Hybrid Mobile Positioning Managment Framework Based on Radio Communication and Global Positioning Approaches

Hamid Mcheick, Abdelali Goundafi

Abstract — *Mobile devices location systems for remote objects (vehicle, person, commodity, etc.), such as RTLS (Real Time Location System) in general and AVL (Automatic Vehicle Location) particularly for vehicles and persons, are increasingly used today by several enterprises. Indeed, this facilitates the management of personal, products, increases productivity, and so on. These systems use positioning devices such as GPS and communication devices to send remote location data. The first constraint of GPS is that it does not provide a precise position at any time. The extensions of GPS such as WAAS systems and A-GPS, that improve the precision, have also other constraints (availability and cost). The second constraint comes when sending remote location data. Often, the communication devices used for this purpose are GSM modules that send data on the GSM network. The use of GSM network is expensive to send data periodically. To overcome these drawbacks (improve precision and send data with minimum cost), we propose a framework on hybrid mobile devices management system to create a reliable and optimal location system by: i) coupling the radio devices at low integration cost with GPS devices, ii) allowing different mobile objects to cooperate and deliver the positioning data to the remote server[1]*.

Key Words — Location system, positioning management, radio communication.

I. INTRODUCTION

Location systems are becoming increasingly sought today to ensure the location of distant objects [Assad, 2007], to facilitate the management of personal, and their products, increase the productivity, etc. these systems are known as AVL (for vehicle location) and generally the RTLS (for real-time location of several objects). These systems can be divided into two approaches: i) positioning approach by satellites, such as GPS, and ii) positioning approach by WSN (Wireless Sensor Networks) that use networks of wireless sensors. This second approach is divided into two categories: Coarse-grained and Fine-Grained.

Coarse-grained. In this category, we have the RFID (Radio Frequency Identification) that uses short range labels or tags (only a few kilometres). To cover an area of hundred meters in diameter, it is necessary to install tens of RFID readers, or a hundred of readers to cover a small town. This technique allows the location by detecting the proximity of the label vis-à-vis of RFID reader. The precision in this case is lesser as much as the readers coverage is larger [Wilson et al., 2007].

Fine-grained. The systems of this category are more accurate than the previous case. It uses several techniques: i) RSS (Radio Signal Strength) that operates as radar system. The signal strength is increased while the transmitter gets closer [Wilson et al., 2007]. ii) TDoA (Time Difference on Arrival) is a technique even more precise and sends our radio signal at the same time than an ultrasonic wave. By comparing the arrival times of the two waves, it can determine the distance from the transmitter (object to locate) [Bischoff et al., 2006]. As in the first category, the number of antennas used is proportional to the area to cover.

For approaches (GPS and WSN), triangulation using three antennas or at least three satellites, provides a point of geographical position. The method is called APIT (Approximate Point In Triangle) [He et al., 2006].

Unlike WSN, GPS does not require complex and costly ground infrastructure to find its position. It is based on an existing satellite network open to the public, to triangulate its position [GPS, 2010].

A GPS device cannot transmit remote data, since it can only read signals from GPS satellites to interpret. Some GPS devices use a GSM-GPRS embedded module to send the location data. Sending data via the GSM network is reliable given the wide coverage of the global network. Because it is a private network, data sent are charged. The accuracy of GPS positioning can be improved by a correction signal from WAAS satellites reaching WAAS (Wide Augmentation Area System) [WAAS, 2010]. This signal is not always received and still rely on the sensitivity of the GPS antenna and weather. A-GPS is a costly alternative, in case of non availability of WAAS data correction. It allows to contact

[1] This work was supported in part by the CRSNG of Canada (CRSNG).

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ground stations that provides data corrections similar to WAAS via a GSM-GPRS. However, the use of communication via GPRS is expensive.

The following sub-sections summarize the problem and describe possible usage scenarios:

A. System Features

The proposed system must meet the following points:

1. How can we improve the positions identified by the GPS at a lower cost
2. How to centralize data from multiple traceable mobiles objects to create a overview of the system and facilitate its management?
3. How to create a cooperative system between mobile objects of the mobile network?

B. Scenario of use

A person with Alzheimer's may get out of a security perimeter. The tracking localisation system reports this dangerous movement by giving the position of the person using the coordinates X, Y, Z. The system also receives the coordinates of vehicles of different services (police or ambulance) to help that person. This system is able to establish radio communication with the vehicles of health services or police to i) identify those who are closer to our patient, and ii) guide the vehicles to the position of the patient.

