PaTac: Urban, ubiquitous, personalized services for citizens and tourists

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Abstract

This paper presents the general design of an architecture, based on software agents and oriented to the semantic Web, for the development and deployment of urban, ubiquitous services for citizens and tourist. The goal is to create a platform able to provide personalized services based on recommendation algorithms, and users' location, profile and preferences. The motivating scenario behind the design and development of these services is one in which citizens and tourists use mobile devices to interoperate confidently with the surrounding environment.

1. Introduction

Never before humans had access to so much data so easily; however, this scenario disappears as we move away from a computer. In our cities, urban services are provided via supports, which practically have not changed in a century: bus-stop shelters, metro-stations panels and screens, maps or urban furniture [http://www.cityofsound.com/blog/ 2008/02/the-street-as-p.html]. This scenario brings up the opportunity to refresh the idea of services that a city provides to citizens and tourists, with the novel possibility of ubiquitously accessing personalized multimedia content: the proposed platform is able to provide services and information anywhere, anytime and in real time.

With very few exceptions, nowadays there are no personalized information-services or digital city-guides being widely accessible in public thoroughfares, shopping malls, airports, railway stations or public spaces in general. Hence people have to visit tourist or information offices in order to obtain accurate, up-to-date information, in which case what is provided is generalist anyway and does not take into account people's preferences (at least when human-to-human interaction is not provided). The few exceptions are represented by the appearance, in recent years, of multimedia information points with interactive contents, offering services to the citizens in the public areas, such as Mediaattori - Urban Mediator: a hybrid infrastructure for neighborhoods [22], "i-kiosks" provided by the Aberdeen City Council, in the United Kingdom, the "Eye in the Sky", from Auckland, New Zealand, Tangerine's "Maidstone Museum Kiosk" and "iMotion" from Infinitus. In all these cases, services are not sufficiently personalized, accessible, usable, customizable or distributed.

The growth of the World Wide Web and the rapid rise of eCommerce and the semantic Web [2] have led to significant efforts to develop standardized software models and technologies to support and enable the engineering of systems involving distributed computation. For example, so-called service-oriented architectures (SOAs) for distributed applications involve the creation of systems based on components, each of which provides predefined computational services, and which can then be aggregated dynamically at runtime to create new applications.

Other relevant efforts range from low-level wireless communications protocols such as Bluetooth to higher-level Web services abstractions and middleware, to the development of agent technologies. Many of these standard technologies and infrastructures for distributed and eCommerce systems provide implementation methods and middleware, enabling the easy creation of infrastructures for agent-based systems, such as standardized methods for discovery and communication between heterogeneous services. Applications now enabled by these technologies are becoming increasingly agentlike, and address difficult technical challenges similar to those that have been the focus of multi-agent systems. These include issues such as trust, reputation, obligations, contract management, team formation, and management of large-scale open systems. [14]

Nevertheless, the greatest potential of the World Wide Web, possibly represented by the hyperlocal Web (the difference between the semantic Web and the

hyperlocal Web — that is hyper as in linked, and local as in location — is that the databases of the new Web are stuffed not only with semantics, but also with geographic coordinates), multi-agent systems and cloud computing[3], is not exploited enough in the streets and other public spaces. In fact, ubiquitous or context-aware computing [1] supporting urban services could be obtained by the integration of existing devices, information retrieval systems, advanced infrastructures and human-computer interactions, bringing new solutions to the streets.

The structure of this paper is as follows. The next section presents the PaTac platform, which offers ubiquitous services to citizens and tourists, using ontologies and software agents. Section 3 describes PaTac architecture's design, detailing the conceptual model, the multi agent system and the user modeling.

2. The PaTac platform

2.1 Ubiquity

We are living in a new communication era, where corporations, communities and personal connections are continuously changing, as Weiser envisioned a decade ago [19]. The PaTac platform is a TMT Factory's initiative designed to reify and enhance the commercial and research potential of *interactive community displays* (ICDs) [4] (see also section 2.2). This enhancement is obtained using technologies and applications based on the hyperlocal Web and agent technology [9]: an open, distributed network platform hosting diverse agents and services.

