Personalized and Location-based Mobile Tourism Services

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Abstract

Mobile users such as tourists require mobile services. Handheld devices promise access to a range of travel-related services while on tour. A number of usability issues, however, still ask for intelligent new solutions. Issues are, for example, the limited capacity of handheld devices, user interaction via small screens, mediation of heterogeneous services, as well as other issues of wireless access to internet-based services. Key features of the CRUMPET system are personalisation, location awareness, interaction facilitation and service mediation. Its realisation as a multi-agent architecture opens up additional prospects.

Keywords: mobile users, personalisation, location-based services, adaptivity, service brokerage, agents.

1 A Vision for Mobile Tourism Services

People travel for many purposes: on business, for recreation, education, and entertainment, to meet business partners, friends and family. They often strive to combine several purposes while travelling. Not so many years ago, travelling required serious preparation: booking with the help of travel agents, buying guidebooks and maps, collecting brochures, catalogues and leaflets. Today, new technologies allow more flexible access to information, booking services, and other tourist support. Therefore, on-the-spot decisions become feasible and travelling becomes more flexible. For example, handheld devices such as WAP enabled phones or PDAs, allow unhampered movement and wireless connection to the required services. However, handheld devices should not just offer services the same way as, for instance, web services are offered, but require special user interaction as well as personalised service mediation.

The tourism sector is extremely heterogeneous. While the cultural diversity of Europe as a travel destination is a stimulus for tourism, the diversity of information services for mobile users is clearly a usability issue. In services offered on the World Wide Web we can see that one and the same service type (hotel reservation service, for

instance) can differ considerably in design and user interaction. It is also difficult for nomadic users to find an appropriate local service.
The European IST project CRUMPET aims at "Creation of User-friendly Mobile Services Personalised for Tourism" (Poslad, Laamanen et al. 2001). The goal of CRUMPET is to implement, trial and validate personalised, nomadic services for tourism, using agent technology for fast creation of robust, scalable and seamlessly accessible nomadic services. CRUMPET favours the following promising approach:

- trustworthy and ambient agencies for user's world-wide, wireless access to local services;
- personalised support for mobile users;
- location-based support;
- exploitation of heterogeneous legacy services, which
  - cover a wide range of locations,
  - supply a wide range of supplementary, complementary, or even competitive services,
  - may differ in service features and qualities.

Some of these are long-term goals that ask for a joint effort of several R&D projects as well as providers; CRUMPET is contributing to this goal technical and conceptual solutions, and is evaluating them in trials.
The remainder of this paper is structured as follows. Section 2 illustrates the use of CRUMPET and some of the key features of the system. Section 3 summarizes usability challenges for this kind of systems. Sections 4 and 5 present our approach to personalisation, adaptivity and location-based support. Section 6 introduces the multi-agent architecture and especially considers the role of middle-agents in building ubiquitous services. Section 7 draws the main conclusions and outlines future work.

2 Scenario of Tourist Support

The following three scenarios give a vision how CRUMPET could support tourists in the near future. The scenarios also illustrate some key features of the system.

> A businessman has an afternoon off. This came rather unexpectedly, and now he strolls through the centre of Heidelberg spontaneously. He has, however, switched on his PDA and enabled the pro-active tip agent of the CRUMPET service. After a while, he hears a tone and sees an icon on his screen indicating a tip. When he clicks on it a note appears saying that he is quite near to one of the historic sites of Heidelberg, in which he might be interested. Indeed he is, and when he clicks on "more information" he receives directions to the site and a short description.

> A new student at a college wishes to have a tour of the campus to get acquainted with the buildings, lecture rooms, and other facilities she has to find and use when she begins her studies. The system suggests a tour that includes all buildings of general interest, such as library and hall, and some of specific interest for her studies. She starts off, finding her way with the help of a map. She can get more information about all places when she is near them, and as far as she is interested. At lunchtime she interrupts her tour and asks for a place to eat. She gets several offers, each with a short description. After she has chosen one, she gets directions of how to find it. After lunch she wants to resume her tour, and the system shows her to the next point in the tour.

