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Location based Informationsystems

Ulrich Furbach, Markus Maron, Kevin Read

In this paper we describe a series of projects on location based and personalised information systems. We start wit a basic research project and we show how we came with the help of two other more application oriented project to a product. This is developed by a consortium of enterprises and it already is in use in the city of Koblenz.

1 The Idea

In the mid 90s, my colleague had a brand new Palm III, we were waiting on a train station in a small Dutch city and began dreaming: what if we could use this Palm to get information about this location, about interesting places around the station and so on and so forth. Back at home we wrote a project proposal and we received funding for the MIA Project [4]. This was the beginning of a series of projects on this topic we want to describe in this paper. Recently, Raj Reddy and Jaime Carbonell, declared a new "Bill of Rights" of the Information Society, therein they claimed, that we should

- get the right information,
- to the right people,
- at the right time,
- in the right language,
- with the right level of detail and
- in the right medium.

We feel that the project described in the following, contribute at least to some of these claims

2 The Projects

The first project in this series, the MIA project mentioned above, assumed that the palmtop device was equipped with a GPS system for its localization and had access to the internet. In addition the system had access to a user profile on a server and hence was able to answer personalized and location-based queries. In the successor projects, described in this section, we avoid connecting to the internet via the mobile device; instead we are focusing on free of charge access to Bluetooth access points. We describe IASON, a basic research project and SpatialMetro, a an EU project in the area of tourist guidance and finally we shortly describe CityGuideBlue, a product which is an outcome of these projects, which is currently used by the city of Koblenz.

2.1 The IASON-Project

The IASON[1] project, funded by the "Stiftung Rheinland-Pfalz für Innovation", aims at providing mobile users (users of a PDA or a mobile phone) with location-aware personalized information. Motivated by the development of powerful mobile devices and the semantic web, we defined a *Semantic Mobile Environment*. In such an environment, so-called service nodes are installed at chosen points of interest. These service nodes broadcast messages to nearby mobile users using bluetooth wireless technology. The kind of message depends on the access point it will be broadcasted by, for example a bookshop could send its latest offers, a pub could present its menu and the schedule of events to its customers or a bus station could offer information about the delay of the next scheduled busses.

One of the main aspects of the project to mention is that the information will be delivered to the user free of charge. On top of that, the information sent is specific to the access points location. The most interesting feature from a scientific viewpoint is the filtering technology. The huge amount of information which will be sent is filtered by the mobile device according to the profile set by the user. For that we annotated the messages semantically with a Description Logic (DL) [2, 3] concept. We also gave the users the opportunity to build their individual interest profile, which was constructed as a DL concept, too.

The user profiles and the semantically annotated messages are based upon the same terminology. So we built a small ontology for our semantic environment. The profile and the ontology are stored on the mobile device. Both are part of the mobile agent, shown in figure 1, which was implemented in J2ME[2]. This application [9] was the first usable prototype of the project. It is able to do more than just storing and displaying incoming messages. It includes a powerful reasoning engine which is able to solve TPTP problems. This reasoner, called Pocket KRHyper [8], is a re-implemetion of the KRHyper [13] system. It is the first theorem prover for first order predicate calculus running on a mobile phone. More information about the entire approach can be found in [6].

To get an idea of what happens inside the mobile application we created a simplified test scenario where we tested our IASON concept. We set up the test-run to gather more data and get hands-on experience with these technologies. This test-run was conducted at the cafeteria of the University of Koblenz. The daily cafeteria menus were broadcast at all times. A client was available free of charge via Bluetooth data transfer for the cafeteria visitors, bundled with profiles fitting the menu and major food tastes. Along with the data and application transmission, users had the opportunity to fill out feedback forms and discuss the technology online in the University newsgroup.

