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ORIGINAL ARTICLE

Mattias Esbjörnsson

From ethnography on infrastructure management to initial user feedback on PlaceMemo

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Abstract This paper reports design requirements derived from an ethnographic fieldwork on road inspectors, the design of a mobile service supporting infrastructure management, and initial user feedback. Seeing that the road inspectors are truly mobile, acting in vast settings full of objects with variable status, they lack overview of their upcoming tasks. The PlaceMemo prototype allows them to place geographically coupled voice annotations in their work setting. The voice memos are played through their entire length before reaching the precise position of the recording, and are also accessible when being geographically distant. By handing out the prototype to a number of users, we successfully demonstrate that this lightweight context-aware system facilitates their mobile work. They obtain an overview supporting the advance preparation of inspection tours, and can easily access earlier recordings while driving, in order to be reminded and to prepare stops in time.

Keywords Mobile work · Location-awareness · Design · Prototype · Initial user feedback

1 Introduction

This paper introduces the PlaceMemo prototype, a system supporting infrastructure managers in their work. The system is developed for a handheld computer connected to a GPS-receiver and allows the user to record geographically coupled voice annotations. While driving, the system provides access to previous recorded memos by playing them in advance of the geographical position of the recording. Additionally, users can access memos while being geographically dislocated. From a limited period of use, initial user feedback reveals interesting issues in the design of context-aware systems. In line with Dourish [1], we recommend a modest design approach wherein the users are intended to create the content and interpretation. This should be supported by a restrained use of contextual factors to maintain a balance between a technical context dependency and a social context, giving the user freedom to control content and coupling to the context. We believe these 'lightweight' systems are favorable, better than incorporating a number of fixed contextual factors. Inputs from many sensors and the use of many predefined functions will only lead to increased complexity.

To illustrate mobile work, we discuss the situation of a road inspector [2]. He drives a 200-km inspection tour on a daily basis to identify, report and take care of defects along the roads. As soon as he spots a possible fault he must quickly decide if it is a defect and if he can make an immediate stop with his vehicle without jeopardizing the safety for other road users. In this case, the roads play two major roles in his work—they are the core of his work, and they are a prerequisite for him to get ahead. Nevertheless, the roads also contain hampering factors considering that the traffic situation often does not allow him to make an immediate stop. Either he has to find a place suitable for a u-turn, or memorize where to stop until he passes the next time. However, memorizing the position of a defect is a complicated issue, considering that the environment does not assist him with either a structure or an overview. That is, a structure would help him to prepare a stop when approaching the defect, and the overview would be of assistance when preparing for the upcoming inspection tour.

This setting provides us with interesting challenges considering that tasks are performed at various, not predefined places while driving and being distant from colleagues. The roads and the road-use are in no way designed for the performance of occupational tasks. On the other hand, the offices are designed to facilitate the performance of certain occupational tasks. They are provided with computers, desks, phones, places to store documents, notice boards, etc. These resources, together

M. Esbjörnsson
Mobility, The Interactive Institute, P.O. Box 24081,
104 50 Stockholm, Sweden
E-mail: mattias.esbjornsson@tii.se
Fax: +46-8-7832460

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with arrangement to temporaily place documents or other objects to act as reminders, play an important role when organizing tasks. Consequently, there are several studies from stationary settings, on how office work is organized [3–5].

However, when work reaches an increased level of mobility the benefits available in the office settings are lost. First, the mobile workforces acting in *vast* areas have no means for reaching a satisfactory overview of the setting and the upcoming tasks. Second, the *movement* contributes to the complexity in creating a structure, i.e. to mark objects. They have to handle their tasks while being on the move. Consequently, the users spend more time on mobility to compensate for these shortcomings. They travel to inspect the roads, and they memorize all upcoming tasks to be able to handle them while being mobile.

