Using Wireless Inter-PANs to Enable Seamless Ongoing Interaction Across Mobile Meetings and Dispersed Settings

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Abstract

This article presents results of a research project aimed at developing novel meeting support for mobile work domains. The system developed, called RoamWare, supports seamless ongoing interaction across collocated mobile face-to-face meetings and dispersed work settings by use of wireless inter-PANs. An inter-PAN is an ad hoc setup of several mobile devices belonging to different users. This article describes the design requirements for RoamWare, and how these have been realized in a working prototype system. RoamWare contributes to the fields of human-computer interaction and computer-supported cooperative work by illustrating how session management models can be modified to incorporate spontaneous mobile meetings into one ongoing session of interaction.

Session management within computer-supported cooperative work (CSCW)[1] refers to the process of starting, stopping, joining, leaving, and browsing collaborative situations [3]. Thus, session management models are critical to all CSCW systems. However, one assumption made in current implementations of session management models in CSCW systems is that sessions are clearly separated and established without previous interaction. Kristoffersen and Ljungberg [4] have challenged this view, arguing that in real life *"establishing interaction always involves interaction. Interaction often interrupts, or replaces interaction. This is done in an unproblematic, effortless and effective way."*

Furthermore, CSCW designers have neglected the fact that interaction, such as meetings, mostly take place outside formal meeting rooms. As a consequence today's meeting support systems are designed to support stationary rather than mobile participants and prescheduled rather than spontaneous meetings. However, empirical studies of mobile CSCW cases suggest that mobile spontaneous face-to-face meetings, ongoing interaction, and coordination with colleagues at particular places at particular times are critical to their work (e.g., [5–8]). In fact, mobile CSCW typically involves both physical (face-to-face) and virtual (i.e., computer-mediated) interaction. According to this, current meeting support systems fail to:

- *Support mobile interaction across physical and virtual meetings.* Some systems have been developed to support both face-to-face and remote participants (e.g., the DOLPHIN system) [9]. However, existing systems assume that meetings always take place in dedicated meeting rooms. Thus, these systems are not very mobile but rather very stationary.
- *Support seamless ongoing sessions of interaction for networking individuals.* Besides belonging to and working within very specified groups or projects, where mailing lists are frequently used to continue interacting with colleagues after meetings, the modern organization is very often characterized by a high degree of *networking* individuals (i.e., talking to colleagues and clients, exchanging and sharing experiences and knowledge) across different project groups and other formal group constellations. As stated by Kristoffersen and Ljungberg [4], real-life sessions are ongoing rather than clearly separated from each other. However, existing implementations of session management models are not very well suited to this kind of support since they force one to do a significant amount of overhead work to set up a new session [3].

The issue of *seamlessness* is an important element within the CSCW research area. Ishii and Miyake [10] define it as *unobtrusive integration of any noticeable system aspect into the surrounding context*, and Borghoff and Schlichter [11] distinguish between several types of seamlessness (e.g., communication media, working mode, phases of the group process, technology, and time).

This article presents RoamWare, a mobile CSCW system that illustrates how wireless inter-personal area networks (inter-PANs) can be implemented to support seamless ongoing interaction across collocated mobile face-to-face meetings and dispersed work settings.

A wireless PAN can be defined as general IP networking

[1] *CSCW is "a shorthand way of referring to a set of concerns about supporting multiple individuals working together with computer systems" [1]. CSCW has generally been addressed in two distinct ways: CScw (the technical perspective) and csCW (the social/organizational perspective) [2].*

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(including security) in an ad hoc connection environment. A WPAN is an application of wireless technology intended to address usage scenarios that are inherently personal in nature. The emphasis is on instant connectivity between devices that manage personal data. An example might be synchronizing data between a personal digital assistant (PDA) and a desktop computer. In this article the notion of inter-PANs is introduced to denote that the content of the data transmitted is still personal. However, the data is transmitted between different persons in a group. *Inter* thus means that it utilizes the relationship between itself and other devices running RoamWare; it is *personal*: a RoamWare device is identified with its user, and carried or worn at all times when in use. Each time a group of people meet, an inter-PAN is established between the RoamWare devices present, and data is enhanced between these devices. Thus, a RoamWare device does not do anything on its own. However, when co-present with other RoamWare devices it automatically establishes an inter-PAN together with the other devices to provide the required services.

The design of RoamWare has been verified through:

- An empirical study of mobile service technicians at a Swedish telephone operator [5]
- The User-Monitoring Environments for Action (UMEA) approach [12]
- Experience with early implementations of RoamWare, that is, observation of the system in use situations

The RoamWare system in its current implementation is especially useful for work organizations where:

- The work typically involves face-to-face spontaneous meetings with different persons.
- Group members are mobile and dispersed.
- Topics are discussed over some period of time through both physical (i.e., face-to-face) and virtual/computer-mediated interaction (e.g., e-mail).