A car equipped with this localization system will periodically send its position and speed to our system. In the case of exceeding speed limit, the system notifies the nearest police cars of the incident.

To increase the precision of measurement devices (GPS) (portable or vehicle) in the two previous cases, the system is able to broadcast data correction (A-GPS) to these devices, via a long range radio communication.

C. The Framework on Hybrid Devices Management System (FHMDMS)

We propose a model network (topology and application logic) and its implementation. In this model we use radio (wireless) devices to freely transmit and receive position coordinates and correction data via a long range radio antenna. Indeed, it is firstly a communication model that provides location data relayed from one device to the others till it reaches our main server. Secondly, our model introduces a new way of using correction data which can be used for accuracy improvement and loading it on the remote location devices. Therefore, this model is providing a cooperating communication system which extends the basic routines of a standard communication system to allow collaboration between all nodes of the mobile system. FHMDMS will be detailed in section 3.

Section 2 contains a short description of technologies and systems used in this research. In section 3, we bring the elements of our solution for an optimal system in terms of cost and location accuracy and availability. We give in section 4 an overview of program implementation via a pseudo-code supported with comments. Conclusion and future research will be given at the end of this article.

II. Backgriund

This section describes briefly GPS, WAAS, AGPS, and communication radio systems that are used in this paper.

A. Global Positioning System (GPS)

GPS (Global Positioning System) is a navigation system that has overall mission in comprehensive coverage of the earth. Through a constellation with between 24 and 32 satellites, it can provide information to GPS receivers on their position, speed and time of acquisition of such information [GPS, 2010].

GPS satellites synchronize sending their signals to receivers on the ground, and the distance is calculated based on the moment of the signal arrival. A signal from a remote satellite takes more time to arrive than the signal of closer satellite to the GPS receiver. To localize, a GPS receiver requires three satellites (2D position) and four satellites for a 3D position (this includes the depth). Moreover, more visible GPS satellite there is more accurate is the calculated position. The position accuracy also depends on the receiver; the majority of location systems has an accuracy of 10 meters which varies depending on the design quality (chipset, antenna type, protocol, etc.). Other receivers use DGPS signals (Differential GPS). These signals include data for correcting the position to achieve accuracy levels of less than 5 m.

The stand-alone GPS cannot achieve optimum accuracy (less than 5m) if weather conditions weaken the signal, or obstacles in urban obstruct the view of satellites and cause multiple reflections of waves [Trimble, 2009]. In these cases, GPS needs assistance through WAAS or A-GPS to correct its position and properly handle the signal location.

WAAS. As with DGPS, WAAS is a differential technique and consists of three geostationary satellites and 25 ground stations (WRS: Wide area Reference Stations). It has the ability to bring precision to three meters or less, in horizontal and vertical [WAAS, 2010] [CDGPS, 2010]. The stations collect data on the constellation of GPS satellites and send this information to two master stations (WMS Wide area Master Station, located on the west and east sides). These stations calculate the clock corrections for GPS satellites and the integrity of collected information to the geostationary satellites. However, GPS compatible with WAAS can make the needed corrections. If the accurate information on data integrity is below the threshold tolerated, DGPS is disabled so that the signal is processed only with GPS signal having a greater precision error margin [FAA, 2010].

Assisted-GPS (A-GPS). Unlike GPS, which requires a receiver and an antenna, the A-GPS works in conjunction with a server hosted by A-GPS operator [SAGEM, 2010]. The mobile terminal, equipped with a miniaturized GPS receiver, sends a request to the server through the IP network. The latter, which knows in real time positioning satellites, and serves as dispatcher tells the terminal to monitor the GPS signals. With this method, the mobile terminal A-GPS receiver can, unlike traditional GPS receivers, detect signals of very low amplitude [A-GPS, 2010]. The A-GPS servers can provide correction data that can bring accuracy on some GPS to a few tens of centimetres [GPSBase, 2010] [FAA, 2010]. Often A-GPS data is sent via the cellular network.

Radio Communication. The radio transmission was initially implemented to provide point to point communication over long distances (microwave, satellite connections geostationary) between the fixed networks.

As we are in mobility-oriented environment (e.g. cellular phones), buildings obstruct the view of the antennas by radio equipments that are at ground level in an urban environment.

The mobility principle was introduced to overcome the problem of non-visibility of the radio mobile equipments by the base station transmitter [res_rad, 2000]. The waves will no longer be spreading only in visibility but we take into account the reflective waves on all types of obstacles (buildings, roofs, trees, etc.).

