SIM BASED LOCATION SERVICES IN GSM NETWORKS

New tracks to the main stream market of Location Based Services

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1.INTRODUCTION

Daily way of life in modern information aged society is more and more driven by services provided by intelligent devices and applications. The "any time any where" service access principle becomes real. In some sense users are looking for two opposite and complementary needs:

- Worldwide generalized access to independent location applications provided for instance via Internet e-commerce,
- Location Based Services (LBS) delivering value-added applications related to Security/Emergency, Information services (ex: looking for a close pizza restaurant), Navigation, Billing, Tracking, Gaming, Mobile office environment and so on…

In terms of business, LBS is much less advanced than "Worldwide Internet Village". We can consider LBS being in the early stage phase.

Today LBS business development is facing several barriers to reach the mainstream market.
In short one can say that there are two main location technologies to address this market in the short term.
First one is GPS, GPS terminals are becoming smaller and cheaper, main GPS limitation is the "Three Satellites Line of Site rule" which is absolutely not a constraint for a cheap selling in the Atlantic ocean but remains a complete non sense for a Paris Quartier Latin walker.

Of course, due to the cellular networks explosion, GSM seems to be the right second candidate to offer technical capability allowing LBS massive application deployment.

Unfortunately, from day one, GSM (CDMA) and even 3G were not designed with location capability in mind.

Based on radio parameters, several techniques can be used to locate a mobile handset.
Beyond the technology, two main questions are driving the LBS business. Number one is the additional money the GSM operator has to invest in the network and number two is the location accuracy required by the application.

SoNear's goal is to allow GSM operator to provide useful attractive Location Based Services in daily customer life. The goal of these micro LBS is to allow GSM operators to increase their ARPU at no extra Capex and Opex network cost.
SoNear's solution is 100% based on the capabilities of the SIM card connected to a regular GSM handset equipment.
One of the Residential oriented LBS application field is to enhance the delivery of **the Right information at the Right time**, for instance, alerting via SMS a kid to do something special as soon as he/she comes home.
For sure, SoNear Micro LBS services address the residential market too. One of the most attractive LBS business is the Automatic Voice call forwarding function from a fixed PABX line to a GSM handset when the user is leaving the office building. Location Based Call Forwarding gives the opportunity to the user to be ALWAYS ON without having the obligation to disclose its GSM phone number to everybody.

We will examine in more details this two key elements, chapter 2 is an overview of most common GSM radio location techniques, chapter 3 is dedicated to the very classical

Client/Server model. Showing the limitation of the Client/Server model, we will look more deeply in Chapter 4 the need to introduce the SIM Based Location (SBL) model.
Some application of the SBL model are described in chapter 5.

2.GSM LOCATION RADIO TECHNIQUES

First of all, the question is to provide location information compliant with the application expectation.

Applications may required completely different Quality of Position (QoP). Of course for security and emergency linked applications in rural area, a 3D precision of ten meters could be required. On the opposite, for Information services a 2 dimensions 500 m precision is acceptable in dense urban area (ex: find a 3 stars hotel in the vicinity).

Depending on the application location precision need, different technologies can be used and location process starts from the simple "Serving Cell Id" up to very complex radio parameters measurements and correlation taking into account Path Loss prediction models (ex: COST 231, Hata-Okumura).

The goal of this paper is not to enter into more derails about GSM location technology bust just to mention that radio location could be based on :

- Received radio signal strength which is the main criteria used by the mobile terminal to select the Serving cell,
- Propagation Time measurement on Time of Arrival (TOA) or Time Difference of Arrival (TDOA)
- Angle of Arrival (AOA),
- Multi-path analysis

All this techniques can be combined to improve the location accuracy.

