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# Mobile Facets—Faceted Search and Exploration of Open Social Media Data on a Touchscreen Mobile Phone

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**Abstract**

We present the user-centered, iterative design of Mobile Facets, a mobile application for the faceted search and exploration of a large, multi-dimensional data set of social media on a touchscreen mobile phone. Mobile Facets provides retrieval of resources such as places, persons, organizations, and events from an integration of different open social media sources and professional content sources, namely Wikipedia, Eventful, Upcoming, geo-located Flickr photos, and GeoNames. The data is queried live from the data sources. Thus, in contrast to other approaches we do not know in advance the number and type of facets and data items the Mobile Facets application receives in a specific contextual situation. While developing Mobile Facets, we have continuously evaluated it with a small group of five users. We have conducted a task-based, formative evaluation of the final prototype with 12 subjects to show the applicability and usability of our approach for faceted search and exploration on a touchscreen mobile phone.

## 1 Introduction

Supporting mobile information needs are becoming more important than ever, be it on a business trip, during vacation, or when going out with friends. However, when accessing the web with a mobile phone one is overwhelmed with the information provided. Smaller display size and limited interaction possibilities hamper the access to information from mobile phones. In the web of today, users typically want to explore several, distributed and independent open social media data sources. For example, in the social web, one wants to retrieve information about a city and its sights from Wikipedia[1], see photos related to the sights on Flickr[2], and explore events happening in the city from event di-

[1] http://www.wikipedia.org/
[2] http://www.flickr.com/

rectories like Upcoming[3] and Eventful[4]. These data sources are open as they offer besides a web-based user interface also access by some publicly available application programming interfaces, e.g., REST in the cases of Flickr and Upcoming. Other data sources have been translated into the Resource Description Framework (RDF)[5] format of the Semantic Web. For example, a Semantic Web version of Wikipedia is provided by DBpedia [2] and made publicly available through a SPARQL[6] endpoint.

In order to explore large information spaces like in the example above, the paradigm of faceted search and exploration has been developed in the past [8, 7, 9, 13, 21]. In fact, faceted search and exploration is an established interaction paradigm on desktop computers and has been well studied in the last decades. It allows users to iteratively navigate through a large information space by constantly narrowing down the result set. This is conducted by applying one or more facets on the information space, filtering out results that are not relevant and showing only those results to the users he or she is interested in. Examples of web applications that make use of facets are, e.g., the shopping platforms Amazon[7] and Ebay[8].

In the mobile world, we have to deal with additional problems in order to provide a mobile faceted search and exploration due to limited interaction possibilities and smaller display size. These limitations are opposed to the complexity and dynamics of the facets and data items (resources) that are retrieved from the open social media data sources and that need to be visualized and explored. As the data is retrieved live, we do not know in advance the number and type of facets and data items. This requires an even smarter user interface and intuitive use of facets than on desktop computers. This is a problem, as providing an intuitive and easy to use mobile user interface for faceted search and exploration is hard.

In the past, there have been different approaches developed for mobile faceted search and exploration. FaThumb is a keypad-driven mobile application providing faceted search by means of selecting facets through the number keypad of the mobile phone. A pen-based interaction is provided by mSpace Mobile running on personal digital assistants based on Microsoft Windows Mobile. Both systems use as evaluation data a predefined, closed data source only. This means that the number and type of the data items is fixed and known in advance. Another mobile application providing faceted search and exploration is the Mobile Cultural Heritage Guide [18]. This application is specifically designed for the cultural heritage domain and focuses on an augmented reality feature for exploring the cultural sights of Amsterdam.

In contrast to prior work, we present in this paper the iterative, user-centered design of Mobile Facets for the interactive, faceted search and exploration of a

[3] http://www.upcoming.org/
[4] http://www.eventful.org/
[5] http://www.w3.org/TR/REC-rdf-syntax/
[6] http://www.w3.org/TR/rdf-sparql-query/
[7] http://www.amazon.com/
[8] http://www.ebay.com/

large, distributed data set from different, integrated social media sources on a touchscreen mobile phone. The Mobile Facets application allows for retrieving entities such as places, persons, organizations, and events from an integration of DBpedia, Eventful, Upcoming, and geo-located Flickr photos and professional content from GeoNames[9]. In order to cope with the dynamics of the resources retrieved live from the open social media data sources, the Mobile Facets application provides a flexible mobile user interface based on facets. The principle idea is to start with a small number of predefined high-level facets, namely Places, Persons, Organizations, and Events, and to fill them dynamically with the facets and resources retrieved live from the social media data sources.

The user-centered, iterative design of Mobile Facets has been carried out with a small group of five users. For the final prototype, we have conducted a task-based, formative evaluation with 12 subjects. These subjects are different from the initial user group. Goal is to show the usefulness and usability of our application. The data infrastructure of Mobile Facets is designed such that it allows for an easy integration of further open (social media) data sources that are available via, e.g., REST interface or SPARQL endpoint.

In the next section, we motivate the need for Mobile Facets by a concrete scenario. The related work is discussed in Section 3. The scenario and related work have been used as input for the iterative, user-centered prototype design described in Section 4. The features of the final prototype are presented in Section 5. The design of a task-based evaluation of our Mobile Facets application with 12 participants is presented in Section 6. The evaluation and the results are presented and discussed in the subsequent sections, before we conclude the paper.

