Location Based Services for Traffic Management

Lemonia Ragia and Michel Deriaz

Abstract. Spatial data are used for location based services and to support traffic management systems. Data are gathered, saved and managed in a central database where, in principal, every user can access them putting data in a temporary database and then integrate them to a central. The proposed system uses a connection between database and trust engines in order to provide transparency. Security is an important aspect in our system to give confidence to the users to use their online services. We present an architecture for the implementation. The implemented system has been used in a small scenario for traffic information in a city center.

1 Introduction

The wireless technology becomes very important in our daily life because it provides a lot of services. The World Wide Web gives the opportunity to the people to connect mobile phones or portable devises to Internet. Universal Mobile Telecommunication System (UMTS) with the new phones Personal Digital Assistants (PDA) enable more services. The number of people that use the Web and the wireless technology is increasing rapidly.

User location was difficult to find out but with the usage of Global Positioning System (GPS) new possibilities are open. The integrated technology of GPS devices gives the location of the people quickly and with accuracy. That means that we can have location based services (LBS) which is a term that connects, in principle, the geographic location with user requests. These services find a great interest in the commerce area. There is a lot of information provided by the Web using the location and there is a great possibility to share these information and to develop applications. The Global System for Mobile Communications (GSM) Alliance Service Working Group decide about the LBS in different areas like asset management, emergency alert services, traffic congestion reporting etc., [1].

In the research area there are several approaches that show personalized LBS services for different applications: in the area of tourism [2] [3] [4] or navigation [5] or traffic [6].

Traffic management is an important issue from local authorities and they try to manage efficiently all the information gathered for traffic control. LBS plays an important role because the drivers can be informed immediately in their cars about current situation of the road, dangerous points etc. There are a lot of aspects for traffic management to ensure the road network. For example, somebody is in a highway and the traffic stops. In this case nobody knows the reason for this stop or the time frame of this happening. What and when did it happen? Is an accident somewhere else in the highway and how many kilometers is the line of the cars without a movement? Is there an alternative way to get through the road quickly?

Other information that could be shared via cell phones is when there is an unusual behavior of a driver then a message can be sent to other drivers in the same road and in a short distance that all the drivers must be careful or reduce speed. In this case another driver who show this event can sent a message to the central server and a new warning message can be received by the other drivers immediately after the first one.

Another example is when some drivers have high speed and reach an area where there are speed limits, then a receiving message can warn the drivers about the speed limits.

In our approach the location based services include lots of request that the user can ask to the system. Our system includes the connection to a central database. Examples of location based services using databases are already discussed and there are some approaches [7], [8]. The system provides interface for the users' request. The user can use internet mobile phone or a personal digital assistant (PDA) for the queries. Today there are also cases where the users can have cameras with GPS and they can take pictures which is related to the location. In this case the question can include spatial data, that means the queries can give also the position to get an answer. In addition, some vehicles carry navigation systems that include information about local position. If these systems are connected to the internet then the answers can be shown in the display of the navigation system. The services for traffic management can be described by the following categories:

Traffic information

This service provides information about the traffic jam and determine the faster route to the drivers. It takes into account a big area of infrastructure and it is always updated. It can also predict the traffic after a specific time to a specific location and give some directions to avoid a traffic jam. It can estimate the total travel time and in case of traffic jam can suggest alternative routes for the remaining time. It is connected with the police information and if a part of the road is closed then anointer route or probable another way to travel like by train can be suggested.

Safety related services

It is possible that the driver is in a dangerous situation. This occurs because of the weather condition or because of an unpredictable reaction of another driver. It happens also that an accident before a driver can cause an immediately slowly movement of the cars. This service gives information about a safe and free travel and helps the users to avoid any kind of difficult occasion.

Interesting location

This covers all the queries about interesting places of the users during the traveling. This could be a restaurant, the next hospital, next stop, next bus station etc. It includes also information about a region in a certain area like accommodation possibilities, parking places, local infrastructure, cultural events e.g. exhibition, etc. The main goal is to inform the user about a big variety of facilities in a specific region.

