

# Positioning in Wireless Body Area Network using GSM

Md.Asdaque Hussain and Kyung Sup Kwak  
*Graduate School of IT and Telecommunications, InhaUniversity*  
*253 Yonghyun-Dong Nam-Gu, Incheon 402-751, South Korea*  
*m.asdaque@gmail.com, kskwak@inha.ac.kr*  
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## Abstract

*Wireless Body Area Network(WBAN) is an emerging trend in ubiquitous society and very prolific for Human being, which consists of low power wireless biosensors, seamlessly placed on or implanted in human body in order to provide an adaptable and smart healthcare system. Positioning of a WBAN user in his/her critical condition is an important issue in WBAN. For this purpose we have canvassed different positioning system, checked advantage and disfavor of those system keeping eyes on the environment of WBAN.A patient equipped with WBAN sensors can stuck into any critical condition anywhere so it is important to monitor them continuously. There are different technologies for localization, but their stickiness with certain application does not make them unanimous. In WBAN we need a technology which can serve two way communication as well as positioning of the user. Since GSM technology is dispersed through worldwide with huge infrastructure so this work tries to elaborate that how GSM is better option than others.*

## Keywords

*WBAN, Positioning, GPS, RFID, GPRS, GSM*

## 1. Introduction

WBAN is a wearable technology by human being with the intention of treating them as patient, providing them personnel network around human body, which consists of miniaturized, low power and noninvasive or invasive wireless biosensors, seamlessly placed on or implanted in human body in order to provide an adaptable and smart healthcare system. Each tiny biosensor is capable of processing its own task and communicates with a network coordinator or PDA (Personnel Digital Assistant). The network coordinator sends patient's information to a remote server for diagnosis and prescription. In other word we can say a combination of various sensor nodes to suffice a human body as its shield. The mobility in human nature makes them slippery in terms of their tracking

and positioning. Because if a person equipped with WBAN sensors is untraceable to Telemetry entity, how can it be served from a remote service provider or through telemetry support in any emergency situation?

As a position tracking tool, we do have different kind of technologies, serving us successfully. Like many other applications our application WBAN has also their own requirement, demand and prerequisite. The necessity of fulfilling the requirement of WBAN compelled us to analyze the technologies on the base of their different attributes which can support WBAN in fulfilling its requirement.

Recently 4<sup>th</sup> Feb 2009, Google launched its Mobile Tracking Service as Google latitude. Although it is not fully based on GSM Model but it has capability to locate mobile with three kinds of signals – Wi-Fi, 2G/3G/4G mobile or GPS satellite.

We have divided our discussion in different sections. In *Section 2* there is some related study of positioning, *Section 3* and *4* discusses some limitation of GPS and RFID tracking which really affects the WBAN positioning requirement, and *Section 5* discusses that GSM is somehow most likely to be a better option due to its very anchored advantages and huge infrastructure support. *Section 6* Concludes our work.

## 2. Related Studies

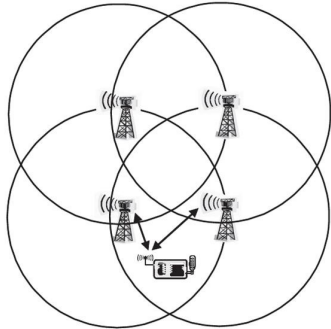
The need for more accurate and pervasive localization technology has been the driving force behind development of location aware applications and systems. The social, mobile and healthcare applications also lean to use these technologies in their favor, due to their precise and vital requirement. Without using these technologies some of the social and healthcare networking will be flawed.

In recent advancement we have an established base of localization technique, but most of them have been designed, keeping eyes on the application's requirement and demand. These location aware applications can be categorized as Indoor localization, outdoor localization and place detection [1]. Falling in the above category some examples are Digital home,

Building Navigation, City wide tourist guidance, Precise soil sampling, enhanced safety of Trains etc.

Active badge is among positioning technique, first designed and build for locating simple portable devices-badges within a building. It uses diffused infrared as transmission medium and it exploits the natural limitation of infrared waves by walls as a delimiter for its location granularity. At the same time all the other disadvantages of using infrared as medium remains there [2]. An RF based user location system known as RADAR also geared towards computation of position estimates. It uses scene analysis techniques comparing the received signal characteristics from multiple anchors with pre measured and stored characteristic value [3]. Similar to RADAR we have CRICKET which also support indoor localization [4]. Due to stickiness to the Indoor specific nature above technique dose not suits our application

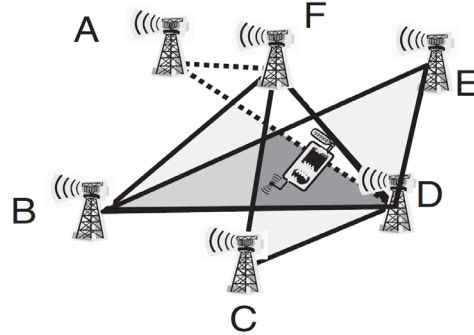
Some of the work remains completely Outdoor specific. Using Overlapping connectivity theorem BULUSU et al [5] work operates without any numeric range measuring. It uses only the observation of connectivity to a set of anchors to determine a nodes position.



