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Huynh Nhu Hop QUACH

Khasfariyati RAZIKIN

Dion Hoe-Lian GOH

Thi Nhu Quynh KIM

Tan Phat PHAM

See next page for additional authors

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Investigating Perceptions of a Location-Based Annotation System*

Huynh Nhu Hop Quach[1], Khasfariyati Razikin[1], Dion Hoe-Lian Goh[1], Thi Nhu Quynh Kim[1], Tan Phat Pham[1], Yin-Leng Theng[1], Ee-Peng Lim[2], Chew Hung Chang[3], Kalyani Chatterjea[3], and Aixin Sun[4]

[1] Wee Kim Wee School of Communication & Information, Nanyang Technological University
{hnhquach,khasfariyati,ashlgoh,ktnq,tppham,tyltheng}@ntu.edu.sg
[2] School of Information Systems, Singapore Management University
eplim@smu.edu.sg
[3] National Institute of Education, Nanyang Technological University
{chewhung.chang,kalyani.c}@nie.edu.sg
[4] School of Computer Engineering, Nanyang Technological University
axsun@ntu.edu.sg

Abstract. We introduce MobiTOP, a Web-based system for organizing and retrieving hierarchical location-based annotations. Each annotation contains multimedia content (such as text, images, video) associated with a location, and users are able to annotate existing annotations to an arbitrary depth, in effect creating a hierarchy. An evaluation was conducted on a group of potential users to ascertain their perceptions of the usability of the application. The results were generally positive and the majority of the participants saw MobiTOP as a useful platform to share location-based information. We conclude with implications of our work and opportunities for future research.

1 Introduction

In recent years, various location-based annotation systems [2, 5, 7, 8] have popularized the use of maps for people to create and share geospatial content. Put differently, a location-based annotation system allows users to create and share multimedia content that are typically associated with latitude-longitude coordinates using a map-based visualisation. As an information sharing platform, location-based annotation systems could facilitate the users' needs in information discovery by the availability of searching and browsing features [20]. Also, in the spirit of social computing, such systems could also allow users' to create annotation as well annotating existing content [1]. Threads of discussion or topics that are organised hierarchically are then induced from the collaborative effort.

Despite the growing amount of research in this area, to the best of our knowledge, there are few studies done to investigate the usability of these applications. We argue that this is critical in the understanding how users perceive these applications and

their constituent features. This will help in the design and implementation of location-based annotation systems.

In this paper, we investigate the usability of MobiTOP (**Mobi**le **T**agging of **O**bjects and **P**eople). As its name suggests, the application supports location-based tagging or annotating. MobiTOP offers a Web-based platform where users are able to freely create, contribute, and comment on location-based content. The application also enables users to explore, search and browse annotations using a variety of techniques. In previous work, we have conducted a small-scale pilot evaluation of MobiTOP [9]. While useful in guiding the development of further iterations of the system, the results were not generalizable due to the small number of participants involved. Here, we complement the previous study by involving a larger number of participants.

The remainder of this paper is as follows. Section 2 provides an overview of the related research while Section 3 introduces MobiTOP, a location-based annotation system that we have implemented. Section 4 presents evaluation of the system. This paper closes with Section 5 that discusses the implications of our work and opportunities for future research.

2 Related Work

Here, we review literature related to location-based annotation systems. One such system is the World Explorer [4] where the users are used to explore and browse large-scale georeferenced photo collections. Using spatial, textual and photographic data mined from Flickr, the system visualizes the most representative tags of a geographical area. This visualization improves users' exploring and browsing experiences. However, World Explorer does not provide any search function that allows users to look for specific tags. Moreover, users of World Explorer are unable to share or discuss their contents directly on the system. GeoAnnotator [3], on the other hand, facilitates location-based discussion threads by connecting annotations to geographic references and other annotations. However, users are limited to sharing only textual content and this functionality is not extended to other types of content such as multimedia content. Urban Tapestries [6], is another system that allows users to share their location-based multimedia contents. Moreover, this system also allows users to follow a discussion thread as a hierarchical content. However, there is no usability study done on the system's map interface and the annotation visualization.

