Intelligent Switching Method using Cell-ID/GPS Positioning on Mobile Application

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Abstract*—At present, a large number of current generation mobile phones have GPS (Global Positioning System) built-in. While the GPS satellites are continuously transmitting a radio message containing information, the GPS receiver fitted in mobile phone receives that information and calculates its current position, speed and heading. The three main key functions for applying GPS are Information function, Security function and Telemetric function. People gain many benefits from having access to mobile phone GPS location such as: tracking elderly people or patients who require intensive care in emergency situations, finding the location of other people, sending SMS to the customer about product promotions when they come nearby the shops and etc. However, GPSs still have limitation on signal transmission in some areas, such as inside the building (Chen & Kotx, 2000), urban or canyons where the satellite links are blocked or the signal is unrealizable. An alternative way to solve the lacking signal problem is by using the existing data from the network to identify which cell site and sector a user is in. Cell-ID based positioning technologies work completely independently from GPS which is not only fast but also support indoor and 3D positioning. In this paper, we present a switching method for signal transmission that mixes between Cell-ID and GPS on Mobile Phone in determining the current position of the mobile phone.

I. Keywords—GPS, Cell-ID, Radio Interface Layout (RIL)

II. Introduction

Location awareness requires obtaining the current location of mobile phone user and having location aware application. The several localization-based systems are proposed into two technologies. The first technology, namely Handset Based technology [1, 2, 3], requires installation of client software on the handset to determine its location. This technique determines the location of the handset by computing its location using cell identification (Cell-ID), signal strengths of home and neighboring cells or the latitude and longitude. If the handset is equipped with a GPS module, the calculated location is then sent from the handset to a location server. The key disadvantage of this technique (from mobile operator's point of view) is the necessity of installing software on the handset. It requires active cooperation of the mobile subscriber as well as software that must be able to handle the different operating systems of the handsets. Typically, smart phones, such as one based on Symbian, Windows Mobile, iPhone / iPhone OS, or Android, would be able to run such software. The second technology, namely Network-based techniques [1, 2, 3, 4], utilizes the service provider's network infrastructure to identify the location of the handset. The advantage of network-based techniques (from mobile operator's point of view) is that they can be implemented non-intrusively, without affecting the handsets. The accuracy of network-based techniques varies; cell identification is the least accurate and triangulation is the most accurate. The accuracy of network-based techniques is closely dependent on the concentration of base station cells; urban environments achieve the highest possible accuracy. One of the key challenges of network-based techniques is the requirement to work closely with the service provider, as it entails the installation of hardware and software within the operator's infrastructure. Often, a legislative framework, such as E911, would need to be in place to compel the cooperation of the service provider as well as to safeguard the privacy of the information. S.H. Chew *(et. Al)* [1] they proposed a service that could be incorporated with personal health monitoring solution as part of the Distributed Diagnosis and Home Healthcare (D2H2) concept. D2H2 is a paradigm shift to resolve current issues in healthcare by transforming the delivery of healthcare from a central, hospital-based system into a patient-centered, distributed and home-based system through integration of appropriate technologies. The incorporation of location tracking capabilities to assist the process of locating mobile patient in the time of emergency is crucial in ensuring that the emergency personnel will be able to estimate the caller's location even if the caller is unable to identify or describe the location. Deblauwe N. *(et. Al)* [5] they proposed a snapshot of free movement areas that were calculated with DCC. Each terminal *ti* is assigned a circular area (called distance job). The center point of the circle is the last reported position, and the radii are chosen in such a way that the mutual distances between a pair of targets can never fall below (above) the proximity distance *dp* (separation distance *ds*) without either one of the two terminals leaving its circle and thus invoking a *PUmsg.* This allows the server to effectively monitor spatial relations without needing to track the terminals continuously.

This paper shows how to provide a switching method for retrieving the location by using GPS Lookup and Cell Tower

Lookup on mobile phone. The remainder of the paper is organized as follows. Sections 2 and 3 describe technical terms that related to our work and a brief description of the involved technologies in order to provide a background for the rest of the paper. Section 4 describes the Implementation that provided the data for the application described above. Finally, section 5 introduces general conclusions about the work.

