# Handheld CSCW

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**Abstract.** In this paper we explore and demonstrate possible contribution of handheld computing in the field of computer supported cooperative work (CSCW). Based on a survey of the CSCW-conference series we discovered that most research is concentrated on support of distributed collaboration. Based on a definition for handheld computing and an extensive description of new options provided by handheld devices we suggest new application domains in CSCW.
In the second part we discuss two of these domains, namely the support for co-located cooperating humans and for environment-mediated collaborative work, in more depth. In the first context we present a heterogeneous infrared communication application for meeting support. In the second we present a framework and experiments that concentrate on the question how location can be exploited for CSCW.

**Keywords:** Handheld Computing, Computer Supported Cooperative Work (CSCW), Co-Located Cooperation, Environment-Mediated Collaboration

## 1 Introduction

We studied the development of the CSCW field in the last decade from a technology and application point of view to assess what kind of collaborative work settings had been addressed. We were interested in very general findings, in particular the extent to which co-located collaborative work had been addressed. To this end we analyzed and classified the contributions to the CSCW conference series from 1986 to 1996, a total of 226 papers, assuming the CSCW conference being representative for the development of the field [3]. Of the total number of papers we found roughly 50% introducing technical solutions supporting collaborative work. We classified these technical contributions according to the well-known time-space matrix defining four classes based on discriminators co-located (same place) vs. remote and synchronous (within time limits) vs. asynchronous/concurrent. The results of this classification are shown in Table 1.

| | Co-Located | Remote |
|---|---|---|
| Synchronous | 8 | >60 |
| Asynchronous | 0 | >60 |

Table 1: CSCW Survey in the Time/Space Matrix

Most papers published concentrated on hiding location, mainly for remote collaboration applications. The only work scenario addressed by technical papers on support of co-located settings are meetings. This theme was relatively prominent at CSCW `86 but has been hardly addressed since.

In our current research we have experienced that handheld devices can provide new solutions for co-located collaboration, in synchronous as well as in asynchronous scenarios. These findings relate to several properties of handheld computers, as described in the next section.

## 2 Handheld Computing

Over the last few years, handheld computing has become a technology option for supporting us in our work environments and beyond. Most notably, Personal Digital Assistants (PDA) became popular for helping users to

cope with every day tasks. Our working definition of Handheld computing goes beyond PDAs and Handheld-PC and includes also other smart devices, such as mobile phones, intelligent active badges, or wearable computers.

**Definition:** Handheld Computer

*A Handheld Computer is an unobtrusive computing device that is accompanying the user most of the time and provides assistance in different situations and for a wide range of tasks.*

The seemingly distinguishing feature of handheld computing to desktop computing is the mobility support for their users. Handheld computing, though, needs to be clearly distinguished from mobile computing as witnessed over the last years, where location-independent usage is the main focus [2]. In contrast, handheld computing implies new ways of using computers rather than mobilizing traditional usage. The really distinguishing feature is to maximize personal assistance [12]. With respect to mobility, the aim of handheld computing is rather to exploit it than to hide it, and hence we strongly believe that interaction of handheld computers with their surroundings will become a central theme in handheld computing.

Most handheld computing applications as to yet are designed for single-user. Generally speaking, they support personal information and time management, note-taking and simple messaging. Recently, the networked usage of handheld devices has become more of a focus, and basically all current products support at least synchronization with networked hosts, many of them also providing some degree of Internet integration. In the desktop world, the shift from stand-alone to networked usage a decade ago led to multi-user applications for support of cooperating humans. In analogy, we propose that handheld computing will lead to new CSCW applications, handheld groupware.

Handheld computing has been driven by very different fields of research, which have hardly been related to each other, namely they are mobile computing, ubiquitous computing [13], calm technology [14], personal digital assistants [7], and wearable computers [11]. Furthermore technologies such as communication (e.g. radio, GSM, IrDA) and awareness [8], are of major importance towards networked handheld computing.

## 3 Handheld Support for Co-located Cooperating Humans

The distinguishing feature of co-located cooperative work is that the participants are being close enough together to communicate directly. Typical scenarios are meetings, classrooms teaching, shared offices, or lab environments, where people are in the same location. Furthermore using the term co-located it is assumed that the participants are in the same location at the same time.

In co-located settings handheld technologies may be the key to overcome well-known problems reported in the CSCW literature. First of all, handheld technologies hold the potential to set up ad hoc and low cost computer-supported meetings, not relying on dedicated rooms and environments. Related to this, the access barrier to meeting support technology may be considerably lower when personal devices rather than shared meeting equipment constitute the user interface; consider the concerns related to transfer of confidential material to shared systems. In meetings, handheld personal technologies can augment communication beyond general document exchange and distribution with rather personal data exchange (business card, as implemented already implemented in modern mobile phones) and secret channels. Further application areas in co-located settings are environment control, meeting coordination support and creativity support.