**Figure 1.** Positioning using connectivity information to multiple anchors [5].

In the Figure.1 we see the Anchors periodically transmit their position to node identifying themselves (with their position). As soon as the node receives these anchors announcement, It is able to determine that it is in the intersection of the circles centered at these anchors. Position estimation takes place using the average of the received anchors position. This approach uses overlapping connectivity keeping eyes on range free detection to decide whether a node is inside or outside the coverage of encircled anchors. Positioning with the use of Approximate point in Triangle , we do have a little different concept according to the idea is to decide whether a node is within or outside a triangle formed by any of three anchors [6]. Using this information a node can intersect the triangles and estimates its own position, similar to intersection of circles in overlapping

connectivity. Figure.2 illustrates the idea APIT( Approximate Point in Triangle ) is used efficiently to decide whether a node is in triangle or not. As far as our topology is concerned, it seems to fit into these algorithms.



**Figure 2.** Positioning estimates using overlapping Triangles [8]

Fact is that recently launched technology for this purpose (localization & Positioning ) is utilizing some of the characteristic of the above discussed technology. We know that positioning of a WBAN user is an important issue, which is supposed to be dealt with an immense sophistication, because if a patient equipped with sensors serving medical purpose, is out of reach and slipped into some critical condition then a Telemetry service or Doctor or Remote service provider is of no use at all. And finally contribution of WBAN is doubtful. A WBAN user can be anywhere; it is almost a random thing to predict. He or She may be indoor, outdoor, at school, at office, in subway, in traffic jam or even in any unpredictable location. Practically the most important system serving for positioning and tracking is certainly Global Positioning system (GPS) and RFID. GPS is based on some of the similar ranging and multilateration principles as described above, despite being anchored from satellite, this system was designed to serve marine, land, and aviation system although its application expanded to agriculture, highways, surveying, Mapping Automatic Vehicle Monitoring etc[7]. In spite of its huge following, somewhere it lags behind in serving our purpose. GPS has some limitations which directly or indirectly affects the requirement of WBAN.

### 3. Limitations of GPS

In previous section we discussed some of the popular Localization and Positioning technique. We saw as per our necessities they do not provide an inclusive support to cope up with the localization issue

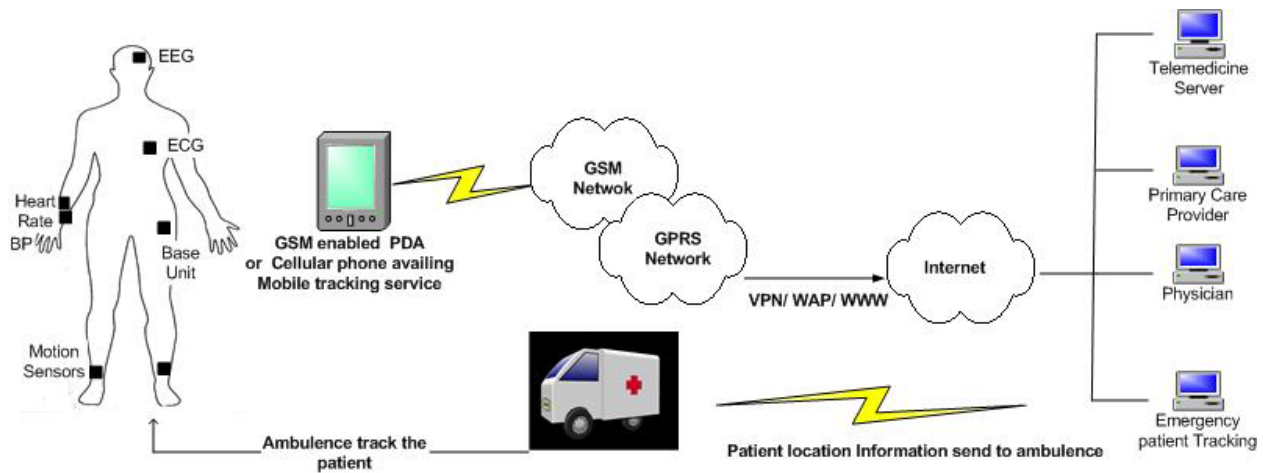


Figure 3. Proposed model for tracking a critical patient

in Wireless Body Area Network. Due to ease and huge coverage, GPS may be preferred for WBAN, but it also has some limitations to discuss.

