Personalized Location-Based Recommendation Services for Tour Planning in Mobile Tourism Applications

Chien-Chih Yu and Hsiao-ping Chang

Dept. of MIS, National ChengChi University, Taipei, Taiwan
{ccyu,ping}@mis.nccu.edu.tw

Abstract. Travel and tour planning is a process of searching, selecting, grouping and sequencing destination related products and services including attractions, accommodations, restaurants, and activities. Personalized recommendation services aim at suggesting products and services to meet users' preferences and needs, while location-based services focus on providing information based on users' current positions. Due to the fast growing of user needs in the mobile tourism domain, how to provide personalized location-based tour recommendation services becomes a critical research and practical issue. The objective of this paper is to propose a system architecture and design methods for facilitating the delivery of location-based recommendation services to support personalized tour planning. Based on tourists' current location and time, as well as personal preferences and needs, various recommendations regarding sightseeing spots, hotels, restaurants, and packaged tour plans can be generated efficiently. An application prototype is also implemented to illustrate and test the system feasibility and effectiveness.

Keywords: Mobile tourism, personalized recommendation, location-based service, tour planning.

1 Introduction

In recent years, due to the rapid advancement of mobile computing technologies, mobile commerce has become one of the hottest research domains. Among various m-commerce related issues, the design, development and delivery of mobile services and applications to assist on-the-move users in making mobility-related decisions is considered as a critical research topic, and therefore more research efforts devoted to this area are highly expected [1,16]. As one of the most important type of mobile services, location-based services focus mainly on providing point of interest information to mobile users based on their current positions [2,10,21]. On the other hand, as major e-commerce and e-business application functions, personalized recommendation services aim at suggesting products and services to meet users' needs and preferences [25,26]. It has been noted that, without proper system support, the integrated process of searching and filtering products, comparing alternatives, and recommending suitable selections for users can be extremely complicated and hard to be carried out. Furthermore, when taking into account the support of mobile users

T. Di Noia and F. Buccafurri (Eds.): EC-Web 2009, LNCS 5692, pp. 38–49, 2009.

with a variety of mobile devices in personalized and location-based decision making, the complexities of the problem and associated solution processes are compounded significantly, and the design and implementation issues for constructing the desired personalized mobile recommender systems become even more complex [15,20].

In the tourism management domain, mobile and wireless technologies have been pointed out as one of the most interesting areas of technological innovation for enhancing Internet applications to tourism [4]. Identified primary functions of location-based services for travelers include localization of persons and objects, routing between them, as well as search for objects such as hotels, restaurants, shops, or sights, and information about traveling conditions. Eventually, tourists are typical consumers who have strong mobility-related needs and have shown significant interests in acquiring location-based services during trips [24]. They like to make their own tour plans while on the trips, and moreover, have a high frequency in rescheduling their trips to suit the dynamically changing conditions and needs. As a key application service in tourism, travel and tour planning is a process of searching, selecting, grouping and sequencing destination related products and services including attractions, accommodations, restaurants, and activities. With more availability of comprehensive data about travelers and destinations as well as more exchanges of experiences between travelers, the location-based recommendation services based on content and/or collaborative filtering technologies attract more interests in the travel and tourism domain [14]. How to provide personalized location-based recommendation services for facilitating tour planning process inevitably becomes a critical research and practical issue in mobile tourism applications. However, existing mobile services related to personalized tour recommendation services are still very primitive. In the literature, although there are more and more mobile applications to explore position information for guiding the on-the-trip users, there is still a lack of personalization in context to meet the interests, preferences, and devices of the individual tourists [22]. Ideal personalized location-based tour planning recommendation services should be able to integrate information about tourists' preferences, needs and constraints, location and time information, destination and attraction information, as well as recommendation models and rules in order for recommending personalized tour plans in which sightseeing spots, restaurants, and. hotels are bundled to match the context and location aware conditions. Since there are very limited previous research efforts undertaking the integrated issues of personalized location-based tour plan recommendations, the objective and contribution of this paper is set to provide a system architecture and development method for efficiently and effectively guiding the design and implementation of the demanded location-based recommendation service systems to support personalized tour planning.