Typical situations are office work and the work setting of field service engineers.

In a later section we present the research background followed by an outline of the design requirements for RoamWare. We then present the RoamWare system followed by a presentation of three subsystems: RoamList, RoamWeb, and RoamLines. We present a use case illustrating how RoamWare could be used, followed by a discussion of how RoamWare meets the design requirements outlined. We discuss some related work and the contributions of RoamWare to that before concluding the article.

Research Background

The design of RoamWare has been verified by both theoretical and empirical work. Concerning the empirical part we refer to our recently conducted ethnographic study of mobile service technicians at a Swedish telephone operator [5]. During our study we observed that the service technicians needed to invent workarounds related to *lack of ongoing interaction* (between themselves, their clients, and the central station staff) [6]. We also noticed that mobility hardly takes place "anytime, anywhere." Rather, there are timeframes, places, and traveling that are hard to eliminate [5]. These problems all lead to disruptions or breakdowns of the work group's interaction and the corresponding need for seamless support for shifting between collocated and dispersed settings. One thing clear from the study was that a person never knows whether the interaction at a given moment will necessarily continue. This implies that a user cannot be expected to manually keep a record of all kinds of interaction, just in case it might be needed later for someone. Instead, the CSCW system must seamlessly support the user when the need for interaction occurs. For more detailed descriptions of the empirical findings see [5].

The design of RoamWare was also inspired by the UMEA approach [12] and the stress it places on the importance of *project contexts* and *interaction histories* when designing interactive system interfaces. The UMEA approach is theoretically heavily influenced by activity theory. The underlying idea of the UMEA approach is that interactive environments are still application-oriented, and there is a need to support higher-level user actions (in this case to integrate mobile meetings into interaction processes across collocated and dispersed settings, and also ease reestablishment of previous face-to-face interactions via computers).

Requirements

This section describes the requirements derived from the empirical and theoretical work. According to the requirements analysis, systems aimed at supporting ongoing and mobile sessions of interaction must meet the following design requirements:

- *Implicit establishment of meetings:* According to this requirement, a spontaneous meeting should be initiated when it happens for both collocated and dispersed group members. Mobile meetings happen spontaneously, and there is never a predefined group of participants at such meetings [8]. This implies that ordinary mailing lists will not be a good solution to support further interaction from such a meeting since they are quite static. Since the work is mobile and thus involves many activities performed outside the computer, the system needs to generate interaction histories that are flexible according to who is physically present at a meeting. There is a need for a device to monitor the vicinity of the user so that ongoing interaction during a meeting can easily be used to reestablish the interaction later on. The issue of user monitoring could raise questions concerning privacy. However, since each user only scans his/her close vicinity for other users (i.e., for information about who is collocated in a face-to-face meeting), this is no bigger privacy problem than ordinary meeting records, which also contain information about who is present.
- *Fluid maintenance of meetings:* According to this requirement, the system should provide support for easy shifting between collocated and dispersed modes of interaction. People spend much of their time away from their desktops in meetings with colleagues and clients, or because they need to use shared resources [7]. In fact, frequent informal interaction is key to the work of a collaborative organization [13]. Whittaker *et al.* [14] and Bellotti and Bly [7] report that spontaneous interaction facilitates frequent exchanges of help and useful information, and that awareness of ongoing activity creates shared knowledge and provides a key context for the interactions that occur. As a consequence, a system designed to support ongoing interaction needs to be mobile and easy to carry around so that it can be used to support interaction across mobile and face-to-face interaction as well as virtual interaction. This also implies that the technology should provide seamless support for continuously shifting interaction between collocated meetings and dispersed computer-mediated interaction. Furthermore, interaction histories must be *automatically* generated so that reestablishing a meeting can be done easily. A system aimed at supporting ongoing interaction must also provide its users with functionality to browse both past and current interaction across the whole group to support fluid joining and leaving of different meetings.
- *Ad hoc meeting distribution:* According to this requirement, when a collocated meeting happens it should also distribute