There are limited usability studies related to location-based annotation systems. Komarkova et al [19] proposed a set of 138 heuristics for usability evaluation of location-based applications. In that study, 14 GeoWeb applications were used to test this framework. The usability of such systems has been evaluated and criticized by a group of expert users. Despite the fact that major online web-mapping systems such as Google Maps or Microsoft Live Search have been significantly improved regarding their usability, there are up to now limited usability evaluations by the end-users of such systems. Studies [19, 21, 22, 23] have found evaluating the usability of applications directly by the end-users to be more promising.

3 Introducing the Web-Based MobiTOP System

MobiTOP has been introduced in our previous work [9], which described carefully the architecture of the whole system as well as the concept of multimedia hierarchical

annotation. The latest version of Web-based MobiTOP provides more functions such as identification, organization, searching and visualization of location-based content. Moreover, using Google Maps™ API for representing the MobiTOP's user interface, these functions has been organised consistently in the web application. In this section, we describe the web user interface of MobiTOP as well as explore its functionality.

The MobiTOP Web client offers an AJAX-based user interface to facilitate its widespread use without the need to installing additional software. We have adopted a map-based visualization to access the location-based annotations (Figure 1). An important component of MobiTOP is its support for hierarchical multimedia annotations that allow users to annotate existing annotations, essentially creating a thread of discussion. Here, annotations consist of locations, images and other multimedia, as well as textual details augmented by tags, titles and descriptions. The content of an annotation is displayed across two columns in MobiTOP (Figure 1). One column displays the hierarchical view of the selected annotation while the other column displays the annotation's content. The content itself is divided among various tabs and consists of the annotation's details, tag cloud, and media attachments.

MobiTOP's functionality may be divided into seven main components:

- **Registration:** Before a user can start to contribute and browse the annotations in MobiTOP, an account needs to be registered. A registered user would be able to view the main interface of MobiTOP (Figure 1) after logging in.
- **Map navigation:** MobiTOP provides standard features for map navigation such as zooming and panning. Users are also able to reposition the map to a specific area by entering the address in the search bar.
- **Browsing annotations:** Users are able to access annotations through various ways. One of these is by using the View menu at the top left corner of the screen (Figure 1). This menu encapsulates the different annotation access features such as viewing all the annotations in the system, the user's contributed annotations, recently contributed annotations, and the tag cloud generated from all

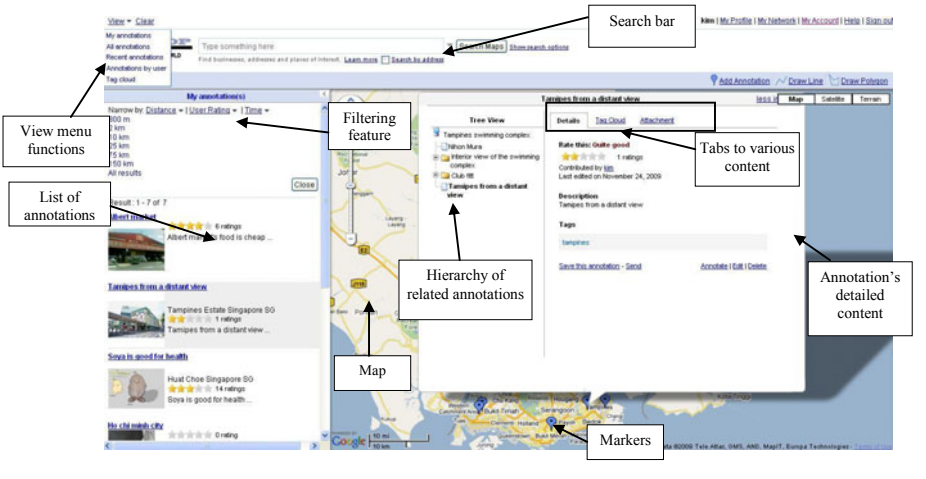

Fig. 1. User interface of the MobiTOP Web client

annotations. These functions enable the users to make serendipitous information discovery. Another way for the user to browse the annotations is by navigating the tree view that is displayed in the individual annotation's details.