As a technology demonstrator IrChat implements mobile communication using the IrDA protocol [5] to exchange information between different types of PDAs or in more general between different kind of machines using infrared communication. Although many PDAs and mobile computers use IrDA as communication standard for infrared communication, there is no application available connecting multiple heterogeneous PDAs to exchange data.

IrChat was developed to collect experiences about the different implementations of the IrDA protocol on different hardware platforms and to demonstrate the interoperability between these machines, see Figure 1. Furthermore there is no support for ad hoc networking. To address this issue we derived from experimentation a model of infrared communication for ad-hoc networking. Based on this model we introduced an algorithm for a peer-to-peer infrared network. This network enables multi-peer networking and in addition location-aware networked applications [1].

Figure 1: Heterogeneous Ad-Hoc Networking with PDAs.

The current version of IrChat allows establishing an IrDA connection and chatting or exchanging files, see the screenshots in Figure 2. IrChat is available for Psion Series 5, Windows CE 2, Apple Newton 2x00 (a PalmPilot version is in development) [4].

Now this technology is used to develop new applications to support ad-hoc meetings using PDAs. These applications will include voting systems, exchange of business cards, meeting agenda and minutes of the meeting.

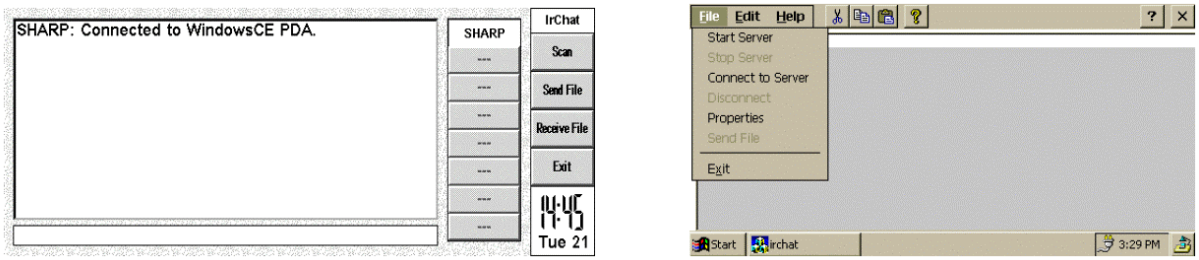


Figure 2: Screenshots of IrChat on Psion and WindowsCE.

Support for meetings based on single display groupware, realized using PDAs is done by Myers [9]. New user interface metaphors such as Pick-and-Drop [10] is a further example of research using handheld technologies to realize efficient meeting support.

## 4 Environment-mediated Collaborative Work

Co-located asynchronous cooperative work has not received much attention in groupware development. With emerging handheld technologies though the concept of having places or in general the physical environment as mediator for asynchronous communication becomes very attractive.

It is difficult to classify environment-mediated collaborative work using the CSCW time-space matrix. In this context we are interested how to exploit the information given by the location or in a more general case by the environment for CSCW scenarios.

We define environment-mediated collaboration (EMC) as follows: collaboration between humans that is environment-mediated, if an instance in the physical environment serves as link between the participants. EMC is foremost a concept, and the conceptual view has to be clearly distinguished from the implementation of EMC. Both views are discussed below, followed by brief consideration of EMC communication semantics.

**Conceptual View.** In computer mediated collaboration (CMC), collaboration of humans is mediated through a computer at the source, a computer at the sink, and a network in between. In EMC, an instance of the physical environment is introduced in this communication chain. The physical instance can be fixed at a location or can be mobile. Following Figure 3 we can distinguish four cases:


Figure 3: From computer-mediated to environment mediated collaboration

a. Direct EMC: the physical instance replaces the network. This case relates to the real-world use of physical places to relay messages from one person to another.

b. Location-bound-delivery: communication is addressed to an instance in the physical environment from where messages are delivered to a sink in that environment. This case relates to the use of places in abstraction of specific people, for example letters are addressed to an office rather than a specific secretary.

c. Location-bound-send: messages are send off from a specific location, where the mediating physical instance takes care of forwarding it to a sink. This case may seem more abstract but think for instance of an emergency message for which the destination is identified by the senders location.

d. Virtual EMC: source and sink use a mediating physical instance remotely, for example visitors of a physical place such as a room in a museum or a lecture theatre addressing remotely (after the visit) other visitors who have been to this place, too.