In an urban environment, communication via radio waves is carried by radio signals that are reflected to all buildings along several directions (multipath). The most used waves belong to the UHF frequency band (300MHz-3GHz) to provide mobile communications in urban areas such as wave allows multi-path, crossing barriers with a tolerable loss of signal, depending on the material (loss: 4dB Wood, Concrete 10dB) [COS 99].

To allow a communication radio, we need modems and radio antennas to increase signal gain. There are several types of antennas. Those we are interested in are the omnidirectional antennas (transmitting in all directions) of type:

- *Whip antennas* found in cell phones and allows a gain of 2 dBi, the antenna length is 6.35 to 12.7 cm, an optimum length for integration into small mobile devices carried out by people;

- *The collinear antennas*, are also omnidirectional like the Whip but allows a higher gain (10dBi-4). This type of antennas consists of a stack of multiple antennas, more the number of antennas is, the highest is the gain. Because of the stacking, these antennas are larger than the Whip and will be more suitable for vehicles [Mes799, 2007].

III. Framework on Hybrid Mobile Devices Management System (FHMDMS)

A. Model Description

The RFID or wave radio location systems, cannot compete with the accuracy of GPS. Our FHMDMS uses GPS to identify object location without going through the GSM network to provide location data. The system may use GPS modules that enable to read the correction data (e.g. RINEX). The correction data will be downloaded via a server connected to a correcting land station through an internet connection. An antenna will be used via a radio modem connected to our server and be able to broadcast the correction data over a dozen kilometres (the chosen modem can achieve a transmission radius of 50 km in open field). The geo-localized objects are classified into two categories:

i) The portable devices: cell phones, portable GPS and other portable devices including a small GPS. Given the small size of these devices and to keep the portability aspect, we must couple these devices with small modems RADIO. The disadvantage of the small size results in a low radio range (800m to 2km).

ii) The large objects: such as vehicles, the old merchandise, etc. These objects give us more leeway for the use of big modem and antennas. On a vehicle, we can install a big radio modem and high-sensitivity antenna on the hood. The coverage radius becomes larger and may reach, as in the case of the antenna connected to our server, several tens of kilometres.

The case of large located objects does not make a problem of coverable radius to transmit location coordinates and receive correction data from our server.

The smallest detectable objects are often located far from the antenna of our server. To overcome this problem, we propose a model to allow portable devices to relay messages to our radio antenna. This later is connected to the server via the largest objects that have greater range and in the vicinity of our short-range devices.

In the case where the short range modem is not in the range of the servers antenna for a direct connection or the range of a relay device as explained before; we must ensure that the location data are transmitted by another mean to ensure the real time aspect. By defining a time or timeout radio transmission, we must switch to GSM-GPRS mode.

In fact, our hybrid communication system provides location data relayed from one source device throughout the other relay devices till it reaches our main server. Second, our model introduced a new way of using correction data which can be used for accuracy improvement and to load it on the remote location devices. Therefore, FHMDMS is providing a cooperating communication system which extends the basic routines of a standard communication system (radio system) to allow collaboration between all nodes of the mobile system.

Each device integrates our OSGI based software which chooses the optimal communication canal (see fig 2 for further more details) in order to avoid the costly GSM/GPRS system as much as possible by using free radio communication.

When a device with a low radio coverage is in need of sending its data to our main server, it broadcasts a signal, on a radio canal said number 1, saying “I am in need of a relay to send my data” over the relaying nodes of our devices network. This signal is sent for example each 10 seconds. This period of time allows us to avoid radio network saturation and jamming the other devices radio signal. When a relaying node (a device capable of sending radio signals farther than small radio devices limited in their transmission radius) is in the neighbourhood of a requesting device, it gets its ID included in the relay requesting signal. The first device signal that reaches the relay node is the first to be processed. Then the relay node sends an acknowledgment signal to the device accepted to be served, by including its own ID in the ACK signal. When the small device receives the ACK signal on the radio channel number 2 with the ID of the relay node, it sends a radio signal containing all its positioning data on this second radio channel that should be received by the relay node. When the relay node gets all the positions, it stores them to its memory in order to send them as soon as it gets a direct radio connection to our main server.

