Close Encounters: Supporting Mobile Collaboration through Interchange of User Profiles

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Abstract. This paper introduces the notion of *profile-based cooperation* as a way to support awareness and informal communication between mobile users during chance encounters. We describe the design of *Proem*, a wearable system for *profile-based cooperation* that enables users to publish and exchange personal profile information during physical encounters. The *Proem* system is used to initiate contact between individuals by identifying mutual interests or common friends. In contrast to most previous research that concentrates on collaboration in well-defined and closed user groups, *Proem* supports informal communication between individuals who have never met before and who don't know each other. We illustrate the benefits of profile-based cooperation by describing several usage scenarios for the Proem system.

1 Introduction

During the course of a day we encounter and meet a large number of people, some of whom we know personally and some of whom we never met before. In everyday language we use the verb "to meet" to describe many different situations. To meet someone can mean to have a face-to-face conversation or to be introduced to someone. On the other extreme, it can simply describe a situation where we are in someone's physical presence without communicating. In contrast to a meeting, an *encounter* describes a situation where we meet someone unexpectedly, for example in a hallway or an elevator. Such an encounter with another person is a chance for striking up a conversation and for exchanging information. It has been realized that unexpected and unplanned encounters between co-workers play an important role in collaboration and coordination of work activities.

Encounters can also be virtual. Visitors can encounter each other in virtual-reality environments and online chat rooms. Similarly, web-based on-line communities like SixDegrees [SixDegress 1999] support the notion of co-presence by informing visitors who else is online. Often, online communities require members to describe their online personality in form of user profiles, a more or less truthful description of who they are or want to be, what they like and what they don't. By giving users access to other members' profiles, online communities are able to foster communication between users who have never met before in real life. In this way,

encounters in virtual worlds or on the Internet can serve a purpose similar to real-world encounters: they promote informal communication by increasing awareness and they are a chance for one-on-one conversations through direct messaging.

Today's mobile technology provides the means to apply the concept of user profiles to real-world encounters between individuals. On the one hand, there is a rapidly growing acceptance of palm-size, handheld and wearable computers, and on the other hand there is the imminent arrival of ubiquitous wireless communication. Based on this background we investigate how the concept of user profiles and online identities can be used to support cooperation during physical encounters of individuals who congregate in groups or large crowds, such as at indoor/outdoor meetings, conferences, and trade-show events.

This paper introduces our notion of *profile-based cooperation* as a way to support awareness and informal communication between mobile users during chance encounters. We also report on the design of a mobile system called *Proem* that we are building as a testbed for our ideas. Proem provides the infrastructure for mobile users to publish and exchange personal profile information during physical encounters. Proem can be seen as an extension of the Inter-Personal-Awareness Device (IPAD) idea introduced by [Holmquist 1998; Holmquist et al 1999] and exemplified by the Hummingbird mobile device.

In the following sections, we will introduce our concept of *profile-based cooperation* and describe the design of the Proem system.

2 Profile-Based Cooperation

We are interested in the question of how mobile devices (handheld and wearable devices) can be used during chance encounters to support cooperation. In particular and in contrast to most previous research, we are interested in how mobile technology can be used during *encounters of people who have never met before and who don't know each other*. We have developed the notion of *profile-based cooperation* as a means to support awareness and informal communication between mobile users. Our idea is based on four fundamental concepts:

1. *User Profile*: a collection of personal data stored on a mobile device that describes the user.
2. *Encounter*: a situation of physical proximity of two or more individuals.
3. *Profile Exchange*: the transmission of personal data between two or more mobile devices during an encounter.
4. *Rules of Encounter*: predefined behaviors that are triggered as side effect of a profile exchange.

We will now discuss these concepts in more detail.

2.1 Profiles

A profile is a description of an individual – his or her personal tastes, interests, expertise, and opinions. What is and isn't in a profile depends on the specific context. A profile is defined by the individual that it describes with the express purpose of sharing this information with others, friends as well as colleagues and strangers. A

profile can contain any information whose exchange with others might be beneficial to either the sending or receiving party.

