PSiS Mobile

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Abstract - *In this paper, we present a state of the art on applications of mobile devices to support decision of a tourist running on a trip. We focus on two types of applications, tourism recommendation and tourism guide, making a brief description of the main characteristics of each one of them. We also refer the main problems encountered on the development of applications for mobile devices, and present PSiS (Personalized Sightseeing Tours Recommendation System) Mobile, our proposal to a mobile recommendation and planning support system, which is designed to provide an effective support during the tourist visit, providing context-aware information and recommendations about places of interest (POI) to visit, based on tourist preferences and his current context.*

Keywords: Mobile Recommendation System, Sight Information Provider, Context-Aware, Client-Server Application

1 Introduction

When a tourist goes to a new location (country, city or region) he would certainly like to have available a user-friendly tool that would help planning his stay according to his objectives, preferences, knowledge, budget and period of stay. It is well known that the task of planning where to go and what to do, in the limited amount of time available, are common problems encountered by tourists when visiting a city for the first time.

In effect, cities are large information spaces, and in order to navigate these spaces visitors often require numerous guide books and maps that provide large amounts of information. Häubl and Dellaert [1] state that this can be both a blessing and a curse. Although the amount of information allows tourists to select more appropriate points of interest, it also turns the process so complex that the tourist might not be able to assimilate all this information adequately.

Mobile devices applications can be used to provide an effective support to tourists in tour planning process. There can be distinguished two types of applications: Guide applications, which only provide information about sights and; recommendation systems that helps the tourist narrow the universe of choice, giving results according to the tourist preferences. This type of system is able to process much more information and points of interest than the tourist could possibly do. With the actual evolution of society and expectations, a tourist that uses a system like this expects location-aware information about the destination domain including history, culture, folk, art, economics, environment and nature. Advanced tourists also expect individualized information and services taking into account their own interests and their history of activities and history of information [2].

This adaptation can be performed using mobile devices, due it's pocket size and computational capabilities, it can help a tourist on the planning of his stay, show detailed information of a specific point of interest and recommend nearby points of interest to visit, according with his profile and environment context [3].

Thus, the question if people would like to use computers as a replacement of the traditional books and maps as tourist guides splits the tourists into two groups: traditionalists that want to stick with classical paperwork, and experimentalists that would like to try out new technologies.

Why the second group still does not use mobile devices? The answer is simple; there are not yet the right IT (Information Technology) systems available. Although Smartphone market has increased significantly, with more powerful and simple to use equipments, giving to thrive a good future in this area.

Mobile terminals are embedded systems with very limited capabilities (limited display size, resolution, power consumption, processing capabilities, low memory and networking capacity) compared to a traditional computer. These limitations need to be considered because of possible technical, ergonomic or economic implications for the mobile user. So, mobile client-server applications performance is a crucial aspect that depends on many factors, such as bandwidth, connectivity, positioning capability and support for the paradigms of interaction, the user interface and security issues.

The set of information that is necessary to interact with the client devices is vast. To a client computer, the volume of information is not very important, depending usually on Internet access speed, but for a mobile device that question is very different. This is different in mobile devices, because their wireless connection can be slower compared with fixed or wired data connections. Besides, they often have a measurably higher latency and it can lead to long retrieval times, especially for lengthy content. Sometimes it’s preferable to download one big file, than a lot of small files.

Even so, this can lead to another problem, which is in the case that the connection is very unstable and always going down, thus the large file can never be downloaded. But nowadays, many mobile carriers are quickly adding high-speed network capacity based on Wi-Fi. With this it is easier to connect to wireless hot spots with mobile phones, in an effort to deliver fast data and clear calls in areas where neither might be possible. Apart from mobile carriers, some cities are also implementing Wi-Fi connectivity throughout their territory. This provides mobile device users, especially tourists, access to the internet. With this, one of the constraints of mobile devices is partially solved. Partially solved, because it is only implemented in a few big cities and, in some areas, the price per MB (Mega Byte) is very expensive.