To summarize, the solution consists of three modules: GPS, radio and GSM/GPRS for handheld devices. The first handheld devices to send the details via the radio module to our server. If direct connection is not possible, these devices ask the long range radio modules nearby to relay information to the server. When the second method fails, the GSM / GPRS module is requested to send location data to the server. Vehicles can also work together if they are out of range of our server radio antenna. In the opposite way, the server broadcasts the data to correct positions without using long range antenna which is capable of covering a large urban area.

B. System Network Topology

Figure 1 illustrates the network topology of our system.

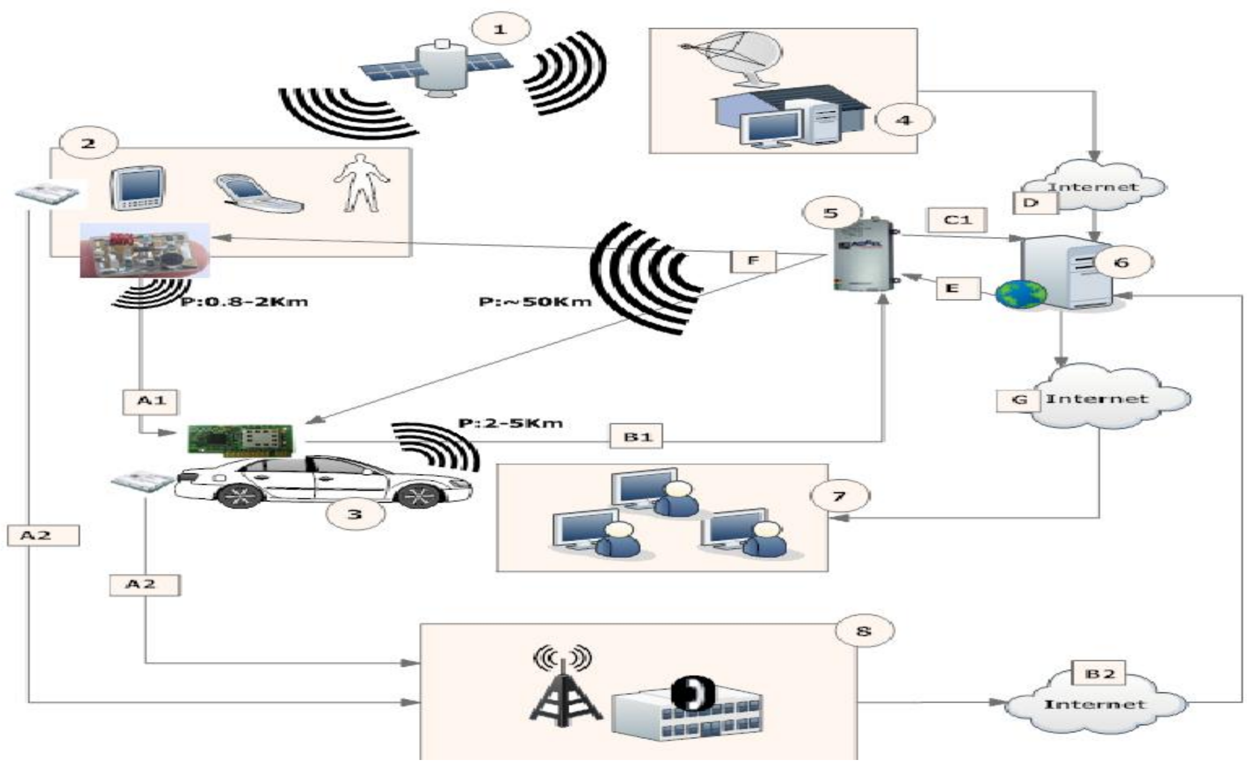

Fig. 1. Network Topology of our system to communicate Radio and GPRS.

This topology is described by the following steps:

i) The GPS satellite sends the signal to three components 2, 3 and 4, which calculate respectively their positions by analyzing the GPS signal.

ii) Set of portable devices that can communicate in radio mode A1 to send their positions to our server 6. In case where the radio fails, the system switches to GSM-GPRS data items A2 that sends data via the Internet (B2) to our server 6.

iii) The vehicles are equipped with larger Radio

Modems with a broader, enabling them to relay location data of Group 2 in B1. Cars can also be equipped with GSM/GPRS module and further to use as portable devices for two (2).

iv) A-GPS station (4) which calculates the positioning error of GPS in its area. These data are downloaded from our server via an Internet connection D. The GPS correction data is broadcasted in F over a wide area throughout a long-range modem at 5. This allows our mobile network equipments (2) and (3) to use the correction positioning data in (4) to adjust their positions.

v) Radio Modem Long Range up to 50 km. It receives location data from our server with a serial connection (USB, RS232, etc..) via E, transforms the data into radio packets and broadcasts to our remote location equipment in 2 and 3 via radio waves F.

vi) Our server collects location data via B1 and B2, formats data and stores them on a database. It can also allow regularly to consult the A-GPS server 4 to download data for correcting the position and spread via the radio modem in 5. It also provides an access interface to an application (GoogleMap), which will display the location data on a terminals (computers, PDAs, etc.) in 7 through an Internet connection G.

vii) A set of users who have access rights to our server 6.