**Implementation View.** EMC can be implemented in several ways, transparent for the user (for both sender and receiver). Three general options for implementation are shown in Figure 4. First, of course, the actual message could physically be left at the mediating physical instance for retrieval by a sink. A second option is to relay only references via the physical instance. A third option is to use an ID of the mediating instance to tag messages that are actually forwarded through some kind of global store in the network.

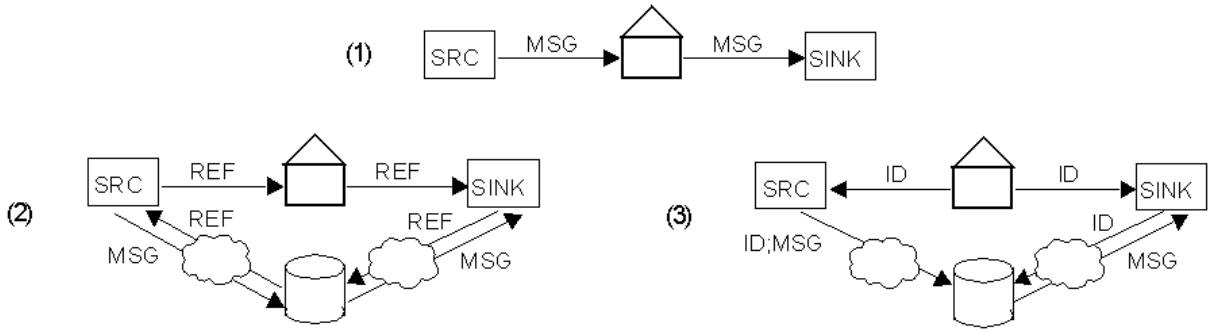


Figure 4: Implementation of environment-mediation.

**Communication Semantics.** In EMC, source and sink are linked by a mediating instance and thus do not necessarily have to know each other. Hence, EMC can facilitate anonymous communication. Having a physical instance as mediator also eases the implementation of different communication semantics, such as deliver-once semantic, deliver-n-times semantic, or best-before semantic.

**General Applications of EMC.** When does it make sense to use a real-world instance as mediator as opposed a virtual representation of such an instance? Isn't it always more flexible to use virtual places to communicate through as it saves us to go there? No! To justify EMC, there is first of all the philosophical argument that computing tools are the easier to use the more they relate to real-world experience and to the principles of calm technology [14]. Beyond such rather general considerations, there are very practical use cases for EMC, for example:

? when not a specific person is addressed

? when the message relates to a specific location/object and is only locally relevant

? when the environment as filter can reduce information overload

Subsequently we consider two application domains that we think would gain from EMC.

**Environment-Mediated Workflow.** EMC can be useful for a wide range of situations in collaborative work, especially when dealing with physical objects at some stage of the process. Typical examples are found in shift-work, maintenance or logistics. By attaching information to physical objects, direct EMC may be use to imple-

ment a selective information flow, and hence improve or even enable workflow applications. In various workflow scenarios physical goods may also be useful as point of delivery to relay messages to whoever is currently working on that good.

To explore EMC in a work environment we are implementing an infrared-based ubiquitous computing infrastructure in our work place, enabling staff and students to use their palm computers to leave and pick up messages in specific locations. This experiment will analyze direct EMC.

**Communityware.** In the CSCW domain the focus has so far been mostly on groupware as opposed to communityware which is now slowly receiving more attention [6]. But as opposed to groups, individuals in communities only know (and only are aware of) part of their fellow community members. The challenge for communityware is to facilitate awareness and interaction beyond the subset of individuals already aware of each other. We propose that EMC is a useful concept for communityware, as it facilitates anonymous communication and the kind of casual communication found in communities, where for instance messages are left somewhere at the off-chance of being useful for somebody.

To investigate the potential of EMC to strengthen interaction within communities we are in the process of setting up an experiment to be conducted with a community of students attending a particular lecture. We will set up the lecturing theatre as mediator for communication among students and assess the effect on community interaction. In contrast to the Environment-Mediated Workflow experiment that explores direct EMC, this experiment will analyze virtual EMC.

## 5 Conclusion

Based on our research findings we conclude that handheld computing device will enhance CSCW. There will be a significant impact especially for co-located collaboration and location-mediated CSCW.

Communication, interoperability of devices, and ad-hoc networking is a major concern for further research in the field of handheld groupware. As a first solution to set up interoperable ad-hoc networks we presented infrared communication based on IrDA.

Exploiting location to optimize collaboration is a further import approach, where handheld and hence mobile device will introduce new possibilities in the field of CSCW. We describe environment-mediated collaboration as metaphor to enable anonymous communication in communities and to reduce information overload by using the environment as filter. Here we focused on new applications for workflow scenarios and communityware. In environment-mediated collaboration a physical instance is used as mediator in the work process.

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