THE HOCMAN PROTOTYPE - FAST MOTOR BIKERS AND AD HOC NETWORKING

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Abstract. We introduce Hocman, a mobile HTTP peer-to-peer application, which supports social interaction among motorcyclists. The system enables sharing of multimedia content, such as HTML documents, audio clips and images over ad-hoc networks. The design derives from requirements found in an ethnographic fieldwork on motorcyclists. Our understanding of speed, the vast setting and collaborative activities contribute to the design of the system architecture. We have developed a rapid mutual peer discovery algorithm, to enable data sharing under these circumstances. We prove the feasibility of our approach by testing the technical performance of the application.

1. Introduction

Biking is chiefly pursued as an entertaining leisure activity with social connotations. Bikers like to spend time with, acquainted as well as unacquainted, bikers. It is a visual practice where it is important to be seen and to observe others, which take place anywhere along the public road network. The vast territory makes it difficult to encounter and forces bikers to organise driving in order to see each other.

We demonstrate the Hocman prototype, which is a peer-to-peer application for handheld computers. It accomplishes the difficult task of sharing HTML documents, images and audio clips over wireless ad hoc networks during brief meetings. The prototype prolongs social interaction as it occurs during short moments of eyesight, during contingent meetings in the physical world. To enable data sharing in this mobile setting we developed an algorithm for rapid mutual peer discovery. Further, it supports pre-planning of such moments, to increase their likeliness, by using data grabbed during physical encounters. This data supports the user when interacting with each other through other media such as the web or mobile phones.

We argue how the prototype meets requirements derived from ethnographic fieldwork presented in earlier papers [7, 8], and test its technical functionality. In the next project phase, the prototype will be evaluated from the users' point of view.

The paper is outlined as follows. First we account for the design requirements based on current biker practices. Second, we describe the architecture of our solution, and discuss how it meets the requirements. Then follows a section describing the technical implementation and how we addressed the problem of establishing network communication during mobile contingent meetings. Finally, we present a test showing that the implementation is a technically feasible approach that meets the bikers' requirements.

2. Requirements

Our project aims at inventing a service for motor bikers, based on mobile information and communication technologies. This section describes requirements derived from empirical and ethnographic fieldwork [14] among motor bikers during the summer 2001 [7]. The sub-sections are concluded with a concise design-requirement.

2.1. Added value

Motorcycling is a popular and highly mobile activity where people spend a considerable amount of time on the roads mostly to enjoy themselves. Bikers appreciate the strong tactile experience given by the roar and vibrations of the engine as well as being exposed to wind and weather. They spend time on the road to experience the feeling of acceleration and the centrifugal force when taking turns. To bikers, biking is a positive and entertaining experience. In many cases, bikers hit the road just for the pleasure of being there. They do not use the roads solely to transport themselves from one point to another.

The service should augment the experience of driving or get them to drive even more, rather than rationalizing their movement in order to decrease travel time.

2.2. Social interaction

A part of the pleasure comes from riding in the presence of other motor bikers i.e. engaging in social interaction. Due to the high speed there is not time for prolonged or even brief conversations during the swift encounters on the road. The possibilities for direct interaction with each other are scant and restricted to gestures; honking the horn; flashing the lights etc. Instead, the interaction between them concerns more indirect and superficial matters. The bikers have the possibility for brief visual interaction, e.g. to impress other bikers with one's choice of bike and its details, or with one's personal equipment. Occasionally they show off by performing tricks such as balancing on the front, or rear wheel. However, it is difficult for bikers to account for what they have seen in a moment of brief social interaction, due to high speed.

Motorcycling would be more fun if moments of visual interaction between fast moving bikers were sustained a bit longer

2.3. Identification

During the encounters they also look for icons and messages on the clothing, as well as characteristic features of the bikes to identify the other person. It is important to correctly identify a biker in order to give credit, or to place him or her in a specific group.

Biking would be more rewarding if there was better means of acquiring knowledge about other bikers

2.4. Heterogeneous user group

Biking is an activity open for anyone with an appropriate driving licence and money to spend on a bike. Thus, people that populate the roads vary in preferences, competencies, interests etc.

The service must be loosely integrated with specific user's needs and fit various people in order to achieve a critical mass of bikers.

