A Provider-Independent, Proactive Service for Location Sensing in Cellular Networks

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Abstract

Using cell information for locating users in cellular networks is a common way to implement location based servers. However, implementations usually rely on infrastructure on the provider's side like special lookup servers. We present a light-weight solution that communicates the cell information to Web services. Our software is event based and therefore well suited for pro-active location based services. While still requiring network specific data, it is provider independent and extensible easily.

1 Introduction

Location is perhaps one of the most obvious context sources for mobile devices and mobile users, respectively. For deriving the location of a user there exists a wide range of location systems with different precision, coverage, technology, and price.

A simple way to determine coarse grained location in cellular networks is by identifying the cell. This paper presents a Web services' based approach for leveraging this cell information. Unlike other approaches, our software is decentralized and independent from the cellular provider. With this we want to lower the entrance barrier for programming location based services, giving more developers the opportunity to create tomorrow's killer application.

2 Related work

The GSM 03.71 Standard [2] defines a way for accessing location information in GSM based networks. The standard requires the network provider to operate a *Mobile Location Center*. This MLC collects cell information from the mobile switching center (MSC) currently responsible for the handset's base station and from the home location register (HLR) that stores subscription data and routing information for each handset. Clients that want to get location data send a request to the MLC. After the MLC has checked the HLR for the client's permission, it queries the handset's MSC for the location. Usually a client must actively query a user's current location, although the standard also specifies *deferred responses* that are sent when the user's location changes.

The MLC has access to the mobile phone operator's infrastructure. It is therefore possible to use more sophisticated location sensing mechanisms to get the location of a handset within a cell. The standard explicitly mentions time of arrival and timing advance based positioning mechanisms to be used by the provider. Zhao [6] gives several more examples of positioning

systems in 3G networks. Next to cell ID based positioning he mentions time difference of arrival based location – possibly extended by intersecting the information from several cells – and the GPS based Assisted GPS.

Implementors of location based services must have a contract with each operator they want to support which might be difficult to obtain and/or expensive with contract prices starting at several thousand Euros.

There is surprisingly little work on retrieving the cell information on a cellular phone directly. The Context project [4] at the University of Helsinki used the cell information to log the usage of a cell phone, along with incoming and outgoing calls and short messages as well as profile changes. Log information was stored on the cell phone itself and anonymously analyzed later. Berkeley's Garage Cinema project [5] uses some of the software from the Context project to automatically annotate photos with context metadata including the cell information.

3 Implementation

Our approach is based on software running on an individual user's cell phone rather than on a central server that may be queried about the location of a user. The software runs on Smartphones based on Nokia's Series 60 or Microsoft's Pocket PC 2003 and monitors the cell information. Once the device enters a new network cell, it publishes the new cell information. For transmission, we chose a low-footprint UDP-based protocol, containing the relevant cell identifiers (mobile country code, mobile network code, location area code and cell-id), the IMEI for identifying the phone and therefore the user, and a checksum. A proxy server in the Internet receives the data and transforms in into a SOAP message containing the very same information. This SOAP message is then broadcasted on the network.

The proxy is transparent to the clients of the location service. A cellular phone could also transmit the SOAP message directly. We chose the proxy-based approach to keep the network usage low. This helps when cooperating with bandwidth intensive application that may be used simultaneously, keeps the cost at the common volume-based tariffs low, and might make our solution more attractive to the cost-senstive end-user market. Specifically, our solution is considerably less expensive than the ones already existing on the German market [1]: about 0.15 € each 100 cell changes instead of 0.20 € for a single location lookup.

3.1 Cell IDs and geographical coordinates

The SOAP message published comes in two different flavours. On the lower level, it just contains the user's identity and the raw cell information. This information already might be used to create services based on cell granularity, for example a pro-active "friend finder" application that notifies its users if other people from their buddy list are in the same cell. However, many advanced services might require the geographical coordinates of a cell. For such services, we extend the basic SOAP message by the WGS84 coordinates of the cell. While our solution is independent from providers, the cell-to-coordinates mapping is of course provider specific as cellular providers are free in how to number their cells. We currently employ two different solutions for this:

- As a general purpose solution, we are using a cell lookup service that subscribes to the basic SOAP messages and looks up the location of a cell from a database. The SOAP message is then augmented by the geographical coordinates and retransmitted. This solution is applicable to any network, but requires manual registration of cells in the database.