The PaTac platform have been designed as an online system, which provides and facilitates access to services in real time, anywhere, contributing to the creation of the so-called Internet of Things[12], interconnecting service providers (e.g., restaurants), locations and people. The purpose of PaTac is to enable a dynamic, intelligent and autonomous composition of services, addressed to changing user's needs. ICDs, integrated with posters, city information panels, bus stop shelters, kiosk systems, and interior panels, are an ideal channel to provide the city semantically-rich services through map-based interfaces [16]. Furthermore, the use of mobile devices can add to the ubiquity of the information[7].

The concept of pervasive computing, context-awareness or ubiquity refers to a computing environment that links humans, objects, and information: an environment where heterogeneous computers are integrated into objects and are

(wirelessly) networked and made available in a user-centered scenario (see Figure 1).

The future goal of the PaTac platform is the integration on an urban, environmental, management information system, or Cityware (Cityware means how the local government and enterprises monitor traffic, chase down leaky water mains, keep tourists on the straight and narrow and offer services to people with functional diversity).

2.2 Interactive community displays

An ICD is a multimodal interface, which allows haptic (tactile) interactions, speech recognition, text recognition and requests via SMS or twitter [http://twitter.com/]. In particular, the research efforts on the natural language processing endow the display with a more natural interaction.

The integration of a radiofrequency-identification (RFID) device lets the system enhance the recommendation given to the users, personalizing the information about all the services offered. The use of RFID permits a private, accessible and trustworthy interoperation of both humans and computers with the environment.

The agents potentially involved in the interaction with ICDs are:
- citizens and tourists;
- the administration that provides information;
- content providers (including advertisers);
- event organizers.

The first release of the platform will use ICDs providing information on-demand in specific locations of the city. Thereafter, ICDs will also work as local access-points, creating a virtual wireless network that let surrounding mobile devices interact with the ICD and among them (e.g., multiplayer games on PlayStations Portable).

Figure 1: User-centered scenario

2.3 PaTac services

Public and private organizations compete against each other to offer the most attractive and complete information and services about tourism through web sites, other digital media and tourist offices, with little or no personalization, and sometimes at a cost.

The services that will be offered by the PaTac platform and available in public city spaces through ICDs' and mobile devices' interfaces are presented below:

- **Interactive map**. The user has information available about all surrounding locations on an interactive map, all the time.
- **Personalized recommendation**. The system can provide different options for restaurants, monuments, bars, places of interest and public transport, according to the profile of the user (or the group of users) identified, her location, and the current time and weather.
- **Description of places of interest**. A brief description of places of interest tagged on the map is automatically gathered from sources on the Internet and provided to the user.
- **Route planning**. The system can plan an itinerary across the city (walking, by bike, by public transport or by car). The system can suggest places at the end of or along the route. When users are not close to an ICD, their location is calculated finding an approximate position over the map. [http://www.google.com/gmm]
- **Social feedback**. With the idea of socializing the real world through the virtual world, the PaTac platform will allow people use tags, send images, add comments about places, events and services, and share all this information with other people.

3. Platform design

3.1 Conceptual model

With the emergence of the semantic Web, many entities are betting for enhancing their applications with semantic data [18]. Ontology-based, semantic metadata are used to define clearly the meaning of words and objects of Web pages, making this knowledge available for sharing. This facilitates a computer's comprehension and manipulation of information. In this project, semantic data are distributed into standard ontologies.

Using standard ontologies as a basis for the conceptual model facilitates data interoperability, information search and retrieval, automated inference, and natural language processing among heterogeneous systems. Upper-level ontologies in PaTac are based on various standards, such as W3C's Time [11] and Geoposition [http://www.w3.org/2003/01/geo/], the

General User Model Ontology (GUMO) [8], FOAF and UMBEL [http://www.umbel.org/].

PaTac's conceptual map (see Figure 2) shows the semantic data organization, which is mainly based on ontology mapping. Ontology mapping is the process whereby two ontologies are semantically related at conceptual level, and the source ontology instances are transformed into the target ontology entities according to semantic relations. There are two main: Cultural Activity and Infrastructure. The relation between them is that instances of the first one are performed at instances of the second one. Moreover, both are subclassified into different domain ontologies and synchronized through UMBEL.