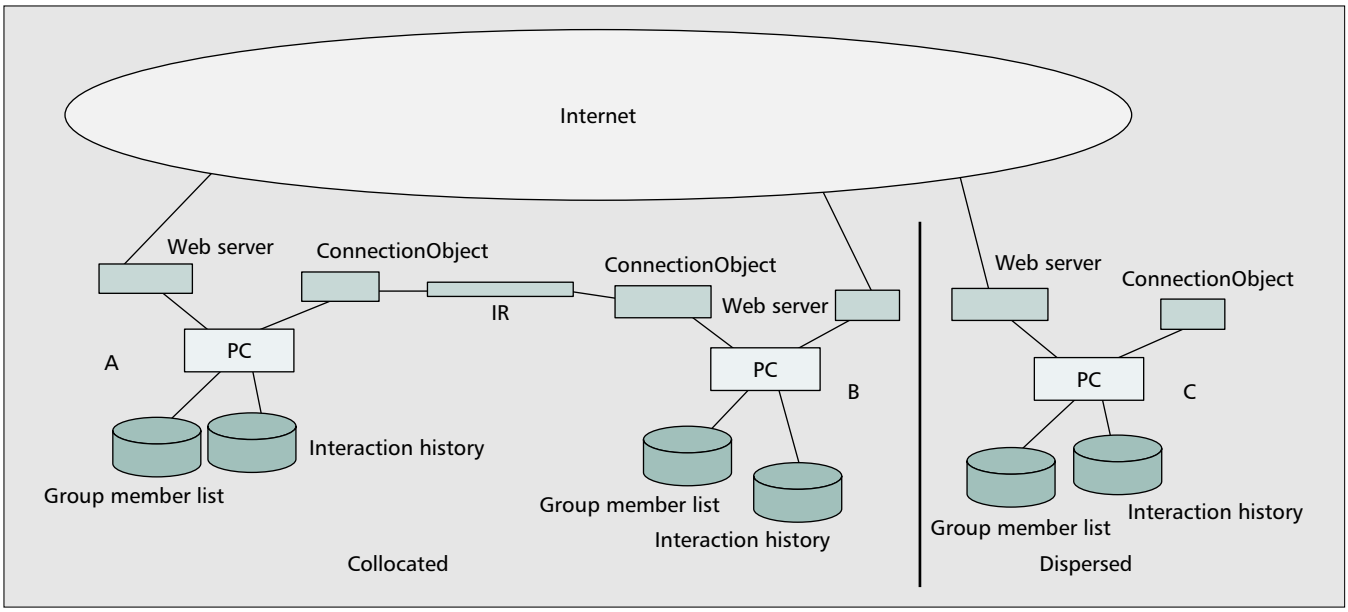


Figure 1. *The overall infrastructure of RoamWare, illustrating how inter-PANs can be automatically established using multiple mobile devices together with Web technology across collocated and geographically dispersed work settings. An inter-PAN is established between three computers (A, B, and C) running RoamWare. A and B are collocated in a face-to-face meeting, while the person who has computer C participates from a remote location.*

its content to dispersed participants. Since topics can be discussed at different moments over some period of time with both collocated and dispersed members, and people often have to leave meetings before they conclude, there is a need to be able to "stretch" out the meetings over time with some kind of history function, and also over different places so that a meeting can be both physical (with those that are collocated) and virtual (with participants that are remote). A requirement for systems intended to support ongoing sessions of interaction across physical and virtual areas is thus to provide users with the option to leave a physical meeting but still be able to follow it and participate virtually. This requirement can be formulated as support for dynamic and sustained meetings across collocated and dispersed settings.

- *Easy access to spontaneous meetings:* According to this requirement, the system should permit participants to easily find the meeting and join it whenever they want. Similar to face-to-face meetings, which quite often occur spontaneously and with no particular problems, the technology to support ongoing interaction for mobile CSCW must support dispersed participants with seamless access. A user should be able to choose a meeting, choose an appropriate channel for interaction (e.g., voice, chat, video, e-mail), and then join the collaboration quite easily, even if the collocated meeting is on the move down a hallway or someone has to leave. As a consequence of this requirement, the technology cannot establish the interaction based on a person (like a normal phone call) since a particular person might leave the meeting before it is concluded. Moreover, the interaction cannot be based on a place (e.g., a call to the conference room) since the meeting could take place anywhere. Rather, the ad hoc group constellation itself, during a specific spontaneous meeting, needs to be addressable when accessing a meeting from a remote location.
- *Meeting priority support:* According to this requirement, the system should support users with visualizations of different threads of meetings to let them easily get an overview of the current state and set priorities about which meetings to attend. Within a group the members participate in a large amount of different meetings. As a consequence, the large amount of interaction histories generated by the group must be possible to search and visualize to make them useful. So, since spontaneous meetings are quite frequent, there is a need to *visualize* the data captured to make it usable as well as *searchable* in an easy way.

From a *seamless interaction* perspective these requirements can be summarized according to the different types of *seamlessness* distinguished by Borghoff and Schlichter [11]:

- Communication media (i.e., available channels for interaction across physical and virtual sessions)
- Phases of the group process (i.e., continuous shifting between physical and virtual interaction, and support for both collocated and dispersed participants)
- Technology (i.e., a unified interface for all interaction)
- Time (i.e., browsing of different individuals' interaction histories, and spontaneous joining and leaving of different physical and virtual ongoing sessions)

The Roamware System

Based on the above requirements, this section describes the general functionality of the RoamWare system. The RoamWare system, or simply RoamWare, consists of three subsystems: RoamList, RoamWeb, and RoamLines that all share the following architecture.