Typical information that could be part of a profile includes: name and address; phone, fax numbers and email addresses; company affiliation; calendar information and appointments; a list of to-do tasks; a list of friends and relatives; health-related and emergency information; a list of the user's favorite web sites; an assumed name or user id; a collection of favorite poems; classifieds the user placed in last week's newspaper; the title and author of every single book the user owns; model and year of the user's car; a list of favorite recipes; a list of the user's publications; keywords indicating the user's research interests.

A profile is similar to a vCard [vCard 1996] in that it is intended for automated exchange of personal data. But a profile goes beyond mere contact information and may include a much more detailed description of the user.

In order to make sense of profile information, users must share a common understanding of the types of information contained within profiles. Users must agree on the meaning and purpose of an attribute such as `interest`, or else they can not successfully exchange profile data.

Profiles should be extensible: individual users should be able to add additional information categories at any time. This requires a semantic foundation for profiles that is similarly flexible.

2.2 Encounters

The purpose of maintaining a profile is to exchange it with other users during an encounter. We define an *encounter* between individuals as a situation

1. where these individuals are in close physical proximity to each other,
2. the mobile devices of these individuals have discovered each other's presence and
3. these devices are able to communicate.

This definition does not say anything about how devices discover each other, nor how close they have to come in order to do so. Many different technologies have been used in the past for discovering nearby devices, including infrared transmitters and near-field radios. Similarly, this definition does not say whether discovery and communication are independent functions or can be combined into one, as would be possible with wireless ad hoc networks, future short-range wireless networks like Bluetooth and Home RF, or Personal Area Networks [Zimmerman 1996].

Encounters have several important properties:

- Encounters can occur between two or more individuals.
- Encounters are asymmetrical: it is possible that user A encounters user B, but not vice-versa.
- Encounters are situations with a time duration, not momentary events: encounters can be short, lasting only a few seconds, or they can be long-lasting, going on for hours. For example, the encounter between two individuals passing each other in a hallway might last just a few seconds. On the other hand, two or more people in a lengthy meeting encounter each other for the full duration of that meeting.
- Encounters are nontransitive: if user A encounters user B, and users B encounters user C, then user A does not necessarily encounter user C.

- An encounter occurs even if no data is transferred between the involved parties.

2.3 Profile Exchange

An encounter between individuals is a chance for an exchange of profile data. There are two parties involved in an exchange: the *owner* is the individual who is described by a profile*;* the *reader* is any individual who accesses another user's profile.

We define the following principles for the exchange of profiles:

- *Owner control*: access to profile data should be controlled by its owner; that includes control over what information to include, with whom to share it, and when to share.
- *Reader selection*: dissemination of profile information should be controlled by the reader, not the owner. In other words, profile data should not be pushed onto devices of unsuspecting users, but required to be pulled by readers.
- *Reciprocity*: owners should be able to restrict access to their data to individuals which themselves are willing to share their data.

Other requirements we see as important are:

- Support for multiple privacy levels with the effect that owners are able to deny strangers access to data which they are willing to share with friends.
- Support for anonymous as well as authenticated exchange: on the one hand, users who wish to do so should be able to hide their true identity, using an assumed identity instead. On the other hand, trusted and secure exchange between authenticated parties should be supported as well.

2.4 Rules of Encounter

Every day we meet and encounter so many people that it wouldn't be viable to manually scan profiles of all these people in the vague hope of finding some bit of information that catches our interest. Our concept of profile-based cooperation thus contains as integral part the notion of software agents that on behalf of the user scan profiles for user-defined patterns. These agents not only should know what to look for, but also what to do once they discover it. Such software agents embody 'rules of encounter' between individuals.

The tasks these agents perform can range from very simple ones to very complex ones. Agents could inform the user that something interesting has been found, they could collect data over a longer time period or they could even perform automated negotiations with agents of other users. Some simple examples include:

- "Alert me when I meet a friend of mine."
- "Alert me when I meet someone who sells an IBM PC110."
- "Alert me when I meet someone who went to my junior high school."
- "Save a record of everyone I meet who is interested in wearable computing."