2.5. Invitation for joint rides

Biking is a social activity that takes place on the public road networks. Bikers cherish meetings with other bikers. However, the chances for social interaction with unacquainted bikers are rather low since the roads constitute such a vast public place. Moreover, even if a biker wants to meet someone acquainted it is still improbable to randomly come across that person. As a consequence, the bikers have developed many ways to increase the enjoyable social interaction.

They organise large public events, where lots of bikers move together in the same direction. Additionally, they move around a selected site at specific occasions, e.g. gatherings at traditional meetings places occurring on a weekly basis. Generally bikers are not satisfied with this alone. They use other means of increasing interaction, such as mobile phones and web-message boards e.g. to plan gatherings of smaller groups. Mobile phones are useful, but only if you know whom you want to reach. Furthermore, using mobile phones on an open invitation basis to establish a group discussion is very difficult. The web-message board, on the other hand, is a useful public medium to post such invitations. However, it is an asynchronous message exchange, which makes it difficult to negotiate the activities. Discussions are lengthy, occasionally spanning several days, and participants are not present all the time. Consequently, all participants are not aware of the decisions taken during the discussion. Since the message board is public, much confusion is also caused by different interests and situated practices among the participants.

It would be easier and more interesting to set up physical meetings, through other prevalent electronic media such as the web or mobile phones, if the people invited to negotiate joint biking where selected among those that had a history of previous encounters

2.6. Simultaneous activities

Driving is a physically demanding task that demands most of the biker's attention. However, biking encompasses other activities, such as when the driver is standing still or walking around. This is the case for example during gatherings or during a short stop at a petrol station.

The service must account for variations in user attention during different modes of biking.

3. The Hocman architecture

Based on the requirements, grounded in empirical fieldwork, the implementation consists of the following architecture. The Hocman prototype is an application for handheld mobile devices equipped with wireless ad hoc networking interfaces. It uses a peer-to-peer architecture to accomplish sharing of HTML documents with peers in the immediate proximity during opportunistic meetings. There are two matters to consider in order accomplishing sharing between peers in traffic. The first is mutual discovery. Such process must operate timely, since it is often the case that users only stay co-located for short periods of time.

We have developed an algorithm, called rapid mutual peer discovery, which accomplish this. The second is transferring data between peers. We use a limited implementation of the HTTP protocol to enable data transfers. Also, the architecture supports two modes: cruise mode and browse mode. Cruise mode is an automatic downloading and logging facility intended for situations when the motorcyclist focuses on driving. Browse mode is a manual HTML browser for other occasions.

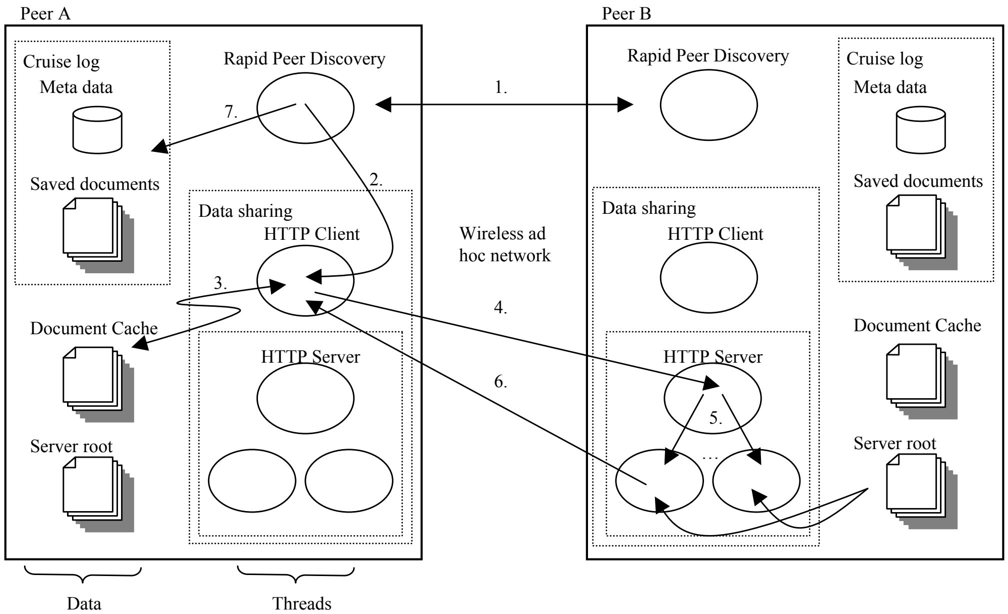

Figure 1. The Hocman architecture.