C. Communication System Process and Algorithm

Below is a chart that describes the algorithm of the communication software:

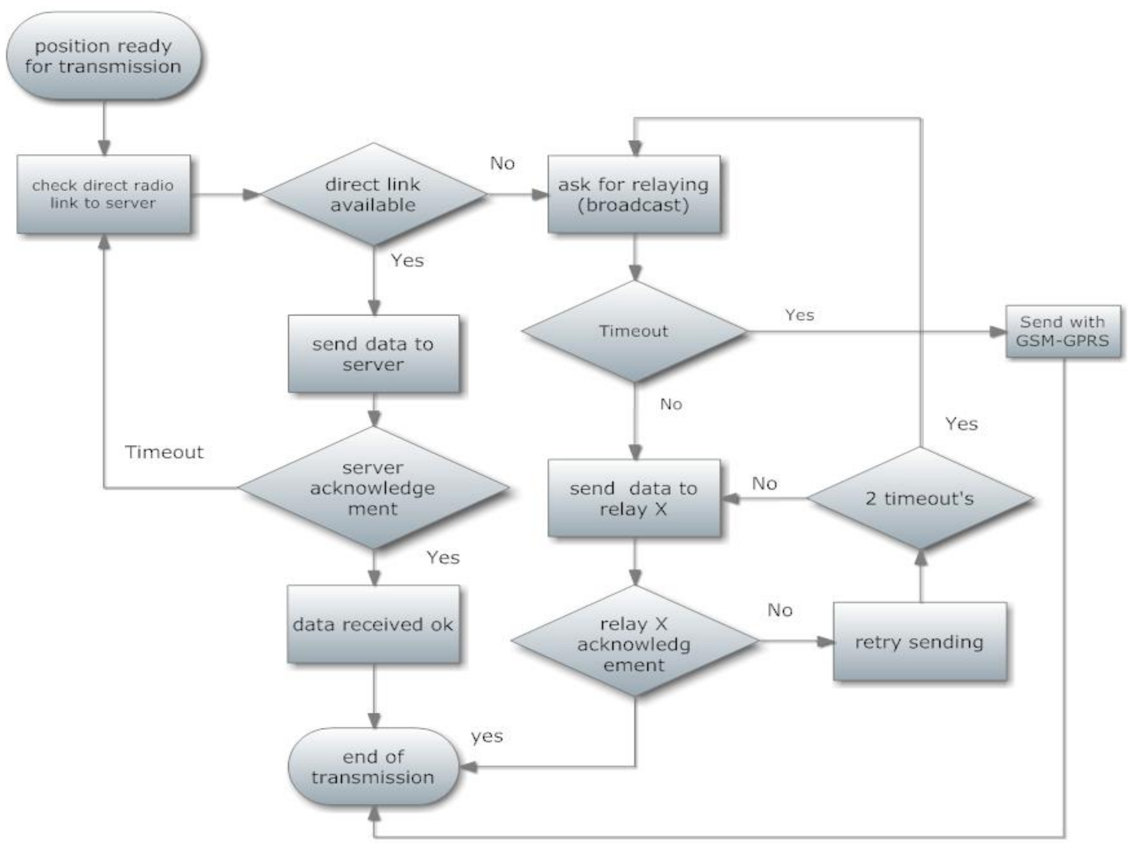

Fig. 2. Communication Algorithm of Hybrid Communication System.

Figure 2 explains extended communication system considering each remote mobile device as a node of our mobile network. This extended communication system allows relaying radio devices with low radio coverage to reach its final destination. It looks like an ad-hoc communication network. However, we use a specific routing algorithm which allows the following:

1) Relay the positioning data of the devices with low radio coverage to the long range available radio device in proximity as vehicles which are able to reach our radio server antenna directly.