The rest of this paper is organized as follows. A brief literature review on location-based and personalized recommendation services is provided in section 2. The proposed functional framework, processes, models and rules for developing and delivering personalized location-based tour planning recommendation services are presented in section 3. A prototype system is illustrated and evaluated in section 4. Section 5 contains a concluding remark with future research issues.

2 Literature Review

Among many research works regarding personalized and/or location-based mobile services, Chen et al. (2005) propose an architecture design of an m-service portal [7]. In their proposed architecture, there are three major components, namely, list manager, profiler, and agency. List manager maintains a personalized list of pre-configured m-services specified by mobile users. Profiler is responsible for storing personal information and preferences such as information needs and message delivery preference. Agency uses intelligent agent technologies to automatically search in the web service/m-service registers to identify appropriate services that satisfy users' needs. Focusing on web service interoperation, Zhang et al. (2005) provide a framework for dynamic and personalized composition of web services [26]. Four major components specified in the framework include storages for personal preference settings, web services for inter-business cooperation, business intelligence to satisfy users' needs, and geographic displays for location-based services. Hand et al. (2006) propose a three-tier location-based development architecture that consists of client communication tier, application-tier, and geographic information system (GIS) tier [11]. The client communication tier is a protocol independent tier, where the users' location is established and where communication with the application tier occurs. The application tier performs all results-set mark-up into the appropriate output display for the user's wireless device. The geographic information system tier performs all location-based application query processing.

As for specifically applying to the tourism domain, Kakaletris et al. (2004) address the design and implementation issues for delivering location-based tourism-related content services [13]. Key points that require careful considerations include service features and procedures, content structure, quality-of-service terms, and security. By illustrating an example of generic tourist guide, Scherp and Boll (2004) emphasize on supporting the dynamic generation of personalized multimedia content in respect of the tourist's interests and preferences, current location and environment, and mobile device used [22]. Aiming at effectively coordinating and integrating disparate information and service resources anytime and anywhere, Chiu and Leung (2005) propose a ubiquitous tourist assistance system that is built upon multi-agent and semantic web technologies for providing personalized assistance and automation to the tourists with different preferences and often changing requirements during their trips [8]. Five agent clusters specified in the system architecture include tourist assistant, ontology maintenance and search, requirement/preference management, package planning, and local tour planning. Ricci and Nguyen (2007) present a critique-based mobile recommender system that lets users expressing session-specific preferences in addition to the long-term collected preferences [20]. The objective is to provide on-tour system support to mobile travelers for selecting products or services based on the integration of both types of preferences. Driver and Clarke (2008), on the other hand, point out that most research related to mobile, context-aware activity scheduling to date has focused on tourist guide applications [9]. This type of application provides the user with a static tour on a mobile device, but does not support dynamic and context-based trail management. An application framework comprising trail generation and trail reconfiguration point identification modules is then proposed for managing mobile and context-aware trails.

As can be seen, although there are several previous works addressing the design and implementation issues for delivering personalized and/or location-based tourism services, only partial solutions to the targeted context and location aware personalized tour planning and recommendation services have been provided. For efficiently and effectively integrating personalized and location aware information to support the recommendation and rescheduling of personalized tour plans, the need of an application framework and development method for directing and facilitating the service system design, implementation, and operation processes is still significant, and more in-depth exploration into this topic is required.

