Localization Through Low Power Techniques

G. Gayatri, Dr. S. Anuradha

Department of ECE, NIT Warangal

Abstract: The increasing use of navigation in day to day life drives the interest to develop more sophisticated mobile applications. Navigation is based on periodic localion update. The update procedure can be achieved in many ways. The selection of optimistic technique is very essential to increase the accuracy, precision, speed of updating, the correctness of the technique in any given situation and in any given place. This paper discusses and evaluates all the possible localization techniques. It also describes what technique to use in a given situation and discusses the pros and cons of using the remaining techniques. Power consumption is also quite challenging in localization. Reducing power consumption attracts wider range of audience. Hence an efficient solution to reduce the power consumption is proposed in this paper. Finally the results of using the low power technique with all the discussed localization techniques is been demonstrated and a real time situation which gets highly benifited using the low power solution along with the best suitable location finding technique is described.

I. Introduction

Navigation and finding Points of Interests(POIs) using location update based applications which is an integral part of any mobile / tablet eco-system. Navigation can only be achieved with the help of localization. There are many ways to get the current location of the device (tablet/ mobile) . The next sections mainly concentrates on GSM, GPS and dead reckoning techniques. As the technology is advancing the size of the battery, the maximum voltage of the battery and inherentely the energy in te battery to support the device are becoming very limited. So power management is very important. The hardware design of the new devices is also done in such a way that the power used by individual components in a device is very less. The only care lies within our scope is to design software algorithms in a way which will use the power efficiently and avoid unnecessarily usage of power.

In this paper, we described a situation which uses the GPS localization technique to automatically notify the user of a Point of Interest(POI) [1] based on user preference when the system (phone or tablet) in a low power mode. The situation assumes that a user is driving his car from Place A to Place B and he would like to be notified of Gas station or restaurants during his journey. One way to do is, the user can check manually his phone or a tablet at every milestone and search for his points of interest. The other way to do is the system can automatically understand his preferences and notifies about the places without user's intervention. This provides a seamless and better user experience with little power consumed and when the system is in idle.

The remaining paper is organized as followings: Section II describes different parameters to be considered to adopt a given localization technique.Section III will brief some localization techniques. Section IV describes how the low power technique. Section V proposes the algorithm for alerting user when the user arrives at his POI along his/her journey. Section VI shows the experimental results and concludes the paper.

II. Parameters in Localization

The cost parameters mainly involved in the localization techniques are described below.

1) **Performance:** This is the most important parameter to be considered in any localization scheme. The accuracy of the algorithm. The error tolerance levels changes according to the application. For example in fleet systems the error tolerance is more so the accuracy can be relaxed. But coming to navigatin in road transport systems the accuracy (as in describing how far the device is from the antenna)is very important.

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So according to the application and the real time parameter analysis the localization technique should be decided.

2) Complexity: Sometimes using a combination of two or more location finding techniques gives better results that increases thr accuracy [2]. But this results in the increase of additional complexity. The combination of the techniques we are combining also determines the complexity. The additional disadvantage is it drains the power also. Hence the evaluation of complexity is must before applying a particular combination. This way of using two or more techniques is used in hybrid systems [3].

3) System Requirements: Some techniques may require extra implementations than what the is available in the existing systems to achieve minimum accuracy. The requirements may be hardware requirements of the network or it can be the software requirements of the handset devices.

III. Localization Techniques

1) GSM-based: In this method, the network and its coverage plays the entire role in determining the current position. The first requirement comes to use this technique is that the handset device must be registered in that particular cell in which the device is present. The information will be stored both in the device and in the network [4]. Now with this existing knowledge of the operators network, the cell identity (cell ID) can be converted to a geographic coordinate. GSM-based localization is accomplished with several benefits:

a) GSM coverage is all pervasive i.e its penetration power over the buildings, roofs etc is more. Its coverage is far outreaching than the coverage we get from of 802.11 networks.
b) This method doesn't require any additional radio interfaces. The existing hardware alone is self-sufficient. The wide coverage and acceptance of cellular handsets/tablets makes them ideal for the delivery of robust computing algorithms.
c) GSM-based localization works best in case of power failures also unlike the Wi-fi networks [5]. This is because the cellular towers are dispersed all across the coverage area [6].
d) The interference suffered from the nearby systems transmitting on the same frequency as in cordless phones, a microwave etc is very negligible. This is reflected to the GSM operation band which is a licensed band unlike other radio networks.

