVE 2 regions we would not only reduce the number of artifacts that must be rendered, but also reduce the amount of information that must be distributed to members of the world, thereby reducing the required network bandwidth and increasing the overall scalability.

In order to do this we need a mechanism for grouping nodes into clusters. LEADS [Ingram'95] is a system

that attempts to make visualizations of abstract information spaces more *legible* by grouping relating artefacts into clusters and by adding other features to aid user navigation such as landmarks.. LEADS as already been applied to visualizations produced by the FDP algorithm (as used in WWW3D) and so is applicable to clustering WWW3D visualizations.

It remains to be seen whether such clustering techniques work in practice and whether they have an adverse effect on users' ability to use the visualisation.

4. SEARCHING THE WEB

Another useful extension would be the provision of support for searching the web. WWW3D currently explicitly shows structural information about web documents, but semantic information about the contents of web pages is only displayed when a user visits a particular web page. It is therefore hard to find information about a particular subject without having to manually browse the web pages. One possibility for improving this would be to add more semantically based visualization features that support searching for information. An example of this style of visualization is VR-VIBE [Benford'95] which allows users to browse bibliographic information by selecting an arbitrary number of keywords which are used to control the layout of document icons in 3D space. WWW3D could be extended to support a VR-VIBE visualisation style in addition to its current structurally based style. Alternatively, the users could be given the option of entering keyword and WWW3D could highlight (for example by changing the colour) document spheres who's text matches the search expression.

5. POPULATING

WWW3D is inherently multi-user. This means that several people may share the same virtual world at the same time, freely navigating their own viewpoints. Each person sees the visualisation from their own autonomous perspective in 3-D space in much the same way as we perceive shared physical space. Each person may also be represented by an embodiment, a graphical object which is attached to their viewpoint and which shows that they are present, where they are located and where they are looking in the virtual world. Embodiments (sometimes called avatars or clones), may range from simple graphical objects

which essentially act as 3-D tele-pointers through to complex animated graphical forms which track the physical movements of their owners (through VR tracking devices), support gestures and even facial expressions (e.g. through the use of texture mapped video).

Another issue we would like to address is the provision of mutual awareness between WWW3D users and ordinary web users. Currently we are experimenting with using Java applets to track netscape users as they navigate the web and showing representations of these users in a web visualisation.

5. SUMMARY

This paper has described our goal of representing the web as a multi-user visualisation that encourages communication and collaboration between users. We described our initial prototype, WWW3D, and then briefly described how this might be improved to increase its scalability and support for searching in addition to browsing. There are several issues that remain to be addressed, including:

- Finding better techniques for representing documents in 3D - the current WWW3D page layout could be greatly improved.
- Finding techniques for increasing the scalability of visualisations without having an adverse effect on their usefulness.
- Integrating the structural display of the web with one that provides better support for content-based searching.
- Providing mutual awareness between VR and non-VR users.

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Component-based Groupware: Issues and Experiences

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ABSTRACT There is a growing trend in both Software Engineering and HCI circles to developing “componentware” systems i.e. systems which are comprised of individual, self-contained systems rather than a single, monolithic application. The advantages of this approach are many, including higher degrees of reuse, more open architectures, end-users being able to choose the “best” components for their needs, and the development of more extensible systems. There may also be disadvantages, such as less than ideal user interface consistency, difficulty in agreeing on integration and inter-operation standards, and lack of high-level, robust componentware architectures. This paper discusses the impact componentware solutions may have on the development of new groupware systems, and gives some examples from the author’s recent research.

KEYWORDS CSCW, groupware, componentware, work coordination, distributed systems

1. INTRODUCTION

Many different kinds of groupware systems and tools exist (Ellis et al, 1991). Examples include asynchronous tools, such as email, note annotations (Oinas-Kukkonen, 1996), and version control systems. Various systems provide synchronous collaborative work support, such as IRC (Pioch, 1993), GroupKit (Roseman and Greenberg, 1996a), Rendezvous (Hill et al, 1994), and BSCW (Bently et al, 1995). Many systems, such as Team Rooms (Roseman and Greenberg, 1996b), W4 (Gianoutsos and Grundy, 1996), and Lotus Notes (Lotus, 1993), combine synchronous and asynchronous modes of communication, usually by providing a variety of different groupware tools.

A great range of applications can make use of a variety of groupware tools, such as email, annotations, shared workspace editing, and discussion. Adding such capabilities to each environment that requires them in isolation results in a great deal of redundancy, and often limited or no reuse of tools.

Component-based systems offer a new approach to developing groupware applications, by building small, open and reusable tools which can be plugged together to form an environment. The end-user of an environment may even be able to choose the particular groupware tools they add to their environment, depending on their preferences or the tool capabilities they require. Some aspects of groupware systems are easy to make into components than others, and componentware solutions must be carefully designed to ensure good resulting environments.

2. COMPONENTWARE

Figure 1 illustrates the basic idea of a component-based system. Component-based systems (or “componentware”) are built by combining a variety of small (and sometimes larger) components, which provide a particular kind of functionality.

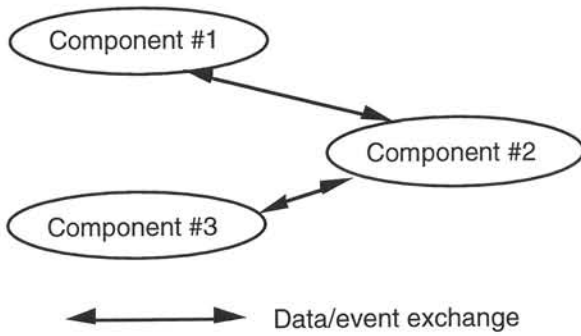


Figure 1. Basic Componentware System Architecture.

For example, for a system requiring multi-user support, components might include an email component, a note annotation component, an IRC-style chat component, a shared drawing editor component, a workflow component, and so on. Rather than continually reinvent the wheel when building systems that require such functionality, we can plug such pre-existing tools into a new system. The great advantage of componentware over e.g. library or framework reuse, is that new tools can be plugged into a componentware system, often while it is running, or old components may be unplugged and replaced.

Components in a componentware system exchange data and control in ways agreed upon by the designers of the system architecture. Components may have their own user interface style, or may agree on a common user interface approach. Some components may even be dedicated to providing an interface, while others deal with data storage/retrieval, inter-component communication, and so on.

Many componentware architectures have been developed in recent times, including OpenDoc (Apple Computer™ Inc, 1996), ActiveX (Microsoft™, 1996) and Java Beans (JavaSoft™, 1996).

Componentware solutions for groupware applications have also been proposed and several have been developed. Examples include TeamWave (Roseman and Greenberg, 1997) and the use of CORBA (ter Hoft et al, 1996).

The following sections outline the author's experiences with component-based groupware solutions, and why I believe they offer the best solution for reusable groupware applications.

3. EXAMPLE #1: SERENDIPITY

The Serendipity environment is a workflow/process modelling system which supports a range of CSCW capabilities (Grundy et al, 1996). These include email-style messaging, version control and configuration management, shareable modification histories, change description annotation, IRC-style chats, high-level group awareness, and synchronous and semi-synchronous editing of diagrams.