Let's shortly describe how it works. The terminology, profile and annotations are considered to be a finite set of axioms $C \sqsubseteq$

[1] http://www.uni-koblenz.de/~iason

[2] http://java.sun.com/javame/index.jsp

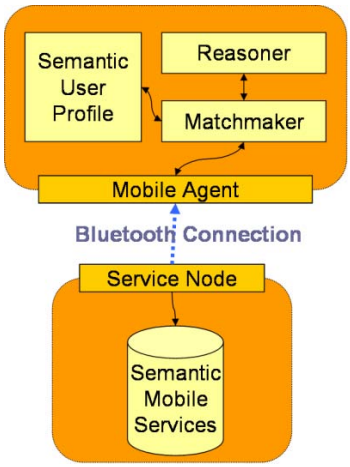

Figure 1: Iason System architecture

D and $C \equiv D$, where C, D are concepts of the Description Logic $\mathcal{ALC}$ extended by inverse roles and role hierarchies. First we needed an ontology for describing our semantic environment, to build the user profiles and to annotate the messages. Part of the whole ontology which has been developed in the IASON project, is shown in figure 2. The syntax of the ontology we used is Lisp-like, KRSS [10], is a subset of the RACER-syntax [5]. This was necessary because a XML-based syntax like OWL [1] or DAML+OIL would require a XML-parser on our mobile device. Unfortunately, at the time of development there was no standard XML-parser available for the J2ME environment. Nevertheless the expressivity of our syntax is close to that of OWL-DL.

```
(IN-TBOX iason)
(DEFINE-PRIMITIVE-ROLE OFFER :PARENTS SHAREINTEREST)
(DEFINE-PRIMITIVE-ROLE REQUEST :PARENTS SHAREINTEREST)
(IMPLIES time attributes)
(IMPLIES afternoon time)
(IMPLIES noon time)
(IMPLIES evening time)
(IMPLIES cuisine attributes)
(IMPLIES attributes abstract)
(IMPLIES meal food)
(IMPLIES food solid)
(IMPLIES solid physical)
(IMPLIES vegetarian cuisine)
```

Figure 2: A Simple Ontology

During the cafeteria test-run we provided an application with fixed profiles. This means that the users were able to choose from a predefined set of profiles but weren't able to edit them. The meaning of the displayed profiles (see fig. 3) are described below:

```
Profiles:
All Infos: (some offer meal)
veg. Abend: (some offer(and meal evening vegetarian))
Abendmensa: (some offer(and meal evening))
Mittagsmensa: (some offer(and meal noon))
veg.Mittagsm.: (some offer(and meal noon vegetarian))
```

For example this is an equivalent notation for the Mittagsmensa

Figure 3: UniInfo Application (Fixed Profiles)

$\exists offer.(meal \sqcap noon)$ in DL syntax.
When in range of the service node, the users mobile device will receive a few offered services which are annotated. The following service was offered as a non vegetarian dish for lunch.

```
Services offered:
Annotation: (some offer(and meal noon))
Subject: Menue 1 Mittwoch 7.Woche
Text: Zigeunerschnitzel mit Pommes Frites und Salat
```

Before displaying the service to the user, the mobile application has to decide whether the information fits to the users interest or not. This deduction process called matchmaking [7] is done by the first order reasoner Pocket KRHyper. For the chosen profile (see fig. 3) the service is compatible and will be displayed. The subsumption test holds.

The decision whether a message matches a users profile is based on concept satisfiability and subsumption of the DL in use.

$$profile \sqcap annotation \not\equiv \bot \quad (1)$$

$$annotation \sqsubseteq profile \quad (2)$$

If the annotation satisfies test (1) the annotation is *compatible* with the profile. Because an unsatisfiable annotation will be subsumed by every profile, the first test prevents any unsatisfiable annotation to be considered as a match. This test avoids spam. Test (2) will give a better *match degree* for those annotations that are subsumed by at least one of the $positive$ terms. We call these annotations a *match*. This second test is only performed after successfully testing satisfiability (1). In the cafeteria context the test (2) was not necessary.

The IASON-project is a ongoing effort. The results and experiences went in to our other projects as you can see below.