3 Personalized Location-Based Tour Planning Recommendation

The information and decision requirements for supporting personalized location-based tour planning services include (1) user profiles containing personalized preferences, needs, constraints and self-specified evaluation criteria, (2) mobile tourists' time and location information, (3) tourism related destination, attraction, and accommodation information, (4) decision associated model, knowledge, and process information. Major location-based tourism information that tourists requested includes destination-oriented information about what to see, where to eat, and where to stay overnight, etc. Specified information for sightseeing spots include tourism types and features (such as culture-archeological site, sport-ski park), sightseeing theme, opening hours, ticket price, location and map, transportation and directions, briefings and suggested visiting time, etc. Detailed accommodation information specified include hotel name, hotel class (star rating), brief introduction, hotel location (city/region/address) and map, transportation and directions, distances to point-of-interests (e.g. train stations, historical sites, city center, etc.), check-in/check-out times, available rooms, facilities, price per room per night, room availability, photos, booking services, website and contact information, and customer rating score, etc. Detailed dining and restaurant information include restaurant name, food type, location, map, transportation, opening hours, customer rating score, menu and recommended food lists, etc.

In addition to information requirements, functional requirements specified include user profile management, tourism information management, location-aware personalized recommendation of attractions (e.g. sightseeing spots, museums, restaurants, hotels) and tour plans, tour plan management, as well as map-based positioning and visualization. A few more functions required in the back end system include model base and knowledge base management, as well as ontology and case base management provided that they are used as matching techniques. The design scopes include functional architecture design, process design, user interface design, presentation design, database design, model base design, knowledge base design, as well as the ontology and case base design, etc. In the following subsections, descriptions will focus on the functional framework and recommendation process, as well as database, model base, and rule base design considerations.

3.1 Framework and Process for Personalized Location-Based Recommendation

Based on the results of requirement specifications, a functional framework for supporting the personalized location-based tour planning recommendation is presented in Figure 1. The core services of the personalized location-based tour planning recommendation offered to the tourists include single-typed attraction/point-of-interest recommendation and packaged tour plan recommendation. A recommended tour plan bundles and schedules a series of selected sightseeing spots, restaurants and hotel with specified sequence and suggested time-to-stay. For an example, a tourist may like to make a half day tour in a city starting from his current position and time, and based on his preference, needs, time and device constraints, as well as criteria for site selections. He would also like to be able to reconfigure his tour plan by the time he leaves a sightseeing spot or restaurant, and use his current time and location for recommending the next visit or subsequent visits with suggested visiting time.

The tourism related information services, tourism related location-based services, as well as GIS and Google map services are supportive services that allow tourists to access tourism information, tourist location information and location aware tourism site information, as well as geographical information and maps associated with tourists and tourism attractions. The core tour planning recommendation services also use these supportive services to generate content descriptions for recommended attractions or the tour plan, and display the result in the tourist's mobile device.

Based on the proposed functional framework, personalized location-based recommendation services can be generated to support tourists in making decisions that answer questions including what and where to eat for lunch or dinner? Are there any nearby interesting sightseeing spots? Are they still open and do we have enough time to visit? Where to stay for tonight? A recommended tour plan summarizes the

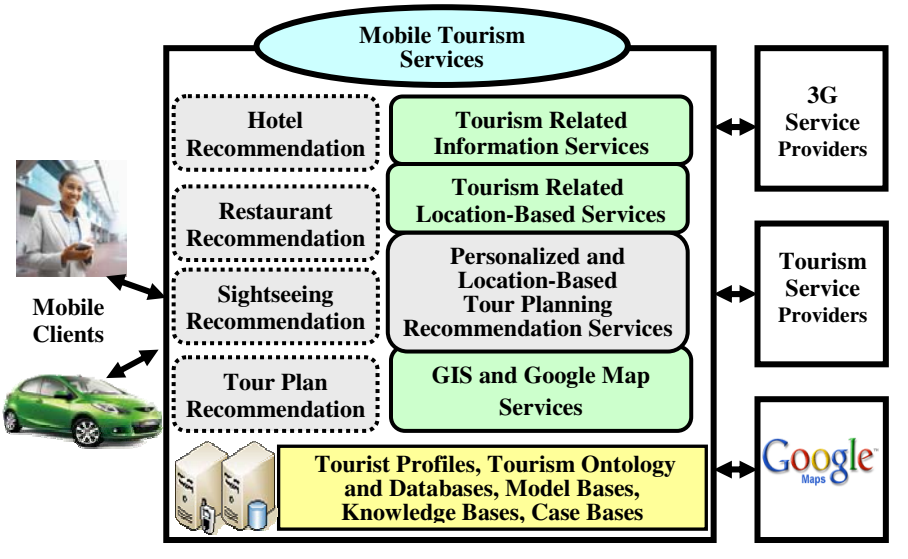

Fig. 1. Functional framework for personalized location-based tour planning recommendation