III. BACKGROUND

This section describes definition terms that related to our solution as following:

A. GPS

GPS stands for Global Positioning System. A special radio receiver measures the distance from user location to satellites that orbit the earth broadcasting radio signals. GPS can pinpoint the position anywhere in the world. According to the government and GPS receiver manufactures, expect user GPS unit to be accurate within 49 feet. [7]

TABLE 1. THE ACCURACY WHICH USER EXPECTS FROM A GPS THESE NUMBERS ARE GUIDELINES; AT TIMES, ACCURACY [7]

Table 1-1	GPS Accuracy	
GPS Mode	Distance in feet	Distance in Meters
GPS without SA	49	15
GPS with DGPS	10-16	3-5
GPS with WAAS	10	3

Clouds, rain, snow, and weather don't reduce the strength of GPS signals enough to reduce accuracy. The only way that weather can weaken signals is when a significant amount of rain or snow accumulates on the GOS receiver antenna or on overhead tree canopy.

Benefit and Limitation of GPS

- GPS high accuracy, but it is the most power-consuming positioning method.
- Current mobile phone batteries last only a few hours when the GPS receiver is turned on

B. Cell-ID

Mobile Phone based station is typically equipped with a number of directional antennas that defined sections of coverage or cells, each of which is assigned a unique cell ID. Cell ID-based location is usually implemented on the network side, and its key advantage is that it works for all phones, as no handset modifications are required. Accuracy depends on the size of the cell, ranging from 150m for microcells in urban cores to 30 km for cells in rural settings. This level of accuracy may be sufficient for some applications, such as weather and traffic reports, but falls short of the requirements for other application such as street navigation and the E911 guidelines, which require that a cell phone handset be localized within 50m 66% [3] of the time. Accuracy can be improved by including in the position calculation the round-trip time (RTT)

Benefit and Limitation of Cell-ID

- Cell-ID offers only very low accuracy but area-wide coverage.
- Very low power consumption.

C. RIL

The Radio Interface Layout (RIL) provides an interface that handles the communication between the CellCore system software and the radio hardware. The RIL provides an abstraction layer that enables to create a single driver that can be implemented on different radios. The RIL abstracts the details of the hardware dependent components of a device to enable OEMs to integrate a variety of modems into their equipment, offering an opportunity for product differentiation. This single driver then allows all of the radios to work under a single set of CellCore components. RIL consists of two modules: the RIL proxy and the RIL driver. The proxy layer is a Windows Embedded CE-based dynamic-link library (DLL) that manages callback notifications and inter-process function calls into the driver layer. CellCore modules use the RIL application programming interface (API) by linking to this proxy DLL.

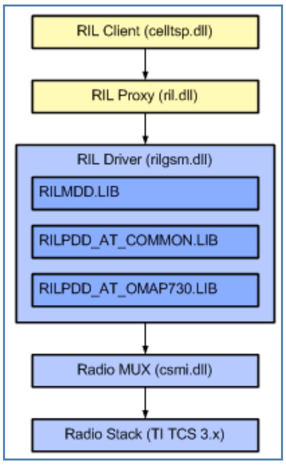

Figure 1. RIL Architecture [2, 11].

When a module first registers with the RIL, it passes in two callback functions. One is used for unsolicited notifications, and the other is used for responses to function calls. For example, when the phone receives a new incoming call, the RIL uses the unsolicited notification callback to notify each module about the incoming call. When a module calls the RIL to get the signal strength, the function call immediately returns a response identifier. The RIL uses the function response callback to convey signal strength information to the module. To ensure that response callbacks are correctly matched with function calls, this callback structure also contains the same response identifier value that is returned by the original function call. This asynchronous architecture simplifies the RIL implementation. If a module needs to call a RIL function in a synchronous manner, it needs to make the function call and block until the module receives the function response callback.

IV. ARCHITECTURAL OVERVIEW

In this section, we describe an architectural overview of our proposed system. The mobile terminals are assumed to possess a GPS receiver (either built-in or externally via a Bluetooth connection) and the capability to determine the ID of the GSM cell they are currently located within. At the terminal, two different positions can be known: a high resolution GPS fix and/or the GSM Cell-ID. By detecting when it is possible to use the low resolution Cell-ID, and when there is the need to switch to GPS, it is possible to minimize the overall positioning cost for the terminal, being expressed here as the amount of consumed battery power.