We argue that the conditions of mobile work could be better understood by studying occupational groups like the road inspectors. Earlier studies of mobile work have focused on factories, the underground, or wastewater treatment plants. The settings are widely dispersed, however, marked off from their surroundings and rather well structured. They are comparatively static and filled with predefined places/objects of importance to perform work, which also allows mounting signs or other annotations. We stress the importance of looking into work practices outside these settings. In the case of the road inspectors, they are constantly on the move; they have limited possibilities making annotations in their workplace, and they benefit from memorizing to create order in their work. However, tasks are often forgotten, and the inspectors are reminded when they already passed the defect. Consequently, they need something that could be left in place, which is not costly and possible to be shared among colleagues.

We introduce PlaceMemo. It is based on previous reported design requirements, derived from an ethnographic field-study on road inspectors [2], highlighting the complexity in performing their occupational tasks. The aim is to investigate the possibilities supporting truly [6] mobile work. To succeed, we suggest voice annotations coupled to geographical locations, providing the workforce with a useful structure and overview of their workplace.

2 Road inspection

The role of the road inspectors is similar to that of the janitor who is employed to clean and maintain a building. The fundamentals of road inspection correspondingly include identification, reporting and repair of defects along the roads. The specific setting for the occupational groups working with infrastructure management contributes to the complexity in developing supportive services. Thus, passing broken road signs, defective road safety fences, or defective road markings, etc, may seem like a trivial experience for most road users. For the infrastructure managers, however, the occurrence of these objects, or loss of them, is a source of daily concern. The road inspectors spend their working days to take care of these defects (Fig. 1). In the fleeting moments when passing the defects, they have to sight them, react and take action, all while managing the vehicle in the traffic. Except for taking care of the defects, i.e. repairing road signs, or removing dead animals, etc. they also have to report each occurrence.

The ethnographic field study [2] revealed how the road inspectors occasionally did not bother to use the current computerized system (containing approximately 50 predefined codes) to report identified defects (Fig. 1). On the contrary they attempted to memorize, or to take notes on paper in retrospect. One hampering factor concerns the coercion in using the predefined coding-scheme when reporting. It is difficult to find a code that described the actual defect in a correct way as it can often be complex. However, the major difficulty for the inspector appears to be stopping the vehicle for communicating or reporting.

3 Related work

It has been argued that many context-aware systems apply an inflexible view of context. Focus has largely been on the challenge of how to use and combine input from different sensors, how to provide the users with accurate information, and how to manage and classify the data [7]. A majority of the systems are designed from a proactive focus, where the developers attempt to make the technologies more sensitive to the details of specific settings of use, by incorporating contextual dependencies. The technical implementations are mostly too inflexible, and fail to address the users' needs. Consequently, this type of system often derives from a strong technological focus, backed by few, if any, empirical findings [8].

When technology facilitates an independence of place, it has been argued that work could be performed anytime and anywhere [9]. Still, people have strong incentives for being mobile, such as the need to be at

Fig. 1 Road inspectors taking care of a defective road sign (*left*). The current reporting-system used by the road inspectors (*right*)

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certain places to perform work, or the need for specific equipment [10, 11]. Work tasks occur at certain places in widely dispersed settings, and cannot be moved.

In the following, we will first discuss related studies on how the workspace is used to organize work, and how mobility affects it. Second, we discuss the difficulties that have to do with people who are actually moving while working.

Based on the knowledge gained in recent studies of mobile occupational groups working with infrastructure management, we have explored the complex mobile work conditions in combination with a widely distributed working area. Examples of the related occupational groups studied are process engineers [12], process operators [13], homecare teams [14], underground staff [11], bus drivers [15] and service technicians [16]. At a glance, the tasks performed by the process engineers [12] could be seen as individual, but their actions affect the running of the plant, and therefore also their colleagues. To facilitate their work there is a need to share information, but not in the sense of universal access to everything, everywhere. The information cannot be separated from specific action, which in turn is tied to specific places and/or machines. Accordingly, Bertelsen and Bødker [12] stress the importance of being on location to take the correct actions. The process engineers cannot have enough knowledge if they do not combine local knowledge with overview. Therefore, they have to leave the control room, but then they lack overview. The work by Nilsson et al. [13] represents a similar view, highlighting the importance of the physical inspection. Based on their findings they propose a solution that attempts to smoothen the transition between physical interaction with the plant and interaction with digital representations of the plant. They introduce a non-functional mock-up that can monitor the status of predefined and stationary objects within the workplace. Aiming the device towards the objects is the initial way of adding them to the system. Thereafter they are visible in a list, irrespective of location. Audio notes can be recorded and connected to each predefined object. These recordings are later available on the device. Other studies describing service technicians [16] reveal certain similarities with the process engineers. A slight difference could be observed in the fact that they perform their work in a much vaster setting, and focus is set on the coordination of activities while being mobile. Another aspect of collaborative work under these circumstances concerns the loosely coupled collaboration style [14].