Figure 2 shows an example screen dump from Serendipity showing several of these facilities in use on a collaborative software development project. The highlighting of icons in the workflow model (top, right) shows a developer what parts of the process other developers are working on. The developer can add/read note annotations (bottom, left dialogue) and carry out a chat (bottom, right dialogue) with collaborators. The centre, textual view shows change descriptions (changes made) shown in a class header, made to the OOA diagram top, right. These changes have been annotated with information from the workflow model to assist developers in seeing both what changes have been made, but also why they were made.

Serendipity was developed by combining several different tools and environments. These included the a workflow modelling and enactment system, a generic annotation system, a generic text chat system, reuse of collaborative editing and version control abstractions, and integration with tools for performing work (e.g. software development and office automation tools).

A strict componentware solution was not used with Serendipity, although some of the tools used are stand-alone applications, and componentware-style event notification was utilised in many places. We needed to make some modifications to some of the environments to get them to work together, and to ensure consistent mechanisms for user interaction and data persistency.

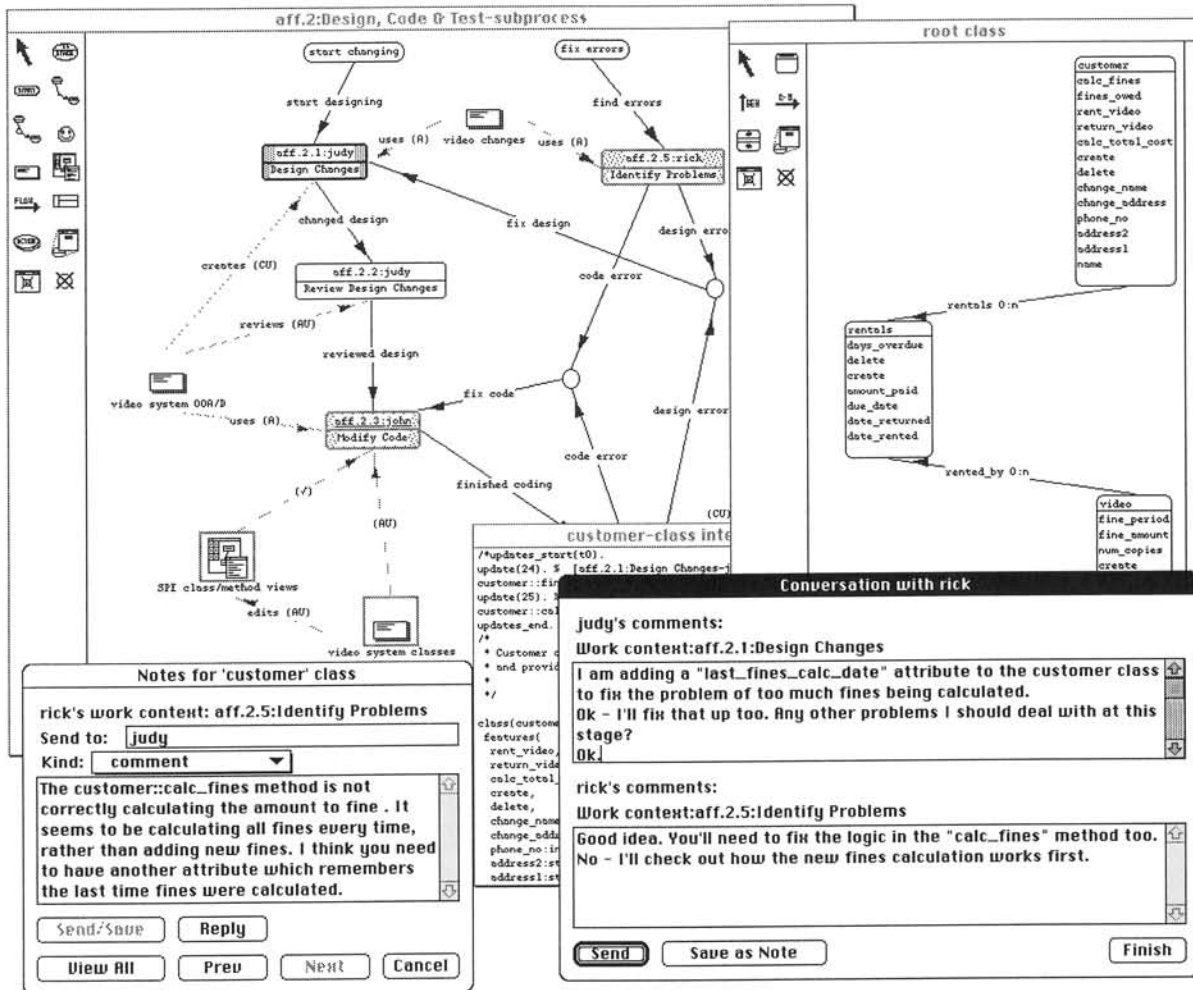


Figure 2. Various CSCW capabilities of the Serendipity process modelling system.

4. EXAMPLE #2: JCOMPOSER

JComposer is a CASE tool for the modelling and generation of environments using a componentware architecture, called Jviews (Grundy et al, 1997a). JViews provides abstractions for building multi-view, multi-user environments using components, and is a successor to MViews (Grundy and Hosking, 1996), the environment used to build Serendipity.

From our experiences with Serendipity and other environments built with MViews, we decided to move our work to Java and make use of the Java Beans

componentware API in the construction of new tools and environments. This has several advantages over our previous approach with MViews, which was implemented in an OO Prolog:

- more portable and faster applications
- more open architecture for use of third party tools
- a proper componentware system, with stand-alone and interchangeable components, fostering better reuse of tools and abstractions
- access to better distributed systems capabilities for supporting multi-user applications

Figure 3 shows an example of a running environment (an ER modeller) built using JComposer. The bottom-left view is the users' view of an ER model, with the top-left view a visualisation of the components making up this view. The top-right view is an entity component which has been linked by the user to a filter (rectangle) and then an action (oval). These filter/action components provide reusable components for dynamic event handling. This model specifies that if the entity is renamed, the user should be notified by a message (using an email-like tool). The bottom-right view shows a visual query language we are developing for component structure querying. JComposer provides an

environment for specifying the appearance of drawing editor icons and connectors, the structure of repository and view editors, and various reusable and extensible event-handling abstractions.

Third-party Java Beans components can be integrated into the environment and their data and events exchanged with those of JComposer components. A key feature of this work is that both environment developers and end-users can configure the structure of these systems, using the visual notations, providing powerful groupware environment composition capabilities (Grundy et al, 1997b).