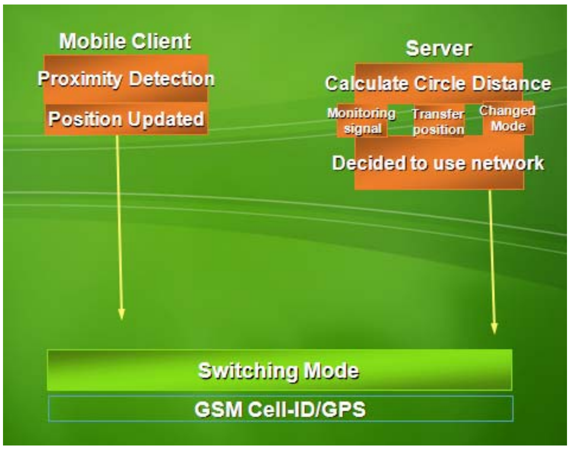

Figure 2: Architectural overview of Switcher method.

A. Server

The server will calculate the circular zones as before. By matching these distance jobs to the cell grid of the GSM network, each of them can be associated with two sets of cells: the safe cells, which are the cells that are fully contained by the circular zone, and the border cells, which are the cells that coincide with the circular zone. There is no need for having the GPS receiver switched on while being in a safe cell, which leads to a first class of energy optimization strategies: when possible, both the calculated distance job and a zone job with the list of the safe cells will be sent to terminal. If available, the terminal as following:

1) Switch on the GPS receiver and start monitoring the less stringent, distance job. The server will only be notified if the circle is left.

2) Switch on the GPS receiver and transmit a positioning message containing the GPS-determined position.

3) Change mode from GPS positioning to Cell-ID network.

B. Mobile Client

On mobile phone side, detecting the spatial relation between every pair of terminal detecting the spatial relation between every pair of terminals *ti* and *tj* , the *distance dist(ti, tj)* is [5,6] mapped to one out of two states: proximity, when the two terminals are located nearer to each other than a proximity distance *dp*, or separation, when those two terminals have moved further away from each other again than a separation distance *ds*. And if the GPS receiver is postponed as much as possible, the position will update again.

V. SYSTEM DESIGN AND IMPLEMENTATION

To implement the system, we used Microsoft visual studio.NET 2008 and .NET Compact framework 3.5 which provide many classes for supporting GPS location and open method.

A. GPS Based Classes

We used 3 Classes that provided on .Net Framework 3.5 as GPS class, GpsPosition class and LocationChangedEventArg class for implementation. First, we have to create an instance of type Gps then call the Open method on that object in order to retrieve the location information. Users retrieve location information synchronously or asynchronously. In this case, retrieve continued updates when there is any change in the data that the GPS radio receives. Users have to be aware that the GPS radio, being an additional radio, drains the battery. Therefore, if you no longer have to retrieve location information inside your application, make sure you call the Close method on the Gps object. Omitting to call the Close method keeps the Gps radio fully powered, even if you no longer retrieve location information. The following screen shows a simple application that can retrieve GPS-based location information, both synchronously and asynchronously. The location is retrieved after using the synchronous method GetPosition and is retrieved continuously by subscribing to the LocationChanged event as shown on Figure 3: The 3 main classes for support on mixed modes on GSM Cell-ID and GPS network

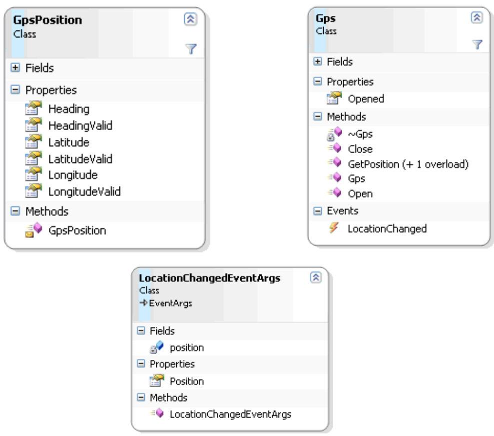

Figure 3. The 3 main classes for support on mixed modes on GSM Cell-ID and GPS network.

Figure 4. The mobile phone retrieved current positioning via GPS.

For retrieving a location asynchronously, user must subscribe to the LocationChanged event, as is shown in Figure 4. When the application is subscribed to this event, continuous location updates are received in the gps_LocationChanged event handler. Identical to the synchronous way of retrieving location information, this information is available in a GpsPosition object. However, asynchronous updates are received on a separate thread, even though this is transparent for users of GPSID. Because it is not allowed to update User Interface controls on other threads than their creator, updating User Interface controls requires some additional work. Controls have to be updated through the Control.Invoke.