Batteries still don't provide the desired amounts of energy without the need to be constantly recharged, and wireless communication increases the power consumption of the device. This means we require less network traffic in communications between clients and servers; to combine on less costs, less battery consumption and better performance.

There are already systems that provide tourism recommendations and others that only act as a tourism guide, some of them can be seen on chapter 2, where we also perform a comparison between studied systems. Subsequently in chapter 3 we will present our proposal for a tourism recommendation system, the PSiS Mobile, with a special concern in providing good, fast and reliable information to users. Finally on chapter 4 we will conclude and provide information about our future work.

2 State of the art

A tourist companion, or mobile device application, provides important services to guide the tourist along its travel. On the other hand, recommendation systems allow the tourist to plan and select an appropriate route and set of points of interest. Although these systems can be (and should be) integrated, very little approaches integrate both systems. TIP [4], [5] that provides recommendation services through mobile devices for tourism, implements hybrid algorithms to calculate tourist preferences, using the defined tourist profile and location data (location-aware).

The TIP system was created to provide sight related information to the users. This system provides not only sight information but also gives recommendations regarding nearby sights, which match the user preferences and his current location. The whole system has a database which contains user profiles, user context, sights context, user travel history as well as their feedback given to the sighs they have visited. The user interacts with the system through a handheld device (e.g. PDA or mobile phone), defining his profile (e.g. type of sights and type of sight information he's interested in) and giving his current location (e.g. by the GPS of the PDA), the system will recommend the sights to visit.

Proximo [6] is a location-aware mobile and recommendation system that fits the pure paradigm approach. It guides users through tours within buildings using Java and Bluetooth technologies. The user's mobile device also tracks the user location and builds a context, providing the system with important information.

The user position is taken by "sniffing out" the fixed Bluetooth devices or low-cost beacons deployed in the area of use. This room-level accuracy means improved precision and is accurate enough for a certain class of trail-based applications such as a tour guide. The mapping service on the mobile device displays a map of the intended area of use, which can be manipulated in a variety of ways. Also, the application constantly monitors the user location and displays the active areas of the building (user position) accordingly.

Since this is an indoor application, in a structured scenario, Quigley and Parle [6] conducted tests under a gallery context at the University College Dublin School of Computer Sciences and Informatics building, where the system was able to guide users through a gallery, and provide recommendations using similar user ratings to paintings.

The Proximo pure collaborative recommendation system relies on its user's item ratings to provide recommendations. As long as an item doesn't have its first rating, it cannot be recommended. Also, user profiles are built using interaction data from the user's mobile device. This data is processed through a weighted nearest neighbors algorithm.

More and more people combine several purposes with travelling, such as business, leisure, entertainment, and education. Such people may not have time to pre-plan a travel schedule in detail. They need location-aware information about the destination domain and expect individualized information and services. Mobile tour guides are the result of years of research in the areas of recommenders, ambient intelligence and pervasive computing. There are systems that only display information about sights, like MultiMundus [7] that has as primary goal to provide multimedia information (texts, images, cards, audio and video sequences) of a sight to the tourist, on his personal mobile device. With this content, it can provide moderated audio guides for travel groups, automatic detection of the tourist physical position on the map and presentation of the sight closest to him.

The GeoNotes [8] system tries to blur the boundary between physical and digital space (ubiquitous computing and augmented reality), and at the same time strives to socially enhance digital space (collaborative filtering, social navigation, etc.) by allowing users to participate in the creation of the information space. It is a location-based information system that allows user to access information in relation to the user's position in geographical space. The main goal of this project is to provide location-based information free to all users.

With this mobile application, tourists can retrieve notes regarding their current location. These notes are introduced by other tourists that visit the same place, and are retrieved using collaborative filtering algorithms rather than using a content-based approach.

Mobile recommender systems based on profiles have the potential to substantially enrich tourist experiences. One of them is the m-ToGuide [9] project. This project is targeted for the European tourism market and offers location-specific multimedia information about major monuments and points of interest. A portable, handheld terminal is used to exchange information between the m-ToGuide system and the tourist. All information and services delivered to the tourist will be relevant to user specific location (location-based) and tailored to that end-user's personal profile.