desired decision outcomes and organized them into a sequential process with suggested time to stay. Figure 2 depicts an example flow chart of the personalized location-based tour planning recommendation process. Once the tourist activates the location-based tour planning recommendation services, the tourist's current location is identified and current time is recorded, personal preferences and criteria are retrieved or specified online. For instance, in the example scenario, the time periods specified for lunch time and dinner time are 11:00am-14:00 pm and 18:00-21:00 pm respectively, the maximal number of visiting spots is set to be 7, and the time for ending daily activities is set to be 21:00 pm. The search ranges can also be set to, for example, 3 km for restaurants and 5km for sightseeing spots.

During the recommendation process, if the updated current time is around the lunch time or the dinner time periods, and the tourist has not eat yet, then the restaurant recommendation service is launched to locate a preferred restaurant within certain search range. If the current time is not in the eating time zones and is no later than 21:00 pm, the number of visited sightseeing spots is less than 7, and there are still nearby open unvisited sightseeing spots with sufficient visiting time, then the recommendation process continues to activate the sightseeing recommendation services. If the current time reaches the time limit 21:00 pm or the number of visited sightseeing spots reaches 7, then the hotel recommendation service is activated. Finally, the complete tour plan consists of sequentially arranged places generated from restaurants, sightseeing spots, and hotel recommendations is sent to and presented in the tourist's mobile device.

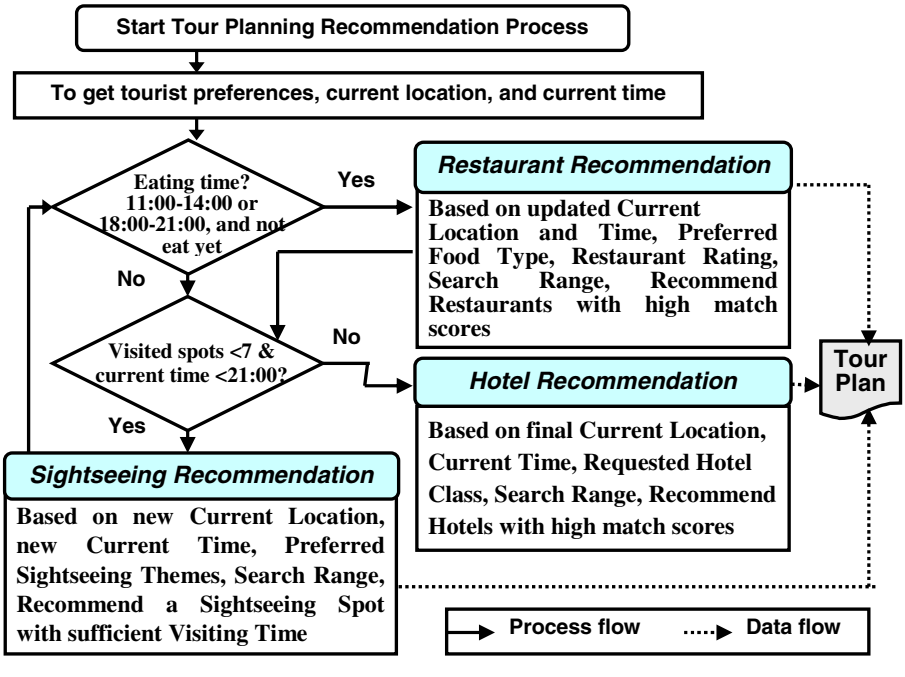

Fig. 2. The example personalized location-based tour planning recommendation process