2 Data Warehouse for Traffic Control

A data warehouse is a large data repository that collects data from different sources. The data warehouse is typically designed for data integration, data management and data analysis. In our approach the data warehouse includes:

- Copying data from local databases to a central integrated one,
- includes operation to manage the data for the specific requests of the users,
- optimizing the data structures in order to accept permanently a large amount of data,
- monitoring the central database after changing a local data source.

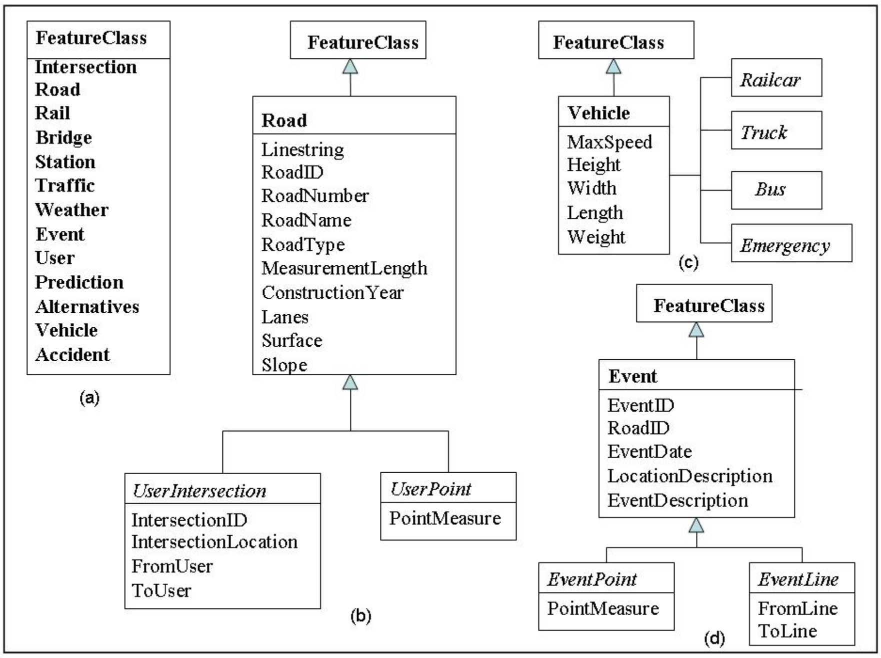

Fig. 1: The data model for the traffic management database. The classes of the model are represented in the figure (a), and the other figures depict the models for some classes of the whole model.

The spatial queries include requests regarding the content, the geographical position, the address and the time. The content describes all the information about a specific thema, e.g. "give the information about the weather". The geographical position is based on the longitude and latitude of a location which can be taken by a navigation system or GPS, e.g. a spatial query can be "next gasoline station to the X and Y coordinates". An address refers to a street (name, number or code), to postal code, to a name of a city, e.g. "give all information about traffic jam in the highway number 5 in Switzerland" and the date can be a a day, a month, week, year, part of day, hour, minute, e.g. "show all the accidents positions during April 2006".

The model of our data base is based on relational model [9]. In figure 1 one can see a small part of the whole schema. The model includes 13 feature classes and each feature class includes features with attributes. For the geometry we follow the standards of Open Geospatial Consortium [10] using their geometrical attributes. Some topological rules have been introduced in the database, e.g. the feature class road has the topological rule "must not self-overlap" or the feature classes intersection has the topological relation "must be covered by" road.

3 System Architecture

Our architecture is based on a framework called LBTrafMan (Location Based Traffic Management). It is divided in two main parts; the client and the server (Fig. 2). This framework runs on a server that is between the client application and a database where the tags will be stored. A tool box is provided on order ease the connections with the database, and to provide some methods allowing geographical operations, like computing the distance between two points on Earth expressed in latitude and longitude.

