An Adaptive Semantic Mobile Application for Individual Touristic Exploration

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Abstract. Expectations towards information access are rising as technology is increasingly pervasive in public spaces. Information for tourists such as on sights, transportation options or lodging is instantly available on mobile phones or public displays. However, it is still mostly up to the users to query different sources for information, find information suitable to their situation and to combine that information afterwards in order to reach their goal. In this paper, we present an approach that provides integrated and situational information on different tourism-related topics. We introduce our adaptation concept based on semantic descriptions of user context and integrated information sources and we describe the prototype implementing our concept. We evaluate our approach in a user study and discuss starting points for future work.

Keywords: Adaptation, Context-Awareness, Semantic Web, Mobile Application.

1 Introduction

Since smartphones and tablets became ubiquitous, tourists increasingly rely on them as an ad hoc information source on vacation. Most of the different tasks while visiting touristic places, for example using local transport and searching for restaurants, are served by a vast number of different applications. Users must manually search for information on the different topics, filter the information that is relevant to them and then combine the information from different sources because there is no system that integrates and adapts information from various sources into one application. Our goal is to semantically combine functionality for tourists in one mobile application and to use a continuous adaptation concept, in order to enhance the individual and explorative experience. Our prototype combines and individualizes public transport information, points of interest and dynamically planned tours. The adaptation concept considers the needs of the users, their interests and the overall situation. We provide a backend based on Semantic Web technologies to integrate different data sources and services.

2 Related Work

A wide variety of mobile applications provides information prior to or while travelling. Most of them, however, are specialized only for one task and some

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additionally focus on only one region or city, like the New York City Essential Guide[1], for instance. A well-known example for an application that provides information on interesting places (points of interest) and accomodation all over the world, is the mobile application of the web site TripAdvisor[2]. It does, however, not offer whole planned tours or route planning functions, but relies on additional navigation applications for that purpose, which is true for many similar applications. Some applications also provide public transport maps of cities and regions, but still a user would have to find nearby stops and correct line numbers as well as timetables by himself. Applications that provide sightseeing tours are often specialized for one specific topic, like, for example the Audioguide Berlin Bus 100[3], that offers an audio guided predefined tour for 22 points of interest in Berlin or the application Anne's Amsterdam[4] that provides a tour of Amsterdam based on Anne Frank's story. None of these applications use linked data or Semantic Web technologies for intelligent algorithms or data integration or offers context-adaptation of its contents.

Lee et al. propose an ontology-based recommendation agent for the city of Tainan that is able to compute route recommendations [5]. The routes are based on google maps and do not take into account public transport. Their ontology is not described in a linked data compatible format, which means that it is not easily extended or linked to other ontologies. Garcìa-Crespo et al. describe their system called SPETA, "Social pervasive e-Tourism advisor" that does provide a backend based on Semantic Web technologies, recommendations of point of interest and a mobile application for pervasive usage [3]. They have a much larger database, because they link to DBPedia [6]. They do not offer any routes or tours, however, but focus on a location-based recommendation, taking into account social- and knowledge-based filtering. Castillo et al. present an adaptive system for tourists that is ontology-based [1]. They model points of interest and user context in an ontology and the system is able to compute recommended points of interest based on the preferences and context of the user. The system also provides suggestions for means of transportation, but does not take into account timetable or real-time information of public transport, as our system does. Castillo et al. write that their system is designed to deliver information on mobile phones and PDAs, but they do not provide a mobile application.

3 An Adaptive and Semantic System for Tourist Information

Our goal is to create an individual experience for tourists by providing information on sightseeing based on their interests and current situation. Our approach focuses on individualization using Semantic Technologies and utilizes deep integration of multiple information sources and services into one application. Our

[1] Available on iTunes.
[2] http://www.tripadvisor.com/apps
[3] Available on iTunes.
[4] http://www.annefrank.org/amsterdam