2.5 Usage Scenarios and User Benefits

In order to highlight the benefits of publishing and exchanging profiles we introduce the following three usage scenarios:

The first usage scenario is a scientific conference or trade show where encounters between people who don't know each other occur often. Typically, at a conference or workshop we only know a handful of people personally, have seen or informally met a large number of other people, but have never met nor spoken to the majority of participants.

The second usage scenario is a swap meet, a flea market-like event where people come together in order to buy and sell rare and unusual items. One of the difficulties of swap meets is to find the person who sells the item that one is interested in.

The third usage scenario is a meeting between a small group of people, such as a visit to a construction site by architects, contractors, and owners.

In these scenarios profile-based cooperation can occur in a variety of ways. A device that implements the functionality as described above could serve multiple purposes:

- As *awareness tool* it could enable us to know the names and company affiliations of other people in a meeting.
- As a *reminder* it could alert us to the presence of people we want to meet or talk to in person ("When I meet Howard, remind me that I need to get the key from him.)"
- As a *diary* it could keep a record of all individuals we meet during the course of a day. This could be particularly useful when we meet a lot of potentially interesting people we don't know yet, but might want to contact later on, such as during a conference or trade show ("Tell me who I met today.")
- As a *matchmaker* it could alert us to the presence of some yet unknown person we might want to meet based on a description we defined. For example, during a swap meet we could be alerted to the presence of someone who sells a precious item we have been looking for for a long time. Similarly, we could set up our device to advertise items we want to sell so that other people can become aware of us. ("Let me know if someone around here sells a head casket for a 1967 Jaguar E-Type.")

Many more uses are possible within the framework of profile-based cooperation.

3 The Proem System

To explore our concept of profile-based cooperation we are developing the *Proem*[1] system. Proem is an experimental prototype that is currently under construction. It consists of several mobile computers with access to a Metricom wireless campus-wide network and a WaveLAN wireless indoor network. We use regular laptop computers as well as wearable computers. One of them is a commercial Via wearable computer, while the other is a self-built wearable computer we constructed from components of a laptop computer (Figure 1). Both computers are described in more detail elsewhere [Bauer et al, 1998; Kortuem et al, 1998; Kortuem et al, 1999a].

[1] A 'proem' is a brief introduction.

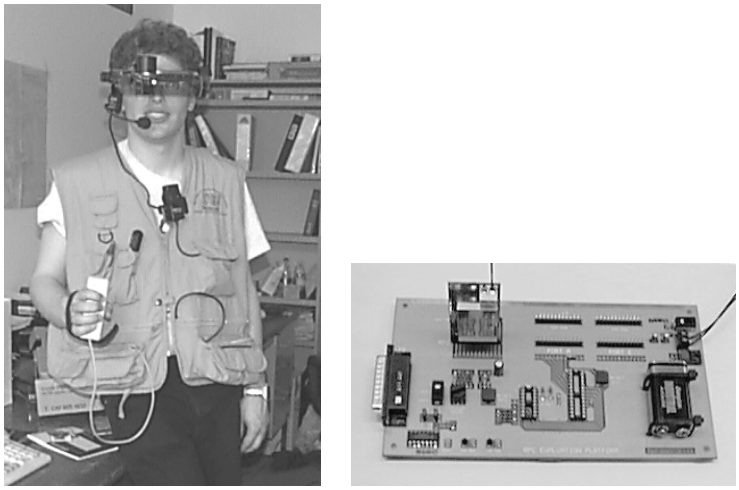

Fig. 1. Wearable Computer and Proem Radio Beacon

Each of these computers is equipped with a simple radio transmitter that sends out and receives beacon signals. These signals can be used to determine which other devices are in the immediate vicinity (the transmission range is about 6-10 feet). The radio transmitters are constructed from radio packet controllers from Radiomatrix [Radiomatrix 1998]. Figure 1 shows an early prototype without case. The final design is much smaller, fitting comfortably in a pager case including 9V battery.
Each Proem device runs software that is implemented in Java and is divided up into three layers as shown in Figure 2.