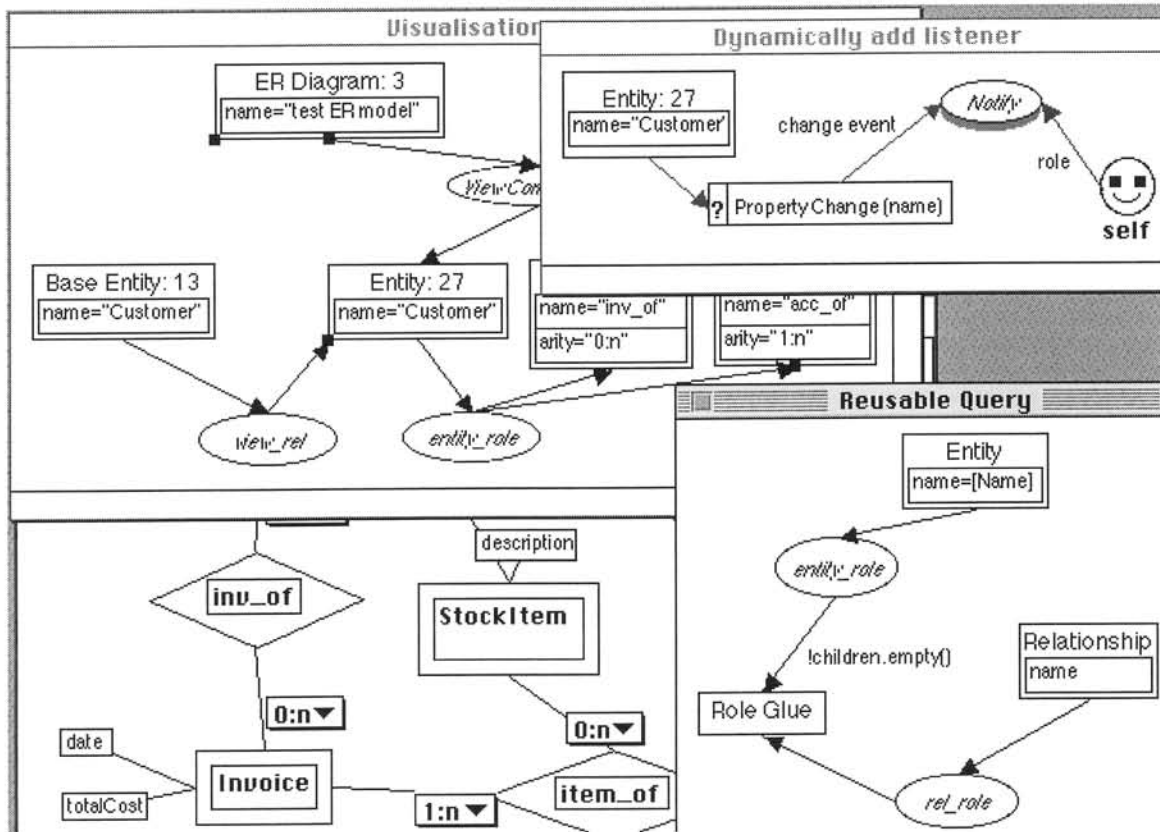


Figure 3. An example Jcomposer environment showing component composition and visualisation.

5. COLLABORATIVE INFORMATION

We are currently designing a new component-based groupware system for heterogeneous, collaborative information visualisation and work coordination. The components in this architecture are user interface tools for the specification, visualisation and navigation of complex information spaces. Additional components allow the system to interact with WWW, Intranet and Corporate Database information sources. These tools interact with a standard Web browser and various desktop applications, such as word processors, database applications, email and chat systems, and so on.

This system will allow a wide variety of complex information sources to be collaboratively visualised and navigated in novel ways, and allow links between information items from different sources to be deduced or explicitly specified. A component-based architecture allows a variety of new and existing third-party tools to be readily utilised, as well as our own tools. Groupware aspects of this system will include JComposer-style work coordination support, messaging and note annotation, collaborative browsing, and various group awareness facilities.

6. FUTURE TRENDS

Our experiences with component-based groupware development has indicated that many aspects of groupware systems can be effectively split into reusable, interoperable components. This leads to groupware systems which are much easier to build than by reusing frameworks or libraries providing low-level groupware capabilities. With the continued development of componentware solutions, including both internet and intranet-based component systems, the development of component-based groupware seems likely to increase.

We have found a major problem with component-based groupware can be in the computer human interface. If great care is not taken to ensure that components have a common look and feel, and common design style, component-based environments can become a mis-mash of poorly integrated tools. Care must also be taken to design component interoperation architectures so sufficient flexibility is provided to integrate new components into a system. We have found that end-users enjoy being able to compose their own component-based systems, but require tools which

do not involve complex programming. Our visual languages are an attempt to provide more suitable human interfaces for composing complex component-based groupware.

Some groupware aspects are more amenable to being made into components than others. The ability to perform shared workspace editing needs to be carefully built into a system, as does provision for the possibility of various group awareness capabilities. We have found our event-based JViews architecture allows component-based awareness and synchronous editing to be supported by a component-based approach. Many existing systems, however, do not provide suitable capabilities to add these features onto an environment.

7. SUMMARY

Component-based groupware systems offer the possibilities of more open, extensible, reusable and, ultimately, more powerful systems than current technologies. Careful consideration must be given to designing the human interface and software architecture aspects of such systems, however, in order to make them feasible. We believe much scope exists for HCI research into these areas, and also into the large problem of end-user configuration of component-based software in general.

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Collaboration Issues for Augmented Realities in an Outdoor Environment

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ABSTRACT To date augmented realities are typically only operated in a small defined area. The size of these defined regions are in the order of a large room. This investigation wishes to expand augmented realities to the outdoor environment. This paper proposes a set of collaboration tasks that may be facilitated by using a wearable computer with augmented realities in an outdoor environment. These tasks are as follows: maintenance work on the outside of buildings, data collections by a group of ecologists, and communication between a group of soldiers.

KEYWORDS Wearable computers, collaboration, distributive systems, user interfaces

1. Introduction

A new physical form of portable computer has emerged in the form of a **wearable computer** (Bass, 1995) (Mann, 1996). Instead of the computer being hand-held, it is attached to the user on a backpack or belt, see Figure 1. This is an alternative to pen based computing, leaving the hands free when the computer is not in use but still allows the user to view data in the privacy of a head mounted display (HMD) (Starner et al., 1995).

We are currently investigating the use of a **Wearable Computer with Augmented Realities in an Outdoor Environment** (WCAROE) as a navigational aid, or as we like to call it, "A map in the hat." The current use of augmented reality is mainly restricted to room size areas (Azuma, 1997), but in the navigational aid investigation we are extending this to campus size regions. The objectives of using WCAROE as a navigational aid are as follows:

1. To determine appropriate visual cues to a user for

navigation in an outdoor environment.

2. To evaluate the effectiveness of virtual reality definition languages for specifying these augmented realities.
3. To implement a system to demonstrate the two concepts above.

The application areas for this form of a computer range from factory monitoring, stock taking, field data collection, and soldiers in the field. In the past these tasks have required at least a two stage process where the initial processing or collection is carried out via pen and paper then entered into a computer in the second stage. This process is potentially time wasting and error prone. A wearable computer could enable this task to be compressed into a single stage and potentially save time and reduce error rates.

This proposal extends the investigation we are performing in the use of a WCAROE as a navigational aid to us-



Figure 1 Full view

ing the system to facilitate collaboration between users in an outdoor environment. This proposal will focus on the infrastructure problems with using augmented realities in an outdoor environment to facilitate collaboration.

This paper first presents an example of a wearable computer system. Three scenarios are then described as examples of performing collaboration with a WCAROE system. The scenarios are as follows: specification of maintenance work on buildings, data collection for ecologists, and detailed coordination between the soldiers in a group. These scenarios are then compared with traditional collaboration technology. The paper concludes with a set of research issues to be solved to achieve such systems.

2. The Wearable Computer System

This section describes a current off the shelf wearable computer system, the Phoenix 2 Computer (Phoenix Group Inc.,). We have been using this wearable computer system in our investigations (Thomas and Tyerman, 1996). It is designed to be worn by a user on a belt with cable connections to a headset, see Figure 1. The figure shows a user using the belt mounted mouse, which is located on top of the battery pack.