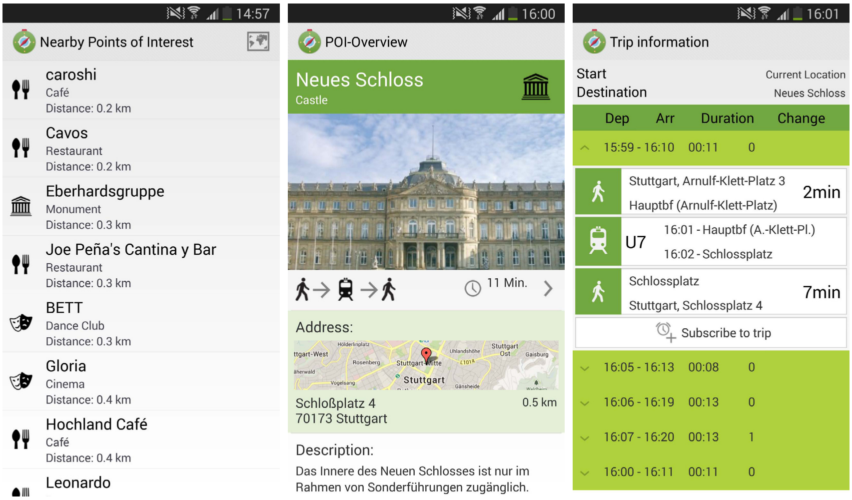

Fig. 1. Screenshots: Points of Interest and trip information

adaptation concept is designed to affect all integrated services that provide functionality in the mobile application. Context information is derived automatically where possible, but can also be supplied by the user.

Based on her current situation and timeframe, the user can search for points of interest and is then routed to them via public transport, as shown in Figure 1. The user can specify which categories of points of interest she searches for, ranging from generic categories like "shopping" or "leisure" to specific subcategories, for example "supermarket", "bakery" or "kiosk". Besides information such as description, opening hours and address, the detail view of a point of interest includes personalized public transport information. It shows, in a concise way, connections, changes and time required to reach the destination from the user's current location, which is displayed in the middle of Figure 1. By selecting the arrow to the right, a view containing more detailed information about the trip is shown.

In addition to finding points of interest, our application can also suggest individual trips of multiple interesting places and the ways in between. They are dynamically generated based on multiple context factors, such as weather information or user preferences on food. The user can specify multiple constraints about the trip, such as start time and duration, starting location and destination and if meal breaks should be considered. She can also define points of interest that should be included in the trip. Based on those constraints and automatically derived context, available points of interest and public transport connections, multiple themed trips are generated and displayed, as shown in Figure 2. Example routes are castle-tours or outdoor-tours. Each trip is computed using the optimal route, taking into account context information such as the current weather, suggestions for meal breaks and user interests as well as adapted real-time public transport information. If the user selects a trip, an ordered list

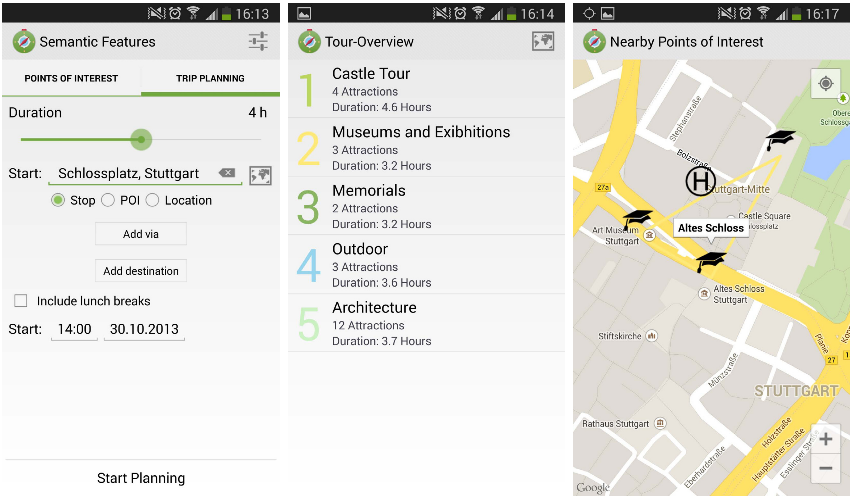

Fig. 2. Screenshots: Planning and suggestion of personalized tours

of all places that are part of trip is shown, including time information for each element. A map view of the trip is available as well. Each trip element can be selected in turn, showing the detail view as described in the previous paragraph.