- The lowest layer is the service layer. It is based on Jini, Sun's network plug-and-play architecture [Sun 1998]. The main function of the service layer is to interconnect two devices during an encounter.
- The middle layer is divided up into three components: the profile, a profile cache for storing other user's profiles, and a rule base that contains the 'rules of encounter'

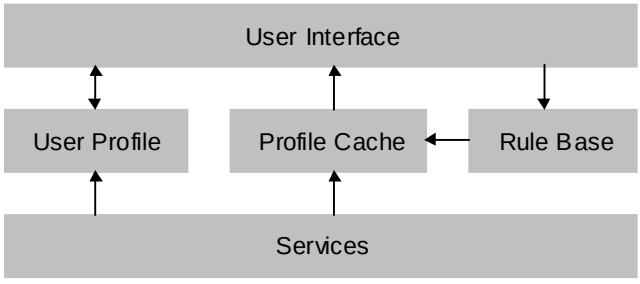

Fig. 2. Proem System Architecture

- The top layer is the user interface and contains functions for profile and rule editing.

In the following sections we will give a brief run down of the overall Proem design from a user's perspective before we explain the service component in more detail.

3.1 Profile Editor

The profile editor (Figure 3) allows users to define their profile.

The profile is a tree-like data structure containing personal information about the user. The leaf nodes of a profile are attribute-value pairs. Interior nodes represent named profile sections. Attribute values are untyped; they are either strings or comma-separated lists of strings. For example, the attribute `fullname` has a simple string value like `'James Joyce'`. The value of the attribute `interests` is a list of strings like `'wearable computing, CSCW, rock climbing'`.

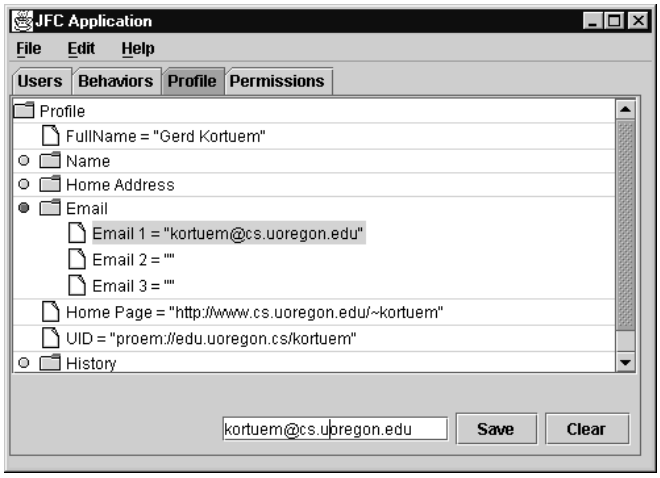

Fig. 3. Profile Editor

Several profile sections require special mentioning:

- The unique user id (`UID`) attribute stores the owner's global unique user id. We use a syntax for `UIDs` that follows the Unique Resource Identifier specification [URI98]. A `UID` is a string consisting of a protocol part, a domain part and a user part. For example, `proem://edu.uoregon.cs/kortuem` identifies the user `kortuem` in the domaic.uoregon.edu.
- The friend section of the Profile contains three separate attributes: `FirstDegree`, `SecondDegree` and `ThirdDegree`. The value of each of these attributes is a list of `UIDs` representing friends of the first degree, second degree and third degree. Friends of the first degree are immediate friends of the user. Friends of the second degree are friends of friends of the user, and friends of the third degree are friends of friends of friends of the user. The user only has to

specify immediate friends of the first degree. The values for second degree and third degree friends are automatically gathered during encounters from the profiles of friends and friends of friends.

3.2 Awareness Tool

The awareness tool is displays the names of all Proem users who are physically close (Figure 4). A time stamp counts the number of time units the respective user has been present nearby. After selecting a name from the list, the user can view or save the entire profile, or take a snap shot of everyone in the immediate vicinity.