The bad news is that all these techniques do not work well in a dense urban area where strong multi-path propagation occurs. In such a dense area, it's very difficult to build a mathematical model linking all together distance and either radio path, or propagation time delay, or Angle of Arrival.
It's the reason why a different approach, based on Individual Propagation Analysis (IPA) can be set up.
In short, IPA needs the GSM network to handle a database describing small sub areas called Pixel (ex: 100 squares meters) via Predominant Cell Predictions (PCP) methods. PCP takes into account the fact that a GSM phone is monitoring several cells radio signal strength at the same time (six as a minimum).
Each Data base Pixel entry is described by a list of "regular" signal strength of each serving cell candidate.
When needed , the mobile phone sends to a dedicated server a vector information (VI) including all the cells signal strength measurements (the actual Serving cell and the neighboring cells). The Server searches the best matching Pixel entry, that is to say the one that seems to be the closest to the received vector information (VI). Different mathematical methods, such as the popular smallest squared difference can be used.

Main IPA concern is to build and maintain the Pixel database. Building and updating an IPA database for a GSM network covering a territory of hundreds of thousands square kilometers (Billion of Data base entries)
makes absolutely no sense.

Just to recap, for dense urban areas, and with today's GSM networks technologies (including 3G), the only simple location method is based on both the serving Cell Id and a centralized Client /server model described in figure 1.

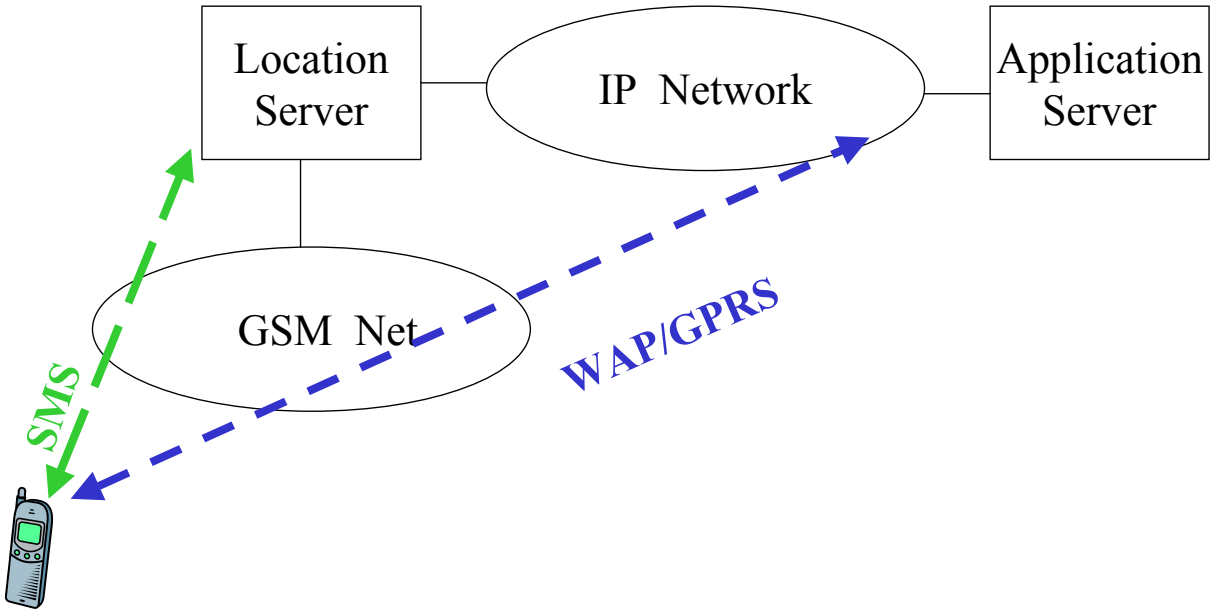
We will examine in more details in chapter 4, SoNear's method allowing a SIM based IPA implementation. SoNear's IPA SIM based approach opens the door to application requiring a much more accurate location detection than the simple Cell Id one.

3.CLIENT / SERVER LBS model

The classical Client/Server model**,** is based on three main subsystems:

- The terminal (GSM handset or PDA) in charge both of the man machine interface and the location process in conjunction with the cellular networks (BTS and dedicated location equipment).
- Radio Location servers managed by the GSM operator.
- Specialized Localization Application Server managed by third party service provider (Map server, Fleet tracking application,…)

Figure 1 describes below the general architecture.