As an insight into the usability of a wearable computer,

we conducted an experiment investigating the functionality and usability of novel input devices on a wearable computer for simple text editing operations. Over a three week period, four different input devices were used by twelve subjects to create and save short textual messages. A mouse controlled screen based text editor (virtual keyboard), forearm keyboard, kordic keypad and voice input devices were used with off the shelf technology to assess the efficiency and usability of this new technology in document management. The results indicate that the forearm keyboard is the best performer for accurate and efficient text entry while other devices may benefit from more work on designing specialist GUIs for the wearable computer.

3. Three Scenarios

We propose three scenarios for the use of a WCAROE system. These scenarios are as follows: firstly, specification of maintenance work on the exterior of buildings; secondly, data collection with a group of ecologists; and thirdly, coordination of soldiers in the field. This section presents these scenarios to highlight different forms of possible collaboration with the use of a WCAROE system.

3.1 Scenario 1 – Maintenance Task

The first scenario entails the task of a supervisor specifying maintenance work to be performed on a set of buildings, where a journeyman is to perform the specified work at a later time. Picture the supervisor in front of a building, and she notices some work to be performed. The supervisor annotates on a screen overlay displayed on top of the building shown on her HMD. The collaboration artifact in this system is the detailed 3D model of the collection of buildings. Using a GPS system, a digital compass, and the 3D model, she can highlight the regions on faces of the 3D model that require work. More descriptive annotations in text, handwriting, drawings, or voice may be attached to the highlighted regions. Figure 2 shows a building with annotations of work to be performed. These annotations are stored in a central database. The next week a set of work assignments is given to a journeyman. The journeyman proceeds to the required building and views the necessary changes on his screen. He proceeds to perform the needed work. Once the work is finished, the journeyman updates the central database indicating the task has been

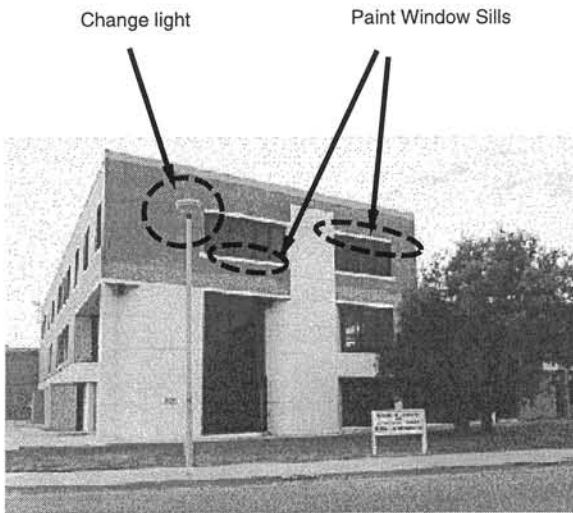


Figure 2 Maintenance task

completed.

3.2 Scenario 2 – Data Collection

Another scenario where a wearable computer could be advantageous is in ecological field work. Ecologists on field trips typically take large books containing keys and databases on the plants and animals in the area they are visiting. In addition they require notebooks, pens and other paraphernalia. On returning to base camp the ecologist must enter the days observations in a database.

A wearable computer for an ecologist could literally replace a large number of these items and allow for database lookup and direct recording of data on the spot. For an ecologist the wearable computer would have the flora and fauna keys driven by an intelligent application. The HMD allows the user to switch focus without moving between the scene and the screen. The animal or bird can be keyed down using the menu driven system and images can be recovered for comparison. A digital camera would enable direct capture and storage of field observations and annotation of the image. The position and orientation of the image can be automatically determined from a GPS and digital compass.

The use of a WCAROE for collaboration between multiple ecologists would add the dimension of being able to exchange data in a timely fashion, while these ecologists are in the field. An example task may be the ecologists marking all the nests of a local bird. A GPS system could



Figure 3 Biology task

be used to record the position of a nest. The position of a nest may be displayed on an aerial view of the area of interest. An example of this is shown in Figure 3. This view gives all the ecologists information of the data presently recorded. With this data each of the ecologists may better plan their data collection activities, or exchange information collected in the previously mentioned manner.

3.3 Scenario 3 – Location Coordination

In the final scenario, the augmented reality may be used to inform each soldier of the location of the other soldiers on patrol. It is paramount that this updating of information occurs quickly and accurately to enable the soldiers to better respond to a given situation. The visual display used may be of the form of an aerial view as in Scenario 2, or it could be rendered as a set of graphical images overlaying the soldier's field of view. The members of the patrol may also wish to exchange information in the form of voice, text, drawing, digital images, or video. In addition information could be supplied from a command post; for example the position of the enemy or positions of other patrols.

4. Research Issues for WCAROE Systems

Using a WCAROE system offers a new dimension to collaborative activities. As the above three scenarios show, this form of collaboration requires the following traditional capabilities: text chat, audio chat, video, elec-

tronic white boards, persistent storage, versioning, and concurrency control. This form of collaboration also requires elements of distributive Virtual Environment collaboration systems, such as: 3D models, six degrees of freedom in the user interaction, and immersive sensory information. In particular, these features allow for gaze directed information retrieval from 3D models.

4.1 What is Different about WCAROE's?

To place a WCAROE collaboration system in context with existing systems, the WCAROE system is defined in a time - place taxonomy (Ellis et al., 1991). The time - place taxonomy is defined by the position of the users and the time of operation of the collaborative system. A breakdown of the taxonomy is as follows: firstly, at the same or different **places** and secondly, at the same or different **times**. The same place is defined as the information being presented at a physical location, and a different place is when this condition no longer holds true. Users are in different times when the delay of the transfer of information between users by the collaboration system is longer than "attention keeping time." A distinctive quality of collaborative activities using a WCAROE system is that they require the use of all four time-space configurations.

For example, scenario 1 as presented is a different time - same place configuration. Suppose the journeyman radios the supervisor back at the office to clarify the work order. The supervisor views the work order as a 3D model on her workstation while the journeyman concurrently views the work order on his HMD. Consequently annotations can be changed by both parties. This situation is now a same time - different place configuration. The supervisor decides to meet face to face with the journeyman to discuss the work order. At the work site, the supervisor and journeyman view the work order concurrently with their own headsets as augmentation to the physical world. The configuration then becomes a same time - same place mode. If the journeyman cannot directly contact the supervisor with his radio, the journeyman leaves an annotation in the 3D model requesting the supervisor to clarify certain portions of the work order. This changes the collaboration to a different time - different place configuration. This example shows how collaborative activities using a WCAROE system require a smooth transition between these four modes of activities. The use of all four modes highlights the difference between

this form of system and the traditional collaboration systems (Dewan, 1997). The remaining two scenarios have the same overlap in the taxonomy.

4.2 What is the Artifact of these Collaboration Systems?

A key difference with this form of collaboration is the artifact the users are manipulating. This artifact can be characterised by the following features: firstly, it corresponds to the physical world; secondly, its models reflect large physical objects; and thirdly, the users are able to physically walk within its models and the physical world simultaneously. This form of collaboration is similar to distributive virtual environment collaboration systems. Both have manipulable 3D models and the position of the users affects their vantage point. The key differences are that the distances the users are allowed to physically move are larger and there is a one-to-one correspondence with the real world.