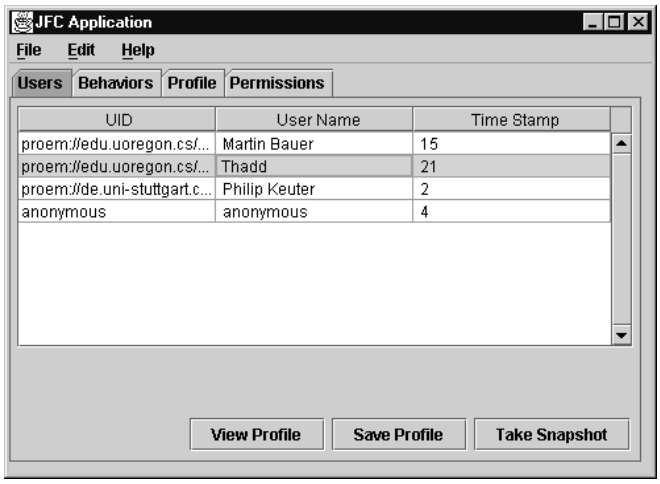

Fig. 4. Awareness Tool

3.3 Rule Editor

The rule editor (Figure 5) allows users to define 'rules of encounter', that is automatic system behaviors that are executed whenever certain conditions are met. Each rule consists of two parts. The *rule action* specifies which behavior will be executed, while the *rule condition* defines when an action is triggered. Rules are executed once for each encountered user.

The syntax for conditions is as follows:

```
<cond>  ::=  <term> <op> <term>
<op>    ::=  == | contains | is_in
<term>  ::=  <attribute> | <value>
```

The `==` operator tests for equality of two strings; the operator `contains` tests if the second argument is a substring of the first argument; the operator `is_in` tests if the first argument is a substring of the first argument.

There are two built in actions that can be used in rules: `alert` brings up a dialog box and is used to inform the user that a condition was met; `call` allows users to

specify the name of a Java procedure that will be called whenever the condition is true.

Using these simple rules, the user can define a variety of interesting and useful behaviors. The following are some examples:

- Alert me if I meet someone with my last name
  `(lastname == “kortuem” -> alert)`
- Alert me if I meet someone who sells an IBM PC110
  `(sell contains “PC110” -> alert)`
- Alert me if a meet a friend of mine.
  `(uid is_in /Friends/FirstDegree -> alert)`
- Save a record of everyone I meet who is interested in wearable computing
  `(interest contains “wearable computing” -> call “save”)`

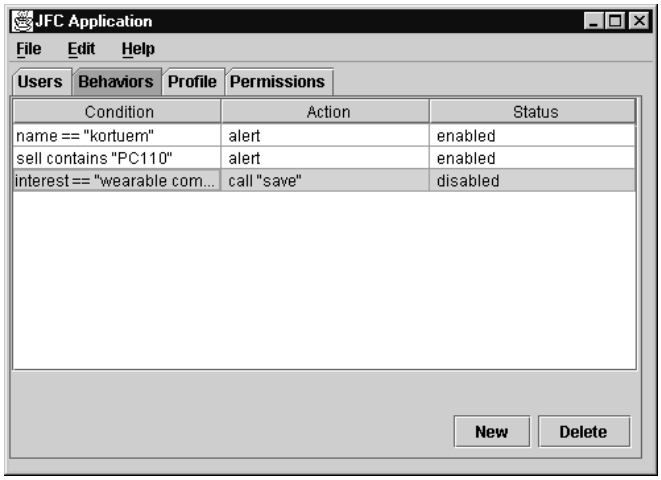

Fig. 5. Rule Editor

3.5 Device Discovery

The main function of Proem’s service layer is to give devices mutual access to each other’s profiles. Our solution for connecting Proem devices in an ad hoc manner is based on Jini, Sun’s network plug-and-play architecture. Jini provides simple mechanisms to plug devices together to form an impromptu community - a community put together without any planning, installation, or human intervention.