The location specific information can be taken from the database in the network. The accuracy depends on the cell size (pico cell or a macro cell), cell type (sectored or an omni-directional) etc. The main advantage is that even the legacy handsets, roaming subscribers are supported in this method. Accuracy can be improved using a sectored-cell which uses more number of antennas (mostly 3) in the cells, and they provide all the essential sector related information. As the sector number goes increasing, the accuracy of the location also increases. For example assume a three sectored cell, which gives a coverage of 1200 for each sector. The accuracy obtained will be 600. Now consider a six-sectored cell, this gives a coverage of 600 for each sector, the accuracy is 300. Now consider an omnidirectional cell, heres the location of the antenna is the location of the handset. Fig 1 shows the omni-directional cell, 3-sectored cell and a 6-sectored cell. For omni-directional cell, for the handsets A, B and C the location is same. While for 3-sectored cell, the locatin of A is the location of the antenna in sector-3, for B it is sector-1 antenna position. While for C it is sector-2 position. In the similar fashion the location in the 6-directional cell is given according to which sector they fall into and is more accurate.gives same location for positions A, B and C respectively.

The accuracy can be further improved if the data is collected from more than one cell. If the data is collected from multiple cells, the next task is which data should be taken into consideration. For this we can go for taking the data from the cell which gives highest receiving signal strength (RSS).

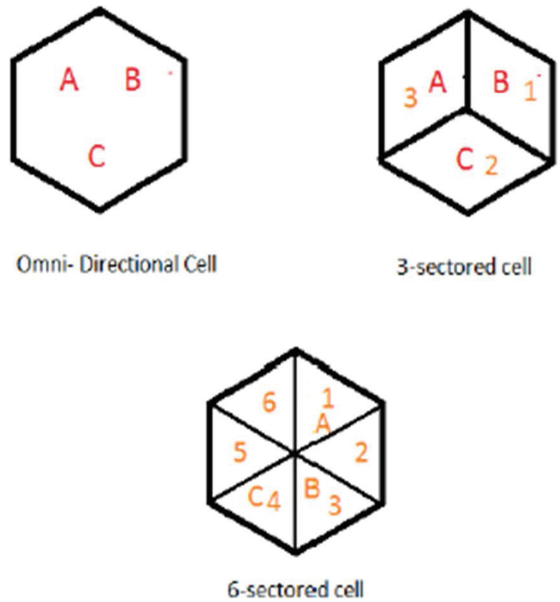

Fig. 1: Localization with omni, three-sectored and six-sectored cells

One more efficient way to do this is to take the weighted average of the RSS of all the data obtained. Equation 1 and equation 2 gives the calculation of the longitude and the latitude information resp, where ’lon’ is the longitude, ’lat’ is the latitude and RSS is the received signal strength.

$$lon = \frac{lon_1 * RSS_1 + lon_2 * RSS_2 + ...lon_n * RSS_n}{lon_1 + lon_2 + ..lon_3} \quad (1)$$

$$lat = \frac{lat_1 * RSS_1 + lat_2 * RSS_2 + ...lat_n * RSS_n}{lat_1 + lat_2 + ..lat_3} \quad (2)$$

2) GPS (Global Positioning System): GPS is a worldwide radio navigation system which constitutes of 24 satellites revolving in different orbits with a speed of 12 hours per orbit. This is a worldwide available navigation system having the highest accuracy. The entire system is designed for localization. Five ground stations monitor the working of a GPS [7]. It basically works on the principle of triangulation. The exact location information can be obtained if the device can be spotted out by a minimum of four satellites. If more satellites readings are taken into consideration the accuracy will improve further [8]. The requirement of four satellites can be understood by referring the table I.

There are many iterative and non-iterative methods to solve the GPS locatin equations which

Table I: Necessity of 4 satellites to find a location

Intersection	Equivalency	Result location
Intersection of exactly two spheres	Formation of a circle	circle
Intersection of exactly three spheres (each intersecting the rest)	intersection of a circle and sphere	two points
Intersection of four spheres	intersection of two points and a sphere	one point

are obtained by the four satellite data. Any timing error in the system will drastically effect the location of the system. So extreme care will be taken inorder to avoid the timing errors.

3) Other Techniques:

a) Dead Reckoning: Given the initial position, the location will be determined according to the speed and direction of propogation.The disadvantage is the error gets propogated with time.
b) Assisted GPS: This system improves the initial performance of the GPS network.
c) Access Points: Relaying on 802.11 radio or 802.11 access points, the laocation identity can be decided [9].

IV. Low Power Techniques

The handset has different modules integrated in it. The modules are specific in their functionality. For exampple Wi-Fi module is used to collect the Wi-Fi related information to the system. GPS module should be exclusively present to get the GPS data. Sound cards used for processing the audio data. Similarly all the other modules also have their dedicated purpose. Not all the modules are required at the same time. So if we want localization alone and we are sure about what localization technique to use, we can use the dedicated module and keep the other devices in low power state. This will certainly help reducing the power consumption [10]. This can be done both in OS level and in BIOS level. To have a good understanding on how a BIOS/OS can control the power consumption, let us see what happens as in the handset is powered ON.