Figure 1 demonstrates the architecture and the cruise mode:

1. Peer A discovers Peer B through the Rapid Peer Discovery Algorithm. A sound icon is played.
2. The peer discovery thread of Peer A dispatches a requests to the data sharing module. The intention is to download the index-page of Peer B's server root.
3. The HTTP client thread of the data-sharing module inspects the local document cache for valid copies of the requested page.
4. If the requested page cannot be found in the cache, a HTTP GET request is sent to Peer B's HTTP server. Otherwise the local copy is returned.
5. The main thread of the HTTP server at Peer B receives the HTTP GET command. It dispatches the call to one of two HTTP response threads. Having a main thread and two response threads allows the server to service up to two simultaneous requests.
6. The response thread returns the document as requested. A local copy of the document is inserted in the cache. The download operation is repeated for every embedded resource (e.g. pictures).
7. When the data-sharing module returns the requested document, the discovery thread saves a local version of it and logs the event. In the local version, all references to embedded resources are re-linked to point to their cached equivalents.

4. How the architecture meets the requirements

4.1. Added value

The Hocman prototype is a collaborative application for handheld computers. It is possible for users to carry the devices with them as they see fit. Further, the services may be used unsupervised when the device is tucked away in a pocket during driving. When appropriate, it may be used explicitly e.g. a biker may inspect other Hocman peers when walking around at a large public event. Thus the service is designed to operate and provide added value to biking even when being on the move, however, it will not disturb the biking activities at hand.

4.2. Social interaction

Facilitating sharing of images and audio files prolongs the experience of visual interaction taking place during an encounter. For example, later when browsing the shared material, a biker may enjoy deepening his knowledge of some other biker. By sharing images, a user may communicate a wide range of experiences e.g. acceleration graphs and pictures of modifications. Audio clips, that contain engines roar, ambient sounds, conversations, music, also add value to this experience.

4.3. Identification

The prototype supports identification of other bikers in several ways. When entering co-location with another biker carrying a Hocman, a sound icon will be played once. The sound played tells the user that his or her Hocman peer is enhancing the meeting.

Second, if cruise mode is active in this situation a biker has a trace of it recorded in the log, together with date and time. Later on he or she may inspect the log and browse the associated pages. The HTML page associated to a particular entry in the log may contain pictures that may hint the identity of the particular biker met. The page may also contain textual information, e.g. name, nickname, or group membership.

4.4. Heterogeneous user groups

The Hocman prototype relies on HTML to encompass sharing of images, audio clips and text. Beside content HTML also allows the user to format his or her documents. The user can choose how to present him or her based on individual preferences. Bikers are differently skilled when it comes to author HTML content. However, HTML is a popular document standard and there are numerous tools, free as well as commercial, available to create and edit such documents.

4.5. Invitation for joint rides

The central functionality in the architecture is the recording of physical meetings to spark future social interaction. The discovery mechanism together with the cruise log gives accurate records of proximity events. Hence, the log constitutes a selection of the bikers a user has previously met. The contents of their pages may provide contact information such as phone numbers, ICQ number, e-mail address, that may be helpful in planning and organizing biking.

4.6. Simultaneous activities

Hocman has two operational modes, i.e. cruise mode and browse mode that fits different activities during biking. The cruise mode is highly appropriate when driving. A user can activate it and then leave it unattended. The browse mode, on the other hand, provides functionalities when standing still or walking about. A user may inspect the HTML documents as he or she sees fit.

5. The Hocman prototype implementation

5.1. Devices and networking

The prototype is implemented in C/C++ interfacing the PocketPC system API. We completed the prototype for two sets of devices: Compaq Ipaq 3660, equipped with a Lucent Orinoco WLAN card; and Symbol PPT 2700 with a built-in Spectrum24 WLAN card (Figure 2). In order to enable ad hoc communication the network cards are configured to communicate in IEEE 802.11 IBSS mode.

We believe that handheld devices equipped with WLAN cards will enjoy widespread usage in the future. Such devices will become personal accessories and be present in many and varied situations of life, and even in the pockets of many drivers. We prefer handhelds to vehicle embedded devices to stage the Hocman prototype for two reasons. First, embedded devices are too coupled to a particular vehicle. A biker's individual road use is greater than driving one single vehicle. He or she may be on and by the road in many different ways, i.e. walking, going by car or public transport. Second, handheld devices are also used "off-road" e.g. during office work. Thus, many drivers will acquire the devices needed for other reasons than road use, which making it easier achieving a critical mass of users.