2.2 The SpatialMetro-Project

One goal of this European Commission project[3] is the use of AI techniques for efficient guidance of tourists in a city. For this

[3] http://www.spatialmetro.org

purpose tourists are guided along themed routes on special maps that are reminiscent of Metro or Underground line maps, hence the name (see fig. 4). Points of interest are the equivalent of Metro stops in this analogy. We developed a stationary information system for this project, and channeled our experiences from IASON into a wireless information system.

Each point of interest will be equipped with a Bluetooth enabled Access Point that will broadcast information about this location. Examples would be historical information, directions to next Metro stops or shopping facilities. Tourists PDAs or mobile phones are contacted by the Access Point and can display the information after reception. This is naturally free of charge, in contrast to wireless LAN or GPRS/UMTS technology, and it is location based by nature.

Figure 4: Spatial Metro Map

The reasoning engine is based on the efforts from the IASON project. Enhancements where made to the profile generation. There are several profiles bundled with the SpatialMetro application, of which one or more can be selected. The description logic terms of the activated profiles are disjunctively linked together. On top of this disjunction, the profile selection also sports the possibility of activating attributes that further narrow down the users interests. These attributes are then added as a conjunction to each profile term. An example of this would be the attribute "vegetarian", that would narrow down all food interest profiles to this kind of foods, without overriding the profiles like "Italian food".

The aforementioned cafeteria test brought significant empirical results. Log data showed that there was a technical barrier in the installation of applications via Bluetooth. Mobile phone providers disable this data transport to force users to download applications over their data networks, thereby generating revenue. This technical barrier was accompanied by a social barrier - installing a foreign and potentially dangerous application on a mobile phone. This was reflected in the feedback forms and also gave cause for discussion online.

Todays mobile phones do not offer a baseline of technical features. Quite to the contrary, the power of the embedded operating system and even standardized features like the Java virtual machine differ significantly. This posed another major hurdle. At the same time the supplier of the Access Point technology announced the End-Of-Life for this product range. All these developments lead to the realization, that we had to redesign the concept to overcome these problems.

First we had to look for a new access point platform which wasn't trivial. To reduce the requirements on the mobile users side and to enable us to do even more complex reasoning in the future we chose to move the reasoning process from the mobile phone to a server. For broadcasting the services we adopted standard bluetooth transport mechanisms instead of the java based communication. With this we also increased the reachability. Different test cases at public events showed that we now reach every bluetooth enabled (mobile) device.

2.3 The CityGuide Blue-Product

The conceptual change turn out to be so good that public entities were highly interested in our research. This led to development of a product called CityGuide Blue. It introduced a Client-Server architecture and a web based Profile Editor that stores users interest in a central database. The reasoning engine used by this project is based on our deduction model. For the use in high load situations we optimized the theorem prover. On top of that we consult the participating companies, utilizing our experiences gained in our projects and research. The City of Koblenz already decided to use the system on various places in the city and currently the University of Koblenz decided to use the system as a campus information system for mobile users ([12, 11])

3 The Results

There are two main results, or better lessons, learned from these projects:

We undertook the first attempt at implementing a powerful reasoning engine on resource constrained devices, like a smartphone. From this we learned that implementation language matters! Our KRHyper system is implemented in Ocaml, mainly because this was the Ph.D. student's favorite language; when we tried to get KRHyper running on a smart phone, it became obvious that we need a JAVA version and hence a re-implementation became necessary. Maybe such a porting could have been taken into account from the very beginning.

The second lesson is more on the project design, concerning the willingness of users to download a piece of software, i.e. the reasoning machinery, on their mobile phones. During the field studies, we carried out, it became obvious, that users are hesitating to download new and unknown software on their devices. But also if they are willing, they very often simply do not know how to do it. Most users use smartphone for phoning only.

Another interesting experience is, that turning a prototype into a real product is indeed a challenging task. Its a long way to go, both in software developement and in matching the users and buyers needs.

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