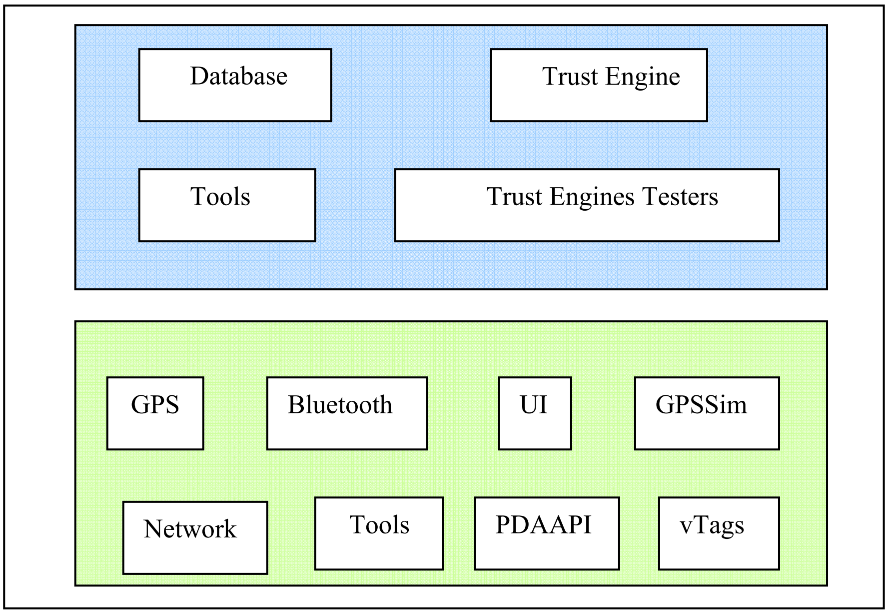

Fig. 2: The LBTrafMan frmework

We will not describe the content of these blocks since it is clearly out of the scope of this paper. We will prefer some global comments of this framework. LBTrafMan provides an API to ease the development of new applications using virtual tags. It provides also some tools, like a GPS simulator, to test the new applications. But the main part is the trust engine. The framework provides of course an API for these engines, but also some tools (like a simulator) that help the user to test them and find the good parameters according to the target application.

Creating a single trust engine that fits all the different applications is a difficult task. One reason is because the way we compute a trust value differs from one situation to another. There are different classes of trust engines. For instance we have situation where changes are unpredictable, like in the FoxyTag scenario [11] where a speed camera can appear or disappear at any time. What if you get an alarm but you do not see any speed camera? You do not know if the former driver was a spammer (and then you need to decrease its trust value) or if the camera simply disappeared. There are also situations where changes are more predictable. In a mountain guides scenario, where guides are tagging dangers, refugee, or other thinks, if someone warns about a danger of avalanches, the user can easily put a deadline to his tag. That means the user that attends the same place six month later is not disturbed by an outdated tag.

We can define also lots of trust engines classes. It is clear that we compute the trust differently when the tags are meant to change often than in situation where the tags are meant to be stable. The LBTrafMan framework will provide a generic trust engine that can be easily extended. Updates in the trust table are made according to the behaviors of the users, and each of this update can be redefined and configured via parameters. Roughly speaking, the designer of a new application will have to code "how much a specific behavior in a specific context costs in terms of trust value". He will therefore only have to code behaviors directly related to its application, leaving the framework doing all the job of maintaining and managing the trust information.

3.1 Security in the System

In a secured spatial messaging system, a user can be sure that the message he is reading is really written by the mentioned author, that nobody has modified the content of the original message, and that all other available messages at this place are available. More precisely, a secured spatial messaging system has to respect the "traditional" security services that are:

- Confidentiality. Protection of the information against divulgations.
- Integrity: Protection of the information against modifications.
- Availability: Information is always available.
- Entity authentication: The author can be identified.
- Data origin authentication: Information can be linked to its author.
- Non-repudiation: The author cannot repudiate a message.
- Non-duplication: Protection against copying the information.
- Anonymity: The real-life identity of the users must be preserved.

These security services are well-known [12] and won't be discussed here. There are many implementations that already proved their efficiency. Our aim is to focus on specific security services, the ones that are required for spatial messaging (in addition to the "traditional" ones). These are centered on the pseudonym concept. What we would like is a system in which an author can be identified, but at the same time we would like to prevent any link with his real-life identity. A new user is therefore able to get a pseudonym in an anonymous way, but only one. If the person can obtain an unlimited number of pseudonyms, then the system can be victim of a Sybil attack [13]. The user must also be able to change its pseudonym. Again, this must be done in an anonymous manner and it must be impossible to link a former pseudonym with the new one.