A group of tourists is visiting town, each member of the group is following their own personal tour or business. But they want to meet for lunch, at a restaurant that suits all, and at a place that can be reached comfortably from the current position of all members of the group. The system judges from the user models of all group members that Italian or bistro-type restaurants would suit all of them. It can also determine an area that is equidistant from the current position of all group members. It then looks up suitable restaurants in this area and offers them to the group members.

The key features of the CRUMPET system as illustrated by these scenarios are:

Making use of personal interests

- Domain-specific interests of the user serve as a basis for selecting and sorting service offers.
- Interests of single users as well as groups can be considered.
- The system learns the user's interest over time, i.e. from the user's interaction with the system.

Making use of the user's current position

- The user's current location is observed on the basis of GPS sensor data.
- The GPS data about the geo-coordinates are related to data in Geo-Information Systems (GIS) of the region.
- The current location serves as input for the service selection.
- Location-based services are offered, such as creating a tour, giving directions, creating maps.

Service mediation

- The system is realized as a multi-agent system, including middle-agents to mediate between user and distributed service agents.
- The middle-agents integrate various support features of CRUMPET and facilitate the user interaction.
- The system may exploit several content providers for one request of the user.
- Pro-active assistance is given, when enabled by the user.

The CRUMPET system has been developed in a scenario-based way. The scenarios given here are only short examples from the elaborate scenarios developed in an early phase of the project. The scenario development has been closely related to the development of the system architecture and further specifications, such as UML use case and sequence diagrams.

Figure 1 gives an overview over the system architecture, as seen from a functional point of view.

3 Usability challenges

When services are offered via wireless connection to mobile users using handheld devices, crucial usability issues are:

- How to facilitate the use of heterogeneous services?
- How to adapt service interaction and display of content to the limitations of handheld devices, especially the small displays.
- How to keep users' expenses for the wireless connection and use of services low and adequate to what they finally get?

- How to deal with changing technical environments (e.g. changing quality of services for the underlying network connections)?
- How to enhance the trust that users feel towards their service providers and how to protect user privacy?

A study on WAP usability (Ramsay and Nielsen 2000) confirms such requirements and states severe usability deficiencies, experienced in autumn 2000. These problems have to be solved not only for WAP, but also for any small, handheld devices with wireless connection to distributed services.

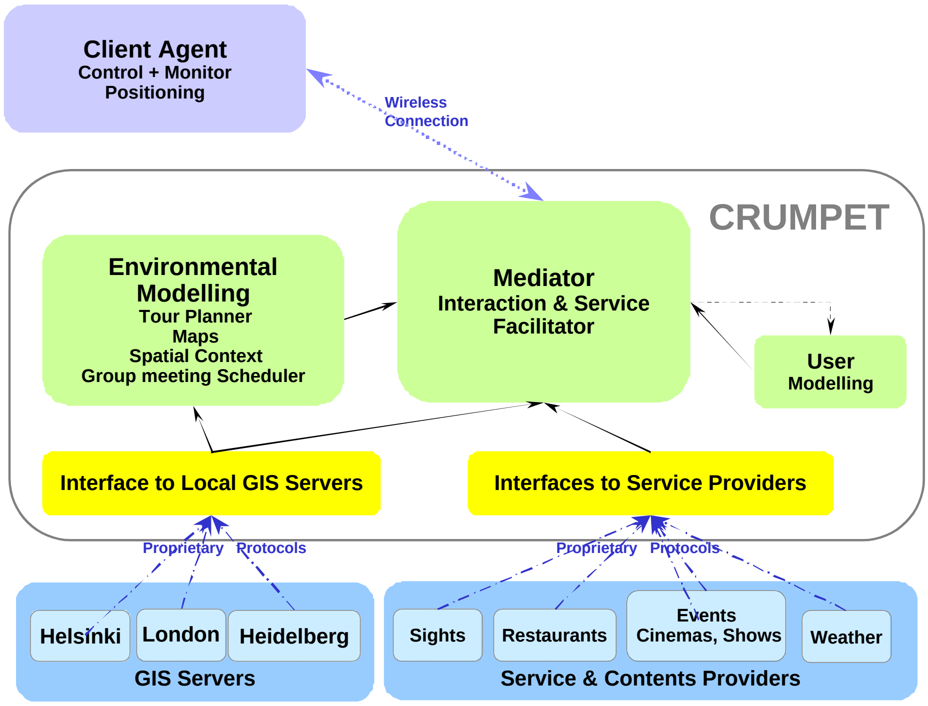

Fig. 1. Functional schema of the CRUMPET system.