When the workspace increases in size, and contain numerous of objects that are neither predefined nor fixed, another type of complexity occurs. The previously mentioned work mostly considered occupations where people move from one stationary workplace activity to another [17]. Johansson and Pettersson [18] introduce a study illustrating the problems of working while actually moving. They discuss how truck drivers interact with the in-vehicle navigation systems while driving. The study displays how the drivers start interacting with the navigation systems at first when having problems finding their way. Accordingly these occasions are not well suited for providing input to the system.

Looking at the area of context-awareness, a number of applications based on the availability of positioning have been suggested, for example: Cyber-guide [19], comMotion [20], GUIDE [21], CybreMinder [22], Geonotes [23] and a reporting tool for fieldworkers [24]. These systems provides the user with relatively high freedom on what to augment, both in the sense of locations and content.

By locating the user, predefined information is either pushed out, or is available, at the corresponding locations. A majority of the digital annotation systems rely on information produced by semi-professional content providers, such as in the case of campus and city guides [19, 21], or guidebooks [25]. The users are considered to be passive recipients rather than active producers of content. However, the reminder-systems and the communication-systems rely on the users as active producers of content. Based on a number of variables they provide the users with specified information, and the geographical location play an important role in this provision of data. Current attention is also drawn towards the generic problems of organizing information [26], seeing that that the electronic spaces could become overcrowded with information.

4 Method

The project was initiated with a period of ethnographic fieldwork to learn more about the contingencies of infrastructure management. We participated in the road inspectors' work by following them in their daily tours of inspection. Five inspectors belonging to three different local offices were studied during a period of ten workdays. We observed their work sitting in the driver's cabin and took extensive field notes, which were transcribed immediately after returning from the inspection tours. The transcriptions were analyzed, and a set of themes were identified. These themes played an important role in the formulation of the design requirements. Details on the empirical findings can be found in [2]. The findings from the fieldwork played a major role in the design process, where they informed the development of the prototype. Towards the end of the fieldwork, the discussions on important areas of improvements emerged. We identified problematic areas in road inspection and discussed feasible design ideas, which later resulted in a tangible proposal. The discussion took place in an interdisciplinary research group that combines an interest in social science with mobile computing. The composition of the group conveys that the discussions were grounded in the ethnographic material, but also technologically informed by an understanding of viable solutions. Accordingly, the design was associated [27] with empirical findings, but also with available technology.

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5 The PlaceMemo concept

A system that facilitates inspection while being mobile could increase the number of reports and communication and thus strengthen the possibilities for articulation. Accordingly, the organization would acquire better knowledge of the identified defects and the work could be planned in other ways, e.g. new forms of job sharing and job rotation. A simplified method of creating annotations would probably lead to an increased amount of reports on defects, which have not yet been taken care of.

We conceive a service which could be used as in the following scenario:

> When the infrastructure manager drives in his daily inspection tour, he spots a damaged road sign. However, the traffic situation does not allow him to stop immediately. Instead he uses PlaceMemo to save the geographical position and record a voice-memo so that he won't forget it. Later the same week, before heading out on the same stretch of road, he listens through the memos. The map gives him a rough idea of where the reported malfunction is situated, and by listening to the voice-memo he knows what equipment to bring. Back on the road he focuses on identifying new faults. When approaching the location of the broken road sign, he can hear the memo just before he reaches it. He gently decreases the speed of the truck and comes to a halt without jeopardizing other drivers' safety, and then gets out to mend the sign.