Location Server is under the GSM operator control. Its main role is to identify the mobile GSM location. Location information (ex: Cell Id) can be provided either directly by the GSM radio sub-systems (ex: BTS) or by the handset via SMS. As soon as the GSM location parameters are known, Location server can translate this information into X,Y Coordinates (ex: latitude and longitude of the Serving Cell BTS).

Based on X,Y coordinates, Application Server (managed by a third party Service provider) is able to retrieve and deliver information (ex: hotel address, map of the vicinity,…) to the mobile device using either SMS or WAP/Imode.

There are two main drawbacks with Cell Id Client/ server model, number one is the limitation of the radio Cell Id accuracy and reliability and number two is the complexity of the model.

SoNear's goal is to provide a complementary approach based on the SIM card in order to deliver location services without introducing new network equipment neither in the GSM networks nor at the service provider computing center.
This flexible SoNear's approach gives the opportunity to GSM operators to quickly deploy new services and increase their revenues (ARPU) at a marginal extra cost (Capex and Opex)
In addition, SoNear's technology allows a simple implementation of the Individual Propagation Analysis (IPA) method opening the door to services requiring a more accuracy location than the simple cell Id one.

4.SIM BASED LOCATION (SBL) APPROACH

One of the major benefits of SoNear's SBL architecture is to allow introductions of new LBS without requiring any modification in the GSM network such as centralized data base or location server translating Cell id into coordinates (ex: longitude and latitude).

The basis of the SBL model is to put all the intelligent functions into the mobile terminal or even better into the Sim card.
In such an approach, no special location features are required to the GSM network. One of the main SBL approach benefit is to allow implementation of new location services on today already deployed GSM networks.

Doing that, services based on non absolute location definition can be implemented in an easier way. Relative location means that location is well known for a customer independently of its absolute coordinates.

SBL PRINCIPLE

Good Examples are Office and Home places having a very clear meaning for a GSM customer. In daily life he(she) doesn't care about the X,Y coordinates of these locations, important information is to know if he(she) is in the place or he(she) is entering or leaving the place.

SoNear's Location Based Service methods allowseach SIM card to learn (cell Id as a minimum) the Home and Office locations and as soon as the GSM customer is entering or leaving Home or Office place, a dedicated action can take place automatically or be prompted to the users.
Actions could be 1) to send an SMS or 2) to prompt the user to place a phone call to a predefined third party or 3) to automatically forward calls to the Voice mail or a Pabx fixed number.

In SoNear's approach, user location recognition (ex: Home, Office) is under the responsibility of the SIM card. Based on the standard STK (Sim Tool Kit) interface, a SoNear's SIM applet is monitoring the MS location (ex: Cell- id, Neighboring Cells).
A soon as the Applet has recognized a key location change such as exit or entrance, a programmable action is set up.

A LBS SoNear Application is split in three phases:

- Location place definition and learning : It's the user responsibility to start and stop the learning phase (20 minutes for a 1000 square meters building office)
- Actions Definition: SoNear's Applet proposes several actions based on exit or entrance of a place (ex: forward calls home from fixed office phone when a telecommuter is coming back home, send an SMS "I am just leaving the office" to the baby sitter GSM phone when the parent is going back home.)
- Actions: Action can, either be started as soon as location status is reached, or under the user control (ex: user is prompted to send a SMS to the baby sitter when leaving its office).