Context-awareness is a key feature of mobile and ubiquitous support (Abowd and Mynatt 2000). Also, context-awareness is supposed to partially solve usability issues of mobile support, as it can be used to ease the user's interaction with the system. The most important context when supporting mobile users is their current location, observed by sensor data. It can be used to facilitate user interaction, e.g., by supplying default values for location-based services. At a closer look, the use of context has to be balanced carefully against other usability principles, as empirical studies of such systems reveal (Cheverst, Davies et al. 2001).

Personalization is also a prevailing means to facilitate the use of mobile systems. Personalization too, at a closer look, poses usability issues that have to be carefully considered when designing a personalised, adaptive system.

We discuss such concerns throughout the following sections 4 and 5.

4 Personalization of Services

Personalization is a key feature that facilitates the use of complex services on mobile devices (Short 2000). Personalization in CRUMPET includes

- adaptation to the user's tourism-related interests and to other preferences;
- adaptivity, i.e. automatic update of the user model based on the user's interaction history;
- location-awareness, i.e. the system's awareness of a user's current spatial context.

The latter feature is presented in more detail in section 5.

4.1 Modelling user interests

The approach chosen in CRUMPET is especially suitable for information brokerage (Nick 2001). The model of interest is based on a domain taxonomy, i.e. a taxonomy of tourism-related services for CRUMPET. The domain model is a domain-specific, structured set of concepts and attributes describing a tourist service. The user interest is seen as a function mapping these concepts and attributes to the probability p that the user is interested in such services (see figure 1).

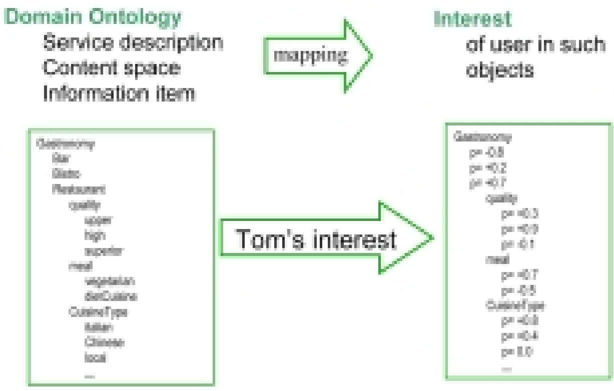

Fig. 2 The user model maps service descriptions onto the probability of a certain user being interested in specific features.

4.2 Making use of the user model

The adaptation of tourist services to personal interests helps to improve usability of handheld devices. When the user requests a service in a very simple way, the request is probably not specified by all the parameters that are needed to get a good result from a service. If user interests are known, the request can be specified automatically to get better results. This would result in a query outcome that contains only objects according to the assumed user interest. It might be inappropriate to confine users to such offers that match their assumed interest. We instead prefer to sort outcome of a query according to a ranking that considers all user interests relevant for the required service.

Another way to use the user interests would be to filter, i.e. to select the most interesting objects only. This shall be used under certain conditions, such as pro-active tips, when it is important to offer a small set of objects only. In general, we consider filtering too restrictive. A user’s interest may vary under circumstances which cannot be modelled in necessary detail to predict such changes of taste. Also, learning interests from user interaction relies on offering a broad scope of information and services to the user, who then reveals his or her personal interests, for instance, by asking for more details about some of these objects.

An essential usability requirement for user modelling is that users can inspect their model and that they can override the model's assumptions (Fischer 2001). CRUMPET allows users to inspect their model and change it on a PC dialog interface. The user can also override the system’s default values by explicitly specifying his or her current interest.

Another concern of users with respect to user modelling is privacy. Customer privacy can be more easily guaranteed within the CRUMPET architecture (see section 6) where the user modelling is part of the middle-agents and accessible only for the mediation component. It is, therefore, intrinsically inaccessible to third parties like service providers.

The trustworthiness of the CRUMPET agency itself has to be established by several technical and contractual means, which is not subject to the current project.