4.3 System Issues

There are a number of systems issues which make this a difficult problem to solve. These issues are as follows:

1. **The mobile nature of a wearable computer makes this form of collaboration inherently a distributive system.** Collaboration facilitated with self contained WCAROE systems, may have users in geographically disparate locations.
2. **The WCAROE requires accurate and timely tracking in the outdoors** (Azuma, 1993) (Fitzmaurice, 1993). The tracking with limited infrastructure in an outdoor environment is a challenging problem.
3. **The data for collaboration requires the construction and maintenance of multimedia databases of the virtual worlds** (Feiner et al., 1993b). This problem requires the storage of such information as audio, video, textual, digital image, 2D graphics in the context of a global 3D model.
4. **These systems use low bandwidth networks.** The network and distributive problems are being investigated (Funkhouser, 1995, Funkhouser et al., 1992), but many of these solutions assume a traditional laboratory setting. Wireless computing is looking at issues of providing Internet like capabilities to the user on the street, or even the outback. The bandwidth

requirement for sending digital images, audio, and video signals is still higher than current technology can provide.

5. **A wearable computer requires a computing system with a set of limited resources.** The HMDs require the use of small displays. The local secondary storage and computing power are both limited.
6. **An augmented reality interface requires a novel form of information presentation.** Traditional user interface technology is inadequate for see-through or small above the eye displays (Feiner et al., 1993a). In the case of see-through displays, a major portion of the screen should not occlude the physical world. There is a need for more information with less pixels. This is possible due to the fact that the system's task is to augment the user's field of view, and not to provide all the contextual information. The registration of overlay images on a user's display is a key issue (Feiner et al., 1993b, Wellner, 1993). We envision a traditional laptop computer to cope with tasks such as word processing.
7. **The outdoor environments limits choice of user input devices.** With the user in an outdoor environment, many input devices designed for an office environment are no longer functional. Hands free viewing of the information space allows the user to perform different tasks while viewing the information in their HMD.

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The WORLDS project: discovering patterns of collaboration

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INTRODUCTION

The goal of the WORLDS project at DSTC is to provide support for the workaday activities of distributed groups. By combining theory-building, consulting and workplace studies and tool construction, the project is working towards the construction of a design pattern language for supporting collaboration, in the style of Christopher Alexander's design patterns for built structures, or Gamma et al's patterns for software construction. To facilitate this, we have been in parallel developing a theory of collaborative activity, based around the notion of *locales* [4][5][6][11] and a sequence of prototypes which serve to evaluate and refine our theory. In conjunction with a range of real-world consulting activities [11][3], our theory and practice serve to shape and direct each other. In this paper we focus on the evolution of Orbit, our collaborative testbed, through several versions, drawing out lessons and directions for future work.

Orbit is an outgrowth of our two previous projects, ConversationBuilder [12] and wOrlds [6]. ConversationBuilder was a flexible, workflow-oriented environment which provided support for the *formal* aspects of work. wOrlds, its successor, began our investigations into support for the *cultural* aspects of workaday activities [14], in the belief that a well-rounded environment for support of workaday activities must necessarily address both. In 1995, the project leader (Kaplan) moved from the University of Illinois to the University of Queensland and the CRC for Distributed Systems Technology (DSTC). The Orbit project is partially a result of the mix of researchers at the new laboratory, and partially built on the successes of ConversationBuilder and wOrlds, filtered through an extended reflection on what we had built and how it should best be conceived theoretically. A more detailed history, a critique of wOrlds, and additional motivation for Orbit can be found in [10].

While Orbit inherits the successful features of wOrlds, such as ubiquitous audio/video conferencing, a persistent distributed object infrastructure, seamless integration with mail and the web, and navigation metaphors, it also addresses many of the weaknesses in wOrlds. These include the inability of a user to participate in more than one locale or activity at a time, failure to account for the need for individual user view and other individual idiosyncrasies,

limited or non-existent support for awareness of other user actions, an inability to project one's presence into the collaborative world, and minimal support for trajectory or history information. In [10] we argue that many of these drawbacks are common to almost all MUD-like collaboration environments, and that solving these problems goes deeper than merely superficial extensions to these environments. Rather, a robust theory of collaborative activity which enables an alternate conceptualisation of collaborative is essential to effective support for these facilities.

LOCALES FRAMEWORK SUMMARY

Broadly, the locales framework can be viewed as both a way to identify the classes of information needed to articulate collaboration support for a particular domain, and an outline for the fundamental infrastructure or collaboration support needed in CSCW toolsets. It is based on Strauss' notion of *social worlds* [16] - groups that share a common purpose and are bounded by limits of effective communication. There are five aspects to the locales framework: locale foundations, civic structures, interaction trajectory, mutuality and individual view.

Locale Foundations. A locale is a conceptual place [4][8] in which a group of people can come together to work on a shared activity. A locale can be thought of as a 'focal point' around which to define, structure, and relate the relevant people, objects, tools, and resources germane to a particular collaborative activity. The locale foundations aspect captures the basic structuring and furnishing of domains of work. Locale foundations is therefore about (1) providing adequate media and mechanisms in available domains to support sharing of objects, tools and resources, (2) supporting a group's notion of membership and related processes, and (3) facilitating appropriate privacy and access mechanisms.

Civic Structure. Civic structure concerns the facilitation of interaction with the wider community beyond a person's immediate workgroups and locales. It includes the lifecycle processes that support the emergence and dissolution of locales, and the structuring of the world of locales in the broader sphere. It defines the relationship of locales to each

other in terms of their mutual visibility, influence, and access, covering aspects such as browsing, navigation and communication of information between locales. This is where external influences beyond the locales of direct interest can be considered, e.g., organisational, legislative, professional, financial, political etc.

Individual View. So far, the framework has emphasized a group view of the world. This aspect looks at (1) the different individual views that can be held of the same locale, and (2) the individual's view over multiple locales. While there may be a group definition of the locale, the individuals in the group may all have a different view of, or interest in, the locale based on their current level of involvement¹. Further, few people have the luxury of being able to focus on one task exclusively; usually they belong to multiple social worlds and work on many different tasks at once, with varying (and shifting) degrees of intensity. Rather than working with the fixed group locale view at all times, the individual will often draw from the relevant locales the things they need as they need them to get their tasks done. The individual is able to move relatively seamlessly and unselfconsciously between these different activities, maintaining dynamically varying levels of focus and participation in the different locales.

Trajectory. Interactions happen over time. Thus, every group has a past, present and one or more futures. Trajectory concerns all the temporal aspects of the group's locale and its associated people and entities. Workflow schemes are just one aspect of trajectory. Trajectory also includes the phasing, articulation and management of interactions.

Mutuality. Mutuality concerns the degree to which presence and awareness must be supported in collaborative work for the purpose of maintaining a sense of shared place. *Awareness*² here refers to the information about any of the entities mentioned above that another entity chooses to accept or focus upon. For example, can you see who is working on a task? What are they doing? What is the current state of an object? With what degree of granularity? *Presence* is the reciprocal of awareness, and concerns the aggregation of personal information (identity, functional and interactional possibilities, current activity etc.) that an entity makes available to, or projects into, the shared place of work. Mutuality is important for both synchronous and asynchronous interactions, although the medium of expression might be very different.