2) Lets the long range radio equipment to wait before sending the positioning data to the server when it is out of its range. In this case the data are saved in an internal ROM till the device recovers its lost direct connection with our data server.
3) If the source emitter (low-range radio) or even the intermediate relay (medium to long-range radio) are not able to transmit their awaiting data to our server, our algorithm allows the system to change its communication mode to work with the costly GSM/GPRS in order to transmit the positioning data before it becomes obsolete.
4) To avoid signal jams in the case of simultaneous transmissions our system acts in three steps (a, b and c) as the following :
   a) The mobile radio equipments awaiting to transmit their data to a relay are sending a specific short signal on the first radio channel including its own unique ID every few seconds and waits for an answer from the available and ready relaying equipment in their range.
   b) The radio devices (long-range radio) of our network that acts as relays, stands in a listening mode till they receive the first low range radio devices request signal as those in step (a). This relaying node (long-range radio equipment) gets the first captured request and extracts the senders ID. The relay is now ready to gather the data of the chosen low range device (first come first served) and sends back to it an acknowledgment signal with its own unique relay ID on a second radio channel.
   c) The relay requesting low-range radio device gets the acknowledgement and starts broadcasting its positioning data with the destination relay ID on the second transmission channel.

The standard ad-hoc mode needs an overstocking wireless network cards compared to our small radio modules that allows making more portable and lighter devices.

With our radio mobile system we also do not need managing the IP addresses of each equipment or using a heavy routing protocols.

Our communication algorithm chooses the optimal communication mode available for transmitting data (see figure 2). Our approach gives, to each mobile radio equipment, the opportunity to transmit its positioning data freely using free radio communication channels. In the case where the radio equipment is not able to send its positioning data directly or through a relay to our main server, FHMDMS system calculates a timeout for the radio transmission. Then it switches to the GPRS mode to send the awaiting data for a direct upload to our server. This strategy avoids to the data uploaded to become obsolete by sending it in a reasonable time. This Smart routing system with lightweight communication is not handled by any of the standard wireless communication systems and allows us insure that our data is transmitted under all circumstances switching between costly GPRS and free radio communication.

D.OSGI Based System

In a mobile environment we need to dispatch heterogeneous devices over our network. The application that will equip our devices should be able to run on different platforms. Portability, maintenance and reuse should be kept in mind for the ease of use of the system, expending the system fast, easily and making the future upgrades and developments an easy task for the programmer or system integrators.

The OSGI (Open Services Gateway initiative) offers, by the mean of a middleware and a set of tools, the required environment to allow applications to be constructed from small, reusable and collaborative components. These components can be composed into an application and deployed.

The OSGi technology provides a service-oriented architecture that enables the components, called bundles, of an application to dynamically discover each other for collaboration. The OSGI Alliance has developed many standard component interfaces for common functions like HTTP servers, configuration, logging, security, user administration, XML, etc.

The technology also reduces maintenance costs and saves time because components can be dynamically delivered to devices in the field without any restart.

The following chart describes the architecture of the OSGI framework that acts as a middleware between any java system based and an application deployed as a set of OSGI bundles:

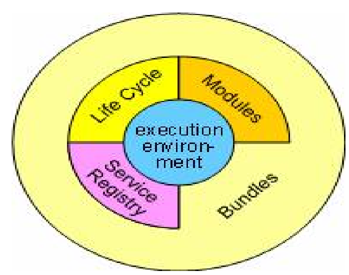

Fig. 3. Layers of the OSGI Framework.

- Layer 0: Execution environment of the Framework that meets the specifications of the Java runtime environment compatible with the configurations and profiles such as Java J2SE, CDC, CLDC, MIDP, etc. The OSGI Framework is able to be deployed on any platform with Java Runtime Environment, from handheld devices such as those used in my model, to larger equipment such as servers.
- Layer 1: Modules layer that defines the class loading

policies. In Java there is a single execution path (classpath) that contains all classes and resources. The OSGI platform adds the "modularization" via the layer "Modules" by adding private classes for each module in order to use separate resources of another module. This layer "modules" can also manage the connections between modules using fully integrated security architecture. This model offers options to deploy closed or protected systems while allowing the developer choosing his own management policies.