A secured spatial massaging system must therefore respect, in addition to the "traditional" security services, the following "specific" ones:

- A user has only one pseudonym at a time.
- A user must be able to change its pseudonym.
- It is impossible to link a pseudonym to a real-life identity.
- It is impossible to link two pseudonyms of the same real-life identity (an old one with a new one).
- Each pseudonym is unique, it is impossible that two different real-life identities share the same pseudonym. This is even true during time; if a user changes its pseudonym, the old one is locked and can never be used again.

3.2 Trust in the System

The previous section discussed the security aspects of spatial messaging. A reader can be sure that a given message is really posted by its signer and that the content has not been modified since. But even if the reader can be sure about the author's identity, it is useless if they do not know each other. This section discusses how to add trust information on spatial messages so that the reader can evaluate the reliability of a message.

Trust is a very complex concept. Even if it is part of everyday life, different people give also different definitions of what trust is. This observation is even strongly accentuated when we try to explain how to build a trust relation between machines, or between humans and machines. The authors' own point of view of trust can be found in [14]. One reason is that most models are only designed and specialized for peer-to-peer files sharing systems. For example, these models do not take time into account. In spatial messaging time is very important. For example a message indicating a high risk of avalanches posted yesterday has to be taken more seriously than the same message posted six months ago.

Spatial messaging needs a specific trust model that takes time into account, as discussed previously, and that is sufficiently flexible to be adapted to different situations. For example, in our Mt-Blanc mountain guides example, we suppose that the community of users is quite small and that a Web-Of-Trust trust model [15] will be sufficient. If Alice trusts Bob at 0.8 (out of 1), and Bob trusts Charlie at 0.5, then Charlie's rating (in Alice's eyes) will only count for 0.8 * 0.5 = 0.4. This does not mean that Alice's trust in Charlie is only 0.4. It is only the number by which Charlie's rating will be multiplied. This easy formula is sufficient to give more importance to close friends, and of course also more importance to reputable ones.

However this model does not work for large communities, like in one designed for road traffic management. In this case we need to know the global reputation of the author. We could of course provide two different models, but what if the community is middle-sized? Anyway this is not a good solution since we can also have a big community that contains smaller ones, in which the people knows each other. And there is a third trust model, the one that informs about the reliability of the message itself, without taking care of the author's reputation. Even a very reputable author can make a mistake and publish wrong information. Or, even more likely, a message signed by a reputable editor can contain outdated information.

The fourth and last trust model we present here is actually the model that will combine the former ones. His role is to answer the "How to trust the different trust models" question. The three previous models will give us three different trust values, and the forth model's role is to determine, according the current situation, how much weight to give to each value. This model could be used to make automatic decisions.

This is a nice model but it is not very generic. We do not want to design a specific trust engine optimized for a very specific situation. We want a trust engine that is generic and that can be easily applied to any situation.

3.3 Implemented Prototype

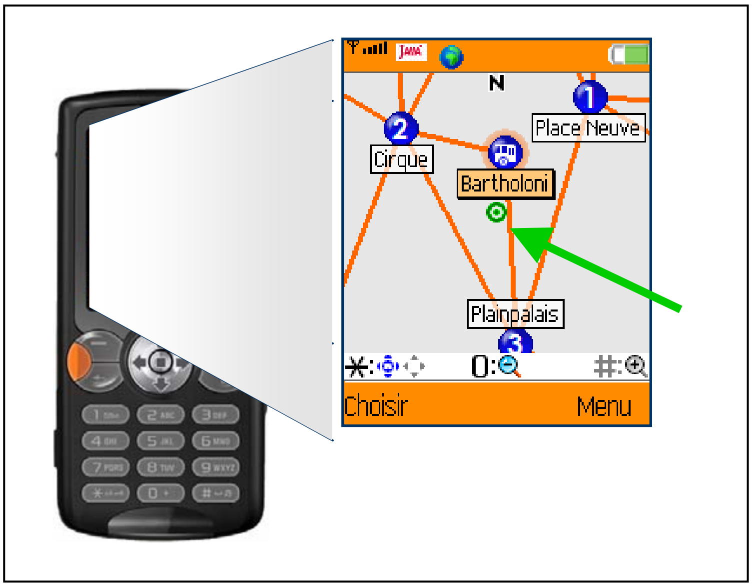

Fig. 3: Visualization of results

We developed an application running on mobile phones that helps the user to find the closest bus stop and prints the timetable with the next departures (Fig. 3). A Bluetooth GPS connected to the mobile phone gives the current position of the user, and the GPRS protocol is used by the mobile in order to connect to the server that hosts the timetables.