Each Proem device implements a Jini service ReadProfile() which when called returns the complete profile. Using standard Jini procedures this service publishes its capabilities and availability by registering a *service advertisments* with the *lookup service* which is Jini’s version of a service trader. The Service advertisement contains a *service handle* and an *offer descriptor.*

A Proem device (the client) that wants to gain access to ReadProfile() services of co-located devices (the servers) has to follow a two step procedure. The first step consists of locating the lookup services of all co-located devices. In Jini, this is done

by broadcasting a multicast request throughout a network. In turn, lookup services of all devices that receive such a request answer back to let the client know that they are able and willing to provide information about services that have been registered with them. The client now queries each device lookup service by supplying a *service template*.[2]. In response, it receives a collection of matching *service proxies*. These service proxies, which are moved dynamically across the network, are then used to call the remote services.[3]

Since users and their devices constantly move around in space, Proem devices do not form long-lasting stable configurations. Thus, having discovered a service and having gained access to it through its service proxy is not a guarantee that a service is *usable*. In between the time a service was discovered and the time a client attempts to access it, the distance between both devices might so large that they are out of range. If this is the case and the service cannot be reached, the service proxy is simply discarded.

The role of client and server as described above is not fixed. Each Proem device is at the same time client and server. Upon request each device makes its service available to other devices, and each device also requests other access to remote services.

3.5 Privacy and Security

Since profiles can contain sensitive information, there is a potential threat to individual privacy that might make Proem users wary of sharing any information. However, the Proem system can only be effective if users are willing to freely share personal data with each other. It is thus critical to address privacy and security issues.

Personal privacy can be secured by a combination of control and awareness:

- The user must be given control over the release of their information, i.e. control over which information is released to whom and when.
- The user should be aware of who accesses his or her profile, i.e. the user should be able to track the exchange and usage of their personal profile.

Our solution for privacy protection is based on a combination of *access control lists* and *user authentication*.

Simply speaking, user can protect selective parts of their profile by an *access control list*. Whether access to a section is granted depends on the contents of an access control list associated with each profile section. An access control list specifies which users have and have not access to that particular profile section. Proem knows four built-in access control lists. While the meaning of these access control lists is built-in, membership is determined dynamically:

- *Degree1* contains those users who are explicitly named in the 'Friends/Degree1' section of the profile. Thus access to a profile section with associated access

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[2] The client filters out responses from devices that are not in the immediate vicinity using the information from the radio transmitter. This step would not be necessary if we used a true short-range wireless network.

[3] The ability of moving service proxies, i.e. compiled Java code, across the network on-demand, distinguishes Jini from other static trader architectures.

```
<?xml version="1.0" encoding="UTF-8"?>
<profile version="1.0">
  <uid access="all">proem://edu.uoregon.cs/kortuem</uid>
  <fn access="all">Gerd Kortuem</fn>
  <n access="all"><family>Kortuem</family>
    <given>Gerd</given>
    <middle>Werner</middle>
  </n>
  <tel tel.type="WORK" access="all">+1-541-346-1381</tel>
  <adr access="degree3">
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             proem://edu.uoregon.cs/jay</degree1>
    <degree2>proem://edu.uoregon.cs/zary,
             proem://de.uni-stuttgart.cs/mabauer,
             proem://edu.washington.hitl/grof</degree2>
    <degree3>proem://de.uni-stuttgart.cs/peterh</degree3>
  </friends>
  <research access="all">
    wearable computing, mobile computing, CSCW,
    augmented reality, wireless networking</research>
  <hobbies access="all">rock climbing, scuba diving, soccer,
    movie posters</hobbies>
  <classifieds access="all">
    <sell>http://sar.classifiedwarehouse.com/search.cw1?t
          =2&lc=news&cat=bst&cp=atv2_&news=news_reg</sell>
  </classifieds>
</profile>
```

Fig. 6. XML-encoded profile with access modifiers (partial)

control list *Degree1* is granted only to those users who are explicitly named in the 'Friends/Degree1' section of the profile.

- *Degree2* grants access rights to all friends of friends of the user, that is, to all users who are named in the Friend/Degree2 section.
- *Degree3* grants access rights to all friends of friends of the user, that is, to all users who are named in the Friend/Degree3 section.
- *All* grants access to all users.

As explained above, the Friend/Degree2 and Friend/Degree3 attributes are updated whenever the user encounters a friend or 2nd degree friend.

User authentication is performed on the service level. The calling client has to provide its guid as first argument of each service call.

3.6 Communication Encoding

Proem profiles are encoded as XML documents (Figure 6). The internal representation of profile information on the device is left to the implementation. Different Proem implementation can use different internal representation formats for profiles.