4.3 Adaptivity of the user model

In CRUMPET an adaptive user model learns user interests from the user's interaction with the system. When a user asks for more information about an object, this adds a small amount to the evidence that a user is interested in objects with these features, more than in others. If a user asks for more and more details about the same object, or even asks for directions to a site/restaurant, this adds a greater amount to the evidence that she or he is interested in such services.

The user model, in order to learn user interests, needs reliable and intelligent feedback from the user interface.

Another idea would be to use a user‘s movements to infer her or his interests. So, for example, it seems a good idea to infer from a user’s visit to a church that this user is interested in churches. (Again, this only adds a little to the statistical evidence of this user’s interest.) While this approach may be useful in a small and closed world, such as a museum, it is risky in the open world, such as a city. The localisation is not precise enough to determine the user’s topological position without doubt. There may also be several reasons why a user stays for a while at a certain position, and these reasons may not be obvious to the system. So, for instance, the visit in or near a church may be because of a concert in the church, or an exceptional view from its tower, or even the little café in the aisle may attract tourists, who are not generally interested in churches; and none of these reasons can be modelled and determined by the system. So in CRUMPET, which is a guide in the open world, we decided to rely on the user’s interaction with the system to learn her or his interests over time.

Learning user interests unfortunately requires a number of events until statistically significant tendencies can be postulated. Several mechanisms to accelerate this are possible. One "shortcut" would be asking the user to confirm early guesses explicitly. Another, complementary, solution will be to initialise the user model using stereotypes. A stereotype is a (small) set of demographic data correlating to a set of typical interests of such tourists. The most appropriate stereotype to start with can then be identified by a few demographic attributes that the user states when registering to the system. In case a user’s profile has been initialised by an inappropriate stereotype, this would be adjusted over time (implicitly) by learning, or can also be corrected by the user explicitly.

The validity of stereotypes, i.e. the correlation of certain demographic data with “typical” user interests, needs to be established by a separate empirical study.

5 Personalised Location-based Services

Location-based services are considered a killer application of mobile computing (Oertel, Steinmüller et al. 2002). Location-based services are, for instance, interactive maps, or giving directions to a destination, or recommendation of tours. This can as well include interaction facilitation. If the system is aware of a user's current location, this can contribute to the ease-of-use in many ways:

- A user's request can be automatically completed by the current location, e.g. if a user asks for a restaurant "near-by", the system can infer from the user's geographic position what "near-by" means and select such restaurants that are in the area.
- A user can ask where he is. If he feels lost, the system can provide the name of the area or an address. It can also point out the current position in a map.
- The user can simply ask "how to get there", if the system already knows the destination (from the dialog history) and the current position, it can provide directions.
- The system can trace a user's progress on a suggested tour and provide location specific information and directions.

Research prototypes, such as Hippie (Oppermann and Specht 2000) and GUIDE (Cheverst, Davies et al. 2000) have shown the benefits of location awareness for tourist support. The personalised location-based services of CRUMPET, as explained below, go well beyond these approaches.

When location-awareness is combined with user modelling, this opens up new possibilities in location-based services with added values for the user. This is outlined in the following sections, for a more detailed presentation including the technical background see (Zipf 2002).

5.1 User Position in Physical Space.

In some modern PDA devices, the sensors for determining the location by means of GPS are already built in or can easily be attached. CRUMPET will use them to enable the features mentioned above. Positioning by GPS states the client's geographical position as x-y-z co-ordinates. So, if a user asks for information relevant to his current position, the system can automatically complete this simple request using the parameter “current position”.

In order to make sensible use of wireless connection, the client device needs some intelligence to interpret the current position and send only the relevant position co-ordinates to the middle-agents residing on the server. The question, which position or rather which change in a user's position is relevant is not easily answered. The assessment of "relevance" of a movement has to take into account several factors.

- The general precision of GPS (if the precision is 30 m, for instance, a move of 10 m, however relevant, cannot be reliably measured).
- The last n positions (if the precision is 30 m, and several small changes accumulate to a movement of more than 30m in one co-ordinate, this is relevant).
- The type of environment (e.g. a small movement that is relevant on a building site might be less relevant within an urban environment, and irrelevant on the countryside).
- The current velocity (e.g. if the user moves slowly, the intervals of observing the position and assessing its relevance could be stretched).