## 2 Scenario

Mobile information needs have been investigated by Sohn et al. in a two-week diary study [17]. Their study revealed 16 different broad categories. We are interested in two of the three most frequent information needs, namely trivia (18,5%) and searching for points of interests (12,4%). Trivia questions happen, e.g., in user conversations or when a user is approaching some artifact like a billboard or a sight [17]. Examples are getting information about "How many inhabitants has San Francisco?" and "How high is the Daimler Chrysler building in New York?". Searching for points of interests is about finding interesting places. We extend this by event information related to places such as people's birthplace, concerts, or exhibitions. Examples are "What events at historic buildings are happening this weekend?" and "Which actors and athletes were born in the vicinity?".

Based on this, we present a scenario of Jim, a business men from London who is visiting Berlin for a fair. He is staying the weekend in Berlin for exploring its sights.

[9] `http://www.geonames.org/`

*(a) Exploring points of interests*: On Saturday morning, Jim takes out his Mobile Facets application and uses the "What's around me?" feature to show places, persons, organizations, and events in his vicinity. He selects the facet Places and refines it to see only sights. Looking at the sights visualized on his mobile map, he decides to go to the Brandburg Gate and to explore some other sights around there. Subsequently, he refines his search to show only ecclesiastical sights. Jim is looking for a specific church in Berlin he is interested in and views some pictures of it. He checks its exact location and walks towards it.

*(b) Searching for celebrities*: Having seen a couple of sights, Jim decides to have a rest and goes to the next Starbucks. While enjoying his coffee, he starts searching for famous persons that are related to Berlin. He queries Mobile Facets to show all known places in Berlin where some celebrity was born, live(d) or died. He is in particular interested in actors and sportsmen and adds these as facets to the query to filter the results. He browses through the list of celebrities, looks at some photos of them, and reads background information provided by Wikipedia.

*(c) Searching for points of interests*: Finishing his sightseeing tour on Sunday evening, Jim is heading towards the airport to return to London. While in the taxicab, he catches a last view of the huge television tower, one of Berlin's most visible landmarks at the Alexander square. He asks himself, how high the tower actually is and wants to compare it with the height of other sights. He conducts a keyword-based search to show transmission towers, selects the tower at the Alexander square in Berlin and reads the Wikipedia abstract. Subsequently, he searches for other sights in Berlin using the "What's around me?" feature to view their height and to compare it with the height of the transmission tower.

*(d) Exploring events*: While Jim is waiting at the airport for his plane to board, a spontaneous idea comes into his mind: he wants to go out in London coming week. He switches the location context of Mobile Facets from his current location in Berlin to search for events in London. Jim browses through the events visualized on the map using the novel time-slider widget [16] of Mobile Facets to see if something interesting is happening the next days. He narrows down the event search by selecting the sub-facet Music. Jim selects some of the events shown on the map and finds out that Shakira is playing Friday evening.

*(e) Searching events*: Jim might go to the particular Shakira concert in London, but he wants to check other locations where Shakira is playing as well. He will be traveling again in three weeks, this time to Dublin, Ireland. Jim conducts a keyword-based search for events of Shakira. He finds out that Shakira is actually playing while he is visiting Dublin. Finally, Jim wants to see what else is happening in Dublin. He changes the location context to Dublin and uses Mobile Facets to show him all other events and points of interests in the city.

# 3 Related Work

## 3.1 Definition of Facets

The term *facet* is used in different contexts and interpreted differently [15]. Nevertheless, there are common characteristics that can be found in the definitions such as that each facet has a name or at least a proper description and that a facet is referring to a category in order to describe an aspect of a multi-dimensional data space [7]. With faceted search and exploration, one cuts this multi-dimensional data space along the different categories, i.e., the different dimensions it contains [14] in order to reduce its complexity and the number of items to be retrieved. The facets act as filters by returning only those items that are conform with the selected facet(s). Thus, in each iteration of a faceted search and exploration, the result list is refined by adding another facet. Besides this orthogonal organization of facets [11], they can also be hierarchically organized [15]. For example, the facets Politician and Athlete are sub-facets of the facet Person. If a (child) facet appears in more than one parent facet and if the path from the parent facet to the child facet are disjoint, they are called poly-hierarchical facets [1]. The relationship between parent facets and children facets is of is-a. This means that each child facet is a specialization of the parent facet. Root facets are those, which do not have further parent facets. They are called high-level facets. Facet categories that do not have further children categories are leave nodes and represent a set of instances.

The high-level facets considered in this work are derived from the facets documented in the literature such as [8, 7, 9, 13, 21] and types of data found in the social media data sources. The high-level facets are Places, Persons, Organizations, and Events.

## 3.2 Faceted Search and Exploration

The principle idea of faceted search and exploration is not new. It has been well studies for desktop computers, e.g., [8, 7, 9, 13, 21]. One of the most well-known applications for faceted search and exploration is Flamenco [21]. It allows its users to explore a multi-dimensional information space along a hierarchy of facets. From this and other work, one can derive generic requirements for a faceted search and exploration of a multi-dimensional information space [8]. Among the most important requirements are a flexible navigation within the information space, i.e., users can freely decide how to navigate along the facets in the information space, avoiding empty results, and seamless integration of a keyword-based search.

Regarding mobile faceted search and exploration, we find FaThumb [11], mSpace Mobile [19], and the Mobile Cultural Heritage Guide [18]. FaThumb is a keypad-driven application for mobile faceted search and exploration [11]. The search result is narrowed down iteratively as shown in Figure 1 by using the number keypad of the mobile phone. Due to the time when FaThumb has been developed, it does not provide a GPS-based map view or a rich media

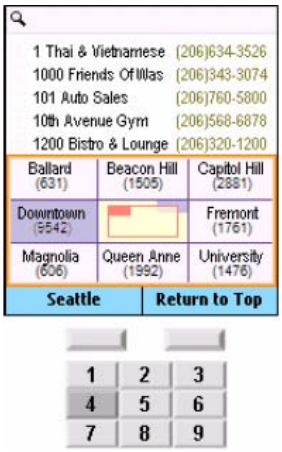



Figure 1: Keypad-driven FaThumb [11]

view, e.g., for showing pictures of the selected items. The application makes use of a single, closed data set, obtained from the Yellow Pages of the US state Washington.