- Layer 2: the life cycle of the bundle is handled by this layer. Although this is the modules layer that manages the classes loading in a bundle, the life cycle layer adds functionalities automatically via an API. This API makes it possible to install a bundle via the command INSTALL when providing the access path of the bundle. The function START uses the ID of the chosen installed bundle to run it. Stopping the execution is performed by the STOP function using the bundle ID as a parameter. Uninstalling the bundle can be done with the Uninstall command when providing the access path of the bundle to uninstall. This life cycle layer provides a robust system of dependency management to ensure perfect execution of bundles. The security architecture used makes it virtually impossible to compromise the operations of the life cycle through the attacks of computer viruses.
- Layer 3 (Service registry) : The service registry layer provides a cooperative model that supports dynamic bundles (new services, services that no longer exist). Several events are defined to manage the services becoming available when entering and unregistering the exiting services. The services are simple Java objects that can represent a server (like http), a phone, a Bluetooth device, etc. A security services model enables secure communication between the bundles.

Our OSGI based system that is used in our mobile devices is described in the following chart:

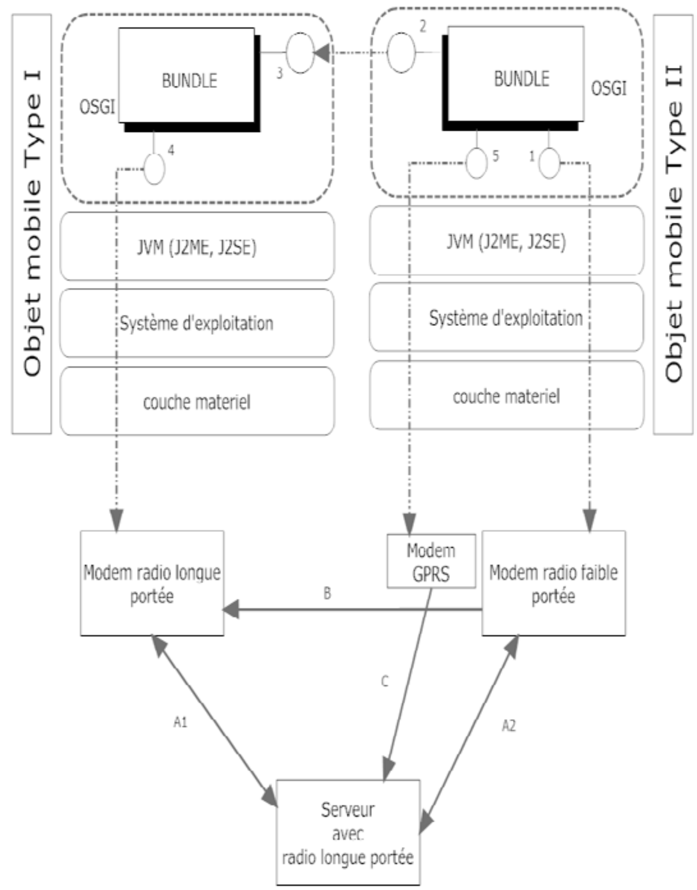

Fig. 4. OSGI oriented application structure for mobile positioning devices.

As we can see in the previous chart, the mobile devices are divided into two categories: type I mobile objects (small handled GPS) and type II mobile objects (bigger positioning devices with higher coverage of transmission that may equip cars). In both types of devices, the same structure is used: The OSGI framework that will run our application bundles, this framework is executed on Java environment to communicate with the hardware (radio transmission modem, GPS chip, etc.) through the operating system of the device. The OSGI environment contains our application bundles and each executed bundle shows its services that can be used by other, internal or external, services (the services are shown as circles connected to their bundle in the figure 4).

E. Cost Study

To illustrate the efficiency of our model (using a hybrid solution of the standard GPRS and a common communication radio system) compared to the classical communication solution systems (using standard GPRS communication system), we have made a cost study on both of them. In fact, the use of the radio communications is free instead of the costly GPRS. Our comparison gives us the following results (see the table 1 below).

The use of the GPRS needs a monthly communication plan, mobile hardware and a server. The cost of this solution is getting higher with the communication plan. The overall cost of this solution on a period of 5 years for 100 units is 416 000 $.

Combining the free radio communication with a smaller GPRS plan in the case that the radio communication falls to transmit data will lead us to a great gain on the overall cost. We need 3 types of devices, Small radio mobiles with short transmission range, medium radio mobiles like the ones we can put in vehicles with medium to long transmission range, and a long range modem with its antenna on the server side to receive the radio data packets. If we consider 100 units during 5 years, this solution costs approximately 122 275 $.

Comparing the two solutions, we concludes that we make a gain of 293 725 $ on our solution compared to the classical GPRS solution because of saving on the costly GPRS communication plan. In other words 2.4 times less than the GPRS exclusively.