3.2 Multi-agent system

The PaTac platform will implement a *multi-agent system* (MAS) [14][24][5] (which will be used also for deployment in the ALIVE project, *Coordination, Organisation and Model Driven Approaches for Dynamic, Flexible, Robust Software and Services Engineering*, is developing new approaches to the engineering of distributed software systems based on the adaptation of coordination and organisations with Model Driven Design), able to gather and manage semantic data in distributed locations in order to deliver the information requested by the users taking into account their preferences. The semantic Web and software agents are highly interdependent and should work very well together to deliver PaTac services[10].

PaTac's MAS is constituted by three components: the content collector; the agents responsible for storing the information in ontologies; and finally the content deliverer, which interoperate among them, namely providing services to one another. Agents involved may not all have been designed together, by the same software development team, or even owned and managed by the same organizations. They may form coalitions with one another to achieve particular temporary objectives, have access to different information sources and have different objectives.

In this paper, we introduce the latter component, described in Figure 3, as a combination of sub-tasks distributed to different autonomous agents, whose communication is based on standard agent communication language (ACL) messages. In Figure 3 it can be seen as the interaction flow begins when the user petition is received as a query; then the agents collaborate to provide information responding to that query in a way that is matching user's preferences.

Figure 2: PaTac conceptual model
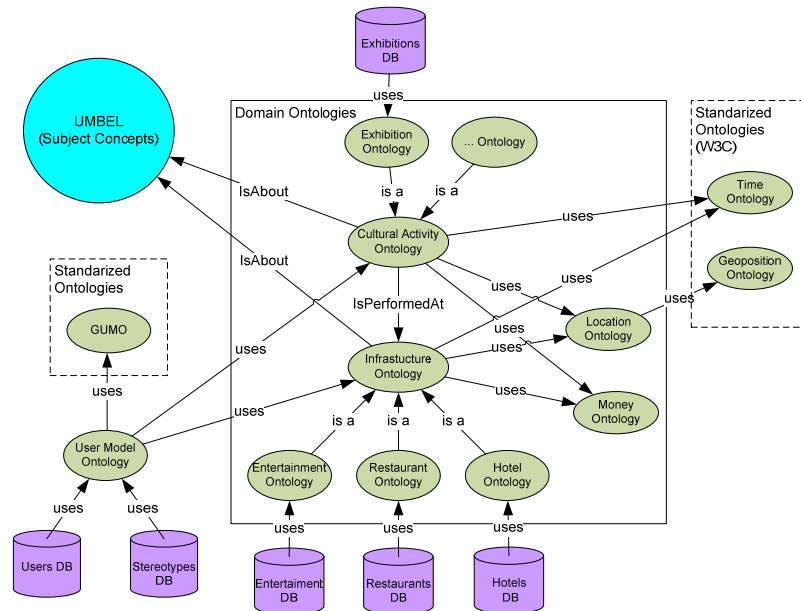
It is assumed that it is possible to submit the system a query from any Internet-enabled device. The query is transmitted to the Communication Agent (CA), which wraps it into an ACL message and sends it to the Session Handling Agent (SHA). The SHA main task is to manage the user session, initializing the user profile through the Profile Managing Agent (PMA).

The SHA transmits the Personalization Agent (PA) the user request. Hereafter, the PA gathers the user preferences via the PMA and the content from databases and ontologies via the Information Service Agent (ISA). Finally, the PA processes the petition using a personalization algorithm and delivers the user the result.

3.3 User modeling

The user profile is also represented by ontologies and user preferences will correspond to relations between concepts in the domain ontology. Collecting user preferences is one of the primary challenges of a profiling system. Social media sites have captured the attention of millions of users and it would be interesting to offer users the possibility to synchronize their personal information in these social media sites and in the PaTac system[23]. However, the PaTac platform needs to capture additional information, to be able to offer accurate suggestions. This can be done creating social-networks plugins, e.g. for Facebook [http://www.facebook.com], asking for a user's food preferences.