1) The CMOS or a similar device check for the custom settings
2) The device drives, the interrupts handlers will be loaded.
3) The registers and power management gets initialized.
4) The power-on self-test sequence is performed
5) The system settings are displayed
6) The boot strap sequence gets initialized and the OS starts booting

The BIOS which resides in some flash memory, is the first thing that executes and performs all the required functionalites before the OS boots. The BIOS keeping ON running as long as the device is not shutdown. But OS is a big thing which manages all the devices. If there is a possibility to get some other device which uses can run the required module alone, the power consumption decreases many more times. The OS method of power controlling can be done by changing the device states. The device can be in any one of the device power states D0, D1, D2, D3 and D4 [11]. The device states and there functionality can be seen in the table II. To achieve the low power mode of operation, the deive which is in operation

Table II: Device power states

Device Power State	Device Power Condition	Behaviour
D0	Completely ON	Device is fully powered and running, capable of delivering full functionality to the user
D1	Low ON	Device ON with low power, performance less than D0. Can be used when peak performance is not necessary
D2	Standby	Partially powered, wakes up on request
D3	Sleep	Partially powered, Device-initiated wakeup. Less powered up than D3
D4	Completely Off	No power.

to find the location can be kept in D0 states and the rest of the devices can be kept in D4 state. The processor which runs the application will also be active. The remaining devices can be in sleep state. The general architecture of a tablet is shown in fig 2 . The idea is to keep the application which is used for navigation/ localization running on BIOS controller unit. Keep the selected localization module says GPS here in D0 state and put all the remaining devices in D4 state [12]. This considerably reduces the power consumption.

V. Positioning Algorithm for GPS

A scenario which uses GPS to find the location is stated in this section. Using low power algorithm in this scenario, it will show how efficiently the power consumption decreases compared to the native way of operating the devices.

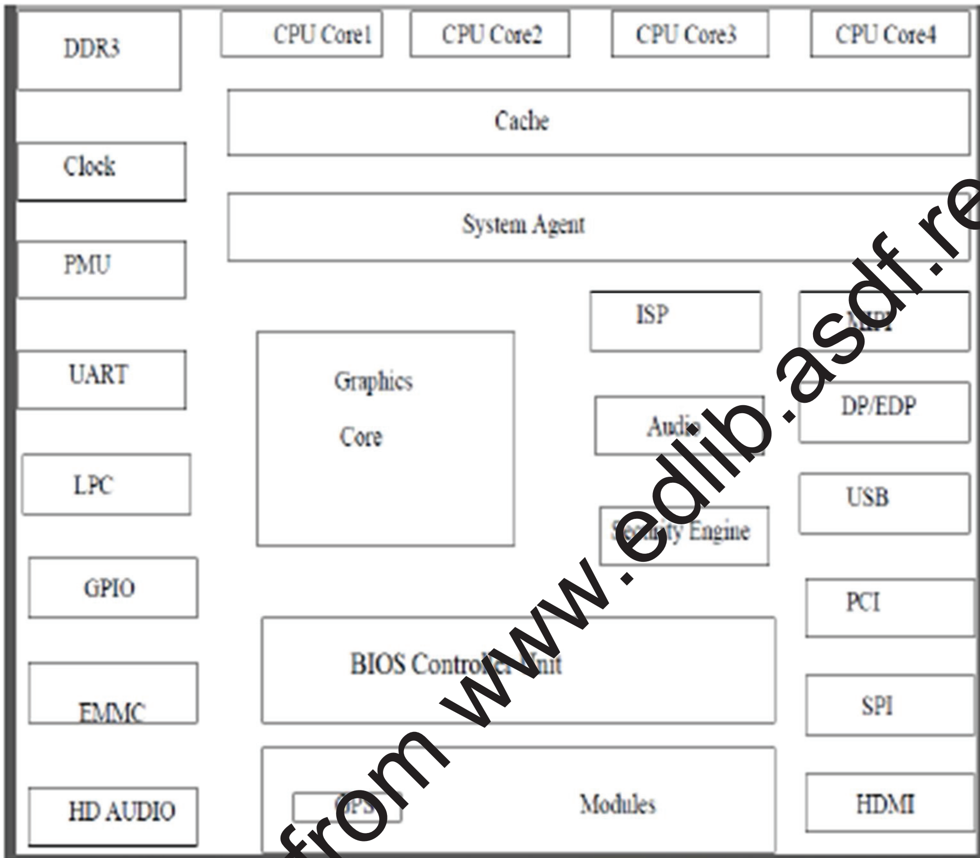

Fig. 2: Generalized architecture of tablet/mobile

A. Scenario

A user is driving his car from Place A to Place B and he would like to be notified of Gas station or restaurants during his journey. One way to do is, the user can check manually his phone or a tablet at every milestone and search for his points of interest. The other way to do is the system can automatically understand his preferences and alerts about the places without user himself tracking. This provides a better and seamless user experience with little power consumed and when the system is in idle. The purpose here is navigation alone so all the other devices shown in fig 2 are put into D4 state. Only the BIOS controller Unit and the GPS unit will be functioning.