- **Searching annotations:** Users are able to search desired annotations by entering relevant keywords in the search bar. However, retrieved annotations could clutter the map and impede the searching process if too many results are returned [14, 17]. We overcome this problem by clustering the results. Here, the annotations in the search results are grouped based on their locations (Figure 2). The clustering algorithm is an adaptation of DBScan [12] that groups the annotations by density. The novelty of this approach is that the clustering results vary between different zoom levels depending on the distance between the annotations. The numbers on each marker on the map in Figure 2 shows the numbers of annotations in the cluster. In addition, a tag cloud of each cluster is also shown to the user. Users are thus able to explore individual annotations in each cluster by clicking on the tag cloud (Figure 3). Further, users are able to search without clustering the resulting annotations.
- **Filtering annotations:** In addition to clustering, filtering the annotations to narrow search results is also supported. Here, options are available to narrow the results by distance, user ratings and by time. (Figure 1).
- **Creating annotations:** When creating a new annotation, a user enters title, tags, description and attaches relevant multimedia files (Figure 4). We attempt to alleviate the problem of noisy tags [18] as well as to save users' time and effort in keying in tags [10] by providing tag recommendations (Figure 4). The tags are recommended based on the location of the annotation [11], its parents' tags and the owners' contributed tags thus far. Given the current location of the user, the

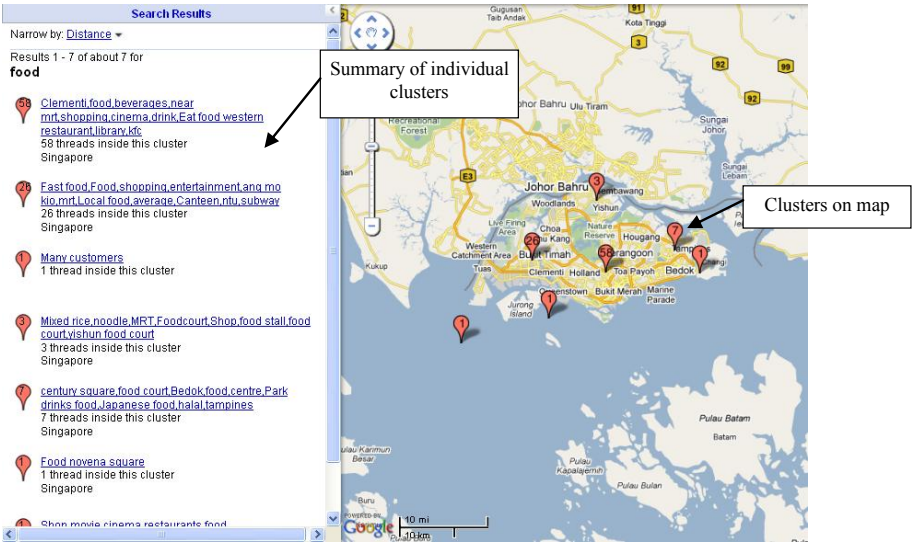

Fig. 2. Clustered search results list are displayed on left panel and on the map

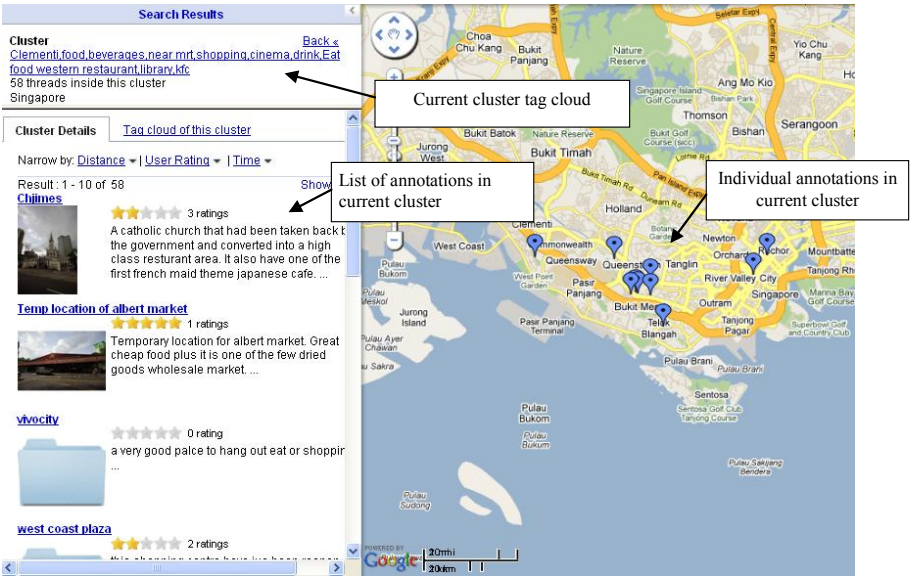

Fig. 3. Interface of the clustered the search results showing the annotations of a cluster