The proposed solution consists of employing reasoning based on stereotypes for every new user of PaTac and then learning algorithms based on implicit and explicit feedback to refine the user profile[15][17].

Stereotype reasoning consists of the calculation of the similarity between the initial user's information (mainly demographic data) and existing stereotypical descriptions. As a result, the user model is associated with the best fitting stereotype, inheriting all its features. The learning algorithm chosen is an adaptation of the history-based algorithm proposed in Fink and Kobsa[6]. This algorithm calculates "probabilities of interest", using the frequency of occurrence of different concepts in the user's history, which are classified by means of a standard significance analysis.

3.3.1 Personalization and recommendation

Unlike tourist offices, PaTac aims to an automatic personalization based on users' profile and actions, using RFID for identification. Moreover, users' feedback will be used to increase the accuracy of descriptions about locations and services. Personalization and recommendation [13][21] are very related in the PaTac system: the agent which makes personalized recommendations, the PA (see Figure 3), calculates the best suggestions taking into account the user profile by means of a content-based filtering method.
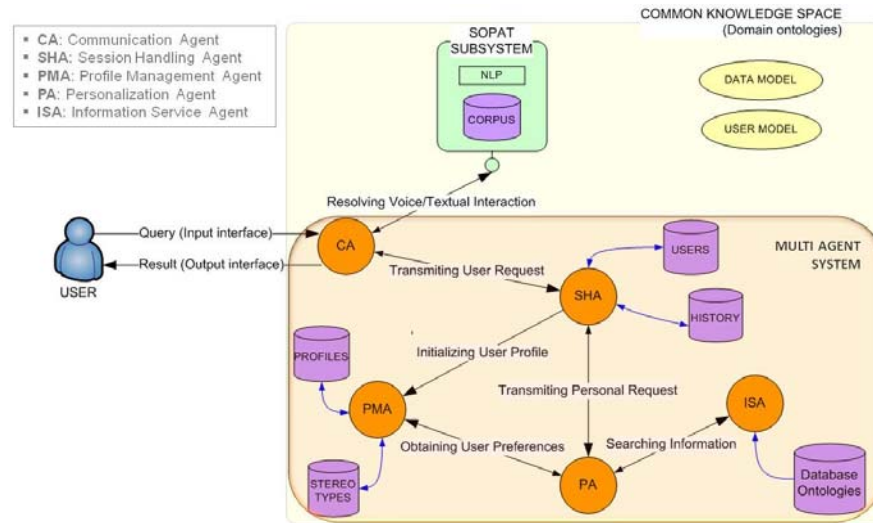
Figure 3: Functional, multi-agent system architecture

The key element of this approach is the measurement of the similarity between some content and a certain user's preferences, indicating how related they are. The similarity measure used consists of calculating the probability that a given content (such as a place, an event or a restaurant) were the user's favorite option. The general process of the personalization algorithm is:

1. Selecting content features that are significantly interesting for the user.
2. Filtering and ranking the content list based on the calculated interest of the features.

4. Future activities

PaTac platform's first ICD prototypes will be deployed in Spain, in 2009. Main objectives at TMT Factory are making services accessible for all, and enabling a more natural interaction between people and machines: improving natural language processing (speech, text and gestures). Also planned is the inclusion, in the interface, of avatars [20] with emotional features, providing an even more multimodal interaction with the users, and face recognition. Finally, with respect to the improvement of the services provided, it will be necessary to collect more relevant information about the user, her interaction with the devices and her physical location.

5. Conclusions

In last two decades, many researchers have been seeking a solution to offer digital, context-aware services in real time across cities' public spaces, using supports such as mobile, GPS-enabled devices. PaTac's efforts are oriented towards a ubiquitous-computing scenario, with some of the services described here already implemented and soon available in the street. The main novelty of the PaTac approach is the integration of autonomous content collection, data management and multimodal user interface, by means of the introduction of a multi-agent system, the use of ontologies and the exploitation of the semantic Web. The objective is to obtain interoperable and portable data and to be able to share them with other platforms, using ontology standards and projects like UMBEL. Finally, we would also add social features, minding on the personalization recommendation of the content, and improving the human-computer interaction, offering a new communication channel on the street.

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