In order to improve location accuracy, and as mentioned previously, the SIM based approach allows the implementation of an IPA (Individual Propagation Analysis) method without requiring the need of a huge centralized database.
In SoNear's view, PIXEL (as defined in chapter 2) are the individual location main places of a GSM user, for instance, Home, Office, Kid's school.
Saying that, the implementation consequence is based on a decentralized database, in other words each SIM card describes and maintains its PIXELs entries (less than 5 average entries per user). Size of the database is small enough to be stocked on a regular SIM card, no special memory size is required.
Initialization of these individual Entries must be done during the learning phase. During the learning phase of a dedicated place (ex: home) SoNear's SIM software (Java applet) is asking every 30 seconds the mobile terminal to deliver the Radio Signal strength of all monitored cells (serving cell and neighboring cells).
Capturing these informations, SoNear's SIM applet is able to compute at least two key statistical parameters for each monitored cell, the Average value and the Variance.
A location place is a defined with a list of cells and the corresponding statistical variables.

When needed, cell radio strength signal are measured and a direct comparison is done with the Pixel's entries to decide if parameters match a known place. Different mathematical comparisons can be implemented. In most cases the Math method is simple enough to be supported by the SIM Applet, otherwise the SIM applet can ask a Math server to make sophisticated and complicated computation.

In addition, based on the capability of the SIM card (ex: memory size) more sophisticated applications can be Set up.One can imagine an Over The Air server (OTA in GSM parlance) sending information to fulfill SIM files handled by the SIM Applet.

SBL Extended Peer To Peer Services

At this stage, we have envisioned applications involving only a single SIM Applet, in other word only one customer has to subscribe to a value added service. Main benefit of this approach is to facilitate the Operator LBS business take off.
In addition, one extra possibility is to deliver enhanced LBS applications based on SIM applet group.
In other words a group of persons sharing common interest such as parents and children or a business team uses SoNear's SIM Applet to enhance their communication level.
For instance, one (A) wishes a business colleague (B) to contact him as soon as he/she arrives at his office.
Assuming SoNear's Applet is available both on A and B SIM cards, the process is divided into three steps:
Step 1: A invokes SoNear's Application to active the service and SIM A sends an SMS to SIM B
Step 2: SIM B receives the SMS and starts Office location monitoring
Step 3: As soon as SIM B detects (via Cell Id or more sophisticated method) the entrance in the office, SIM B prompts user B (display on the GSM screen) to call colleague A.

5. Examples of Applications

Several criteria can be taken into account to classifiy applications, for instance:

- Business vs Residential,
- Stand Alone vs Group users.

These three examples described below are based on these criteria:

Baby Sitting notification.

Baby Sitting Notification is classified as a residential stand alone application.
In short, this application allows the father/mother to notify the baby sitter via a regular SMS text in two main situations:

- If the parent is still at work after a programmable hour (ex: 5 pm), SoNear applet prompts the mother/father to call or send a predefined SMS alert (Sorry, I am late) to the baby sitter,
- When the parent leaves the office, a SMS is sent to the baby sitter either automatically or under user control (father/mother is prompt via the terminal screen).

Location Based Call Forwarding

Call forwarding is classified as a business stand alone application
This service gives the possibility to automatically forward a business calls from a PABX fixed line to a Mobile terminal when the user is leaving the office building and vice versa.
As an option LB Call forwarding allows business voice calls to be forwarded at home if needed when the user is going back home.

Location based SMS

LBS SMS could be used either in business or residential environment.
LBS SMS is the capability of user A to send a **location dependant visible** text message to user B.
For instance A wishes B to see a text message as soon as B enters his business office, example of message " Please John, pick up Mary and come together to my office".
In a residential situation a mother's message to her sick kid could be " Don't forget the medicine" .

GLOSSARY

AOA : Angle Of Arrival
ARPU : Average revenue per User
BTS : Base Transceiver Station
GPS : Global Positioning system
IPA Individual Propagation Analysis
LBS : Location Based Services
OTA : Over the Air (Server)
PABX Private Automatic Business Exchange
PCP : Predominant Cell Prediction
QoP : Quality of Presence
SBL : Sim Based Location (Model)
SMS : Short Message System
STK : Sim Tool Kit
TDOA : Time Difference Of Arrival
TOA : Time Of ARRIVAL
VI : Vector Information

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