Figure 5: Retrieving Location Information through Cell Tower Lookup

From Figure 5, Most Windows Mobile devices are, of course, phones. Depending on the Mobile Operator that is being used; the mobile phone has the capability to retrieve Cell Tower information programmatically. Included in this information are a cell tower code, an area code, and a country code. Given this information, we can retrieve the location of the cell tower on mobile phone it is currently connected to, providing more or less accurate information about current location. The advantage of using Cell Tower Lookup is that the current location can be retrieved very fast without using additional battery power. The disadvantage is the varying accuracy, assuming that we are not using cell tower triangulation. Another disadvantage is that we have to create additional code to retrieve the location. Getting cell tower information can be achieved through the Radio Interface Layer (RIL) on the Windows Mobile device. However, just an identification of a cell tower and country and mobile operator information is not enough. All this information must be converted to a location. We can pass the retrieved cell tower information to a third-party Web service. To retrieve cell tower information inside this application, we must access the Radio Interface Layer (RIL) of the device. The recommendations for OEM RIL implementation suggest disallowing entrusted applications to access RIL functionality. Therefore, we either have to code sign on mobile application with an appropriate certificate or limit to make use of RIL functionality inside mobile application on unlocked devices. To retrieve cell tower information, we basically must call one single RIL function. Additional functions must be called for a handle to RIL and to clean up that handle after we have finished using the RIL functionality as shown on figure 6.

Figure 6: Retrieved information on Cell tower with RIL.

Retrieving the location of the cell tower that the mobile phone is connected to, require additional functionality, for example a database or a Web service to look up the Cell-ID with coordinates. There are several commercial and free Web services available to retrieve cell tower location information. This article uses two Web services hosted by Yahoo to obtain latitude/longitude information about a cell tower. Yahoo has a fairly easy-to-use Web service available to retrieve the postal code for a cell tower. Having the postal code of a cell tower, can then pass the postal code to another Yahoo Web service to convert a given postal code into latitude / longitude reading. When we have passed the country code (dwMobileCountryCode), network code (dwMobileNetworkCode), location area code (dwLocationAreaCode) and Cell-ID (dwCellID) that you retrieved from RIL_GetCellTowerInfo, we get a postal code that contains the location of the cell tower. We can pass it to another Yahoo Web service to give a latitude/longitude reading of the cell tower we are currently connected to. In order to use these Web services, we had to sign up and obtain an application ID. We got the application ID by reading the description of the mentioned Web services. The following screen shows the cell tower location through different Web services.

Figure 7: Switcher mode between Cell Tower/ GPS lookup.

If each location provider implements this interface, an application can retrieve location information through ILocationProvider without having to care about the physical way in which location information is retrieved on the device. In Figure 7, two location providers were implemented, one that retrieved location information through Cell Tower Lookup and one that retrieved location information through GPS. Inside an application, location information can now be retrieved in two ways. In the sample application that is provided as part of this article, the user can select either Cell Tower or GPS Lookup. Of course this is also something that can be automated, letting the application start reading Cell Tower information until GPS is available. Retrieving location information on a Windows Mobile device is fairly easy. This article discussed how to retrieve the location by using two different methods:

- Cell Tower Lookup, which is fast, does not consume much battery power, but is not entirely accurate.
- GPS Lookup, which might take some initialization time (sometimes up to minutes), drains additional battery power, but is very accurate.

VI. CONCLUSION

In our proposed system, we implemented a prototype method for switching Cell-ID and GPS on mobile phone by adopting suitable network technologies for current position retrieval. At present, mobile phone market lacks of accurate satisfactory location technique which is economical and easy to deploy. Current technology provides high accuracy, but requires substantial technological and financial investment. In this paper, we proposed an implementation of intelligent switching method using Cell-ID/GPS positioning techniques which is high accuracy and inexpensive in order to assess its accuracy and its suitability for the provisioning of location based services.

Next step, we will evaluate the accuracy of Cell-ID in urban, suburban and highway scenarios (in Thailand) and present the concepts of discovery-accuracy and discovery-noise to estimate the impact of positioning accuracy on the quality of resource discovery services.

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