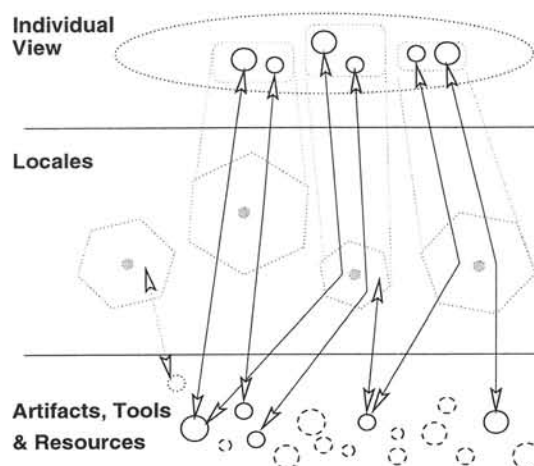


Figure 1. Social worlds structure *artifacts, tools and resources* in the computational environment into *locales*; Users filter *Individual views* from multiple locales according to their current level of participation.

In summary, the framework extended the basic concept of locales which originated in the wOrlds systems (and documented in Locale Foundations) in a number of directions towards: supporting a world of locales, which support interactions through time, recognising that users may view multiple locales simultaneously. When we had reached the point of considering further prototyping, we decided to focus on three aspects of the framework: Foundations, Mutuality and Individual Views.

THE EVOLUTION OF ORBIT

One of the main goals of the new prototype, dubbed *Orbit*, is to evaluate selected implications of the locales framework for the design of collaborative systems.

At the time of writing, we have developed three completely separate versions of Orbit: Orbit-Mercury, Orbit-Lite and Orbit-Gold. All three versions are based on the "three-layer model" introduced in [4] and summarized in Figure 1. Ideally, Orbit implements locales and views based on external objects, represented in the lower layer of the model. As the state of systems support for true shared, distributed objects improves, for example through OpenDoc or JavaBeans, we believe this layer will become pervasively available. Our focus is therefore on the upper two layers. The intent of Orbit is to provide a 'ubiquitous collaborative desktop' through which users will perform all shared and individual tasks. They will employ the 'views' layer to allow them to have views into multiple locales simultaneously, with differing degrees of intensity. The locales layer will act to group objects and tools together and provide the infrastructure for supporting presence, awareness and trajectory information. New user interface metaphors, for example semi-transparent 3D interfaces, will support the multiple views and foci required for awareness of several tasks simultaneously.

¹There has long been an interest in the HCI community providing users with radically tailorable interfaces to support such personalised views [1][2].

²There is a growing interest in the CSCW community about the importance of awareness in collaborative work settings, e.g., see [9][7].

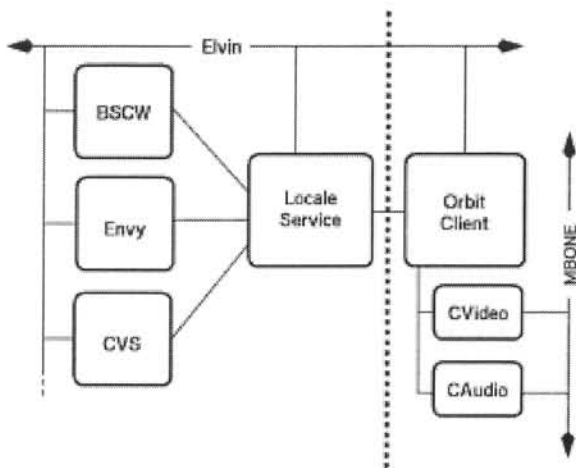


Figure 2. (a) The design of Orbit-Gold.

Currently, of course, our prototypes have not yet reached the point of realizing this vision; our three experiments are intended to investigate portions of our goals and move us incrementally towards the complete Orbit system.

Orbit-Gold

The third version of Orbit is being built at the time of writing. We are aiming to build a version that fulfils a number of needs:

- It should test the locales framework.
- It should be usable by the project members as a collaboration tool.
- Its design should be robust enough for eventual external release.

To fulfil the first need, we are extending the concepts prototyped in Orbit-Mercury to cover more of the Locales Framework.

To fulfil the second need, we are trying to incorporate some of the good ideas of BSCW by having the Orbit client deployable via the web and providing access to actual documents and objects. At the same time, we are aiming to overcome some of the problems we had with BSCW by using Java for the user interface rather than web pages with CGI and by supporting code repositories as well as document repositories.

We hope that by revisiting the design for Orbit-Mercury, taking longer to get the basic design right and following better coding practice we are ensuring that the third need is fulfilled as well. We are reasonably confident in our current design, but only time will tell.

The basic design of Orbit-Gold is shown in Figure 2. The core of the system is the Locale Service which manages user sessions, stores the definitions of locales (members, furnishings, group views), user details and handles locale-related events. The Locale Service is written in ParcPlace Distributed Smalltalk and communicates with the other

elements of the system via CORBA-IIOP.

Behind the Locale Service is an extensible set of repositories. Each of the repositories stores the types of objects for which they are designed. The list of repositories we are currently planning to include are:

- BSCW - for storing simple, office documents and for backward compatibility with Orbit-Lite which is still in use;
- Envy - for Smalltalk code since our group actively uses Envy already, it would be foolish not to support it;
- CVS - for C, Java and Python code which are extensively used throughout DSTC - this may devolve into RCS.

We intend that a variant on the basic architecture will also support other repositories such as Lotus Notes.

The user's interface to Orbit consists of the Orbit Client (a Java applet with frames outside the browser), Mbone-based audio and video clients which are controlled from the Orbit Client via CORBA and specialised clients for objects within the repositories.

It doesn't make sense for Orbit to try to replace the user's familiar tools and provide an all-encompassing interface. Instead we adopt a similar approach to BSCW and use MIME types to launch an appropriate tool on the user's workstation to handle each object.

Orbit provides a unified overview of the objects in locales and synchronous awareness of other users and their actions on objects. The medium for awareness notifications is DSTC's Elvin notification service [15]. Elvin is a scalable, distributed, publish-subscribe event bus which supports content-based subscription. It contrasts with the CORBA Event Service which only supports channel-based subscription so that subscribers receive every event on a given channel.

Elvin decouples publisher and subscriber, allowing us the luxury to simply generate notifications whenever any potentially interesting event occurs knowing that those notifications will not be sent anywhere unless someone subscribes to them. Awareness notifiers can be built to notice specific events or patterns of events without changes to the applications which are the source of the events.

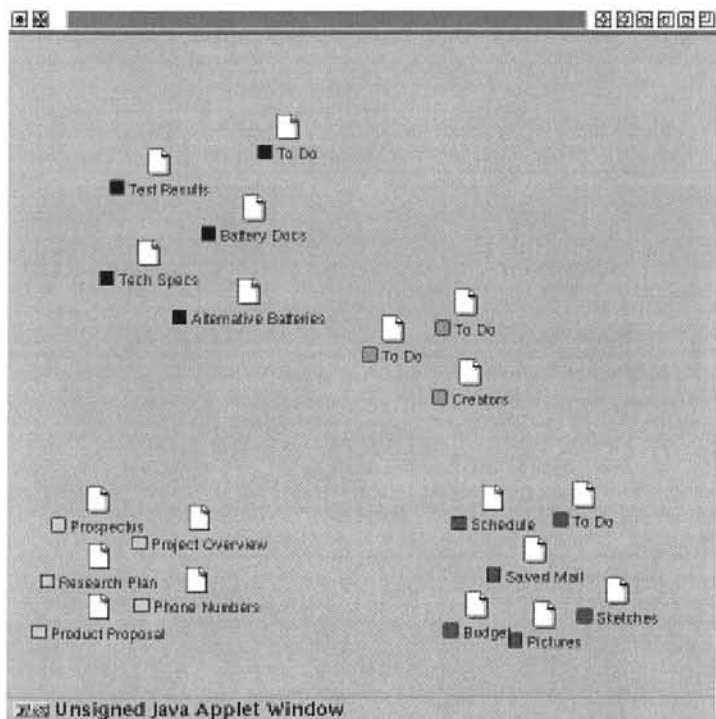
User Interface

A user gains access to Orbit-Gold via a Web page with an embedded login applet.