Figure 2. Compaq Ipaq 3660 and Symbol PPT2700

Traffic is a highly mobile situation. High speed makes opportunistic meetings brief and the Hocman prototype must be able to act promptly on them. It requires four properties of the wireless network; a high and predictable bandwidth; networking of low delay; and a minimum range of 100 meters. This is an appropriate situation for mobile ad hoc connections over WLAN, in contrast to current and future mobile telephony (WANs) and Bluetooth networks. The transient nature of ad hoc networks implies that distributed applications cannot rely on infrastructure, such as routers or servers. However, a peer-to-peer software architecture is highly applicable.

5.2. Browse mode

Following functionalities are available when the biker is standing still. The Hocman prototype contains three displays arranged in tabs labelled: "Browser", "Peers", and "Log" (Figure 3), in order to implement the requirements. Local and remote HTML pages, i.e. other peoples' pages, are rendered under the browser-tab.

Figure 3. The “Browser” (left), “Peers” (middle) and “Log” (right) displays.

The peers-tab shows a dynamic page, displaying status information and links to other co-located peers, i.e. people in wireless reach that also are using the Hocman application. Finally, the log-tab displays a page listing links of the entries in the cruise log, i.e a history of encounters with other Hocman peers.

The browser tab shows local pages as well as remote pages. When following a link in the log-tab, the prototype switches to browser-tab and the local document associated with that link is shown. Links within this document pointing away from it cannot be followed since cruise mode only downloads the index page and its embedded resources. The index-page of the local server root is displayed in the browser-tab, when clicking on the link to "this peer," in the peers-tab. Clicking on a link to a remote peer in the peers-tab will make the application execute the necessary HTTP commands to download the index page of that peer. The document is displayed in the browse-tab.

The peers-tab displays status information, as well as current and reachable co-located peers. The status information consists of the title tag found in the index-page of the local server root. This information is visible to other peers. The status information also consists of the IP address and port number to which the HTTP server is bound. Current and reachable peers are shown in a list of links. The content of the tab is automatically reloaded whenever peers go away or come within reach.

The log tab list all entries in the cruise log. The entries consist of the date and time, and a link to the associated document. It also consists of connectivity information, in the form of IP address and port-number. The link text displays the content of the title tag of the associated document.

There are three buttons in the menu section, at the bottom-left part of the screen i.e. reload, cruise mode and empty-log. Clicking the reload button will reload the contents of the active tab. The cruise mode button activates the cruise mode, which handles the logging of proximity events. Finally, the empty-log button displays a dialog window making it possible to clear the log.

5.3. Enabling Sharing Among Fast Moving Users

Common to all peer-to-peer applications is that they need means to discover other peers. Traditional discovery protocols [5, 9, 10] assume properties of the networking infrastructure not present in mobile ad hoc networks such as fixed infrastructure, routers, name-servers. DEAPspace [11], on the other hand, is designed to establish mutual discovery among nodes in the immediate proximity in a bandwidth and energy efficient manner. However, the time to reach mutual node discovery is unacceptably long. In the Hocman prototype, we have developed a discovery algorithm that overcomes this limitation.

In order to accomplish rapid mutual discovery in a group of Hocman peers we constructed the following algorithm. Each node keeps a list of known peers. Each entry in this list contains connectivity information, such as which port that peer's Hocman application listens to and its network identifier. Each entry is also associated with a timer. The entry is removed and the corresponding peer is deemed unreachable, when it times out. At a regular interval, but slightly jittered to avoid synchronization, each peer announces its presence by broadcasting a hello message, containing the connectivity data for that peer. When receiving a hello message from a peer present in the list, the timer of the corresponding entry is reset. Otherwise, an entry is created and appended.

It takes x seconds before mutual discovery is established with a hello-message broadcast rate set to x seconds. Our solution to speed up the process is to broadcast a reply message whenever a new entry is inserted in the list. This reply message contains connectivity information of the peer that is about to send it (A) as well as connectivity information of the peer that was inserted in the list (B). When other peers receive this reply message, they check the following condition: is A unknown and is either B present in the list, or is B this peer? If so, then the receiving node can safely assume it can reach peer A and appends it to its list. However, it refrains from sending a reply message. If the condition does not hold, the reply message is ignored.