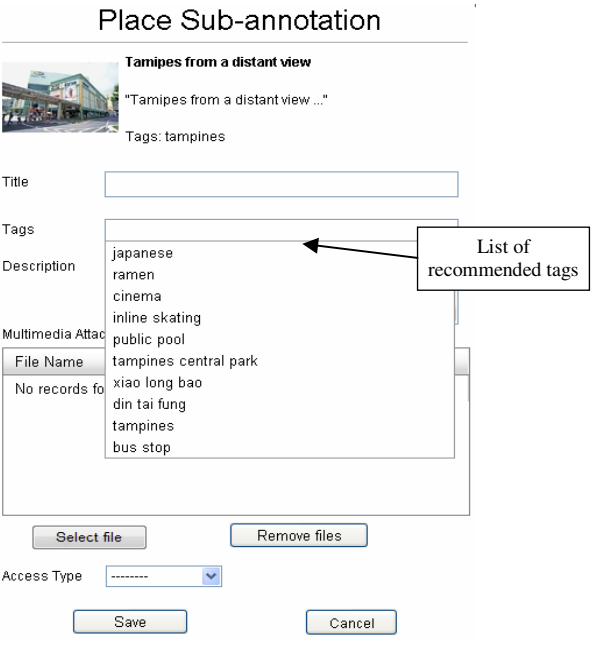

Fig. 4. Creating an annotation and list of recommended tags

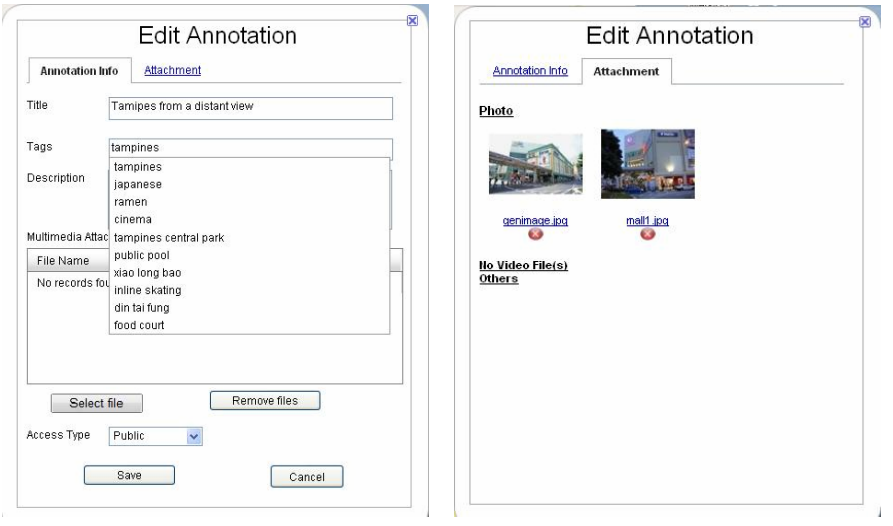

Fig. 5. Editing an annotation textual content as well as its attachments

algorithm first aggregates the tags that had been used in the surrounding location. Each of the tags that had been used in the surrounding location is given a score based on the frequency of its usage. We go further to make distinctions between the number of times the tag is used by the current user and other annotation creators. This is to maintain the preference of the current user over other owners. The tag's score is also determined by how recently the tag was used. Again, we made distinction between the current user and other owners. Finally, the top ten tags with the highest score are recommended to the user.

- **Editing/deleting annotations:** Users are only able to edit or delete the annotations that they had created. The edit form (Figure 5) provides functions that are similar with that to create annotations. Users are also able to edit the textual content, add or delete multimedia files.

4 Usability Evaluation

A study of the MobiTOP's Web user interface was conducted to determine its usability. A total of 106 participants took part in the evaluation. There were 57 male and 49 female participants, and they were students and working adults. Their ages ranged from 18 to 37, with an average age of 23. Further, 38% of the participants had a computer science background while the rest had other academic backgrounds. Participants were familiar with the use of social computing applications such as blogs, wikis, photo/video sharing, social tagging and social networking. Here, 65% of the participants reported to view such content at least once a week, while 55% of the participants reported to contribute such content at least once a month.