To support these issues, we propose the following five design requirements.

5.1 Voice-memos associated to geographical positions

We advocate a system which demands less from the user in terms of activities on the spot of the defect, considering that the inspector is occupied with driving and keeping an eye on the traffic. Still it is essential to save the geographical position of the problem that should be handled. Consequently, the interaction with the computer should be limited while driving. We believe that there it is possible to create annotations in the form of voice recordings while driving, which are associated with certain geographical locations.

5.2 Support several work tasks

The current system is designed to support the preparation of administrative documents, i.e. formal reports, which are essential when giving an account for what has been done. This focus leaves out the support for inspection as a dynamically changing and on-going activity, which also explains the limited usage of the system. We believe that the use of audio-recordings connected to geographical positions has the possibility to become a more integrated tool for inspection work. To fit with current practice, i.e. the articulation work, it is essential that the system should handle different forms of information, that is both situated and contingent ways of representing defects as well as the filing of data according to the formal organizational requirements. Voice-recordings are easier to do and less restricted in terms of vocabulary than predefined coding schemes.

5.3 Support individual work

In many cases, the inspector needs to prepare for the inspection tour, by bringing certain equipment. Before heading out on the road, he will have the possibility to retrieve a list of all recorded memos, and choose the ones he wants to listen through. While on the road, he should be reminded about upcoming defects before arriving at the specific location. Thus, the system should include two modes, one for stationary use only, with greater freedom for choice and possibilities for interaction, and a second mode for driving, where the human-computer interaction is of limited scope, with easy reporting and automatic triggering of voice-memos.

5.4 Support easy reporting

To achieve a higher number of reports in the present reporting system, the suggested system should act as a supporting tool in the formal reporting procedure, seeing that it will be saved for a better occasion than when driving on the highway. The inspector could for instance listen through and code the voice messages during a break, i.e. he will import the reported data into the present system. It could be done with the computer in the vehicle, but also between the suggested system and the central database.

5.5 Support for delegation

We believe that delegation could be performed on more suitable occasions. The recorded information is a support when calling a colleague, as a starting point to discuss the delegation of a task. Alternatively, the voice memos and corresponding coordinates could be shared among chosen colleagues.

6 The PlaceMemo prototype

PlaceMemo (Fig. 2) is a prototype service designed to meet the requirements. It is based on handheld mobile devices running the Pocket PC operating system. In this specific implementation it uses the Bluetooth-equipped

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Fig. 2 The functionally of the PlaceMemo prototype in map mode

HP Ipaq 5450, and the Emtac Crux BTGPS™ GPS-receiver to achieve the positioning. The configuration allows the users to record voice memos connected to geographical locations. The flexible format of voice gives the user freedom to articulate messages according to the specific situation at hand.

The prototype contains two modes. First, placing and triggering, and second administering place-memos. Placing and triggering represents functionality used while working on the roads. In the other situation we imagine the user to be more focused on the device. Interaction can in this case be far more visually demanding, and is thought to occur prior to an inspection, during a break, or when the inspection is completed. The primary objective for the user in this context will be to remotely access information regarding a certain area.

In order to annotate places, the user presses the recording-button once (see Fig. 2). This normally occurs while driving and inspecting. Consequently, looking for defects as well as driving requires that the driver stay focused on the outside environment. The interaction with the device at this point must be designed so that it can be performed without, or with limited use of the user's visual attention.

When pressing the button, a geographical position is immediately saved and the recording of the voice memo starts. The Placememo, consisting of a wave file and GPS data, is stored in a database once the recording is completed.

In accordance with the design requirements, when a previously marked location once again is approached, the system will trigger playback of the voice memo associated with the location. Finally, the memos are played before reaching the precise position, calculated from the speed of the vehicle and the length of the recording.

Seeing that the system is not intended for navigational purposes, we choose not to implement a detailed map. The system rather 'draws' a map based on the routes driven. When zooming in, a grid where the previous routes are visualized as lines, appear. A flag along the lines symbolizes each reported voice-memo. When in stationary mode the users can mark the flags with the pen, and display them in a list. Additional information such as time and date for the recording is available. It is also possible to listen through the voice-memos and delete the non-desirable ones. According to the design requirements, this mode should include the possibility to send memos to colleagues, unfortunately this version of the prototype has only a button illustrating this, with no built-in functionality.