3.2 Database, Model Base, and Knowledge Base Design

For designing and developing system database, the Object-Oriented (OO) database design approach is adopted to create the conceptual data model, and then the OO model is translated into an entity-relationship (ER) model which is further transformed into the internal relational model for physical database implementation. Figure 3 presents the OO data model in which identified objects include Tourist, Tourism Information, Tour Plan, and Recommendation Process. The Tourist object composes of Needs and Preferences (N&P), Search Range and Criteria, as well as Current Location and Time objects, and the Needs and Preferences object is further classified into Sightseeing N&P, Restaurant N&P, and Hotel N&P objects. The Tourism Information object aggregates three sub-class objects including Sightseeing Spots Information, Restaurant Information, and Hotel Information objects. The Recommendation Process object has several component objects including Process Input, Recommendation Model, Recommendation Rule, and Process Output. The Tour Plan object consists of Sightseeing Spot Selection, Restaurant Selection, and Hotel Selection objects as the components.

For model base and knowledge base design, the process modeling, decision modeling, and rule base approaches are used. Focusing on the example presented in the previous sub-section, Figure 4, Figure 5, and Figure 6 respectively illustrate the recommendation process model as well as associated decision model and rules for the hotel and sightseeing spot recommendations. The inputs to the personalized location-based tour plan recommendation process include tourist current location, the current time, search range (e.g. 3 km to the current location), constraints and criteria (e.g. 11:00am-14:00 pm and 18:00-21:00 pm as the lunch and dinner time periods respectively, 7 as the maximal number of visiting spots), sightseeing spots needs and preferences, restaurant needs and preferences, and hotel needs and preferences. For more specifically specifying needs and preferences, we take the hotel

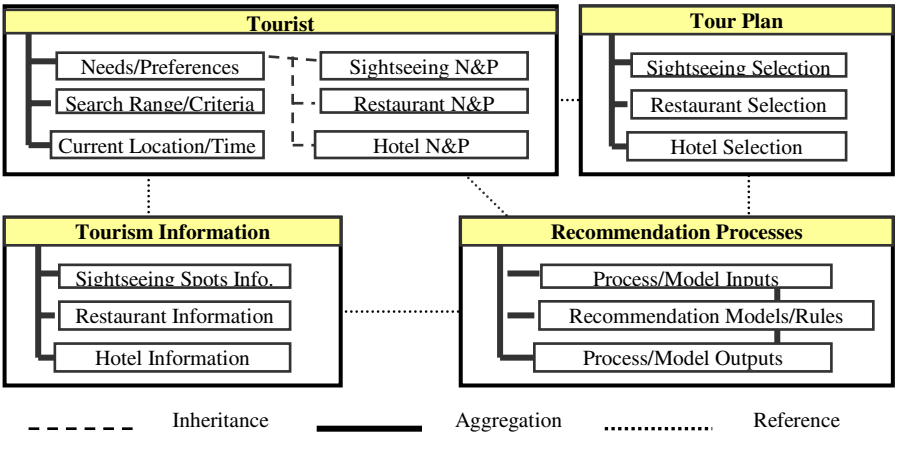

Fig. 3. The Object-Oriented data model

Tour plan recommendation process model

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Record current location and current time
Set restaurant search range, preferred lunch and dinner food type, restaurant rating
Set sightseeing search range, preferred sightseeing theme, opening hours
Set hotel search range, preferred hotel class, room type, room rate, facility, customer rating
Set temp_time=current time
Set temp_location=current location

While loop
 If temp_time is between 11:00am and 14:00pm and lunch status=no
     or temp_time is between 18:00pm and 21:00pm and dinner status=no
     then Activate Restaurant Recommendation Service Model (temp_location, restaurant search
          range, preferred food type, restaurant rating)
     Temp_time = temp_time + suggested_eating_time
     Temp_location=location_of_recommended_place
If temp_time<21:00pm and number_visited_site<7
     Then Activate Sightseeing Recommendation Service Model (temp_location, sightseeing search
          range, preferred sightseeing theme, opening hours)
     Temp_time = temp_time + suggested_visiting_time
     Temp_location=location_of_recommended_place
End loop