A trial project was performed and tested with an on-the-go ticketing facility that allows tourists to make bookings and reservations directly from the terminal via GPRS. The m-ToGuide experience can be personalized to give tourists direct access to the information and services they prefer. The trial results indicated that the system was useful but the charged prices were not well accepted by users.

Deep Map [10] realizes the vision of a future tourist guidance system that works as a mobile guide and as a web-based planning tool. Deep Map is a mobile system able to generate personal guided walks for tourists through the city of Heidelberg, Germany. Such a system shall consider personal interests and needs, social and cultural backgrounds (e.g. age, education and gender), type of transport (e.g. car, foot, bike or wheelchair) as well as other circumstances (from season, weather, traffic conditions to time and financial resources). The core of Deep Map is a typical geographical information system (GIS) and can handle spatial and topological queries while allowing navigation and route finding.

Tourism information is location-dependent by nature. Each sight, building, hotel and restaurant does have a spatial location. Therefore, Deep Map is taking a step further, making use of the so-called agent-oriented software architecture.

The agent based approach allows an easy re-use of components in different systems that may consist of a different set of agents and thus providing another range of services. This is especially important in a scenario where there are two quite different application platforms: a Web-based system for home users and the mobile system for tourists on site.

Map-Agent is a Java based Deep Map module that gets the geometric data of the spatial features that have to be displayed from a geo-server, and renders this vector data on client side. Normal maps just contain 2D information, but Map-Agent includes 3D information to generate route instructions that do not sound as:

"go 205.4 meters straight, turn 30 degrees to the right and go 67.9 meters straight,"

but rather like,

"follow the street and turn right after the big red building and head towards the church.".

In the future, virtual tours in a 3D-reconstructed city will be possible. Because many types of data are not only spatial but also temporal, e.g., environmental, climate, or city development data, Deep Map handles 4D data, facing questions of tourists standing in front of a historical place like a ruin of a castle asking "how did that look like when it was not destroyed?". In this case, we would like to "turn back in time" and allow the user to go through a virtual time travel displaying a reconstruction of that place as a virtual model.

2.1 Systems comparison

We choose to describe CATIS system separately because it aroused our interest, since it is very complete (the most comprehensive among all those who we have described) and similar to our proposal. CATIS [11] is a context-aware tourist information system with a Web service-based architecture. The context elements considered to this project are location, time of day, speed, direction of travel, personal preferences and device type. This system will track the user location providing the user with information relevant to his location and time of day. For example, if the user is traveling at noon, a simple integration of the time context, the location and respective user preferences for restaurants, will result on a list with restaurants to lunch. This is the primary goal of this project, user context, to simplify all the user-system interactions.

To do this, the system implements three adaption capabilities. First is location and time-based adaption. With this information, the system will track the users position and time to provide them information relevant to that location and time of day. Second, is personal adaptation; the application provides services adapted to users specific profile (e.g., users want to receive information about resources that match their personal tastes such as nearby restaurants that offer their preferred cuisine). At last, we have device adaption, knowing device features, the sent information will be more adapted to that device, for example, the device has a certain screen size and may not support certain image formats.

The architecture of this system is constituted by a thin client device that hosts a Web Browser (CATIS isn't a mobile application installed on a mobile device, it works via a browser), an application server that delivers web content customized to the user's context, and an UDDI (Universal Description, Discovery and Integration) services directory that provides users with a centralized registry of tourist information services (e.g., a restaurant finder service). A context manager is present to track the user dynamic context as well as user preferences. CATIS main goal is to be platform independent, thus having a web service based architecture.

To setup the system, the user must enter his preferences to complete his profile. After that, the system will track his location using the GPS receiver, if it's available. If not, it will ask the user to manually input his current position.