Figure 1 illustrates the RoamWare infrastructure with three PCs (A, B, and C) running the system. As Fig. 1 illustrates, each computer runs a Web server and is always connected to the Internet over a wireless LAN (IEEE 802.11b). The figure also illustrates how the devices communicate across both collocated and distributed settings. Each machine has a group member list and an interaction history stored. The group member list holds a record of a person's contacts for all the persons who belong to his/her working group (including colleagues, business clients, friends, etc). As seen in Fig. 1, one device (A) can automatically identify another collocated device (B) by use of a *ConnectionObject*. The ConnectionObject is a data structure that serves as a basis for each client to establish a connection to the other machines in the ad hoc network. The ConnectionObject is described in Table 1.

The ConnectionObject works as follows. A new connection with a new collocated device within the ad hoc network is

Part	Description
Connection	An object variable representing an existing ConnectionObject
ConnectionString	A String containing connection information
UserID	A String containing a user name to use when establishing the connection
Password	A String containing a password to use when establishing the connection
Source	A String used to pass the interaction histories created to the Web
ActiveConnection	A String that evaluates to a valid ConnectionObject variable name containing a definition for a connection

Table 1. *Description of the ConnectionObject.*

established through a ConnectionString, UserID, and Password instantly sent out by each device over an infrared link. When that happens, a handshake string (the ActiveConection string) is sent back from each receiver to establish an ad hoc network connection with the new device (i.e., an ad hoc setup of an inter-personal area network, inter-PAN). The new device is added to the interaction history, which is a list of all Recordsets, for the clients as well as automatically reflected on the Web servers running on each client, which is the Source part of the ConnectionObject (Table 1). In this way, the server reflects the history of a clients' ConnectionObjects that is used to identify and retrieve information about which devices are close to each other (e.g., who is having a collocated meeting), building up the individual interaction histories, and for the ad hoc establishment of the inter-PAN.

In the next section the implementation of the RoamWare system is described followed by a full description of how the three subsystems (RoamList, RoamWeb, and RoamLines) were implemented.

Implementation

In the current implementation, RoamWare provides mobile support for personal computers and is built on top of the TCP/IP suite of protocols. The PC client part of the system has been implemented on several notebook PCs and a subnotebook PC, all of which have built-in infrared ports and IEEE 802.11b wireless LAN PC-cards. The client application on the PC (RoamList) runs on the Windows 98 operating system and uses Windows' own drivers for infrared (IR) communication and TCP/IP for Internet communication. However, just to be notified by the others during a physical face-to-face meeting, almost any IR-equipped device can be used. In this project, a wide variety of devices were used for this purpose (i.e., mobile phones with IR ports, various kinds of PDAs, notebook PCs, and subnotebook PCs) (Fig. 2).

The RoamList client has been implemented in Object Pascal, while RoamLines has been implemented in Java.

The following gives a more detailed description of the three subsystems RoamList, RoamWeb, and RoamLines.

RoamList: Private Interaction Histories — The RoamWare system uses IR communication (IrDA) to automatically detect the participants in proximity during a collocated meeting. For every identified device, the ID number (i.e., the UserID part of the ConnectionOject) is used to associate a handheld device (e.g., another notebook, a PDA) with the name and e-mail address of its owner. If an unknown device is detected, the system provides the user with the opportunity to add that device to the interaction history by typing in a name and his/her e-mail address. The system only adds people to the list when the list indicates a meeting is in progress. This avoids unwanted persons being added to the interaction history even if no interaction has taken place (e.g., passing someone in the hallway who also has the system running). The name is added to the interaction history list with a pointer to the correct e-mail address (Fig. 3).