4.1 Methodology

During the one-hour evaluation session, participants were first briefed on the concept of annotations and were introduced to seven components of Web-based MobiTOP as describe in Section 3. After that, the short demonstration was provided to the participants to show them how to perform some basic tasks directly on the web application. Right after the introduction and demonstration, the travel planning scenario together with fifteen tasks were assigned to each of the participants in order to evaluate the user interface. The tasks focused on using the seven components of MobiTOP as described in Section 3 in order to plan and share travelling trips through the system. Research assistants were on hand to clarify doubts that the participants had while doing the tasks.

After completion of their tasks, participants were required to complete a questionnaire with demographic questions and those related to their perceptions of the usability of the MobiTOP system. Each question was given in the form of the affirmative statement followed by a scale of 1 (Strongly Disagree) to 5 (Strongly Agree). The usability section of the questionnaire was further divided into two parts. The first sought to determine MobiTOP's overall usability via four indicators [13]:

- **Learnability:** measures how easily the users learn to navigate the system and complete a task.
- **Efficiency:** determines the users' ability to complete a task within a reasonable amount of time.
- **Error Handling:** verifies the users understanding of the error encountered and the ability to recover from the errors.
- **Satisfaction:** validates the users' sense of satisfaction after completing the tasks and intention to adopt the system.

The second part of the questionnaire focused on the usability of each component, and questions were asked about the ease of use of the respective features. Participants were also encouraged to elaborate in their evaluation by answering three subjective questions about which components they liked or disliked, as well as suggestions on useful features that could be included in future versions of MobiTOP.

4.2 Results

Table 1 shows the mean and standard deviation (SD) of MobiTOP's overall usability with respect to the four indicators. Results indicate that MobiTOP was perceived to be relatively usable in general. For instance, during the study, most participants were observed to be able to complete the tasks after the short briefing, suggesting the learnability of the system ("It is easy to learn using the application"- Participant 2). In addition, the efficiency indicator suggested that participants took a reasonable amount of time to complete their tasks. It was observed that all of the participants were able to complete the tasks within the specified amount of time. Further, participants generally knew the meaning of error messages encountered and were able recover from the errors without seeking help from the research assistants. Finally, they appeared to have enjoyed creating and sharing annotations with others, and most of them felt satisfied after completing the tasks ("I can get a lot of information if users upload their experiences to MobiTOP… It is an interesting system"- Participant 37).

Table 1. Overall usability results (1 = strongly disagree; 5 = strongly agree)

Usability Indicators	Mean	S. D.
Learnability	4.08	0.36
Efficiency	3.72	0.54
Error Handling	3.60	0.59
Satisfaction	3.84	0.51

In addition to overall usability, Table 2 shows the mean and standard deviation of the usability of each of MobiTOP's seven major features. The results indicate that participants found the individual components to be usable as well:

- **User Registration.** Overall, all participants knew how to register for a MobiTOP account without any trouble. They found the registration form to be intuitive and this could be due to their familiarity with other Web applications' registration components. In addition, all participants knew how to handle registration errors.
- **Annotation Navigation.** All the features of the View menu were appreciated by the participants. For instance, Participant 4 commented that "viewing my annotations helps me to conveniently keep track of all my uploaded annotation". Participant 29 found viewing annotations of a particular user to be useful as it "allows me to search for their friends' activities easily". Similarly, Participant 7 found tag cloud function to be convenient: "I don't have to think about the word I want to search, it's great". Finally, Participant 45 liked the viewing of recent annotations as it "allows me to quickly update the information in the system". On the other hand, the "View All Annotations" feature received less positive responses compared to the others. One likely reason was that most users could not access their preferred annotations are among the large number of annotations in the system. In summary, the participants were able to learn how to use the features in the View menu without any difficulty and most of them found that this component greatly helped the way they accessed the annotations.
- **Map Navigation.** Most of the participants felt comfortable in browsing the map. Additionally, they felt that the map-based interface was quite intuitive. The reason could be their familiarity with Google Maps as 70% of the participants used Web-based mapping applications at least once a week. The way of representing annotations on the map was also well received by the participants ("It's quite easy to navigate the map and explore annotations through pop-up windows"-Participant 98).
- **Creating Annotations.** The participants found that the annotations were easy to create because of the simplicity and responsiveness of the interface. As Participant 46 remarked: "The speed of uploading the annotations amazes me. It doesn't take more than a minute to add a new annotation. It's simple to attach a picture too". Although the concept of hierarchical annotations was new to most of the participants, they were able to create sub-annotations easily. Perhaps the tree view visualization provided them with the proper mental model to understand the concept of hierarchical annotations. The participants also realized the advantages in organizing the annotations hierarchically. This sentiment was echoed by Participant 6 who felt that creating sub-annotations was easy as "we