The following example illustrates the message exchange in the algorithm. Consider the case when three peers A, B, C come within wireless reach simultaneously (Figure 4.1). Assume Peer A broadcast a hello message announcing its presence. When Peer B and C receive the hello message from A they update their respective list (Figure 4.2). Assume Peer B send a reply message before C, indicating it has received the hello message from A. Peer A and C receive the reply and update their respective list (Figure 4.3). Finally, Peer C sends a reply message indicating it has received the hello message from A. Peer A and B updates their respective list on reception. No more messages are sent since all nodes are aware each other (Figure 4.4).

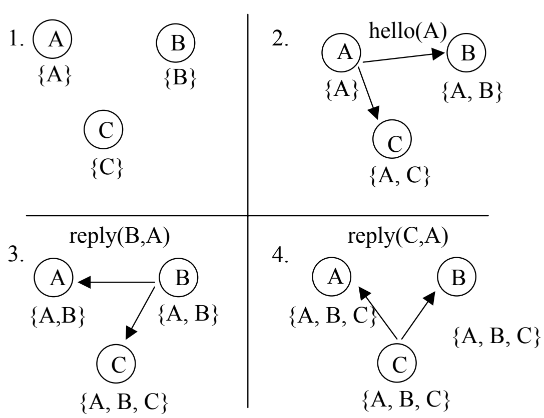

Figure 4. Rapid mutual peer discovery algorithm message exchange.

Data sharing in Hocman consists of distributing HTML documents and embedded resources with the HTTP/1.0 [1] protocol. The client uses two methods, get and reload, to retrieve documents from co-located peers over the ad hoc network. When retrieving documents using the get method, the cache is examined for local copies. If a copy is found, it is returned immediately and no communication is performed. Otherwise, a regular HTTP/1.0 GET command, with the Keep-Alive option, is issued. When the reload method is used, the client immediately issues a GET command with the If-Modified-Since and the Keep-Alive option included. Documents in the cache are ignored.

6. Testing

We have tested Hocman to measure its performance in order to determine whether the implementation constitutes a reasonable technological approach to fulfil the requirements. There are several studies of how the performance of the communication sub layer is affected by mobility [4, 6, 15, 12]. The performance is measured in fundamental metrics such as throughput, delay and loss rate. In these test the dominating definition of mobility is a relative large number of nodes moving randomly within a flat open rectangular area. Johansson et al [15] demonstrate an alternative to this, where they define mobility by artificial movement scenarios and objects that possibly obstruct the communication path. This investigation differs from the related work in that the test subject is a distributed application, not a communication sub layer. All testing is performed in a real world implementation, and the choice of mobility patterns is motivated from the ethnographic fieldwork. Furthermore, this test is not concerned with fundamental performance metrics directly but rather the implications they have on perceived application functionality.

6.1. Measuring mobility

Based on our field study, we assume that motorcyclists' engage in three different types of encounters, which differ in the relative speed of the movement patterns. The first type emerges when the relative speed is low for a longer period of time. This is the case either when two or more bikers are standing still or when a couple of them are cruising together along the highway. The second pattern occurs when a biker, or a group of bikers, pass a stationary individual or group. This is similar to the case when passing somebody moving relatively slower in the same direction. The final case occurs when meeting somebody travelling in the opposite direction. The relative speed between each pair of bikers is captured by the mobility metric [15], where the overall mobility in a particular scenario is described with a single value. By definition, it expresses the average relative speed and direction between all participants over the time a particular scenario lasts. The first type of encounters are concerned with a range of low values, 0 to 5.0. The second spans a range of medium values, 5.0 to 15.0. The last range is concerned with high values, above 15.0. Browse mode must withstand conditions of low to medium values.

Cruise mode must endure the whole range from zero to high values.

6.2. Performance testing strategy and setting

Three factors are relevant when testing the performance of the sharing as it is affected by mobility. The first is concerned with the number of active prototypes in a scenario. The second concerns the amount of data, which the prototype is able to distribute. The third aspect of data size is the amount of embedded resources.

We evaluated the Hocman prototype in three variables: mobility as measured by the mobility metric; the number of devices in each scenario; and the size of shared data. The goal of the test was to locate the limits of the functionality, i.e. to find the mobility conditions when the prototype ceases to operate as intended. We set this condition to: when a file failed to download, failed to be added to the log, or failed to appear visually (or audibly).