7 Initial user feedback

To examine the empirical findings as well as the resulting prototype, we handed out PlaceMemos to a number of people working with infrastructure management, to retrieve initial user feedback. The test-period for each user

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was initiated when handing over the prototype, together with instructions on how to handle the device.

The test-subjects were supposed to use the prototype during a limited period of time in their vehicles, while working on the roads. We decided not to force the users to perform a range of predefined task. We rather let them use the system during normal work hours, to try it out when performing their unusual tasks. We had no intention to replace any of their current tools or procedures during the test period. The focus was rather set to retrieve comments that could contribute to improve the system.

In addition to interviews, we video-recorded one test person when he used the prototype. In all the cases we saved the recorded voice-memos. However, the principal method for retrieving user data was semi-structured interviews performed in conjunction with the trial. The interviews and the voice-memos were transcribed and coded, i.e. categorized into a set of themes. The coding scheme evolved while working with the material and it has been a necessary tool when analyzing the material. The level of detail is chosen with reference to the claims we are making.

7.1 Participants and working tasks

Three people working with infrastructure management tasks, in separate organizations, took part in the test. They were selected on the basis that they share the common denominator of working on roads, inspecting vast areas while driving, however with slightly different areas of responsibility.

- Peter, working at a company focusing on maintenance of road markings. He is held accountable for the regional inventories; delegates tasks within the organization and follows up the work performed by his colleagues. During the trial he had access to PlaceMemo for one month and he used it occasionally during everyday work.
- John, working at the Swedish National Road Administration, which is the authority, assigned the overall sector responsibility for the entire road system. He performs thorough inspections on certain roads with a predefined interval. Currently he prepares inventories of all objects along the road network, such as road signs, railway crossings, etc. to specify the precise geographical positions. He had access to the PlaceMemo prototype for 2 weeks.
- Sara, working at the Swedish National Road Administration Production in the region of north Stockholm. She is responsible for a group of road inspectors, and also performs road inspections herself. She had access to the PlaceMemo-prototype for 2 workdays.

During the test period the users could chose between having the device on the passenger seat, or mounted in a temporary holder on the dashboard. To increase the volume of the memos an external speaker was connected to the device.

7.2 Creating memos while driving

During the trial we were concerned about using PlaceMemo while driving. Related studies had shown how drivers perform working tasks while driving, mainly focusing on the use of mobile phones [28, 29], or navigation systems [18]. In the case of the PlaceMemo-trial, the task is a bit more complex as the landscape has to be inspected while driving. In the following, John discusses his impression on using PlaceMemo in traffic.

> Whatever you are doing I consider this to be really safe to perform while driving, in comparison to other solutions, where you have to focus on the device while pushing several buttons. You just push one button and talk.

He continues by discussing the importance of not stopping the car while recording the voice annotations.

> On the highways you have to follow the traffic rhythm, which means that you have to go at 90 km/h. Like on the E4 through Stockholm, there are no possibilities to stop to report the position, you must do it on the move.

However, the reporting strategies varied depending on the traffic situation and reporting task. As he says in the excerpt above, he is obliged to follow the traffic rhythm while performing the inspections. In his area the traffic is hectic, and there are no possibilities to stop near all identified objects. In the case of the inspections on the smaller and less busy roads, they easily stop their vehicles to report. In some cases they also step out of their vehicles to take a closer look. They can easily record voice memos regardless of whether they are inside or outside the vehicle, since there is wireless connection between the device and the GPS unit. Except for the freedom provided by the hardware, the format of the memos, i.e. the voice recordings, provide them with a better way of articulating the reminders.

> In comparison to writing a memo, the chance to say something is bigger.

This comment not only concerns the simultaneous activities of driving and reporting, it is also about the possibilities of inspectors to express themselves while being out on the roads. Voice recordings provide them with a greater freedom of expressiveness, than systems with predefined codes.