With mSpace Mobile, we find a pen-based mobile application for faceted search and exploration of location-based information [19, 20]. It is designed for personal digital assistants running Microsoft Windows Mobile. The user interface is divided into tiles as shown in Figure 2. Each tile shows one aspect of the information space such as a list of points of interests, a map, or metadata. The upper tiles serve as navigation within the available facets. By selecting them, the content of the lower tiles changes such as points of interests on the map and information about the selected facet. The mSpace Mobile application makes use of facets extracted from different data sources of the classical music domain and movie databases. The facets are stored in an own database.

The Mobile Cultural Heritage Guide [18] is a tourist guide application for Amsterdam providing an augmented reality view. Users can explore the artists that have lived and worked in the city and have a look at the places today from the perspective of the painters in former times. The application is specifically designed for the cultural heritage domain and does not provide a generic interface for mobile faceted search and exploration. Thus, the Mobile Cultural Heritage Guide does not provide a flexible user interface to cope with, e.g., a dynamically filled list of sub-facets where the number of sub-facets is not known in advance or might contain many entries. As data set it uses general knowledge about geo-locations and points of interests as well as specific knowledge about the cultural heritage domain.

In contrast to the prior work, we present in this paper a generic user interface for faceted search and exploration in a large, multi-dimensional information space of social media data on a touchscreen mobile phone. We do not assume to know in advance what kind of facets the users will receive and how many facets


Figure 2: Pen-based mSpace Mobile [19]

and resources one finds at a given user location. This is due to the fact that we query the social media data sources live and are not using any predefined, closed data set. In addition, the architecture of Mobile Facets is flexible with respect to integrate further (social media) data sources.

# 4 Iterative Prototype Design and Evaluation

The design of our Mobile Facets application for mobile faceted search and exploration is based on the scenario presented in Section 2 as well as inspired by the existing applications discussed in Section 3. We have started with a paper-based prototype, which has subsequently been implemented as a running prototype. The running prototype has been iteratively refined. In each iteration, we have conducted requirements gathering, prototype engineering, and evaluation with a small user group of five subjects. The goal of this iterative, user-centered development was identifying usability issues and weaknesses in the control flow of the application [6]. In the following, we briefly describe the iterative, user-centered design of Mobile Facets.

## 4.1 Design and Evaluation

We have applied an iterative design process [10] under continuous involvement of end users for developing the Mobile Facets prototype. Goal was to continuously carry out evaluations in order to detect issues in the design and workflow of the application. To this end, we have asked a small group of five users (one female) to provide early and continuous feedback. The age of the users is between 26-35 years. The experience in using mobile phones in the group is between good to very good. In addition, two users are experts on user interfaces.

Starting with a paper-based mock-up prototype, we have created and continuously improved a running prototype that the users have tried out on a

touchscreen mobile phone. In each evaluation session, the users were asked to conduct a series of tasks relevant to the scenario described in Section 2. We have also asked the users to think-aloud [12] in order to obtain feedback from their feelings, spontaneous reactions, and thoughts. In addition, we have received feedback from the users in a dialog after the session.

We have detected several usability issues at an early stage of the prototype development such as problems in the control flow of the application and have received feedback on critical design decisions. In the following, **we highlight the two most important design questions**: designing the users' interaction for **searching and exploring the open social media data using facets** and the **visualization of the selected facets** to show the current state of the system to the users. Finally, we discuss further comments and feedback received from the small evaluation group.

## 4.2 Search and Exploration Using Facets

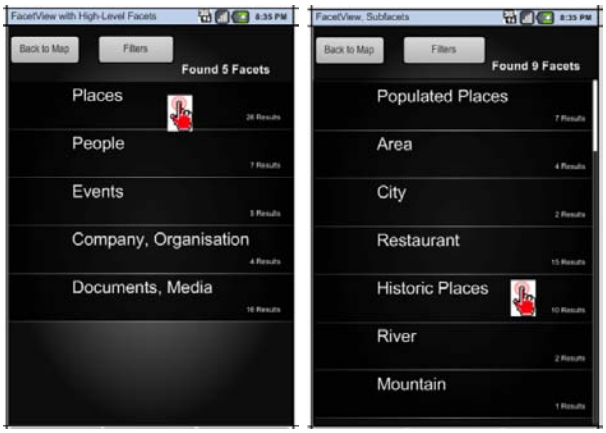
Goal of the search and exploration using facets is to enable the users to find interesting places, persons, organizations, and events in their vicinity through a poly-hierarchy of facets. When navigating in multiple facet hierarchies, users should still be able to keep track of the choices they made and should not feel lost [3]. To achieve this, we have created three different design variants for our mobile search and exploration using facets. In all variants, the users start with the high-level facets Places, Persons, Organizations, and Events.

In the first design variant shown in Figure 3a, the user clicks on a high level facet such as Places. By this, the user navigates into the facet hierarchy and the sub-facets of Places are shown such as Populated Places, Area, City, and so on. For each facet, the number of results is shown such that the user knows which (sub-)facets are more populated than others. Please note that in our initial designs, there was a fifth high-level facet Documents/Media that has been removed later.