**GPS Signal Reception-** Undistributed signal reception from four of the twenty four (at minimum) satellites are necessary for proper functioning of a GPS receiver. The transmitted signals from these satellites to the receiver antenna travel along the line of sight. These satellite signals are unable to penetrate Water, Soil, Walls etc. In context of our application when WBAN node is hindered with all these obstacles, GPS doesn't seem a good choice, because in everyday life a person can visit many places, where these obstacles may disturb the efficient access. It is also a matter of fact that GPS satellite visibility suffers in urban areas with skyscrapers. In such areas, the signals can be stymied for extended period of time or even continuous unavailability could occur. Handling these situations requires the forecasting of the situation and that it will not affect communication for long and user should be confident that no inconvenience will occur during this period of signal loss. The other option is, to facilitate user with some optional technology which can heal these problem at the time of signal distortion. [ 9 ]

**GPS signal Integrity-**Position and time computing by the GPS Processor/Receiver is done through range measurement to the GPS satellite, using satellite position derived from information encoded in the transmitted signal. With one measurement to each of four satellites there will usually be a unique receiver position solution. However wrong satellite position or wrong range measurement will result in incorrect calculation of receivers position. If the fault remains

undetected it can turn into a disaster in an urgent state of affairs.[9 ]

**GPS signal accuracy-**There are some common factors which affects the accuracy of GPS [10].

- GPS Technique Employed (i.e Autonomous, WADGPS, DGPS, RTK etc)
- Surrounding conditions (Satellite Visibility, Multipath).
- Number of satellite in view.
- Satellite Geometry (HDOP, GDOP, PDOP etc).
- Distance from reference receiver.
- Ionospheres conditions.
- Quality of GPS receiver.

The points which we discussed as limitations of GPS, in fact they are the question marks over capability of GPS over serving WBAN successfully. So here we are again in an establishing situation against of using GPS for Wireless Body Area Network.

#### 4. RFID Limitations

- **Dead areas and orientation problems -** RFID works similar to the way a cell phone or wireless network does. Just like these technologies, there may be certain areas that have weaker signals or interference. In addition, poor read rates are sometimes a problem when the tag is rotated into an orientation that does not align well with the reader.
- **Security concerns -** Because RFID is not a line of sight technology like bar coding, new security problems could occur. For example, an adversary through hackers could set up a

high gain directional antenna to scan tags of the patient. Could get the control of BAN Coordinator and hurt the user by stopping some of the important functionality of the whole network. So fraud is always a possibility.

- **Ghost tags** - In rare cases, if multiple tags are read at the same time the reader will sometimes read a tag that does not exist.
- **Proximity issues** - Tags cannot be read well when placed on metal or liquid objects or when these objects are between the reader and the tag. Nearly any object that is between the reader and the tag reduces the distance the tag can be read from

## 5. GSM seems most favorable

According to GSM (Global System for Mobile communication) promoters, The GSM Association estimates that 80 percent of global mobile market uses GSM and that is around 3 billion, across 212 countries [12].

The area covered by a GSM network is divided into a number of cells, and each cell is served by its own base station called base transceiver station (BTS). Each cell is distinguished by a unique cell identifier (ID) and is allocated one or more uplink /downlink frequency pairs. More than one BTS may be grouped together under the control of a base station controller (BSC). In turn several BSCs are usually controlled by a mobile service center (MSC) which serves as the interface between the mobile network and the Public switching telephone network (PSTN). In the GSM specification, a mobile telephone is referred to as a Mobile station (MS) at a particular site. A common configuration is to have three collocated BTSs coverage pattern offers some extra information for use by a positioning system[13].

The GSM positioning differs from the GPS locating in many aspects. GSM positioning or locating is simply said the detection of a certain GSM-network user or a certain GSM-hardware in a cellular network. GSM positioning differs generally from the well known GPS locating. GPS always needs a special antenna with a view to sky orientation and a communication to at least 3 (4) GPS satellites. So a mobile installation of a GPS-based locating device is much more complex.