7.3 Retrieving memos while driving

The handling of PlaceMemo concerns not only the creation of PlaceMemos, but also the other important issue of the retrieval of memos, irrespective of being at the geographical location or not. The system relies on the general idea that users will benefit from creating

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and listening to personal memos. These are played automatically when being in the proximity of the position of the recording, but can also be listened through at remote locations, providing an overview of upcoming tasks. During the initial period of use, the system suffered from some software bugs. Several memos were not played when passing the saved positions. However, after some minor corrections in the code, it worked as intended.

> Here is the next one (a memo is played: "Trunk road 30, the entrance to the Växjö, the area needs to be taken care of manually"). It appears to work as intended.

In this case Peter is driving at 80 km/h when the memo is played. He is satisfied with the timing of the memo playback.

> The sound starts so early that I can decrease the speed and take a closer look.

The memos were played in their entire length before returning back to the position where the memo was recorded. The calculation of message length and current speed fitted with the driving situation. It gave him time to react, either to stop, or as in this case, at least lower the speed and take a closer look. After passing a few more memos, he commented on the precision.

> The memo is played approximately 200 m in advance, that's reasonable. I don't think the precision is so important, because you are always describing the position in the voice-memo.

Despite the memos being played at the position given by the GPS, he is not so convinced on the importance of the geographical precision on the memos. When using it for personal reminders he most often knows what it concerns when hearing the memo. Except for the precision, he also noted that the direction is not an issue. The messages are played irrespective of the direction he is driving. However, what is more important is the administration of memos. The simplicity in creating new memos, easily lead to large numbers of memos, and the inspection tours tend to become tedious.

> It's a bit so-so. When you record all these memos, there is a signal every time you pass the position. In some cases you pass the areas quite often, and it is really annoying hearing these sounds.

The handling, i.e. deleting old messages, is more complex than creating new ones. This is done while being stationary, seeing that the memos must be marked in map-mode, and thereafter deleted in list-mode. Additionally, during the trial we found out that identifying each memo in map-mode was complicated. Despite noting the simplicity, Tomas had obvious problems in finding the memos during the interview. The low level of details in the maps made it very difficult to find the correct memo. It was not only the identification of each memo that was difficult. The zoom functionality was not precise enough and its sensitivity made it difficult to control.

During the interview he reverted to the discussion on the possible benefits of using the system when performing his daily job. The main problem as he saw it, was the fact that it has to fit in with existing systems and how formal reports are made today.

7.4 The geographical connection

The concept of associating voice-memos to geographical locations appealed to the participants in the field trial. Two users had earlier been using tape-recorders to save voice-recordings while driving, however with no geographical connection. This was helpful in their perception of the PlaceMemo as a tool for associating voice-memos to geographical positions. Accordingly, there was no difficulty for them to understand the concept. When asked about the importance of displaying the map, Peter gave the following comment:

> To put it out bluntly, this figure, where we can see our position, is not as important from my point of view. I prefer only being reminded that I have recorded something here. Most often I know where I am.

As he says, for obvious reasons, he is not interested in using the system as a tool for navigation while driving, seeing that he is familiar with the area of inspection. Even if the area is vast, he drives, through the inspection area with a predetermined interval. Consequently, the issue is not a navigational one. It is rather one of being reminded.

When it came to practical usage, some problems occurred with the underlying model of the PlaceMemo-design. Depending on the variety of reporting tasks, the inspectors were sometimes interested in specific geographical spots, alternatively in areas up to several kilometers in size. For example when the tasks concerned inventory of road signs, the specific spots of interest were easily marked up with PlaceMemo.

> Then I'll do like this, I push the button and say 50, then you just push one more time to stop the recording.

During the inventory of road signs, John records a voice-memo with the current speed limit, in this case 50 km/h, at the precise spot of the road sign. He does not provide any additional details in the memo. In comparison, the inventories of road markings contain memos that concern larger areas. In the following case Tomas has stopped the vehicle and looks out on the area that needs to be fixed, while recording his voice-memo.

> Trunk road 30, the entrance to Växjö, the area needs to be taken care of manually.