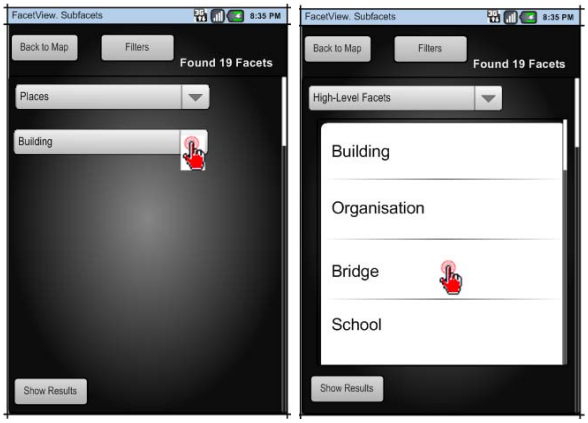
In the second design variant shown in Figure 3b, the facets are selected by means of pull-down menus. First, a high-level facet is selected like Places. Then, a pull-down menu appears showing the sub-facets of the previously selected facet. The users can select a sub-facet from the list to further refine the result list.

The last design variant shown in Figure 3c is inspired by mSpace Mobile [19]. The screen is divided into several smaller areas for facet selection and exploration. The user starts at the top-left corner to choose from a high-level facet like Places. Subsequently, the right hand side is filled with the sub-facets and the users can choose one from it like Historic Places. The result list is than further narrowed down in the bottom left part of the screen.

The user group found it in principle useful to navigate by means of lists of facets. This was seen as a strong advantage of the first design variant by most users. But the users mentioned that the font should be large. It was also mentioned that it might be cumbersome to navigate through multiple hierarchies of facets which may contain large lists of sub-facets. Advantage of the




(a) Variant 1




(b) Variant 2


(c) Variant 3

Figure 3: Search and Exploration Using Facets

second approach is that the users see which (sub-)facets have been selected. However, the users disliked that the drop-down menus are dynamically added to the screen. In addition, selecting items from the drop-down menus was considered cumbersome. In the third design variant, again the users can keep track of the interactions, i.e., the facets they have selected. However, the problem is that the available space of the screen is limited and thus the interaction with the mobile phone is difficult.

From the three design variants the best rated was the first one. The only disadvantage with the first design variant is that the users do not see which facets were previously selected. This circumstance has received specific consideration when improving the user interface. In the end, a visualization of the selected facets together with the faceted search and exploration as shown in Variant 1 (Figure 3a) has been integrated in the prototype and is described in the next section.

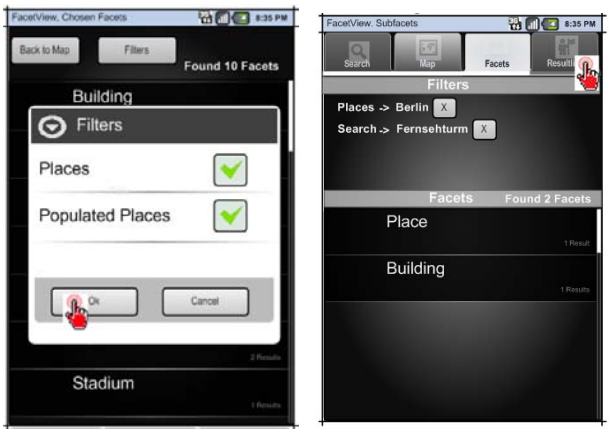
### 4.3 Visualizing Selected Facets

In order to support users in keeping track of the facets they have selected, the current state of the system needs to be shown to them appropriately. The user group has been presented two different design variants A and B showing how the selected facets can be visualized.

The design variant A is created such that it can be applied together with all three design variants for faceted search and exploration as presented in the previous section. To see the currently selected facets, the users can click on the "Filter" button shown in the top of the screenshots of Figure 3a to 3c. Please note that at that time of the system design, the term "filter" was used show the currently selected facets. It was later removed and replaced by the term facet. Subsequently, a menu pops up depicting the currently selected facets as shown in Figure 4a. The selected facets are, e.g., Places and its sub-facet Populated Places. To unselect a facet, the checkboxes at the right hand side can be used. When sub-facets such as Populated Places are removed, the system falls back to the higher-level facet, in this case Places. However, when unselecting the facet Places, also the facet Populated Places is unselected as it is a sub-facet of it.

In the design variant B depicted in Figure 4b, the currently selected facets are shown together with the search and exploration via facets as depicted in Figure 3a. The user has selected the high-level facet Places and has further narrowed down the result list by choosing the sub-facet Berlin. We have also added a keyword search, in this example a specific kind of sights, namely transmission towers (Search $\rightarrow$ Fernsehturm). The facets can be unselected, by clicking on the small "X" button on the right hand side of it.

In the design variant A, it was clear how to unselect facets. However, the users did not found it intuitive that the facet Populated Places is a subfacet of Places. Although a keyword-based search like for the transmission towers was appreciated in general, integrating it into the selected facets as shown in the design variant B (Figure 4b) was not considered useful. In general, however, the




(a) Variant A (b) Variant B

Figure 4: Visualizing Selected Facets

design variant B was considered more intuitive. This also reflects the experiences made with facets in the context of desktop computer applications (see Section 3).

Finally, the question came up what happens when the user clicks on the "X" on the right hand side of the facets of Figure 4b. Is just the last sub-facet removed from the result list or should the entire hierarchy of selected facets be removed? Here, the evaluations showed that it was more intuitive and useful to remove the entire facet.