4 Discussion and Related Work

Profile-based cooperation is a way to support awareness and informal communication between mobile users during chance encounters. Our work has precursors in many areas.

More recently researchers have started to understand how important informal communication and awareness is for effective workplace collaboration. Several researchers [Dourish and Bly 1992, Greenberg 1996, Tollmar et al 1996; Whittaker 1994; Whittaker 1997] investigated the role of informal communication in office settings, while others [Belloti and Bly 1996] studied the same question in settings where people are mobile within an office. Most of this work, however, focuses on creating awareness between people who know each other, for example co-workers. In contrast, our work is motivated by the question in how mobile technology can be used for awareness and informal communication between people who have never met before or don't know each other very well.

At first look Proem fits the description of an Inter-Personal Awareness Device (IPAD) laid out in [Holmquist 1998;Holmquist et al 1999] and exemplified by the Hummingbird. It can initiate contact between individuals – for example by identifying mutual interests or friends, but it is not used for a sustained actual communication. Like the Hummingbird, Proem devices are not designed to carry on sustained communication or to replace actual face-to-face conversations. Proem, however, differs from Hummingbirds in several respects. Most importantly, Proem supports informal communication between individuals who have never met before and who don't know each other. Hummingbird only supports inter-personal awareness among members of a well-defined and closed user group. In that respect, Proem is similar to the Lovegety [Iwatani 1998], a popular Japanese toy that functions as matchmaker between users of the opposite sex. The success of the Lovegety is a hint that anonymous exchange of preferences and interests can be useful even on a relatively shallow level.

More elaborate profiles have been used in the Groupwear system that is based on interactive nametags (called "thinking tags") that assist conversation between people by informing users how much they have in common with regard to a set of precompiled background information [Borovy 1996; Borovy et al 1998a; Borovy et al. 1998b]. Our concept of profile-based cooperation differs from Groupwear in two

important respect. First, GroupWear requires and supports only face-to-face conversations while Proem allows two users to exchange their profiles whenever they are physically close, regardless of whether they talk to each other or not. Second, Groupwear relies on a predefined profile structure. Users have no real control over the content of their profile, they cannot change it or add to it, nor can they decide to hide certain information from other users.

One of the most important differences to the works quoted above is Proem's ability to create a record of the user's encounters. As such Proem is less of an awareness device than it is a memory aid or electronic diary. Thus Proem's function extends well beyond the actual time of an encounter. Whether or not two users' preferences match can be determined well after the actual encounter occurred. Users might or might not have been aware of the data exchange at the time it happens.

Another source of inspiration for our work was the growing body of research on web-based online communities and personalized delivery of web content. The Open Profiling Standard (OPS) introduced by Firefly defines a framework for the trusted exchange of profile information between a web site and its visitors [Firefly 1997a;Firefly 1997b;Firefly 1997c]. The Firefly Passport is an individual's trusted identity and personal profile that stores information about who people are, what people like, and what they don' t. OPS emphasis on trust and security reflects the primary intended application of OPS, which is e-commerce. Our domain of interest does not seem to require the same level of trust and security. We see, however, a need to provide ways to grant or deny access to a profile section based on the readers identity. For example, most people do not want to give out their address to anyone who happens to pass by, but they might not care whether a friend or colleague gains access to it. Similarly reservations can be expected for other types of information as well.

5 Conclusion

In the preceding sections we have done two things: we have laid out a framework for what we call *profile-based cooperation* of mobile users, and we have described the design of *Proem*, a system that exemplifies some of our ideas. We see profile-based cooperation as a way to support awareness and informal communication during chance encounters of mobile users who have never met before or don't know each other very well. We discussed some principles such as *owner control*, *reader selection* and *reciprocity* that we believe should guide the exchange of profile data.

While the first experiences with the prototype are encouraging from a technical point of view, we have limited insight into the social issues of exchanging personal profile data. A systematic evaluation is made difficult by the limited availability of the current system and the small size of the user population.

We are now pursuing continued research in the directions discussed in this paper. In particular, we investigate the use of negotiation protocols for further automating the exchange of profiles [Kortuem et al, 1999b].

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