Activate Hotel Recommendation Service Model (temp_location, hotel search range, preferred hotel
     class, room type, room rate, facility, customer rating)

Output tour plan (selected sightseeing spots, restaurants, and hotel with sequence numbers)
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Fig. 4. The tour plan recommendation process model

recommendation as an example for explanation. As a specific instance, data elements and values such as "hotel distance to the current location < = 3km", "room type = single", and "availability = yes" can be used as the matching criteria in the data retrieval step, and then, the data elements and values such as hotel distance to the current location, hotel class (3 star and above), price per room per night (less than US$150), facilities (Internet access), and customer rating score can be chosen as the hotel evaluation criteria in the ranking and selection step. Hotels with the highest total evaluation scores are ranked and presented to the tourist for selection.

The resulting output elements of a recommended tour plan include tour plan ID, sequence number of attractions/activities, types of attractions/activities (sightseeing, restaurant, hotel), attraction/activity ID, attraction/activity name, information of selected sightseeing spots (e.g. name, location, address, distance to the updated current location, sightseeing theme, suggested visiting time, etc.), information of selected restaurants (e.g. name, location, address, distance to the updated current location, food type, suggested eating time, customer rating score, etc.), information of the selected hotel (e.g. name, location, address, distance to the updated current location, hotel class, room type, room rate, check in/check out times, facilities, distance to point-of-interest, customer rating score, etc.), as well as a map showing all selected attractions with their sequence numbers. Through using the attraction/activity ID, detailed information about the recommended sightseeing spots, restaurants, or hotel can be accessed and reviewed. Similarly, sightseeing evaluation model and rules are shown in Figure 6.

Hotel evaluation model and rules
Record current location Set hotel search range, room type, room availability Set preferred hotel class, room rate, facility, customer rating Retrieve hotel distance to the current location, hotel class, room rate, facility, customer rating
If Hotel distance to the current location = 0, then T1 = “100” else T1 = (100-10*(Hotel distance to the current location) IF Hotel class a is >= Preferred hotel class a1, then T2 = “100” else T2 = 100 – 20*(a1 – a) If Room rate b is <= Specified room rate b1, then T3 = “100” else T3 = 100 –(b – b1) If Facility set F contains Specified facility set F1, then T4 = “100” else T4 = 100 – 100*Count(F1-F)/Count(F1) If Customer rating c is >= Specified customer rating c1, then T5 = “100” else T5 = 100 –10*(c1– c)
SET HT = Sum(T1*W1,…,T5*W5) Subject to Sum(W1,..,W5) = 1 where HT = total score of hotel evaluation Ti and Wi are value and weight of the ith hotel evaluation criteria, i = 1,…, 5

Fig. 5. The hotel evaluation model and rules

Sightseeing evaluation model and rules
Record current location, current time, recommended and visited sightseeing spots Set sightseeing search range, preferred sightseeing theme Retrieve sightseeing distance to the current location, sightseeing theme, suggested visiting time
If Sightseeing distance to the current location = 0, then T1 = 100 else T1 = 100 - 10*(Sightseeing distance to the current location) If Sightseeing theme set S contains Specified sightseeing theme set S1, then T2 = 100 else T2 = 100 – 100*Count(S1-S)/Count(S1)
SET ST = Sum(T1*W1, T2*W2) Subject to Sum(W1, W2) = 1 where ST = total score of sightseeing evaluation Ti and Wi are value and weight of the ith sightseeing evaluation criteria, i = 1, 2

Fig. 6. The sightseeing evaluation model and rules

4 The Prototype System

A prototype system that enables the delivery of the personalized location-based tour planning recommendation services is developed. In the system environment, system and application software in the back-end server side include Windows XP, Microsoft IIS Web Server 5.1, .NET Framework 2.0, and Microsoft SQL Server 2005, as well as ASP.NET 2.0, Web Services, and Google Map API 2.0. Besides, the CHT Windows Mobile 5.0 Smart Phone Emulator is used as the client-side emulator. Figure 7 presents the prototype system environment that allows tourists to use PDAs or smartphones for accessing the web-based applications and activating desired personalized location-based recommendation services. Sightseeing spots, restaurants,

and hotels can be selected, or a packaged personalized tour plan can be generated based on tourists' location-aware needs, preferences, constraints, and criteria.