Referring to design variant B, it was also discussed how the hierarchy of facets from the high-level facet to its last sub-facet should be visualized. Here, we have created further three design alternatives as depicted in Figure 5 and asked the users to valuate them. The first alternative shows the complete hierarchy of facets. Depending on the depth of the facet hierarchy, the list of sub-facets shown can be very long. To avoid this problem, the second alternative uses [...] to hide the middle sub-facets and only shows the high-level facet and the last sub-facet. This design alternative allows both to keep an overview of which high-level facets have been selected and to which specific sub-facet it has been narrowed down. Finally, the third design alternative only shows the last selected sub-facet.

For the first design variant, the users assumed that the system is searching for Places, Populated Places, Building, and Stadium. But as this is a hierarchy of sub-facets only entities of facet Stadium are shown. The second design variant alleviates this problem. However, here the context of the facet Stadium is unclear, i.e., where in the hierarchy of facets it belongs to. The same holds true for the third variant. The second design alternative was considered useful when the list of facets is too long to show it on the screen. After explaining the different design alternatives to the user group, in particular how the first design

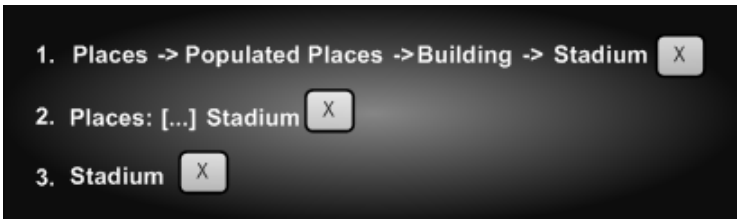



Figure 5: Three Design Alternatives for Visualizing Facet Hierarchies

variant is to be understood, there was a common agreement that the first design alternative is the best choice.

### 4.4 Further Comments

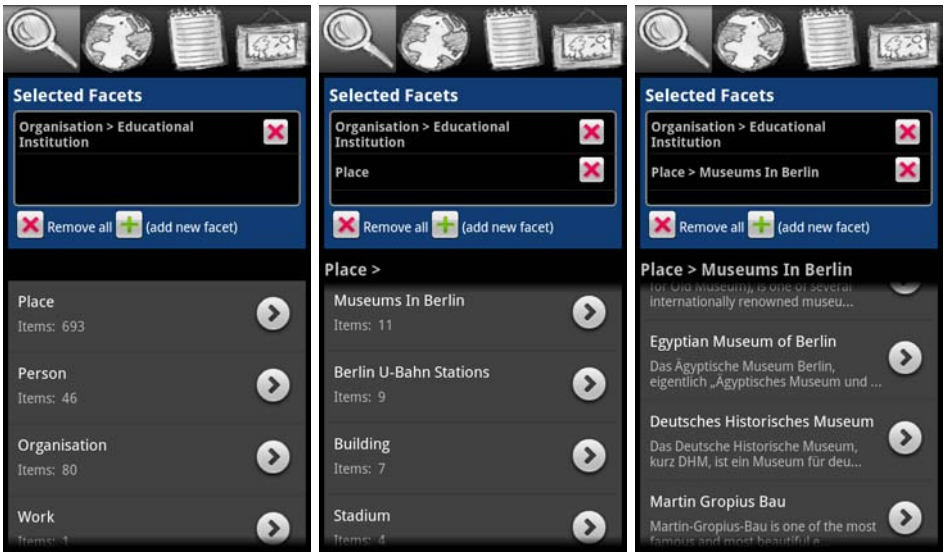
There were a couple of further comments mentioned during the evaluations of our prototype that identified several usability problems and issues in interacting with the application. For example, besides searching and exploring the information space via facets, the users wanted to have a keyword search as well. This coincides with other studies on faceted search and exploration on desktop computers [8]. We suggested a live preview of the results when typing in a keyword, which was considered a useful feature.

Some users were confused by the terminology, namely the use of the two terms facets and filters. As said above, we decided to use the term facet only although in literature and existing applications the term filter is also found like with the DBpedia browser of Neofonie[10]. Similar to other location-based applications like Google Maps, our Mobile Facets application only searches within the area of the current map view. In our evaluation group, most users found this intuitive, only one disagreed. When starting the Mobile Facets prototype, the map view was the first one shown to the users. However, as no query has been executed yet, the map was empty. This was not considered useful by the user group and thus the facet view for search and exploration is shown when starting the Mobile Facets application.

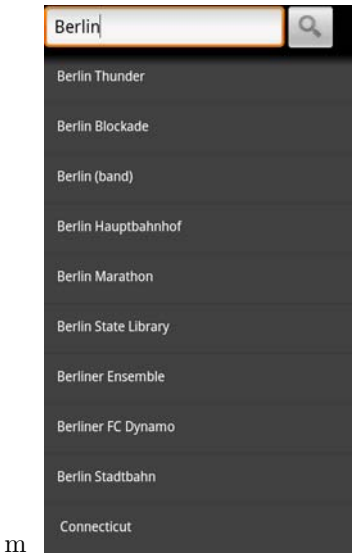
## 5 Final Prototype

Result of the iterative, user-centered design of Mobile Facets is a prototype application for faceted search and exploration of places, persons, organizations, and events on a touchscreen mobile phone. To show the usefulness and usability of the Mobile Facets application, we have conducted a formative evaluation with 12 additional subjects. Before we describe the formative evaluation in Sections 6 and 7, we present in this section the design and functionality of the Mobile Facets prototype along the tabs it provides, namely faceted search and

[10] `http://dbpedia.neofonie.com/`




(a) Faceted Search and Exploration View: High-level facets, Sub-facets, and Instances




m

(b) Keyword Search

Figure 6: Final Prototype of Mobile Facets Application

exploration, map view, result list view, and photo view. Finally, we present the details view of resources. The users can switch arbitrarily between the tabs by clicking on the corresponding icon at the top of the application.