As a unique identifier, despite the coordinates given by GPS, he uses the road number, and the highway

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entrance as a reference point when describing the defective area in his recording. What is vaguer, on the other hand, is the description of what action to take when returning to the spot. In his memo he says that the road markings have to be improved manually, i.e. not with the road marking vehicles. He explains that initiated colleagues have a good understanding of which action to take when being at the site of a reported defect. The environment and its shortcomings are most often obvious when entering an area. That is, the physical properties of the area provide an informal work description.

Another example of the complexity when referring to areas, in comparison to specific positions with PlaceMemo, is obvious when road sections are in focus for the inventories.

> Currently we are supposed to make inventories of the asphalted areas. This is really good, when you enter a road section. You just start by saying that the asphalt starts at this spot. Then you continue to drive, and at last you record an 'end'-message.

The functionality of creating memos covering geographical areas was not built into the system. However, they came up with workarounds to solve the problem at hand. In this case two voice-memos was recorded, i.e. one 'start' and one 'stop' message. During the interview, he added that he usually knows in which direction he drives during the inventories. The inspections can mostly be done in one direction.

7.5 Application areas

The test subjects' work consists of a wide variety of tasks and procedures, which have to be considered when introducing a new system. Accordingly, several comments considered the integration with other systems and procedures. The ordinary way of reporting, and creating reminders, relies on the use of paper and pen while seated in the vehicle. After returning to the office, the data is used to fill in the formal documents and computerized reporting systems. Hence, when Peter discusses the deficiencies of PlaceMemo, he relates to what he normally does.

> Usually when I arrive to a 'new' city I try to find some of the tourist-maps. They are usually the best. You can draw on them, and they are also for free.

These free maps, available at the entrances to the city, comply with several requirements. They are easy accessible, contain updated information; the level of detail is high; they are cheap; easy to draw on; and provide a good overview, etc. All of which are qualities difficult to compete with. One of the most important aspects is that they are easy to write upon. Nevertheless, despite the fact that he already converts the information to other media while back at the office, he believes that the work becomes more troublesome with PlaceMemo.

> Then I rather prefer a cassette recorder, where I record all the information needed.

When asked about the lack of positioning, he does not see it as a problem seeing that he also would record a position description.

> Of course I'll tell the position.

The discussion concerns the accomplishment of formal reports. The voice-memos and GPS-coordinates have to be transferred into words and sentences on paper. The ordinary paper forms have fixed text fields, and play an important role in the administration. He sees no advantage of using the coordinates given by GPS, considering that it is impossible to interpret the actual geographical position. However, other viewpoints on transferring PlaceMemos to stationary geographical information systems were expressed during the interview with John, who gave a vision on his future use of PlaceMemo.

> When I arrive back home, I can export the data from PlaceMemo, and import it into my GIS-program. The audio-file will be available from the map, where I easily can listen to it. The position-data of the memo can then be used when I compare the reported position, with the one we have on our old maps. In an easy way I can compare them, and this is one of the advantages of such a system.

He requests a function where the voice-memos and their corresponding positions could be easily imported to his current stationary system. While working in the office he could perform the actions within his current GIS-system, where he compares the positions of the road signs on the maps with the reported positions. Consequently, the level of precision is of major importance during this type of inventory work.

When it comes to delegation of tasks, the prototype did not have any built-in supporting functionality. However, based on the user's experiences of the prototype, the discussion dealt with the current work practice and whether it possibly could replace any of today's methods. Peter is really convinced of the benefits using paper and pen for the filling the formal work orders, which are the base for delegation of tasks.

> A work order with all information, phone numbers, etc, is difficult to replace. We are forced to use this type of documents when performing work. And these orders contain information, which is given by rules; customer, date, accounts, contact persons, phone numbers, billing address, etc. Perhaps I am old fashioned, but sometimes when introducing new systems, they are a bit too much.