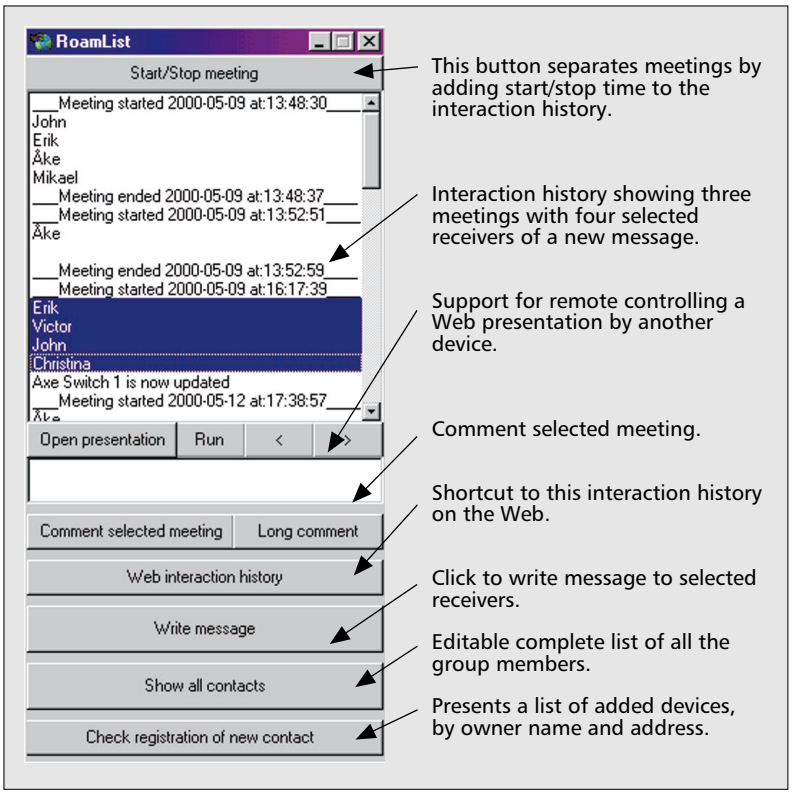
As seen in Fig. 3, a meeting can be selected to send a group message to all participants of a certain meeting. A meeting can also be *inverted* so that a message can be passed to everyone in the group that did *not* attend a certain meeting. Of course, participants can also be selected from different meetings as well as from the list of the whole group (the "Show all contacts" button in Fig. 3). RoamList also has some extra features to support meetings held in ordinary meeting rooms. In the PC version of RoamList, a participant can connect the notebook to a projector and then control a presentation with any device supporting the IrDA standard (e.g., a mobile phone or PDA).

RoamWeb: Public Interaction Histories — Reynold [15] has stated: *"Perhaps users could be portrayed in a communication space as public (visible to others) and private selves. Users could browse another person's public appearance or 'introspect,' that is, view their own private and public representations."*

We believe that the implementation of RoamWeb is one way of doing this, to support both physical and virtual appearances. How we did that is outlined below. For dispersed group members, the RoamWeb system provides mobile groups with meeting information by automatically reflecting interaction histories generated by the RoamWare system on the Web. Figure 4 shows a Web mirror of a personal interaction history generated by a RoamList client.

The interaction history published on the Web is an exact HTML copy of each client's interaction history list. The Web interaction history can provide synchronous as well as asynchronous information to other group members. As soon as a person takes a note and his/her client is set to public mode, which is easily implemented by adding a <PUBLIC> comment to the interaction history, the RoamList client automatically reflects the content to the Web. Private comments were imple-

Figure 2. *The diverse set of devices used in this project.*

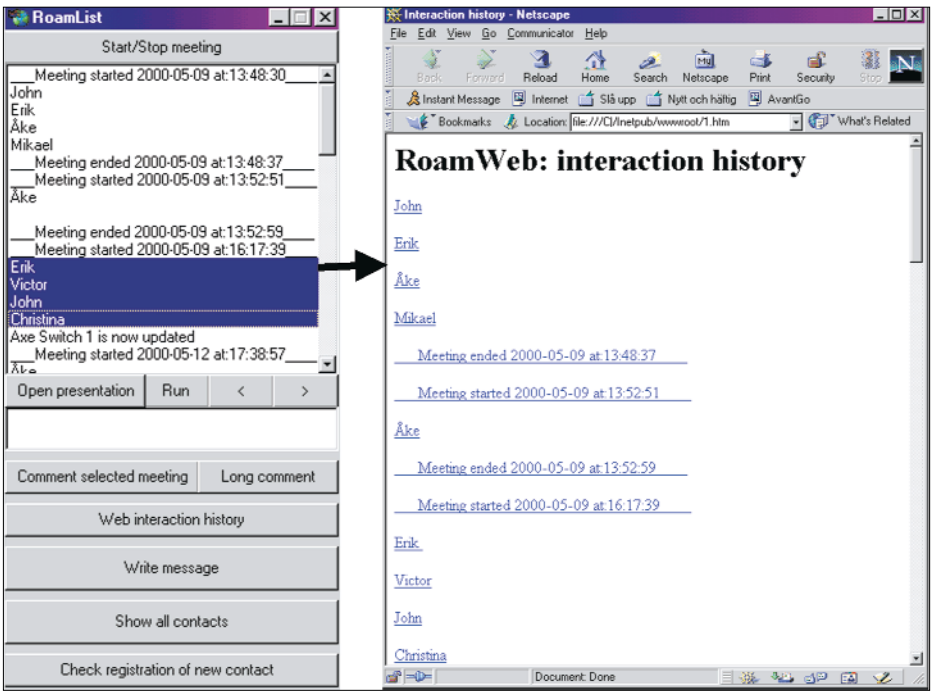


■ Figure 3. *A screenshot of the RoamList client.*

mented the same way (i.e., <PRIVATE>) A remote person can then easily follow the meeting over the Web and see notes taken, issues discussed, and persons joining the meeting.