The applet sends the login information to the Locale Service which authenticates the user and sends back a list of the user's locales, the views of those locales and the objects in those views. This information allows the client to construct the user's default workspace configuration. The client then displays two windows, the Navigator (Figure 3(a)), which is similar to the locale control panels from Mercury, and the Workspace (Figure 3(b)) which displays the objects which form the views.



Figure 3. (a) Orbit-Gold navigator



(b) Orbit-Gold workspace

The workspace displays only the objects, allowing the user to focus on the work at hand without clutter. All information about other users and the locales is displayed in the Navigator pane. The whole user interface uses the Netscape Internet Foundation Classes [13] as a GUI framework.

Using the navigator, a user can edit the details of locales, including name, member list and personal colour choice using a "locale details" popup. Views can be defined simply by rearranging the objects in the workspace, changing the set of visible objects and turning video or presence off or on using a "furnishings" popup if necessary, and then renaming the view.

Objects within the workspace are presentations of the actual documents or chunks of code in the repositories. Users can access the actual objects by clicking on the presentation object. Depending on how the repository is integrated, the Orbit Client may then receive a URL which it passes on to the browser or it may send a CORBA request to a local client program (such as Envy) to fetch the object from the repository. In some cases, it will fetch the object itself via CORBA. By using a variety of techniques, repositories can be integrated tightly or loosely as necessary.

Where possible, each repository is modified to generate Elvin notifications when significant events occur. The Orbit Client is responsible for unifying the notifications with the presentation object in the workspace so that the user can observe the recent history of the object at a glance. The list

of events can remain attached to the object for objects which are under continuous scrutiny (for example code under continuous revision by multiple authors) or be relegated to a popup from the object.

SUMMARY

The WORLDS project at DSTC is attempting to team consulting and workplaces studies with experimental prototyping and deployment and theory-building to work towards the construction of a design pattern language for collaboration.

We believe that by identifying problems through consulting and studies and offering solutions through prototyping and deployment we will identify known patterns of collaboration support. By matching this process of emergent discovery with grounded theory-building, we will be able to develop our growing *pattern catalogue* into a *pattern language*.

BIOGRAPHICAL INFORMATION

Simon Kaplan For the past seven years, Simon Kaplan has been investigating environments for support of collaborative work. Through the development of the several prototype environments mentioned in this paper, he has been developing models for collaboration, and studying the interactions between systems software, distributed object and database technologies, and collaborative systems requirements. He is currently Professor of Computer Science at the University of Queensland, Principal Scientist

of the CRC for Distributed Systems Technology and Adjunct Professor of Computer Science at the University of Illinois. He is also WORLDS project leader.

Simon received his Ph.D. in computer science in 1986 from the University of Cape Town. In 1995 he received the University of Illinois Xerox College of Engineering Award for research excellence. He is the author of over 70 research papers on CSCW, Distributed Systems, Software Engineering, Programming Languages and related fields. He has also served as chair or program committee member for numerous ACM, IEEE and international conferences and on the editorial board of several journals.

Geraldine Fitzpatrick has nearly completed her PhD in Computer Science at the University of Queensland. Her thesis topic is about the development of a design framework, called the Locales Framework, for collaborative systems. In the evolution and deployment of the Locales Framework, she has undertaken several workplace studies and also contributed to the design of the Orbit system. She has also been closely involved in a telemedicine project linking clinicians across three Queensland hospital intensive care units for remote consultations.

Tim Mansfield is a Senior Research Scientist at the CRC for Distributed Systems Technology. He completed his PhD in Computer Science at the University of Queensland in 1996 on the topic of user-customizable user interfaces. He is currently the project manager for the WORLDS project.

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Collaborative Design Studios

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ABSTRACT This paper describes two networked collaborative architectural design studios and presents an empirical analysis of observations based on these experiments. The studios involved architecture students from different countries, spanned different lengths of time, and used a suite of collaboration tools. The paper highlights issues relevant to the design of collaborative environments and interfaces.

KEYWORDS networked collaboration, architectural design, virtual design studio, group interactions

1. INTRODUCTION

In the context of evolution of user interface research, Grudin (1963) identified the following five foci for interface development: at the hardware (1950s), at the software (1960-70s), at the terminal (1970-80s), at the interaction dialogue (1980s), and at the work setting (1990s). It implies that, over the last few decades, the reach of computing has been increasing from the interaction between a machine and a single-user to encompass work settings. This is also demonstrated in collaborative design studio experiments that span time zones, geographic boundaries, and a spectrum of (a)synchronicity of collaboration. To develop a better understanding of geographically dispersed design teams working together on a design project, a series of collaborative design studios was undertaken. This paper describes empirical analysis of two such collaborative design studios. Based on the analysis, we describe briefly our near-term and future research focus in developing the next generation of collaboration design environments.

2. COLLABORATIVE DESIGN STUDIOS

The first design studio involved students from the Swiss Federal Institute of Technology (ETH), Zurich, and the National University of Singapore (NUS), Singapore. The program brief called for a design proposal for an exhibition pavilion on sites in Zurich and Singapore. The students from Zurich were given a site in Singapore and the students from Singapore were given a site in Zurich. The students from ETH and NUS were teamed up, and each team was responsible for answering and providing all local contextual information to its remote partner team. The design projects from this studio (28th November- 5th December, 1994) were documented on the Web. Daily sessions of synchronous conferencing were set up using a suite of public-domain computer software for audio and video conferencing (*vat* and *nv*), shared whiteboard (*wb*), and the Web browsers (Figure 1), supported by standard UNIX utilities such as *email*, *talk* and *ftp*. The entire process, the tools used, the students' projects and feedback are documented online (ETH, 1994).

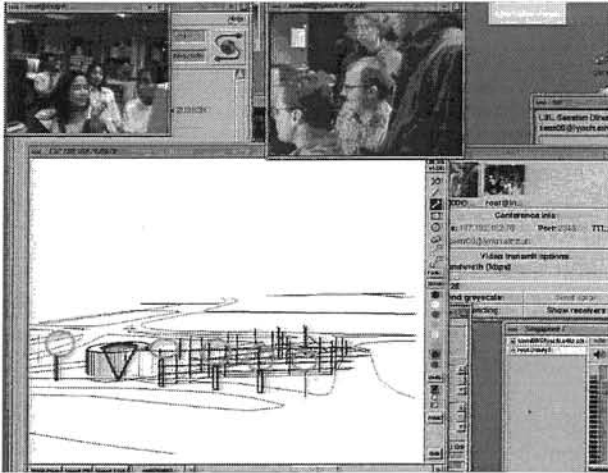


Figure 1: Snapshot from the networked design studio between Zurich and Singapore.