In the test scenario three Hocman peers were used. Each peer was running on a Compaq Ipaq 3660 with a Lucent Orinoco Network Cards, set in IBSS mode with no encryption. We did construct three websites that we think represent typical future usage and assigned each site to a particular peer. The size of the index page, the number of embedded resources (images and audio-files) and their collective size are depicted in Table 1.

Table 1. The peers and their resources

Peer	Index Page Size [Bytes]	# Embedded Resources	Resource Size [Bytes]
bergman	1 310	2	67 914
esa	921	1	8 597
matti	1 241	1	7 138

We placed the B and A peers next to a straight, flat road and drove by with the C peer at various speeds, each test run was repeated 5 times. For each repetition, the log and the cache of each peer were cleared. The success criterion was set to: while running cruise mode the A and the B peers must download, log and display the index page and the corresponding resources of the C peer; however, the C peer must download and log from both A and B.

6.3. The Results

The success rate (in percent) for each peer and the mobility metric for each speed, are given in Table 2. The mobility metrics are estimates calculated on simulations of this scenario.

Table 2. 9.0 in mobility metric corresponds to driving by at a speed of 50 km/h; 12.6 to 70 km/h; and 16.2 to 90 km/h. Walking by (at a speed of 3.6 km/h) corresponds to mobility metric 0.7

Peer	Download from	Object	Mobility Metric		
			9.0	12.6	16.2
matti	bergman	page	100	100	100
		image	100	100	40
		audio	100	100	20
	esa	page	100	100	100
		image	60	100	60
bergman	matti	page	100	100	100
		image	100	100	80
esa	matti	page	100	100	100
		image	100	100	100

In the column, showing the success rates for mobility metric 9.0, the C peer failed twice to download the embedded resource from the B peer. We have not found the cause for this. We note that all peers, except the B peer, fails to download the embedded resource it is supposed to in the column showing the rates for mobility metric 16.2. However all nodes are successful in downloading the index pages. We are confident that the Hocman prototype demonstrates a technologically feasible approach to the requirements.

7. Related work

There are several research projects that propose badges, devices, and software applications to provide interpersonal awareness and support collaborative activities. The principal ones are the Hummingbird device [13], GroupWear Tag [2], the Meme Tags System [3], and the Proem system [16]. These systems have in common that they are designed for semi-stationary settings. The users must be in close range, standing still or moving slowly relative to each other. Systems designed for such settings are not applicable for bikers that move in high speed over large areas. Moreover, these systems share rigid and highly structured data, both in terms of content and format.

Hummingbird is a device used to monitor the presence of other Hummingbirds in the close proximity. Sending and receiving a beacon signal of limited range achieve this. The GroupWear is an active badge system that lets user share and compare answers to a set of multiple-choice questions. In the GroupWear system, the badges store the answers and automatically exchange them with other badges over infrared links. The Meme Tags System also provides mechanisms to monitor other user's presence, but at a shorter range than the Hummingbird device. When two users meet face-to-face, their tags will exchange the stored memes. Workstations may be linked to the tags, providing the user the capability to author fresh memes. Finally, the Proem system is a Java application that let users share profile information during encounters. In this system the user enters his or her personal information in a document formatted with a predefined XML syntax. The proximity awareness is similar to the Hummingbird device, but the profile exchange is implemented with Jini over a campus wide WLAN.

8. Conclusion

Several of the related projects are similar to Hocman in their proposal of devices and software applications to support collaborative activities. However, there are major differences. First, we initiated our work with ethnographic fieldwork to search for requirements informing the design. We believe this method plays a major role when inventing new and useful applications based on acquaintance with people's mundane habits. Second, the motorcycling activities we explore take place in an extreme setting, where the mobility by far exceeds what has been reported in earlier work. We have invented the rapid peer discovery algorithm, in order to facilitate their social interaction, during these conditions. Besides providing awareness, the system also handles means for the user to express identity through HTML, which is a popular multimedia content format. Finally, in order to get an understanding of the functionality of the prototype, it is important to step out of the controlled test-lab or the theoretical simulations. Our technical test is performed in a real world implementation and the choice of mobility patterns is motivated by the fieldwork. The prototype supports the discovery and sharing of data among bikers during high speed and brief contingent meetings.

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