When a tourist needs information and interrogates the system about, for example, restaurants in his vicinity, the system works in 5 steps, as shown on Figure 1. The mobile device requests the information to the application server, which will query the context manager for user context information, such as location and restaurant preferences. It then sends an inquiry to the UDDI Server to get the addresses of the available restaurant Web Services. Then, the application server sends a request to all the Web Services along with the user's location and desired distance from the user. The Web services search their databases for the appropriate addresses and filter out those that are too far away, returning a XML list to the application server. Finally, the application server filters the XML documents according to the user preferences, prepares the presentation of the information and sends it to the client.

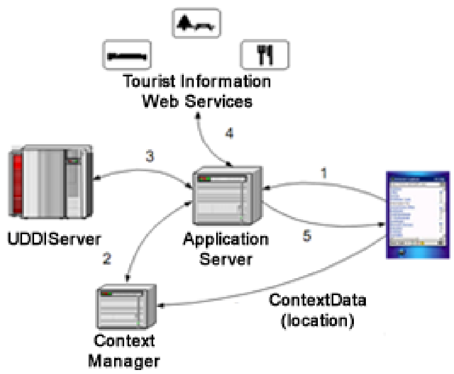

Figure 1. CATIS architecture

This system is nowadays implementing only two dynamic context variables, namely time and location (in addition to static user preferences). In the future, it is planned to complete the other dynamic context variables and to investigate issues regarding the scalability of the system.

2.2 Systems comparison

Although all the described systems are designed to help the tourist on a trip, there are factors that distinguish them. To make a summary of the main features of the studied systems, we present a table with features that we consider to be important in this type of systems, which were:

- Capability to recommend a personalized tour, based on the tourist profile;
- Sightseeing Guide Information, that is the support to provide information about a specific sight according to user position;
- Systems that store user profiles and perform information filtering according to those profiles, thus supporting personalized information delivery;
- Booking, as the functionality to book a restaurant, a hotel and so on;
- Personalized recommendations based on history, which states if the system should recommend sights that not only match the user profile, but also their travel history;
- System Domain, describes if the system is ready to work in any place of the world and not only in a specific location.

Table 1. Comparison table for Mobile Tourism Information Systems

	Recommend Personalized Tour	Sightseeing Guide Information	Personalized Information Delivery	Booking	Recommend Based on Travel History	System Domain
MultiMundus		√				√
GeoNotes		√	√		√	√
DeepMap	√	√	√			
Proximo	√	√	√		√	
CATIS	√	√	√		√	√
mToGuide	√	√	√	√		√
TIP	√	√	√		√	√

Analyzing this table, we can conclude that all of them have guiding capabilities, but none of them offer all the described features together. The most complete system, as we said on chapter 2.1 is CATIS, followed by TIP. Both of them can be improved, with some features like booking and augmented reality with 4D representation of sights like DeepMap. Another feature that is present in TIP but not on CATIS is the collaborative recommendation (based on user's similarity), this feature can be important to improve the recommendation results.

On the other hand MultiMundus is the simplest described application and it only displays information about nearby sights.

One aspect that is also very important focuses over the capabilities of mobile device, that are very limited, and that none of the described systems take as a main concern. CATIS works on every mobile platform, because it's a web-service based system. On the other hand, the use of a web-browser in a mobile phone is slow (parsing HTTP plus a SOAP header is a very expensive processing task to a mobile device) and imposes some restrictions, so it's preferable to use a standalone application, even though it forces the creation of different applications to every mobile operating system.

3 PSiS Mobile

PSiS [12] is a tour planning support, it aims to define and adapt a visit plan combining, in a tour, the most adequate tourism products, namely interesting places to visit, attractions, restaurants and accommodations, according to the tourist's specific profile (which includes interests, personal values, wishes, constraints and disabilities) and available transportation system between different locations. To ensure a good visit plan, working schedules as well as transportation schedules are considered.

The system gathers knowledge about the tourist's profiles, creating groups and stereotypes with specific interests and features, allowing characteristic inheritance. Tourists travel history is stored, which leads to accumulated knowledge about personal profiles. This knowledge, together with tourist stereotypes offer a mean of learning about general and specific interests of tourists. Also, it is possible for the tourist, to provide feedback on accomplished tours.