3.1 Architecture

Our prototype system consists of a semantic backend system and a mobile application, as shown in Figure 3. The backend system semantically integrates data from different sources. Among others, we use data from the LinkedGeoData project [8], augmented with our own handcrafted data to describe points of interest, as a basis for the points of interest information service and the computation of sightseeing trips. Additionally, our backend integrates the different Web services we use for real-time and timetable information of public transport providers and for weather information.

The non-semantic data provided by these services is transformed into semantic data by a data conversion component that can transform data from the eXtensible Markup Language (XML) into RDF data[2] using a given ontology. The XML responses of queried Web services are converted into instances in our triple store and linked together, where necessary. A semantic context component combines the available context information and provides an interface for context data to the other components. For data on points of interest, we developed a tourism-themed ontology based on the schemas of LinkedGeoData and schema.org[5], linking it to our ontology on public transport and transformed data from the LinkedGeoData project into our triple store.

A third component combines the context data describing the situation, real-time information of public transport providers and data on points of interest with the

[5] `http://schema.org`

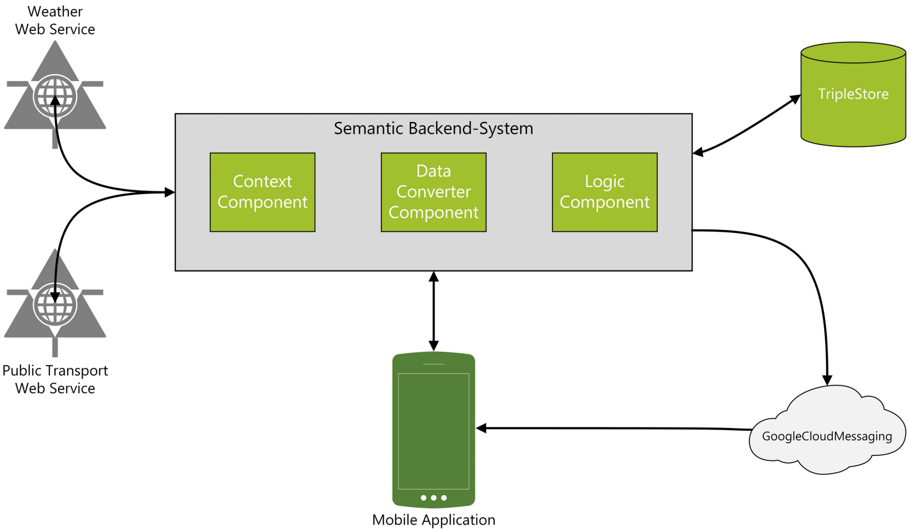

Fig. 3. Architecture of our prototype system

help of adaptive mechanisms to generate individualized information and computes personalized sightseeing trips. The synchronous request-response communication between our backend-system and the mobile application is realized over HTTP using the JSON format. For asynchronous communication, for example for polling the current location of the user's mobile device, we use the Google Cloud Messaging Services implementing a push service. The mobile application of our prototype system is implemented for the Android operating system.

3.2 Adaptation Concept

In order to personalize selection and presentation of points of interest as well as for the generation of individualized sightseeing trips, we build a semantic description of the user's situation. As a first step, we collect data from different sources of context information, as shown in Figure 4. The mobile device is a source for direct context information about the user's location and current time and it is polled by the backend using push messages as described above. The sensors of the mobile device may also be used as additional context sources, but at the moment we are only referring to location and time. Another context source are preferences of the user that are also retrieved from the mobile application. The user is able to configure her preferences regarding public transport, including preferred transportation modes, required time for interchanges or accessibility of public transport, as well as preferences regarding restaurants and meals, museums and other points of interest. In our current mobile application, the user has to enter her preferences manually and they are then synchronized with our semantic backend.