The content is automatically updated through a <meta http-equiv refresh> HTML tag that reloads the Web page continuously. Furthermore, RoamWare supports publishing of Web interaction histories from *persons*, *roles*, and *places*. For example, a PC running RoamWare can be placed in an ordinary meeting room. This way remote participants can browse the Web and see who has currently joined a certain meeting and follow notes being taken. For example, by restricting the access to, say, board rooms, the board members can easily take part in meetings even if they are away or on the way.

As Fig. 4 illustrates, other group members can navigate another *person's* public interaction history over the Web and contact the persons who are participants of a certain meeting. The names of the participants on the list are linked to an e-mail application (i.e., are mailTo: HTML links), so contact can easily be established. Of course the publishing of the list is optional in order not to conflict with integrity aspects of the work. In the same way *roles* can be customized for Web publishing (e.g., group leaders, secretaries). In this way group members can virtually follow notes taken during physical face-to-face meetings and follow who has attended (or are currently attending) a certain meeting.



■ **Figure 4.** *A public mirror of an interaction history.*

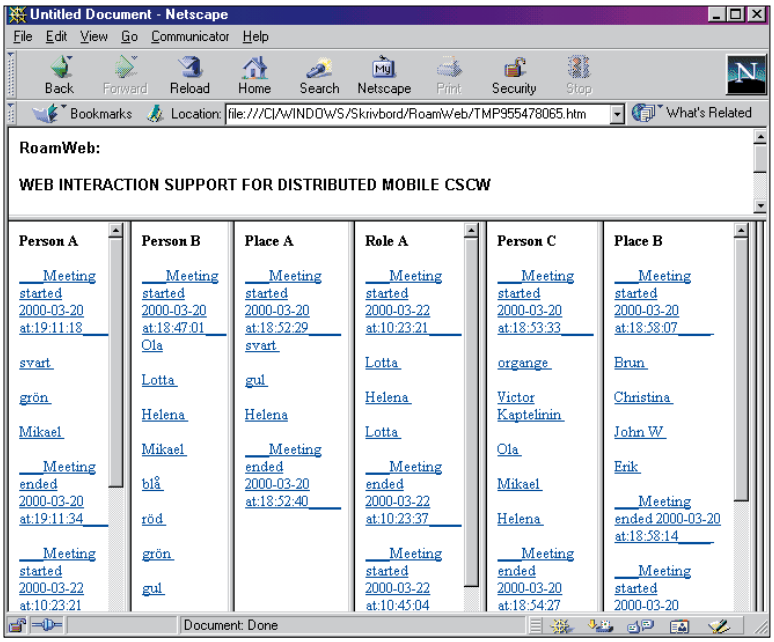
At the RoamWeb Web site, navigation of all interaction history lists (including persons, roles, and places) are provided on a single Web page, thus making it possible for the user to get an overview of all current and past activities of the group by just a glance at the site (Fig. 5).

In short, RoamWeb provides a collection of all clients' interaction histories generated by the RoamList client to provide an overview of the group's current and past interaction.

RoamLines: Overview of Threaded Meetings — Finally, the RoamWare system also contains the RoamLines subsystem. RoamLines provides group members with visualizations of different threads of interaction among the members of a mobile group. RoamLines supports querying the system about topics such as who has been to which meeting, who was absent, who has discussed a specific topic (possible to see if notes about the meeting have been added in the RoamList system), and so on. The queries are made of basic Boolean expressions (e.g., and, or, not). The results of the queries are graphically visualized as threads of chronologically ordered meetings where each meeting has boxes with meeting attributes attached to it (participants, time, date, notes, etc.).

Figure 6 shows an example of such a thread. A query has been made about meetings in which Erik as participated. The query is stated in the Threads Navigator, and the result is presented above as threads of meetings with associated participants. The meetings are chronologically ordered over time starting with the X box, which represents the current time.

As seen in Fig. 6, group member Erik has been to three meetings. The most recent one in time was with Mikael, and the topic was an "Axe Switch." RoamLines uses the rubber



■ Figure 5. *A group's public interaction histories.*

band technique [16] to graphically separate the items in space and connect the meeting objects and attributes chronologically. This technique gives the visualization the dynamic needed to represent different threads of interaction evolving through personal face-to-face interaction over time. This technique also provides the user with support for arranging the threads any way they want, very directly.