He refers to the internal rules, what they normally do when performing their tasks. The delegation of task relies on handing over well-specified paper forms,

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containing all conceivable information at a detailed level. He also favors using paper maps, where the road sections of interest are marked up by drawings. This is the normal way of performing work, and he sees it as difficult to introduce new methods, or systems. From the information given by the maps, it is easier to inform about, and locate the places that must be taken care of. This seemed to be more problematic in PlaceMemo.

> I have to consider if I will delegate the task. In those cases I have to provide more detailed information. Of course I have to tell the specific address, otherwise it's impossible to understand. Then I have to drive to the place before I know where it is.

Especially if the memos are supposed to be used by other persons, the test subjects reflected on the level of details in the memos. It was not only enough with the coordinates given by the GPS. The colleagues needed additional information to locate the defects. Also, the overview provided by the generated map was not sufficient to get an understanding of the geographical positioning.

8 Summary of initial user feedback

The test subjects used the system for different purposes, personal reminders as well as for formal inventories. This disparity in incentives for usage led to a variation in level of details in their recorded memos. The system lacked in supporting the current practice of filing standardized forms. Nevertheless, it supported the users in reminding them on previously reported defects. The feature of playing the memos in advance of the geographical positions was appreciated. Unfortunately, the access to memos when being dislocated was insufficient. The memos were difficult to identify without the use of a proper detailed map providing overview, and the controls to zoom in and out were difficult to handle. However, an important aspect was that the test subjects used the system in the car while driving, either with the device on the passenger seat, or with a temporary holder on the dashboard. The design seemed to fit with their practice, seeing how they used it for a wide variety of tasks. The recording of, as well as the listening to geographically bounded voice-memos acted as intended. The users understood and benefited from the positioning functionality. However, during the trial we observed the users' somewhat conflicting interest in areas versus precise locations. This caused minor trouble, but was solved with a workaround by the recording of two memos, one indicating start and one indicating stop. Seeing that this necessity was not anticipated, the flexibility of the system yet allowed the users to solve the problem at hand.

The trial displayed the different reasons for performing inspections, in which the level of precision, and description of places, vary depending on task. When it came to reporting, the evaluation proved to be problematic, seeing their strong relation to existing formal procedures. Some saw the problems in yet another way of retrieving data, while it still is simpler to collect data by the use of pen and paper. However, one test subject saw the possibility to easily transfer information to existing geographical information systems. They all seemed to agree on the possibilities of recording, and saving, data while on the move. The level of acceptance of the system varied according to the level of formalized procedures in their current organization of work.

Many of the comments from the users touched upon the unique qualities of paper, when handing over tasks and descriptions to colleagues. Properties that are beneficial in collaborative work, but also when the level of precision on the positions plays an important role. The delegation demands improved functionality for access and overview of PlaceMemos when a on distant location. A detailed map is needed to understand the geographical positioning of the memos. There seem to be a need for handling delegation of tasks, or informing colleagues. The current implementation of the system is, as earlier mentioned, lacking in these details. Data cannot be sent between devices, and the interface gives an insufficient overview of the setting.

9 Conclusion

Mobile activities, like road inspection, occurring in vast areas, constitute a challenge for the development of mobile services. This project increases our understanding of important issues in organizing mobile work. The fieldwork reveals the importance of accounting for the road inspector's insufficient overview of the setting. In addition to only making a statement from the analysis of the empirical data, we have designed a system, which has been brought back to its intended setting and evaluated. However, the task is problematic when it competes with an existing daily work practice. The users focus on the performance of their routine tasks, as well as on the new system. These conflicting focuses lead to comments that touch upon the prototype's functionality in comparison to current work practice. Nevertheless, this is the setting where the system is supposed to be used, and improve on existing practice.

Except from an increased understanding of the prototype, we have learnt more on the contingencies on mobile work. We have explored the occupational group's insufficient possibilities to take notes, or make annotations, due to the vast setting, the lack of predefined objects, and also the fact that they are driving. We advocate 'lightweight' context aware services, providing the user with control of the content, as well as the coupling to contextual factors. Despite the fact that PlaceMemo is developed with few contextual dependencies, the initial user feedback have indicated some areas for improvements, for example the marking of areas in addition to locations, and most important, to

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provide a better map enabling an overview when on a remote location.

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