For positioning there are also other techniques available, for instance infrared sensors, Bluetooth, or GSM/UMTS. For certain applications it might be useful to complement GPS for outdoor positioning with infrared positioning. This is very precise and can also be used to directly identify a location without reference to a GIS. It requires, however, the installation of sensors on a site. This can be feasible and efficient in a restricted area, such as a campus, an amusement park, or within a museum.

In addition to positioning, the orientation of the user can be of interest. An electronic compass in the client device can help to interpret the location of the user, and offer more specific information.

A privacy concern is that users may not want their whereabouts to be constantly observed by a system. Therefore it must be possible that the user can switch off the positioning. Of course, the system support in that case is limited, and the user has to explicitly input the positioning parameters required for location-based services.

5.2 Exploiting Spatial Context

So far, we have only mentioned the geographic position, given as x-y-z co-ordinates, which is a precondition for location-awareness. In order to offer location based services (LBS), the logical or topological position of a user is equally important. This is, for instance, the position in terms of addresses, town name or town area. This is also the topological relation to other geographical objects, like "on Trafalgar Square" or "in front of St. Paul's Cathedral". We call this the spatial context of the user.

Most services are not based on co-ordinates but on addresses and names of areas (e.g. country, town, or area in a town). The translation of a coordinate to an address or area, which can be used to find a service or facility by a kind of yellow pages, has to be done by a separate geo-coding service. It is also necessary to have the inverse translation, i.e. from area or address to coordinates, because this enables more helpful features. For instance, the distance between a destination and the current position of the user can thus be calculated.

5.3 Pro-active Sightseeing Tips

The user of the CRUMPET system will have the option to enable the pro-active tips agent, as illustrated in the first scenario. This provides the means to draw the user's attention to objects of interest that are near-by. In order to deliver personalised location-aware tips for tourists, the system needs to be aware of the user's position, the location of objects as well as the user's interests.

The pro-active tips are given in an unobtrusive manner, for instance, by an icon indicating that there is a new tip. When the user wants to see the tip, the small list of recommended sights is displayed, otherwise the icon disappears when the user moves on or when new tips become available. Apart from these proactive tips, the user can explicitly ask for a recommendation of sights nearby that might be according to his or her taste. These recommendations differ from proactive tips in that they have a much lower threshold of interest and a wider understanding of “nearby”, thus retrieving a ranked list of possibly interesting objects from which the user can choose some to get more details or to be included in a tour.

5.4 Generating Personalized Tour Proposals

Two services for generating personalised tour proposals are being developed in CRUMPET: a Route Agent and a Tour Agent.

The Route Agent computes a path through a network of streets that includes two or more locations in the network. A typical application of the Route Agent is calculating and displaying the best or shortest route between two specified locations, e.g. from the user's current position to a certain destination. There are many different routing algorithms. In cases where street addresses are specified as either the starting or ending points of the route, an address geo-coding service is required.

The task of the Tour Agent is much more complex, as it tries to suggest individual sight seeing tours according to the tourist's interest. Heuristic approaches are needed, because the underlying mathematical optimisation strategies are too complex (so called NP-hard) to actually compute an optimal solution.

5.5 Personalized Adaptive Maps

Maps are of great value, when a tourist is moving in an unfamiliar area and searching for some kind of business or sight. Maps have the potential to represent large amounts of information about the area of interest as a single, relatively small picture. The art to design maps in a way that such condensed information is not confusing but easy to understand has a long tradition. Automatic design of maps is a challenge for AI and smart systems; it is a complex task that also involves cognitive and psychological aspects.

Map adaptations can take into account a wide range of factors, such as technical conditions (e.g. size of display screen, colour depth, raster versus vector graphics), the cognitive abilities of the recipient, and its purpose of use (e.g. topographic map, navigation map, thematic map, and historic map).

Some prominent examples of map style are the culture-specific use of colours and symbols. There are different official signatures for map features in different countries. It is possible to specify different particular map styles for different countries. The Web Map Server developed in CRUMPET will also support different styles, but is being enhanced by allowing modifications to a wide range of graphical properties.