## 5.1 Tab 1: Faceted Search and Exploration

When starting the Mobile Facets application, the first tab for faceted search and exploration is shown to the user as depicted in Figure 6a. The screen is divided into two parts as discussed in the iterative design of the prototype in Sections 4.2 and 4.3. In the upper area, the facets and sub-facets selected by the user are shown. In the example in Figure 6a, the user has selected the facets Educational Institution and Museums in Berlin. The resulting resources are all organizations of educational background merged with all places that are museums in the city of Berlin. By clicking on the cross next to the facets, the entire facet is removed. In addition, the user can remove all currently selected facets or add a new facet using the "+" icon. In order to meet the requirement of avoiding empty result lists (see Section 3.2) when searching and exploring using facets, the number retrieved items, i.e., the number of sub-facets or instances is shown under the facets. For example, there are eleven Museums in Berlin.

The lower area of Figure 6a shows the available facets and allows the users to select and explore the information space using facets. The facets are initially filled when starting the application or by executing a "What's around me?" query from the applications menu (no screenshot provided). One starts with selecting a high-level facet and narrows down the result set using sub-facets. Figure 6a (left) shows the high-level facets Places, Persons, Organizations, and Events and the selected facet Organisation → Educational Institution. The user selects the high-level facet Place. Subsequently, the sub-facets of Place in Berlin such as Museums in Berlin, Berlin U-Bahn Stations, and others are shown as depicted in Figure 6a (middle). The user clicks on the facet Museums in Berlin and the instances of this facet are shown as depicted in Figure 6a (right). By clicking on one of the instances, the details of this resource are shown as described in Section 5.5.

Besides using facets for search and exploration in the information space, also a keyword search is offered as depicted in Figure 6b. The keyword search is independent of the current location of the user and allows to find people, places, organizations, and events. It provides a live view of the results once the user starts typing in a keyword. The live view not only searches in the titles of the resources but also exploits semantic relationships. For example, in the query of "Berlin" in Figure 6b also the state Connecticut in New England is found as there is a town in this state that is called Berlin.

## 5.2 Tab 2: Map View

Once the users have selected appropriate facets using the tab described in the previous section, they can visualize the results on a map. To this end, the users click on the map view tab, which allows standard map-based interaction such as

zooming and panning as depicted in Figure 7a. The map view shows all search results that have a geo-location like places and organizations. When clicking on a point of interest, its details are shown as described in Section 5.5. The blue stars shown on the map are events, i.e., point of interests that are of interest during a specific period of time like a concert or an exhibition. The Mobile Facets application provides a novel time-slider widget [16] to browse through time, which is located at the bottom of Figure 7a. The events are rendered depending on the temporal distance to the currently selected date of the time-slider widget. Events happening today are shown in shaded blue-red whereas events happening up to 30 days in the future are more and more lightened up. This provides the users immediate feedback when events are happening while operating the time-slider widget.

### 5.3 Tab 3: Result List View

Besides a faceted search and exploration and map view of the results, there is also a plain list view of matching resources as shown in Figure 7b. It contains all resources of the currently selected facets as described in Section 5.1. The resources shown in the result list view can be any instances of the high-level facets or its sub-facets. In the example, the facets Archaeology Museums and Urban Public Parks in Berlin are selected and its five results are shown in the list. The users can click on the results, which again opens the details view.

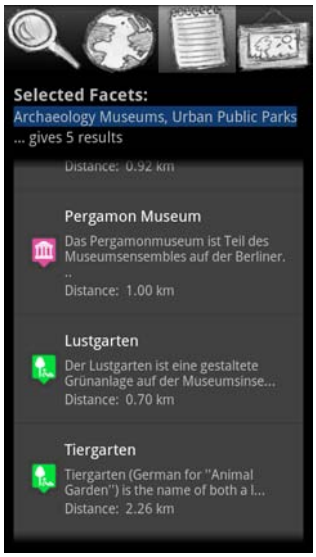
### 5.4 Tab 4: Photo View

The photo view depicted in Figure 7c is the last tab in the Mobile Facets application and shows images from Flickr that have been taken in the vicinity. A gallery of photos is shown at the top. Users can scroll through it and click on images they like to see in larger resolution.

### 5.5 Details View

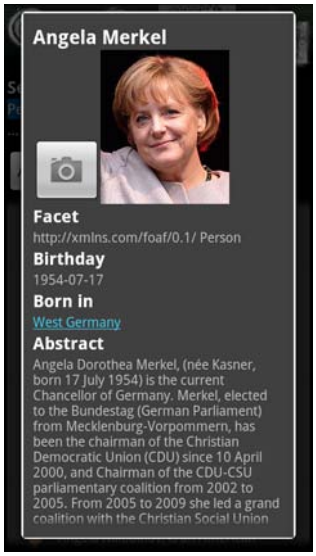
The details view of a resource can be opened from all tabs of the Mobile Facets application. Depending on the type of resource, the details view shows different information: For DBpedia resources, i.e., places, organizations, and persons described on Wikipedia, the details view provides a title, thumbnail (if available), link to the article's web page, abstract, and others. As an example, Figure 7d shows the details of Germany's chancellor Angela Merkel. The users can click on the photo icon to switch to the photo view. For resources with a location, also an icon to switch to the map view is provided. For event resources, the details view shows the event category, start date, end date, address of the venue, and the event description (no screenshot provided).