The second design studio was set up between ETH and the University of Toronto (UT), Toronto. It involved two design projects, each lasting about 8 weeks (January- April, 1995). The first project required a design proposal for an exhibition pavilion in Zurich and Ottawa, and followed a structure (Figure 2) similar to our previous studio project with NUS. The second project- called 'Crossing', was aimed at seeking design proposals for an imaginary digital landscape. The final design projects are documented online (ETH, 1995)

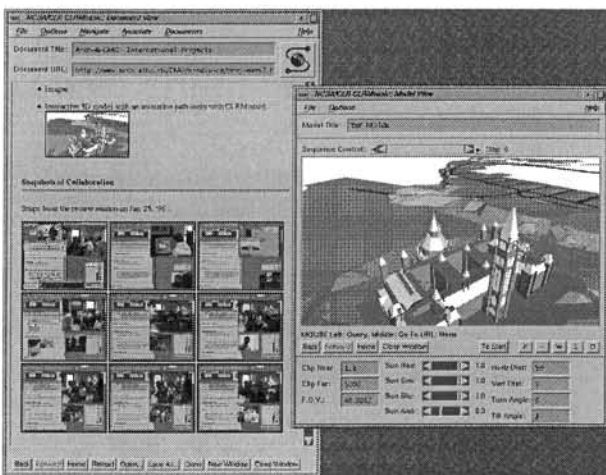


Figure 2: Snapshot from the networked design studio between Zurich and Toronto.

2.1. Empirical Analysis of Collaboration

Both the collaborative studios were run as special projects. Except for the brief but necessary introduction in the use of software, no special training was given to the students. The following empirical analysis is based on our observations during the studio sessions and subsequent reflections.

We noticed that the design process gets affected due to the peculiarities of given computing tools, e.g., designs may look more finished than they really are (or intended), or designers may be forced to take decisions they might otherwise defer in traditional media. These problems may get inflated in networked design studios for the following reasons. First, in order to maximize the information exchange during synchronous sessions, design ideas may get articulated and presented at a faster speed than on paper. Second, if design ideas are not structured or detailed to a sufficient degree, it becomes difficult to express design intentions on the fly, especially if collaborative tools such as a shared whiteboard does not support dynamic display of three dimensional data. Consequently, what is possible within a suite of collaborative tools may drive a design collaboration session.

We encountered this phenomenon when students from ETH and NUS presented their design models to each other. The shared whiteboard we used supported import of Postscript plot files of a size less than 16 KB. Some students saw this as a limitation, and justifiably so. Some other students saw this as an opportunity to increase the information to byte ratio. These kinds of issues will probably become less of a hindrance in the future but they suggest that design representations get affected by the collaborative tools used and that designers need to become more expressive in using more than one representational technique.

There also exists a tension between the limitations imposed by computing environments and apparently limitless amounts of information that could be generated. It occurred in our studios when students started documenting their design projects on WWW. Only a limited number of graphic formats and text layouts are presently supported in the Web pages. Some students found it difficult to conceive of balanced narratives comprising graphics and text to explain their projects. On the other hand, the possibilities for linking

information came as a liberating influence from the static two-dimensional restrictions of a screen layout (just as it is also present in traditional media such as paper drawings). Even if students sometimes get carried away with either the limitations or possibilities, we think that it is a necessary learning experience. Our strategy was to show example narrative structures at the beginning of design studios which allowed an initial transition for students, and to let them subsequently explore their individual expressive styles.

A difficult issue to deal with (that arises even in single-user CAD contexts) is that most computer based design models contain far more information than is visible at any one time on a computer screen. Static representations that mirror the techniques in traditional media such as paper provide only one way of representing such information. More dynamic ones in which three-dimensional models may be developed, presented and explored- with and without the guidance of their creators, are needed for both synchronous and asynchronous collaborations. During the second studio with UT, we used tools such as *CLRMosaic* (UofT) that permit such three dimensional explorations of design models including animations and links embedded on three-dimensional objects.

The process of collaboration is an intriguing aspect of networked design studios. When design teams in distant locations have not met before, opportunities and means for socialization become a necessity. In our studios, we made time and space available for such activities. During the initial synchronous sessions, students introduced themselves to each other and then were encouraged to talk their way through whatever interested them without any kind of prepared scripts. Gradually, they developed a rhythm of conversation and made wish lists of information to be asked and delivered for the subsequent synchronous sessions. This process is very crucial for networked design studios as all participants need to feel a sense of interdependence that can only come about if they develop a sense of working together as a social group.

Sometimes communication and exchange of design ideas became problematic during synchronous collaboration when students switched to a wrong conceptual model of their actions. For example, quite often students tended to forget that software applications are not gaze-directed but need an explicit

action such as a mouse click to change focus of input/output pipeline. When this was forgotten during conversations, all user input/output was directed to the wrong window.

At other times, the participants used elaborate body gestures, e.g., movement of hands and fingers, facial expressions, shifting in their seats, etc., just as they would during face-to-face meetings in a group. Some learning time is required to appreciate that such body gestures or finger pointing to some region on one screen is not visible on the other end, that video camera resolution may not pick out a raised eyebrow, that a smile may get transmitted and received at the other end only after a lapse of some seconds, or that window sizes and their locations for a shared application on both ends may not be identical. These issues lead to situations in which some gestures get transmitted which were not intended, whereas some subtle gestures go unnoticed.

The online conversations took place initially as bursts of exchanges and then became smoother and flowing. This may be due to the fact that audio connections introduce some lapse of seconds in signals between senders and receivers. Besides, all the participants have a different rhythm of conversation; some react immediately, some take time before responding, some others suggest their presence with brief confirmations. These patterns are similar to how they happen in telephonic conversations and it is better to let the group develop its own conversational rhythm. The only time some restraint in conversations was suggested was while making humorous remarks since humor from one culture does not always travel well to another culture.

At one time or another, most participants felt insecure about whether their collaborators actually received and understood the information that was transmitted. Quite often, they asked each other for a confirmation in many different ways. This has an important implication for interface developers and collaborative software designers. A participant's own actions as well as actions of others should become transparently visible as much as possible otherwise much bandwidth is expended in simply acknowledging each other's actions.

Finally, the design projects developed by students are qualitatively acceptable given the time frame and the computing environment in which they were produced. One measure of this is, of course, the projects as documented and presented. Another measure is the kind

and number of design related questions it generates from the distant collaborators. In this regard, we were quite fortunate in having good students in both studios who repeatedly attempted to bring back the conversation to design issues from the supporting technological issues.

3. FUTURE GOALS

Many research groups in this area have focused on expanding the range of and enhancing data transmission protocols, and also emphasized design issues related to user interface and CSCW toolkits. In this context, our analysis leads us to explore research issues of a different kind. We believe that research into computational architectures for CSCW environments can benefit by empirical studies of the actual use of CSCW tools in routine but domain-specific contexts. Our experience suggests that a number of separate but simple to use collaboration tools are sometimes more effective than a complex homogenous environment that may impose higher costs simply because it needs to coordinate and synchronize all the services under one umbrella. Our research interests revolve around the following two themes:

- expanding the range of collaboration services; in particular, flexible and simple ways to access distributed information repositories and computational processes (e.g., rendering or design analysis programs) that can be called upon in a collaborative design context. Towards this aim, our near-term focus is to explore extensions of mark-up languages such as HTML (UofM) combined with agent technologies (Finnin et al., 1992) for search and retrieval of distributed information
- developing interfaces that feature different operations depending on the collaboration contexts, an objective that is still under articulation.

4. ACKNOWLEDGEMENTS

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