Examples of adapting a map presentation to context and personal profiles are:

- Calculate the boundary of the requested map in order to include the current position of the user.
- Adjust the boundary of the requested map in order to include objects of high interest.
- Represent objects of higher interest more dominantly by suitable symbols.

Intelligent automatic production of location aware, personalised tours and maps is still a challenging research area. It also needs more insight in usability needs, as will be gained by validating the prototypes developed in CRUMPET.

6 Mediation of Tourism Services

Once personal interests and current position of users have been identified, they are used for mediation and facilitation to improve the usability of the CRUMPET services. The mediator in the CRUMPET system has two main goals, i.e., to facilitate the interaction of users with CRUMPET services, and to mediate between different service providers as well as between the user and service providers.

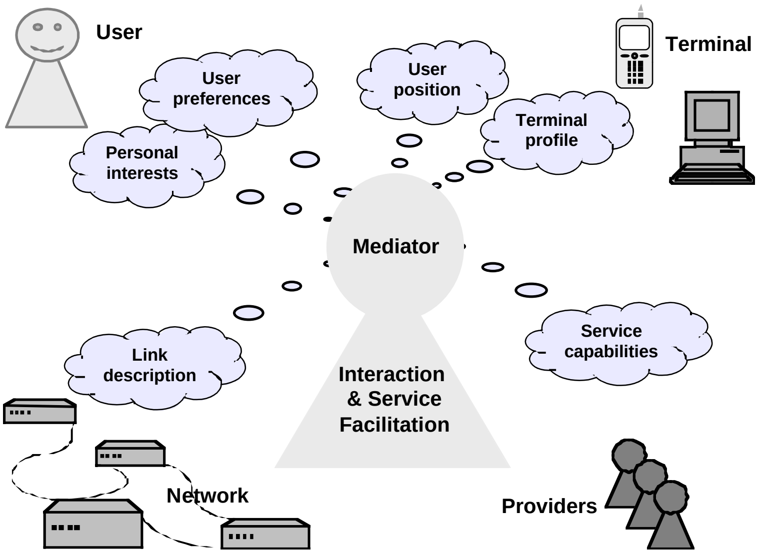

Fig. 3 Mediation between users and providers in the CRUMPET system.

This is achieved by a multi-agent system, i.e., a system of intelligent, collaborative software agents. Such a system of specialised agents, co-operating to achieve a common goal is referred to as an *agency*. CRUMPET is using and enhancing the FIPA[1] standards for its agent implementation (Poslad, Laamanen et al. 2001).

The multi-agent architecture chosen in CRUMPET has in essence a three-tier-structure (see figure 1), with requesting agents (representing the tourist users), provider agents (representing legacy contents providers and other tourism-related information services), and middle-agents. Middle-agents help requesting agents and provider agents to locate each other, and may also facilitate their co-operation. This architecture has advantages with respect to scalability, trust and usability (Klusch and Sycara 2001).

In CRUMPET, the middle-agents serve to

- facilitate user interaction with the system, both for user request and for presentation of request outcome,
- locate available and suitable providers (match-making),

[1] Foundation for Intelligent Physical Agents Homepage. http://www.fipa.org. 2001.

- match clients' requests and preferences against the offered services and their features,
- combine several services to the required support level,
- adapt the query outcome to client preferences and networking conditions,
- handle potential failures of service and network providers, and
- guarantee trustworthiness, especially by maintaining users' and providers' privacy, and by a fair consideration of competitive service providers.

Interaction facilitation and service mediation are supplementary; some features of mediation contribute to facilitation as well, and vice versa.

6.1 Facilitation of User Interaction

In more detail, *interaction facilitation* includes:

- making use of the dialog history and user movement in space;
- serving as a facilitator in exploiting complex and dynamic services, while user's view on services is kept as simple as possible;
- serving as a presentation performer (combining results to "digestible" information output to user device, reaction on dynamic changes in technical environment);
- employing user interests to filter or sort large amounts of information received.

Since the user will be roaming in very different network conditions, and the amount of information sent over the wireless link should be minimised, some kind of content adaptation on the network side is required. This content adaptation should take into account the type of terminal the user is using at the moment, and the network conditions (Helin and Laukkanen 2001). Together these define how much and what kind of information should be sent to the user. For example, if the network connection is poor, it’s not practical to send large quantities of data, such as movie clips. And if the user is using a mobile phone with text-only capabilities, he cannot receive images even if the network connection is good.