usually share our experiences in the some similar topics with others. The tree structure let us to conveniently organize the information".

- **Editing/Deleting Annotations.** Participants found editing an existing annotation to be easy and useful as they were able to provide updated information to their contributions. They also found deleting their annotations to be easy ("The … delete annotations (was) made simple and easy" – Participant 63).
- **Searching Annotations.** Participants found that the search without clustering feature was easy to use as the results were ordered by relevance and organized across pages. Participant 44 found that the "searching feature is easy to use and it helps me to find the information I need". On the other hand, presenting the search results in clusters was a new concept to some users. However, most participants managed to complete the tasks related to this function. A common sentiment shared by the participants was that clustering helped to reduce information overload. Participant 10 sums this nicely: "Clusters are neatly organized and the tag cloud of each cluster helps in the searching process". However, there were comments on the unresponsiveness of searching with clustering. This was because of the processing time required by the clustering algorithm.
- **Filtering Annotations.** Most of the participants agreed that being able to filter the annotations by different attributes was helpful in discovering information and at the same time reduces information overload. Participant 106 commented that "it is a handy tool to narrow down the information from the large results list".

Table 2. Components' usability results (1 = strongly disagree; 5 = strongly agree)

Components Usability	Mean	S. D.
Registration	4.22	0.51
Annotation Navigation	4.19	0.48
Map Navigation	3.99	0.61
Creating Annotation	4.11	0.52
Editing/Deleting Annotation	4.13	0.63
Searching Annotation	3.82	0.56
Filtering Annotation	4.17	0.55

5 Discussion and Conclusion

In this paper, a usability evaluation was conducted with the goal of ascertaining the usability of MobiTOP, a location-based annotation system. The overall usability was found to be above-average by the 106 participants. This is despite the fact that there were new concepts being utilized to support information access such as hierarchical annotations and clustering of search results. Moreover, observations during the evaluation showed that participants needed very little training to be able to use the system. Arising from our results, the following are some implications for the design of location-based annotation systems:

- Using familiar visualizations to represent new concepts helps users to orientate themselves more quickly to the system. We have adopted the tree view to represent the hierarchical aspect of annotations and the map-based visualization to represent the annotations. As these visualizations provide the relevant mental

model for users to map the respective concept with the visualization, users are more likely to find the application easy to use, as demonstrated by our results.

- As with any information system, searching is an essential component. Additionally for a location-based system, searching is often tied to a specific location and is visualized on a map. However, presenting results as individual annotations on the map may overwhelm the user especially when there are large numbers of annotations returned. As such, clustering results on the map should be considered to alleviate the information overload.
- Provide filtering functions that are based on the different attributes of the data model. As our annotations are contributed by the users, having a mechanism that distinguishes the more useful annotations from the less useful ones would benefit the users. In terms of geo-spatial attributes, narrowing the radii of search focuses the users to the relevant area of interest. Finally, being able to filter the annotations by time attributes narrows the annotations to the relevant time period.
- Finally, eliminate the need for the user to manually input the data by providing recommendations. For instance, in MobiTOP, relevant tags are suggested to the user when while creating an annotation. The users of course have the freedom to make their selections. This reduces the mental effort needed to create annotations, thus improving users' perceptions of the usability of the application.

There are limitations in our study that could be addressed in future work. First, our clustering algorithm is limited to geo-spatial locations. Perhaps clustering the annotations semantically [15] in addition to location would further help users obtain relevant content. Next, our evaluation was cross-sectional in nature and confined to the use of MobiTOP in a single session. Further work could track the usability and usefulness of the system over a longer period of time. Finally, memorability was not considered as a usability indicator. It would be interesting for future work to investigate this aspect of MobiTOP [16].

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