B. Algorithm

1) Select the location A and B
2) Spot the route from A to B [13] [14]
3) Divide the entire route into subdivisions. This can be visualized in fig 3.
4) As the user is travelling from A to B, location update happens with GPS, if the coordinates of the current position and the coordinates of the Point of Interest matches, the user should be alerted.

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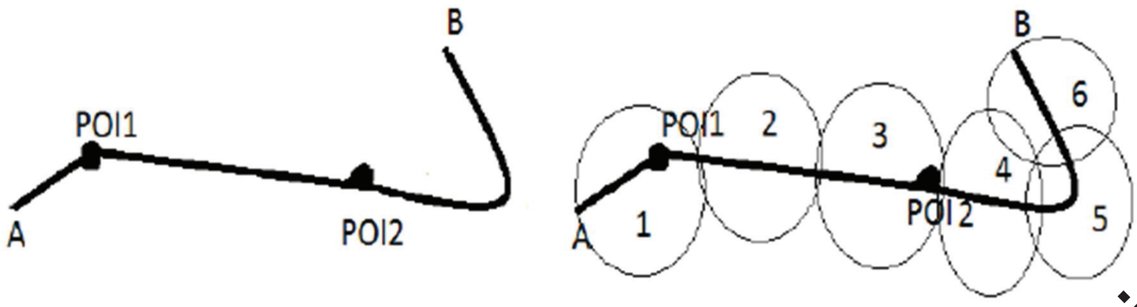

Fig. 3: Routing from A to B

This all happens in the low power state. The responsibilities of user, application and the handset is depicted below.

1) User:

a) The user opens the Location application and selects the points of interests which he would like to be notified, like an alarm.
b) The user selects his starting place and destination place.

2) Application:

a) The application saves user preferences in memory.
b) The application computes the coordinates of the journey and the places he have to navigate.
c) It builds a local database of the places along the journey path.
d) It communicates the journey details, places of interest that needs to be notified, database of points of interest to the sensor hub which is residing in the processor.

3) System:

a) The processor is made of many different modules along with core processor. The processor supports entering low power mode very aggressively by turning off devices and also parking the core microprocessors in a deep sleep mode (C6[the low power CPU state] or higher based on implementation)
b) The operating system will timeout if there are no further actions or if the user presses the power button to turn off the display, and after a certain interval the platform will enter low power state. In this state most of the devices will be in D3 or D4 (turned off),the core (microprocessor) will be in deep sleep state and the platform will be in S0i3 state where the power consumed will be negligible.
c) The PMU (Power management Unit) is responsible for managing of power to internal modules, voltage rails, managing CPU core states and power supply for the overall platform through the PMIC interface.
d) Once all the cores are in C6, and if there is an idle resiliency detected, the PMU is responsible for putting the platform into S0i3 (deep sleep state) based on each devices D3 status. PMU initiates the action to put the platform into a deep sleep state (S0i3).
e) The PMU during transition to the platforms deep sleep state, leaves the following devices in powered on state
   i. System Agent
   ii. PMU
   iii. UART which communicates with GPS [15]
   iv. GPS module
f) Once the system in Low Power state (S0i3), the following actions takes place
   i. Polls the GPS sensor periodically to get the location coordinates

ii. Based on the coordinates, check for points of interest available in the periphery
iii. If any points of interests match
iv. Wakes the system from S0i3 and notifies the application
v. Application alerts the user by displaying the places and plays a sound.
vi. Else the polling continues

VI. Results and Conclusions

The scenario described in section V is shown here. The points of interest observed here is a petrol bunk. The handset here automatically alerts the user when it arrives to the petrol bunk. The points A and B are taken as Bangalore and Chennai. Fig 4 shows the traversing using the low power localization application using the GPS.

All the devices other the which are used for localization are kept in D4 state in this algorithm. This delibrately reduced the power consumption. The GPS navigation is taken here because it is the best

Fig. 4: Point of Interest identification along the route from Bangalore to Chennai

technique for road traffic. Because GPS is available all the way. If any other technique like GSM, if the coverage is missing the localization will not work. The power drain due to GPS will be compensated by the low power technique used.

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