Currently, PSiS only interacts with tourists through a web application accessible only from a browser, but it's indispensable to have a tool to assist tourists "on the field". Thus, we are studying and developing a mobile tool to be integrated in the PSiS project, called PSiS Mobile. This tool also takes into account the tourist current context and nearby sights context.

In a preliminary phase, PSIS Mobile will be limited to data from the city of Porto, Portugal. But it will be designed so that no data or user restrictions are imposed. It is composed by two pieces, the server-side and the mobile client. All the main information like user profiles, history and similarity values, is compiled on the server. In other words, all the recommendation aspects are on the server, since it classifies sights with a rate to that specific user. There is a complete database with all information about points of interest in a certain city/region, and a complete portfolio of users as well as their visit history.

The mobile client is a very important piece in all system, because it interacts with the user. With a PDA, the user can set his profile and provide information about his location (context, that can be automatically updated using the GPS position), thus receiving context-aware information and recommendations on what to visit next. The system works on three possible usage scenarios:

I. Trip that has more than one day;
II. Single day scenario, where the tourist will only have one day to visit that city;
III. Single use scenario, which is useful if a user is just passing through a town and wants a restaurant to lunch, with no planning.

Our mobile application will manage some basic recommendation routines only. What we mean with this is that it will not classify (or rate) points of interest, but only show the results to the user. For example, if a user likes Chinese food, certainly a Chinese restaurant has a higher classification value according to the user preferences (might not happen if classification is given using collaborative filtering, since the restaurant might have a negative classification by similar users).

Our mobile client will show the points of interest, for that user and for a specific category, ordered by classification (downward; higher classification appears first). After visiting some points of interest, the user can provide feedback about the visited place.

A possible use case can be defined like this: a tourist registers on PSiS using the web application, defines his profile (demographic information), and requests a recommendation for a trip that has two days, in a specific city. After that, the tourist loads the generated information into the mobile application. The mobile device connects to the system, for example via Wi-Fi or USB, and receives the needed data to client application. Now, the mobile application has all the information about the places to visit that match the user profile. With this context-aware information we can suggest more effectively points of interest to visit, and re-plan the initially generated trip. Besides, the user can inform the system if whether or not he liked a suggested point of interest.

When the user is going to see a point of interest, the application will show detailed information about it. With this, the tourist knows more about what he is going to see, for example, the history of a museum.

We also want to implement Augmented Reality in our system, meaning that the user will have the options of pointing the PDA to the point of interest direction and access to its detailed information. These details will include information like pictures of the point of interest in other seasons of the year (i.e., covered in snow). This application will offer built-in social networking too, so the user can share his pictures with the community in a matter of seconds. Despite all the features to be implemented in our application, we want a smooth and easy to understand interface to the user. To facilitate navigation throughout the application it is essential that the number of clicks between various features is kept at the minimum.

To conclude, we want to make a real application that really helps people on seeing what they expect to see, or going where they like. It is important to develop an optimized communication mechanism to ensure that a tourist does not waste too much time just to gather the necessary information.

The following topics will describe each aspect of the application.

3.1 Systems architecture

For the PSiS mobile application we will use an Android device, chosen for two reasons. First, Android is an open platform, and secondly there are nowadays more and more Android devices on the market. Besides, the perspective of growth for the next few years is very good, because it's an open source system, and nowadays more and more mobile phone companies are adopting this OS (Operating System) in their Smartphone's, expanding this OS to all the world.

In our case scenario we have Microsoft server side technology, and all the recommendation system is working under .NET framework. The database, that is present in the same physical server, is implemented on SQL Server 2008.

At user side, we have a PDA running the Android OS. The problem is that Android uses Java technology. So, there are two different modules, implemented with different technologies that need to communicate. Another issue is the low RAM memory capacity: only 288MB for the whole system, so we need to be very careful with the mobile application development. On the other hand, this PDA is equipped with HSDPA/WCDMA interface that allows up to 2 Mbps up-link and 7.2 Mbps down-links speeds.