In the next section a use case is outlined to describe the general use of the three subsystems of RoamWare.

Use Case

The use case below summarizes the functionality of RoamList, RoamWeb, and RoamLines as presented earlier according to activities performed before, during, and after a meeting:

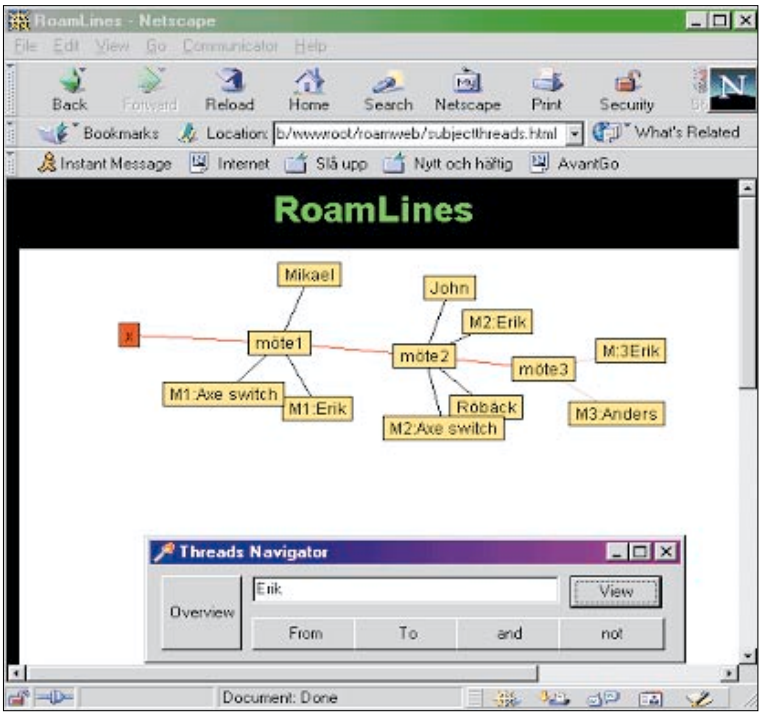
- *During* a face-to-face meeting every group member has an IrDA-equipped device. The devices recognize each other during the meeting, and each device adds the current meeting and the participants recorded to a *personal interaction history*. The interaction history contains information about the meeting date, start/stop time, participants, and notes taken during the meeting (RoamList).
- *After* a face-to-face meeting a participant can choose to continue a discussion virtually by just selecting the meeting from the interaction history. In the current implementation of RoamWare, the discussion continues over e-mail, but other solutions that have been considered include group calls, chat rooms, and support for group videoconferencing on small mobile devices (RoamList).
- *During* a face-to-face meeting remote participants can virtually follow a meeting over the Web by the interaction histories and take part in the meeting by calling group members or sending them e-mail notifications. A remote participant can also search or browse through other current or past meetings to find notes and related people of importance concerning an important topic (RoamWeb).
- *Before*, *during*, and *after* each meeting people have to plan and make priorities about where to be physically. RoamWare makes it possible for mobile workers to better choose between taking part physically or virtually. This is done by making the personal interaction histories public to the group over the Web. RoamWare makes the interaction histories searchable and easy to browse through graphical visualizations of meetings. In future versions of RoamWare, we also plan to include a feature for announcements of new meetings.

How RoamWare Meets the Requirements

In this section we try to, given the current implementation (as discussed earlier) and the use case presented above, summarize how RoamWare meets the requirements previously outlined.

Implicit Establishment of Meetings — RoamWare supports the implicit establishment of meetings (i.e., the automatic establishment of an inter-PAN) to the extent that people can spontaneously join a meeting and automatically be recognized by use of infrared links. However, the user must push the start/stop meeting button to separate different meetings and avoid meetings being generated even if there is no interaction taken place (e.g., passing by someone in the hallway). So far RoamWare does not support identification of dispersed participants so that they are added to the interaction history. Rather, that is handled by additional applications for collaboration (e.g., e-mail systems, ICQ [http://www.icq.com], shared workspaces, chat room).

Fluid Maintenance of Meetings — Today, RoamWare only monitors people joining meetings (when the participants aim their devices towards each other), not how long they stay or when they leave. To really make this transparent, we have considered user monitoring using short-range radio technologies (e.g., Bluetooth wireless technology) as an alternative.



■ Figure 6. *Threads of meetings in RoamLines.*

Concerning the fluid maintenance of meetings, we believe the interaction histories created are useful for users so that they can "split the use" instead of their attention. For example, quick notes can be taken during meetings where the focus is on the interaction and the participants. Afterward, these notes can be reformulated and distributed easily by just selecting the recipients from the interaction history.