In Figure 8, a few screenshots of the personalized location-based recommendation services are illustrated. From the left hand side to the right, the first screenshot shows the list of mobile tourism services including restaurant, hotel, sightseeing spot, and tour plan recommendation services, as well as user profile management services. The second screenshot displays user interactions for setting matching items and values, as well as evaluation criteria to activate the tour plan recommendation. As mentioned, these items include search range, multiple sightseeing themes, lunch food type, dinner food type, restaurant ratings, hotel class and room rate, etc.

The third screenshot presents the overview of the recommended tour plan with photos and names, sequence numbers (in red balloon), distances to the previous locations, suggested visiting time frames, and location maps of the recommended sightseeing spots, restaurants, and hotel. Clicking on these items will show enlarged

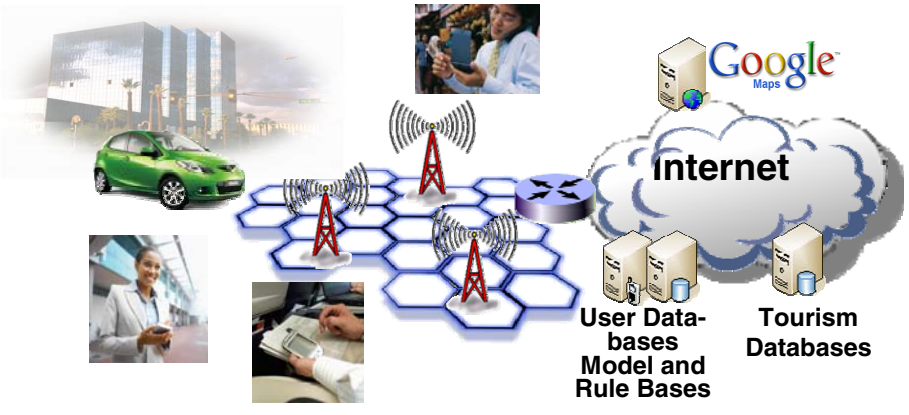

Fig. 7. The prototype system environment

Fig. 8. The prototype system UI and output screenshots

pictures or detailed information of the corresponding places. The right hand screenshot is a Google Map display that visually spots all the recommended places.

The prototype system accessible by 3G mobile devices is evaluated by 28 recruited students who have both mobile usage and travel experience. They are asked to complete an evaluation questionnaire that consists of 22 items in 6 categories. Based on a 5-point Likert scale (1 as strongly disagree and 5 as strongly agree), the average scores of the 6 criteria including user interface and layout, functionality, ease of use, understandability, satisfaction, and intention for future use are 3.87, 4.07, 4.10, 4.45, 3.76, and 3.81 respectively with the overall average score being above 3.7. The outcome indicates positively the applicability of the proposed framework and methods.

5 Conclusion

In this paper, we propose a service framework, design methods, and process models for developing and delivering personalized location-based mobile tour planning recommendation services. A system prototype is built and tested to validate the feasibility and effectiveness of the proposed approach. This research integrates advanced mobile and recommendation technologies to guide and facilitate the development and delivery of powerful location-based recommendation services for supporting pre-trip and/or during-the-trip personalized tour planning that take into account tourists' location and time, needs and preferences, as well as constraints and criteria. Future research works include evaluating the operational efficiency and user acceptance of the system using real world cases, and enhancing the recommendation functions by integrating ontology mapping and case-based reasoning mechanisms.

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