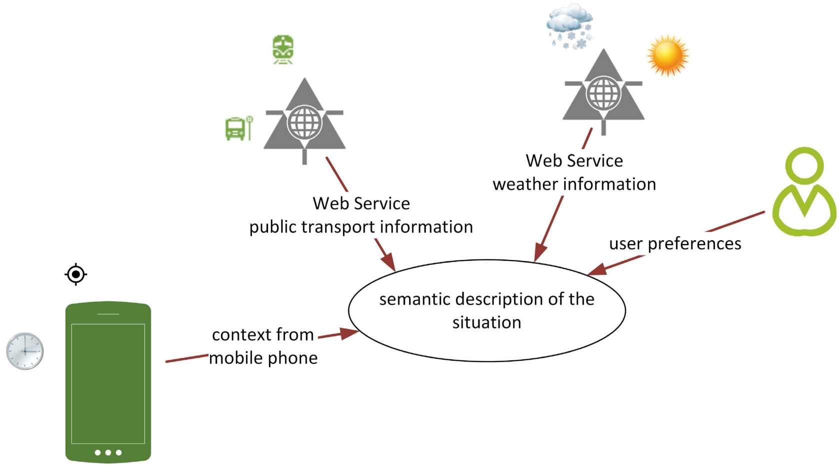

Fig. 4. Combining context sources

Additionally, we integrate external sources for context information. It is possible to add multiple Web services in our backend that contribute different context aspects. In our prototype, we query a weather Web service for information on the current weather and a weather forecast for the user's location. Furthermore, we use a Web service that provides public transport information, including schedules and realtime information on disruptions or delays. In our semantic backend, we transform the context information that comes as non-semantic data into semantic and linked data, to get an integrated description of the situation. In order to add new context sources, it is necessary to provide an ontology describing the context information, to link this description with the overall context ontology and to provide means of requesting or extracting the data. This can be done in a very modular way and therefore adding new context sources is easily done. The context data that is gathered and linked in the first step then serves as basis for different adaptation steps. It is used to specify information requests and to adapt and improve the generation of individual sightseeing tours. We query external Web services like the public transport information system and customize those requests to the customer's preferences and situation. Furthermore, we customize the selection of points of interest based on context information. Depending on weather conditions, reachability by public transport and user preferences for the different categories of points of interest, the results of a points of interest request are rated and filtered. While computing an individual sightseeing tour, the context information is used to rate the points of interest that are considered for the tour and to pick each next step in one tour. Based on the situation, some tours are only generated if they fit the situation. An outdoor tour, for example, is only calculated if the weather is dry and warm enough. The used filtering and rating steps are implemented in a modular way so that the adaptation can easily be extended with new filter and rating rules, for example, if additional context sources are added.

4 User Study

We conducted an explorative user study using the thinking aloud method, described among others by Jørgensen, to test the user acceptance of our adaptation concept and to find if and which problems users would mention using the adaptive application [4]. We evaluated the mobile application with eleven participants, following Nielsen's findings that a high percentage of problems can be found relying on 5 or more study participants [7]. The study was performed in a lab setting and took about 30 to 40 minutes per participant. We asked the test persons to fill out a questionnaire before the test and conducted an interview after the test, where we asked about the participant's experience with our application and their suggestions. While the participants performed the tasks, the mobile phone and their interaction with the mobile application was filmed. They were asked to think aloud while completing the tasks. Their statements and interactions with the mobile applications were evaluated afterwards.

Since we were not interested in testing the user interface of the application itself, but its functiontionality and adaptation behavior, we first explained the mobile application and its features to the test persons. We wanted to reduce possible usage errors due to unfamiliarity with the user interface. After the introduction, the participants were asked to perform two sets of tasks using the point of interest information and trip planning features of the mobile application. The GPS position of the mobile phone was preset to two different locations in the middle of the town that was chosen for the test setting. Each set of tasks was placed at a specific location. We used two mobile phones, identical in model and setup, each given a forged location. The test scenario for each set of tasks was explained to the test persons before they were given the assignments. The two sets of tasks were tested in two rounds, where one was performed without personalization and context-adaptation and the other was performed with given user preferences and context information taken into account. A group of five test persons performed the test without context-adaptation first and the second group of six test persons solved the tasks with personalization first and then moved on to performing the tasks without adaptation.