6.2 Service Mediation

Mediation between client and complex, dynamic (third party) services is performed by the middle-agents by

- retrieving user interests to specify user's simple requests;
- serving as a mediator, while protecting user's privacy and interests, and managing fairness among service providers ;
- integrating several agents’ capabilities to a service with added values, beyond what each agent’s added service could provide.

The user should be given anonymity while using the services. Users do not generally want to reveal their interests to unknown third parties. This can be achieved by middle-agents acting as brokers or mediators: the user contacts the mediator and the mediator contacts the services while maintaining the user’s privacy. Not only is a user anonymous to the used service providers but also they cannot even build up individual profiles as they are contacted by mediator agents who may serve several users in turn. It is also considered an usability advantage when the user modelling server resides on, and is managed by, a central agent or service, compared to user profiles build by single providers. The user modelling is more consistent, it learns from more information events than a single provider could assemble, it has cross-service effects (Fink and Kobsa 2000). When it comes to transactions such as electronic payments, this concept may be too demanding. The agency could handle the payments if the necessary technical and organisational conditions are given, or it can then allow a direct contact between client and provider, and the provider handles the actual process of buying and paying. In this latter case, the lot of the information gathering and negotiation is handled with clients being anonymous, but when it comes to a contract both client and provider reveal their identity.

Middle-agents have also to further the trust of competitive content providers in agencies. A broker may find more than one suitable provider when requiring a service. A trustworthy agency has to guarantee the providers to exploit competitive services in a disinterested, unbiased way. The chosen architecture of the CRUMPET agency is one pillar in building a trustworthy and secure system, but other measures are needed in addition to this. The full scope of this issue could not be tackled within the current project but needs a broader effort of the R&D community (Poslad, Charlton et al. 2001).

6.3 Exploitation of distributed legacy systems

How will local content and service providers be able to have their services integrated in this agency? Legacy systems can be integrated and exploited by means of wrapper agents, which register their existence and services with a CRUMPET agency, and interact with the middle-agents. There are several options regarding which role such a wrapper agent can assume, e.g., whether it acts as one interface to all "hotel reservation services", or on behalf of one hotel chain, or even one single hotel.

Another issue concerns the heterogeneous ontologies that are likely to be used by legacy systems. Ontology in this context is a description of the domain specific semantics that are associated with the terms that exist within the information sources. Service brokering, as characterised here, requires an ontology that allows matching and relating user requests, user interests, and service offers. The mediator agents and the user model are ontology-based and cover

- the tourist domain (e.g., hotels, restaurants, sights)
- service features (e.g., mode of payment, certain provider),
- information request habits (e.g., preference for short information, dislike of animation).

The latter two points require that services and the available information units be described by suitable metadata. Currently, this is not usually the case in internet-based services, but future development towards a "Semantic Net" (Berners-Lee, Hendler et al. 2001), (Maedche and Staab 2002) requires that tagging of content and services is carried out with reference to defined ontologies.

The integration and exploitation of heterogeneous, location-based services cannot be tackled in due detail in this paper. There are still open issues, subject to ongoing design and development. As mentioned earlier in this paper, CRUMPET aims at goals that can only be achieved in a joint and continued effort of several projects.

7 Conclusions and Outlook

The personalised and location-aware support of mobile users, an adaptive, ontology-based user model, the scalability with respect to clients and providers, the multi-agent architecture with middle-agents performing brokerage - these are promising design concepts of the CRUMPET system. By employing middle-agents usability will also be improved as they exploit information about the expected network performance, provide agent control over transfer operations. Additional and equally important goals of CRUMPET are its contributions to the open-source agent platform implementation, FIPA-OS, primarily providing new functionality for supporting agents in "small footprint" devices, and the intelligent handling of networking problems (Poslad et al., 2001).

A heuristic evaluation of a prototype has been undertaken in January 2002, in Heidelberg. Further informal evaluations of prototypes are planned in the first half-year of 2002. The final trial and evaluation is due in summer 2002, in Heidelberg, London, Helsinki, and Aveiro. The major results of the trials shall be reported when this paper will is presented at the MobileHCI in September 2002.

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