But, if we want to conserve battery power and decrease latency on these devices, we want to stay off the "radio" as long as possible, download as few bytes as possible and avoid time consuming data parsing routines, since they consume too much battery power. So, we must have a balance between usability and features, and performance. In our case, we prefer to spend more time retrieving all data (using sockets that don't impose too much overhead compared to Web Services), and spend less time parsing data.

There are many considerations at the mobile application tier, including data availability, communication with middleware, local resource utilization, and local data storage. In addition, many business factors need to be considered.

Since we have two different technologies communicating with each other, and the base system is already implemented, we must create a middleware that bridges communications between these two technologies. This means that the mobile middleware will play a crucial role on the system.

Some of the important features of the middleware include security, data synchronization, device management, and the necessary support for multiple devices.

When extending an application onto mobile devices, the challenges mentioned in the previous section need to be effectively addressed. The architecture needs to consider components that work in tandem to address these challenges.

For the communication protocol we used sockets to transmit server requests and responses when internet connection is available. Because this will be an occasionally connected application (Smart client), a temporary database is used on the mobile device to permit access to parts of the data without constant traffic consumption over the network, and to allow the application to work without internet connection (with multiple limitations, like no access to new points of interest and recommendations).

First of all, after requesting a recommendation for a trip, all the necessary data is transferred from the server and stored on the mobile device. We find this to be necessary, because of the low Internet speed rates on mobile phones and its possible unavailability. When we say necessary data, we mean, the information of all the nearby points of interest that will be on the planning schedule, and other points of interest nearby the first ones. This approach is useful if the tourist wants to re-plan the schedule in real time.

All the collected data, photos, user context and others will be stored on the device, to then be sent to the server.

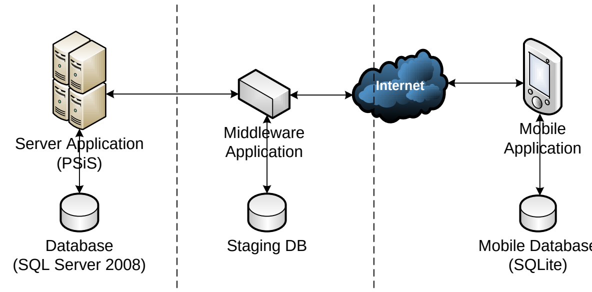

Figure 2. Mobile architecture overview

This architecture from Figure 2 can be summarized saying that:

- The existent system will does not need to be changed;
- The middleware application is a component that will reside on the server side and will be developed on .NET Framework, with directives to permit the communication between the existing system and the mobile application;
- The mobile application runs on Android devices and is used to capture/send data from/to the field. The application also has a synchronization component to synchronize the handheld data with the server database;
- Internet connection is used to retrieve/update itinerary information, sites information and personal preferences. Data is uploaded and downloaded using sockets, and data is sent through encoded messages, automatically without user intervention. Updated data is available to the user via background synchronization.

Nowadays, as Internet connectivity problems in mobile devices are being tackled with free Wi-Fi access in large cities, one of the greatest issues when addressing mobile devices has become power consumption.

PSiS Mobile will be prepared to preferentially use the mobile device Wi-Fi connection, because it has much less latency than a 3G connection.

4 Conclusion

We have introduced the main concerns present in the development of a mobile application in a client-server environment, as well as a state of the art in tourism mobile recommendation applications. Until now several applications were developed, but they have important limitations and most of them do not account for the multiple restrictions of mobile devices, thus lacking a solid implementation to be used in the real world. We also describe the PSiS Mobile architecture, and in the future, we will evolve further by exploring new technologies and possibilities. Although mobile devices have many constraints, we want to provide a good user experience, giving tourists a fast and user friendly tool including context-aware adaption, a route planning system, augmented reality and built-in social networking features, to provide the user with important and significant details about what he is seeing or is about to see.

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