Ad Hoc Meeting Distribution — Due to RoamWeb and RoamLines, RoamWare provides the user with support for following a certain meeting from a remote location. Since a meeting can be traced based on a topic or constellation of people instead of just related to a person or place, it is easy to maintain interaction even if the situation changes, for example, when someone has to leave. All of this is handled by each client's ConnectionObject as described earlier.

Easy Access to Spontaneous Meetings — Today all incoming interaction to a collocated meeting is handled through other technologies (e.g., e-mail systems, mobile phones, chat rooms). However, in future versions of RoamWare we plan to include this in the interaction histories as well. Besides this, the meeting distribution mechanisms of RoamWare make it easy for dispersed persons to find a good way to get in contact.

Meeting Priority Support — Finally, RoamLines meets the requirement to create an overview of all meetings, both current and past. This makes it easy for the user to get a quick overview of the group interaction, decisions made, questions raised, and so on.

Related Work

There have been several attempts to support mobile collaboration at physical meetings with multiple PDAs. However, all of them focus on using the devices during a meeting instead of using the ad hoc setup of multiple collocated PDAs as a lightweight way to provide meeting support to collocated and dispersed group members both during and after meetings. Myers *et al.* [17], for example, use a set of multiple PDAs using the Palm OS, connected to a PC. However, their research focuses on how to use these devices *during* meetings rather than as *bridges between* physical face-to-face and virtual meetings. Another attempt is the NotePals system [18], a collaboration tool that runs on several PDAs using the Palm OS. However, this system supports sharing of notes on the Web taken on PDAs *during* a meeting rather than using the PDAs as *bridging devices* for later physical or virtual meetings.

There have also been attempts to use small devices for *user monitoring*, for example, Active Badges [19] that support location tracking, and Hummingbirds [20] that support groups with presence awareness. However, none of these uses information collected by the devices as *interaction histories*, which can be used later to reestablish interaction.

Another prototype developed related to RoamWare is the "Forget-me-not" system [21]. "Forget-me-not" shares several requirements with RoamWare (e.g., sensing the user's environment and automatic data capture of location of events, people present during events, and focus of the event). However, "Forget-me-not" was developed as a personal memory aid, whereas RoamWare is developed for collaborative use.

Concerning the RoamLines system there have been some attempts to use threads for information visualization. Gutwin and Greenberg [22] use threads to provide workspace awareness, and Whittaker *et al.* [23] use threads for visualizing lightweight interaction in the desktop. However, none of them has explored the use of threads for visualizing threads of ongoing and mobile face-to-face interaction.

Conclusion

This article contributes to the current body of research within human-computer interface and CSCW by demonstrating RoamWare as a novel way of using a diverse set of wireless mobile devices as Inter-PANs *to support ongoing interaction for mobile workers* across physical and virtual arenas. The RoamWare system in its current implementation is especially useful for work organizations where:

- The work typically involves face-to-face spontaneous meetings.
- Group members are mobile and dispersed.
- Topics are discussed over some period of time through both physical (i.e., face-to-face) and virtual/computer-mediated interaction (e.g., e-mail).

Typical work of this sort is, for example, office work and the work setting of field service engineers.

SupportING *ongoing* rather than *separated* sessions of interaction opens up new interesting areas of research concerning how to seamlessly integrate other communication and interaction technologies into ongoing sessions of interaction across physical and virtual arenas. Finally, this research contributes to research on session management models for CSCW systems by illustrating a way to implement sustained and dynamic session management as an alternative to the common view of managing sessions as an act of separating sessions in time and place through establishing, maintaining, and finishing sessions. This opens up new interesting questions concerning how to help users to easily choose between, and negotiate their participation in, different threads of ongoing interaction.

We believe that RoamWare has several novel advantages over traditional e-mail systems, especially:

- Showing how physical meetings can be used as contact lists (interaction histories) to reestablish interaction as a virtual meeting
- Connecting a physical meeting to a virtual representation, thus making it possible to follow from a remote location, and virtually comment and contact its participants
- Providing a unifying overview of group members' interaction histories, thus helping a single user get in contact with the right recipients for a specific message
- Providing an overview of threads of interaction according to meetings held among group members

Future work includes the development of RoamWare as a commercial product, which may ensure its relevance and usefulness. For this work, PDAs equipped with Bluetooth wireless technology and IEEE 802.11b WLAN technology running the Windows CE operating system will be used. The RoamList client will be implemented using embedded C++ for Windows CE. Further research also includes user studies and evaluations of how RoamWare supports and influences group collaboration. Especially, focus will be directed toward the role of mobile meetings in work processes and how these informal meetings can be integrated in explicit decision and knowledge sharing processes.

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