The implementation of our system includes spatial queries in SOAP protocol and in XML language and answers can be shown in a display via XML or SOAP also. SQL statements for the database can be possible also and the HTTP protocol can be handled by Java servlets.

4 Conclusions and future work

In this paper we presented an approach adding information of a database to a system for location based services for traffic management. The data are stored in a central database and other data can be imported from local repositories. We try to improve the quality and reliability of our system and offer security in the results using a trust engine. We implemented a scenario using real examples and we used the cell phone display to show the results of the spatial messages. The users can send spatial queries via Internet and get the answers real time.

Currently we work on the implementation of the designed services to improve the results. We would like to use a bigger scenario with real data. From the database perspective we will work more in the database integration and try to use the system in other applications. In order to solve this we must introduce the concept of ontologies with semantics which cover a big variety of different domains. In addition, we will check the model for the trust engine in order to provide a general framework.

References

[1] GSM The GSM Alliance Services Working Group http://www.gsmworld.com
[2] Zipf A., Malaka R., 2001: Developing Location Based Services for Tourism the service providers. In: P. Sheldon, K. Wöber, D. Fesenmaier (Eds.), Information and Communication Technologies in Tourism, Proceedings of ENTER 2001, 8th International Conference. Montreal, Springer Computer Science, Wien, NewYork, pp. 83–92.
[3] Antikainen, H., Rusanen, J., Vartiainen, S., Myllyaho, M., Karvonen, J., Oivo, M., Similä, J. & Laine, K., 2006: Location-based Services as a Tool for Developing Tourism in Marginal Regions. Nordia Geographical Publications, 35: 2, pp. 39-50.
[4] Zipf A., 2002: User Adaptive Maps for Location Based Services (LBS) for Tourism. In Proc. Conference for Information and Communication Technologies in Travel & Tourism (ENTER). Springer-Verlag.
[5] Müller J., 2006. Location based services Indoor Navigation. Presentation. ifgi.uni-muenster.de/~muellerj/lbs06/vortraege/8-IndoorNavigation.ppt
[6] Stamoulakatos, T.S., Sykas E.D., 2003: A network architecture to obtain traffic information for location based service applications. ConTEL, 7th International Conference on Telecommunications, Zagreb, Croatia.
[7] Jensen C.J., Christiensen A.F., Pedersen T. B., Pfoser D., Saltenis S. and Tryfona N., 2001: Location based services – A Database Perspective. In J.T Bjorke and H. Tveite (Eds). Proc. Of 8th Scandinavian Research Conference on Geographical Information Science, pp. 59-68.
[8] Gruber B., Winter S., 2002: Location Based Services using a Database Federation. In: Ruiz, M.; Gould, M.; Ramon, J. (Eds.), 5th AGILE Conference. Universitat de les Illes Balears, Palma, Spain, pp. 243-252.

[9] Codd E.F., 1970: A relational Model of Data for Large Shared Data Banks. In Communications of the ACM 13(6), pp. 377-387
[10] Open Geospatial Consortium, http://www.opengeospatial.org/
[11] Foxytag http://www.foxytag.com
[12] Charton E., 2005: *Hacker's Guide, Edition DeLuxe*. Campus Press.
[13] Douceur J.R., 2002: The sybil attack. In Proc. of the IPTPS02 Workshop, Cambridge, MA USA, March.
[14] Deriaz M., 2006: What is Trust? My Own Point of View. In D. Konstantas (Eds), From Objects to Mobile Systems and Services, Technical report of Advanced Systems Group, Centre Universitaire d' Informatique, University of Geneva.
[15] Zimmerman P., 1994: PGP User's Guide, The MIT Press.