(a) Map View with POIs and Events




(b) Result List View Showing Places in Berlin


(c) Photo View




(d) Details View

Figure 7: Final Prototype of Mobile Facets Application

# 6 Evaluation Design of Final Prototype

To show the usability and usefulness of the Mobile Facets application, we have conducted a task-based evaluation [12] of the application with 12 subjects. In this section, we present the design of the evaluation.

## 6.1 Test Subjects

The age of the 12 subjects (two female) has been between 22 and 34 years. The subjects of the final prototype evaluation have not participated in the iterative design and evaluation described in Section 4. All users had some experience with a keypad-based phone. Six of them said that they are used to touchscreen mobile phones. None of the users consider themselves experts in using mobile applications or mobile phones. None of the subjects have used or seen the Mobile Facets application before. However, they were familiar with the facet concept on desktop computers.

## 6.2 Data Corpus

As data corpus, we use publicly available sources of social media and a geo-location website. This includes DBpedia [2], the event directories Eventful and Upcoming, geo-located Flickr photos, and content from GeoNames. The data is queried live from the data sources. Thus, we cannot make any assumptions about which facets and how many data resources the Mobile Facets application receives in a specific contextual situation. The data is social as it is generated by users, but with GeoNames, Eventful, and Upcoming it also contains professional data.

DBpedia contains resources such as places, persons, and organizations. In the context of this work, we use the English language version of DBpedia with 3.4 million resources. They are retrieved by means of using the rdf:type property that classifies resources to concepts. The information about which facets a resource belongs to is extracted using the dbpedia-owl property. Here, we conducted a static mapping of the DBpedia concepts to the four high-level facets Places, Persons, Organizations, and Events. Eventful and Upcoming are platforms that allow registered private and commercial users to create and share event descriptions. Resources from eventful have different (event) categories, which serve as sub-facets in our data set. Typical categories are music, performing art, or education. Similar, also Upcoming provides private and commercial event descriptions and categorical information for the events. GeoNames is a comprehensive database of geographic places and objects of the world. It contains 2.8 million populated places. Flickr is a social photo sharing platform with more than 5 billion photos. For Mobile Facets, we are using those photos from Flickr which have a geo-tag.

### 6.3 Tasks

Like with the initial evaluation, the evaluation of the final prototype was carried out by conducting tasks along the scenario described in Section 2. For each paragraph (a) to (e) in the scenario, we have defined between three to seven tasks such as searching and browsing interesting sights, refining results using facets, reading information about people, exploring events, and others. In total, 25 tasks were defined. Subsequently to finishing a set of tasks (a) to (e), the users were asked specific questions related to the tasks and providing general feedback on the usability of the application. While conducting the tasks, the subjects were allowed to ask questions to the instructor in case something was unclear. In addition, the subjects were motivated to think aloud.

## 7 Evaluation and Results

The evaluation was carried out as a controlled laboratory experiment. Each evaluation session took between 30 to 60 minutes. The subjects could conduct the evaluation tasks derived from the scenario in Section 2 at a speed convenient for them. They have also been instructed that it is not the goal of the evaluation to measure the efficiency but to obtain qualitative feedback on how they like and feel supported by the application in conducting the tasks.

After starting the application for the first time, a two to three minute introduction to Mobile Facets was given. The introduction comprises the presentation of the faceted mobile search and exploration and the different tabs of the application. The users acquainted themselves with the touchscreen mobile phone and could play around with the application. Subsequently, the actual evaluation began. To this end, the subjects have received a list with detailed instructions of the tasks they had to perform. All users were able to accomplish the tasks. However, some tasks were more difficult to solve than others due to the interaction workflow with the application as well as quality of the provided facet information. We present and discuss the results along the set of tasks (a) to (e). The qualitative feedback was captured using a questionnaire based on IsoMetrics-L [5] using a standard 5-point Likert scale. In this scale, a value of one means strongly disagree and the value five is a strong agreement.

*(a) Exploring points of interest*: In the first set of tasks, the users had to select the facet Place and then a sub-facet of it to choose a specific category of point of interests. The users had to switch to the map view and explore the points of interest on the map.

The users were asked to valuate if the approach for refining the result set using faceted search and exploration is intuitive to use. When the application starts the first time, it immediately searches for facets in the vicinity. All subjects agreed or strongly agreed that this is a useful feature (avg.= 4.75, SD= 0.2). Regarding the question if the facet tab provides all required features for faceted search and exploration, the users rated it average (avg.= 3.42, SD= 0.28). Reasons for this was that the users wanted besides a sorting of the sub-

facets by number of resources found also an alphabetical sorting. In addition, the users stated that the data contains ambiguities. For example, the facet Places has the sub-facets Populated Places, Settlement, and Town. As the facets are retrieved live from the open social media data sources, the Mobile Facets application has no influence about the kind of facets and the quality of facets and resources provided. When conducting the task to find a specific church in Berlin (see the scenario in Section 2), the subjects had difficulties finding it as there were many resources found. The church was associated under the facet Landmark, which many users did not found intuitive. Thus, in a future work, the data quality of the facets should be improved.

*(b) Searching for celebrities:* In the next task set, the users were asked to add the facet Persons to the currently selected Place facet and further refine this facet to Politician and Athlete. Most people find this feature useful (avg.= 4.22, SD= 0.41).

*(c) Searching for points of interests*: For searching transmission towers in Berlin, the users conducted a keyword-based text search with a live view of the search results. This means that when the users enter the keyword, a result list is immediately shown similar to Google's instant search. This feature was rated high by the subjects (avg.= 4.59, SD= 0.28), confirming that users like to have a keyword search besides faceted search and exploration like for faceted search on desktop computers (cf. [8]).