A GSM device can be located well inside vehicles or containers without any visible external antennas, which is not possible for technical reasons with a GPS locating device. Practice has shown that a positioning accuracy down to few meters, as it is

possible by GPS, is not necessary in most applications. We can see in the Figure.4 that none of the technology is accurate enough in all kind of environment. When we we have hybrid out of the best technologies then there is possibility of precise accuracy.

The power consumption of a GSM locating process compared to a GPS position is only about 2-5%. Positioning using GSM technology is well thought-out by many author in their work such as Christopher Drane et al., Alex Varshavsky et al., VVS Naresh et al., Veljo Otsason et al [13][14][15][16] etc. These works includes outdoor as well indoor localization of any GSM enabled device, and their work comprises the logic for positioning with utmost accuracy. Our requirement in context with WBAN also keeps the accuracy on top of its chart.

As Varshavsky et al [14] specify in their work that for emerging location enhanced applications, client based GSM localization can provide an adequate solution both in terms of coverage and accuracy in a device people already carry. According to their preliminary results using GSM it is feasible to achieve 2-5 meters median error and room level localization indoors, 70-200 meters median error outdoors, and to detect people go in their everyday lives. It is well understood that the WiFi had better accuracy as compared to GSM. But due to their high power consumption, current WiFi enabled devices are not frequently used on-the go and, unless a power line is available nearby, are used intermittently [14]. Henderson et al discuss this in their work. Although people do use their WiFi enabled devices in several locations, they tend to power them off before moving to a new place and do not power them on unnecessary [17].

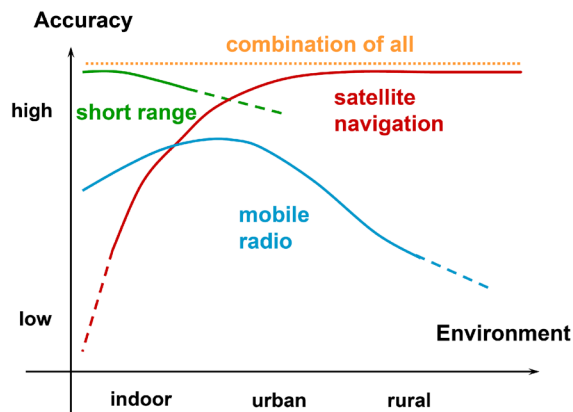
Fortunately, there are devices that people do carry with them most of the time with uninterrupted connectivity e.g. Mobile phones having low power consumption, ubiquitous connectivity, established interface metaphors, wide adoption and almost satisfying result in terms of accuracy.

### 5.1. GSM Advantages

- GSM coverage is all but pervasive, far outreaching the coverage of 802.11 networks.
- The wide acceptance of cellular phones makes them ideal conduits for the delivery of ubiquitous computing applications like WBAN. Localization system based on cellular signals, such as GSM, leverages the

phone's existing hardware and removes the need for additional radio interfaces.

- Since cellular towers are dispersed across the covered and dense areas, a cellular based localization system would still work in situations where a building's electrical infrastructure has failed. Moreover, cellular systems are designed to tolerate power failures.
- GSM, unlike 802.11 networks, operators in a licensed band, and therefore do not suffer from interference from nearby devices transmitting on the same frequency.



**Figure 4.** Comparison of different technology's accuracy.[20]

With the huge infrastructure support and many other advantages GSM seems better choice over others. Figure.3 Proposes a GSM model which explains the two way communication between patient and serving Telemetry system as well as tracking of patient. Using GSM mobile/PDA and a GPRS network the patient data is transferred to the Telemedicine server. They keep examining their patient through processed data. If any worrisome situation occurs they try to interact with patient and if situation is so critical that patient is unable to respond then Positioning through GSM is applied and tracking of patient is done. This urgent tracking is handled by Emergency tracking system. Through Mobile tracking browser (There are many Mobile tracking browser launched in Europe and US) Telemetry generate a query to Service provider and then they respond back with the tracked position of patient utilizing the GSM tracking system.

## 6. Conclusion

Our study focused on Localization and Positioning issue in Wireless Body Area Network.

This is an important concern in WBAN to locate a patient which is in critical condition. We just had some canvassing of different launched technology for this soul purpose. In terms of fulfilling the need of WBAN all these are not much suitable, but unless we don't have better option we have to work with the latest and wait for newest which can satisfy these entire requirements. It seems that for accurate positioning we have to merge all of them (GPS, WiFi, GSM).As per this work GSM seems better than others in fulfilling the requirement of WBAN. Because of the two way communication and positioning we can rely upon single entity. Our further work includes some analysis on hybrid technology of GPS, GSM, and RFID.

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