Without context-adaptation all participants used the pre-selection possibility to specify the categories for the point of interest search. Most of them used the categories and sub-categories to specify their request for the given task. About half of the test persons intentionally did not use the sub-category specification for some tasks, because they stated they would want to choose the points of interests from a greater variety of results. All participants were using the category specification at some point, though. Based on the given results, all of the participants then were able to solve the tasks and to find suitable points of interest.

For the task group that was performed with the context-adaptation feature, the users were asked to first set the user preferences to a given set, with the possibility to add their own preferences and then to perform the tasks. All but one test person then additionally used the selection of a sub-category of points of interest to further specify their request. The expectation of all participants was that the selection of restrictions via user preferences and sub-categories will only result in places that exactly meet these restrictions. However, since we use a rating algorithm based on the given context information, our system also provides results that do not meet all given context factors. We decided for this approach to always be able to show results, because a great variety of strict restrictions and context factors would often lead to an empty result set. This behavior was confusing to most of the probands. They obviously interpreted the given options as exclusive filters for the search results, not as a basis for rating. Many of the test persons then interpreted the results correctly and guessed that some restrictions must have been ignored to show otherwise good results. Some then suggested that they would like to see which preferences and context factors led to each result, to then decide for themselves if they considered the result or not.

Most of the test persons stated that their expectations for the sightseeing tour planning features were fulfilled. There were some interesting points on this feature, though. Most of the tours calculated by our system are a little bit longer than the trip duration a user defines in his request, some trips also are shorter. This is due to the computation of the trips, caused by the selection of points of interest that are more remote combined with their rating by context factors as well as deviations in heuristics on public transport trips and the actual given trips between points of interest. If the tour was way too long or too short than the given timeslot, all probands rejected the suggested tours. Most of the participants thought a variation of about half a hour would be acceptable. This issue again showed the conflict between the participant's expectations towards adaptations, especially of given restrictions and the difficulty of generating good adapted content, where not all given factors can be completely met.

Almost all participants rated the suggested themes for sightseeing tours positively. Many of them however stated that they would like to have the opportunity to combine the given themes and results to create a more varied tour. They also would like to be able to remove points of interest from tours and to add alternatives manually. All participants liked the idea to add meal breaks to a tour. Some of them pointed out that they would prefer a free time slot for meal breaks in the tour instead of a given location. They would rather use the point of interst search functiontionality of our system to get information about suitable food establishments nearby during their tour or tour planning. Although many participans mentioned that they would like the sightseeing tour results to be manually alterable, the majority was statisified with the results and the possibility to use context factors to improve the results. They judged the results as a good basis for manual refinement and liked the idea of being inspired by a variety of choices suitable to their context.

5 Discussion

All of our participants found the combination of different data sources and the integration of public transport and sightseeing information very helpful. Many of them suggested further integration of data sources like community-based rating of points of interest. We are currently working on the extension of our semantic data integration to include such data sources.

The main issue we found during our user study is the acceptance of the results, especially using context-adaptation. Due to the possibility of configuring their preferences and restrictions, the expectation of the probands towards the system and its results were increased significantly. If the results did not conform exactly to these expectations, they were considered not as helpful as the results without adaptation. The acceptance of the context-adaptive results depended on plausibility and traceability of the adaptivity effects. However, all but one participant stated in the interview after the test, that they would likely use such an adaptive tourism application and they considered that the application would save time getting one's bearings in an unknown town. We therefore think that the given suggestions of visualizing the effects of context factors on the chosen results in the point of interest search as well as for trip planning should be given further thought, to increase the user's acceptance by making part of the rating and choosing process more comprehensible. Also, we are planning on adding implicitly deduced user preferences in order to minimize the user interaction necessary to collect context information on the user. The issue of keeping the adaptations comprehensible will probably increase, if more context factors are unknown to the user, which is why our future work will also focus on communicating learned preferences and their impact on results to the user. Additionally, we think that giving the user more control of the results by making sightseeing tours editable and mixable, for example, would further increase the usability of our application and the usefulness of our adaptation concept.

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