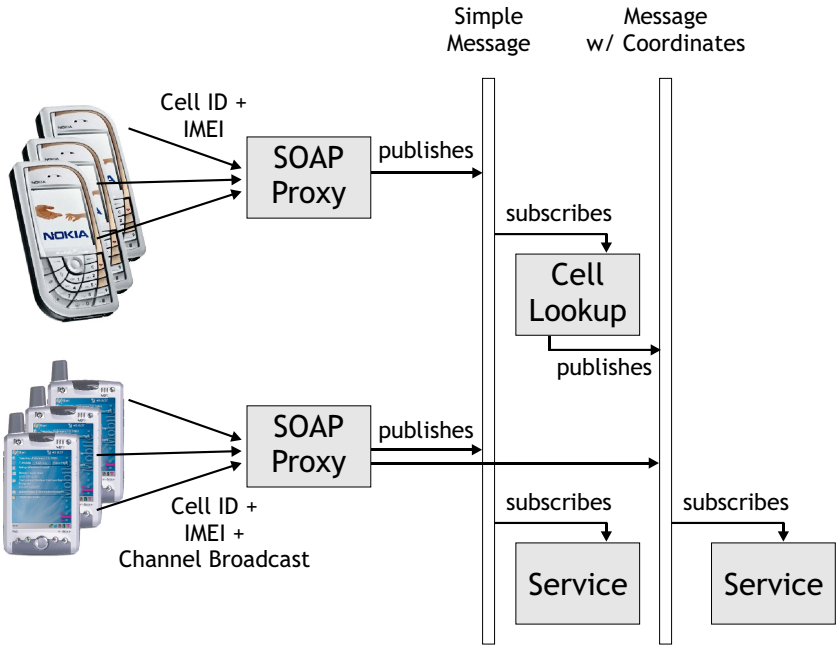

Figure 1: Example setup of the location sensing service with an event based routing transport.

- For the German provider O2 we also support another solution: we use an extended UDP protocol containing a field with the data from cell broadcast channel that contains the Gauss-Krüger-Coordinates of a cell. The proxy automatically converts this into the extended SOAP message.

As the low level cell information still might be of interest for some users, the extended SOAP message contains both the cell identification information and the cell's geographical coordinates.

3.2 Security considerations

Up to the moment our solution does not support any security or privacy. Location messages may be faked easily and location based clients may subscribe to any user's location information. While this eases testing and simulation, it is obvious that a production system must support secure transmissions and privacy.

The publisher of the SOAP message may ensure its integrity by signing it. If the proxy based approach is used, the UDP message might also be signed or symmetric key exchanged between proxy and handset.

Privacy might be ensured by encryption of location data in the SOAP message with a user specific key. Only those location based services trusted by a user would get her key and only those services could then decrypt the location data. The user ID would have to remain unencrypted in order to select the appropriate key for an incoming message. The event mechanism used by the system therefore would still allow the detection of movement of one user.

3.3 Programming location based service clients

Being a transport-independent protocol, SOAP does not specify the protocol used to deliver messages. We are using MundoCore [3], an event routing service that deals with the distribution of the location events transparently from the applications using it. Applications only need to

subscribe to the channel that is used for location message delivery to get an event when a user's cell changes.

As an alternative to MundoCore, applications may use the standard HTTP binding for SOAP-RPC to get information about location changes. Every time an event occurs, a callback function is invoked.

3.4 Sample applications

As a sample application, we built a location aware real-time train schedule. The service keeps track of the cell of a user by subscribing to the location information of a user. It determines the location of the nearest train station and keeps track of the train delays of there. The application may be queried explicitly using a WAP interface whereupon it shows the current timetable. Additionally, the schedule may use the data from the context aware calendar presented in [1] and notify the user when she should leave for a train.

4 Conclusion

We presented a way to implement a low-cost way for location sensing in cellular networks. The location information is based on the cell information that can be read by software on the mobile phone. The software is decentralized and provider-independent. For transmission of the data we chose a combination of a low-footprint UDP based protocol and a SOAP based event notification in order to balance between communication overhead and ease of use in location based client. For mapping the cell information to geographical coordinates we showed two possibilities: Looking up the position of a cell in a database or using provider specific features of the network.

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