For the "What's around me?" feature, some subjects said that they liked to see a short message on the screen saying that the search is only conducted on the currently selected area of the map. These subjects have chosen a too small area of the map when initiating the query. The fact that the search is only conducted on the current map area was told to the subjects at the beginning of the evaluation. However, many subjects expected when searching for, e.g., towers, that the system does a retrieval on all instances independent of the user's current location and selected map area. To alleviate this issue, a message could be added to Mobile Facets.

*(d) Exploring events*: In this task, the users had to change the location context from Berlin to London in order to explore events there. Mobile Facets offers two options to change the location. Either a keyword query for *london* is executed and then the facets are filled with the target location or one changes the location by manually panning the map and using the "What's around me?" feature to fill the facets. To our surprise all subjects except one decided to use the map panning option to change the location context. Using a keyword search was considered more cumbersome than panning the map from Berlin to London. Exploring events using the time-slider widget was considered very intuitive. The subjects immediately understood the interaction metaphor to change the time in order to find out what is happening in the next days. The visualization of events using blue stars that fade out the further away the currently selected date from the event date is and the use of blue-red shaded stars depicting events happening today was considered appropriate (avg.= 3.68, SD= 0.37).

*(e) Searching events*: Searching for events in remote locations was considered a very important feature (avg.= 4.46, SD= 0.28). In the concrete context of

| | Avg | SD |
|---|---|---|
| The number of steps to accomplish a task is appropriate. | 4.02 | 0.76 |
| The steps required for conducting a task are intuitive. | 3.95 | 0.87 |
| The application supports me in conducting the tasks. | 3.96 | 0.89 |
| The application behaves as expected. | 3.8 | 0.97 |

Table 1: Overall Usability Scores of Mobile Facets

Dublin, however, it was criticized that some points of interests were shown that the subjects did not consider very interesting such as the neighborhoods of Dublin. Here again one has to refer to the varying quality and openness of the social data sources used, which is not under control of the Mobile Facets application.

Finally, we have asked the subjects to judge the usability of the Mobile Facets application. These measures have been captured for each task block (a) to (e) separately. Table 1 shows the average and standard deviation of the ratings on the applications' usability over the five task blocks (a) to (e). Thus, it is a measure how coherent the usability of the Mobile Facets application is. The four questions in Table 1 measure how appropriate the number of steps are to accomplish the task, how intuitive it was to conduct the task, how well the Mobile Facets application supported the subjects in conducting the tasks, and if the application behaves as expected. The ratings are good, i.e., between 3.8 and 4.02. A standard deviation of 0.76–0.97 indicates some variety over the different aspects of usability measured for the Mobile Facets application.

# 8 Concluding Discussion

The results of our evaluation show that it is possible to create an intuitive to use application for mobile faceted search and exploration of a large, social media data set on a touchscreen mobile phone. Applying facets for exploring a large, multi-dimensional data set is an established interaction metaphor on desktop computers for web sites like Amazon and Ebay (see Section 3). To our surprise the evaluation of Mobile Facets revealed that some subjects initially had difficulties transferring the known concept of faceted search and exploration from desktop computers to the mobile application. However, after successfully conducting some mobile faceted search and exploration tasks, this was no further problem. A general criticism was that the feature for conducting a "What's around me?" search should be faster and that it should be possible to sort the facets also alphabetically. In addition, when there are no or only very few search results in the map area, the Mobile Facets application could automatically increase the area to retrieve more results.

However, more important was the feedback on the facet quality. As the application uses different open social media data sources that are queried live, the Mobile Facets application is not in control of what kind of data is provided and how many resources are returned. For example, in the scenario there is the task block (a) to explore points of interest. Some of these points of interests such as a church are associated under the facet Landmark, which is retrieved from DBpedia. Also a church can be considered in general a landmark, it would be more intuitive to find the church under a facet like Churches or Sacred Buildings as well. To improve the data quality of the open social media sources in order to retrieve better facets, semantic ranking techniques like TripleRank [4] could be applied in the future.

# 9 Conclusions and Future Work

In this paper, we have presented the iterative design and evaluation of Mobile Facets, a mobile application for faceted search and exploration of a large data set of open social media data on touchscreen mobile phones. The data is retrieved live from different sources allowing to apply Mobile Facets at any location in the world covered by Wikipedia, GeoNames, Eventful, Upcoming, and Flickr.

The design of an application for faceted search and exploration on a mobile device is significantly harder and more complex than for a desktop computer. This is due to the fact that the interaction possibilities with the mobile device are limited and the display size is smaller. In addition, the Mobile Facets application has to cope with the dynamics of the data, i.e., the fact that one does not know in advance the number and type of facets and resources retrieved live from the integrated open social media sources. Here, the initial prototyping phase with a small user group of five subjects helped significantly to design the user interaction for the faceted search and exploration on the mobile phone and to identify potential usability problems. The evaluation of our final prototype with 12 additional subjects has shown that it is possible to create an intuitive to use application for mobile faceted search and exploration on touchscreen mobile phones.

As future work, one could extend Mobile Facets with respect to integrating more semantic data sources. In addition, it should be investigated how the system scales with respect to large number of users. The system currently does not detect duplicates in the data sources such as same events in Eventful and Upcoming. This was not an issue in the evaluation of the Mobile Facets prototype but could occur of course in future uses of the application as the data is retrieved live from the data sources. In addition, the data quality of the social media sources should be improved in order to retrieve better facets, e.g., using an approach like TripleRank [4]. To improve the data quality, it might also be interesting to extend Mobile Facets to allow the users to provide feedback on the quality of specific facets by relevance feedback.

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