TABLE I

COMPARE THE COST OF CLASSICAL SOLUTION GPRS AND RADIO COMMUNICATION

	classical Solution GPRS		Radio modem solution		
GPRS communication cost[2]	65 $ / Month (Rogers)		15$ / Month (of GPRS data in case of a non availability of radio communication)	-	-
Hardware cost per unit[3]	250 $ (GPS+GPRS+A-GPS)	1000 $ (Data server)	Small mobile equipment	Large mobile equipment	Server side equipment
			35 $ (GPS+A-GPS) + 75 $ (MB) + 90 $ (RF 1-2km) + 75 $ (GPRS) = 275 $	35 $ (GPS+ A-GPS) + 75 $ (MB) + 200 $ (RF 10-24 Km) = 310 $	500 $ (RF 40-50 Km) 1 000 $ (Data server) = 1 500 $
Cost based on a period of 5 years	100 units (75 mobile objects + 25 vehicles) ((65*12*5*100)+(250*100)+1000) = 416 000 $		75 units (small mobile objects) ((15*12*5*100)+(35+75+90+75)*75) = 111 525 $	25 units (vehicles) ((35+75+90+75)*25) = 7 750 $	2 units (1 relay + 1 central) ((500*2)+(1000*2))= 3 000 $
Overall cost during 5 years	416 000 $		122 275 $		
Benefit accomplished by using our solution during 5 years	293 725 $ (2.4 times the cost of our system)				

IV. REALIZATION

This section briefly describes in pseudo code the

[2] Cost based on the average cost of GPRS plans according to the main telecommunications companies in Quebec as ROGERS, FIDO and BELL.

[3] Cost according to the GPS and radio devices resellers prices.: www.sparkfun.com, www.semiconductorstore.com, www.data-linc.com, www.electronicdiscountsales.com.

implementation of the communication program (Figure 2). Subsequently, we illustrate the communication with the GPS on a COM port. Finally, some screenshots are given.

A. Pseudo Code of Communication Program

This section specify a set of functions used to establish the communication between mobile devices in FHMDMS.

```
Function send_serv(msg, Id)
Start function
If connexion_serveur_radio.open(port)==true do
```

/* We have the parameters as location message to be transmitted, a random verification key generated by RAND and the Id_serv which is the ID of our server for a shipment sent (Id_serv) */

```
Send_radio( message_localisation, cle_aleat, Id_serv)
```

/* connexion_serveur_radio with "port" which is our local radio port parameter is a function that opens a connection via the radio port. if the connection is established, it returns true, otherwise returns false.*/

```
Timer1=5000; // put the variable to 5 seconds
```

/* Check_Ack function that turns timer1 awaiting acquittal. the server when it receives our message, pay our random key, and ack cle_aleat are compared, if they are equal, then the payment is positive and we conclude that the transmission is complete. The function returns true if matching and false otherwise */

```
If  Check_Ack(cle_aleat, ack, timer1) == true do
connexion_serveur_radio.close(port)
// closure of the radio connection
elseif
```

/* when you do not receive acknowledgment from the server to the end of timer1, there is a new invocation send_serv (msg, Id) and the current is stopped with a return. */

```
send_serv(msg, Id)
return
end elseif
elseif
```

/* if no possible connection to the server, it tries to pass the message to a relay object (vehicle radio device with long range) which will relay it to our server and exit the current function.*/

```
…
send_relais(message, Id)
return

End Elseif
…
End function
```

/* function demande_relais broadcasts via the radio device comprising a message identifier (id) of the issuer needs to relay a message. If a relay receives the signal and is capable of relaying it to the referring customer (id) are a different ID (id2 example). The function demande_relais (customer_id) will return the id received from the runner, if not return null */

```
Function  send_relais(message, Id)
…
Start function

Id_relais=Demande_relais(id_client)
If  id_relais different of null do
Count=0
```

/* the counter Count is initialized to 0 each time we send a message to our purpose relay and the timer function included in the Relayer(message, id_relais, id_client) expire, we make a second attempt in the loop and hang that increment the narrator, until the relay function returns true (success of the operation) or that the narrator reaches 2. In the latter case, we stop running the relay function and we invoking the function GSM shipments, send_GPRS(message, addr_serv) */

```
while count <> 2 do
Relais=Relayer(message, id_relais, id_client)
if  relais ==false do
     Count++
elseif
     break
End if
End while
if  count==2
send_relais(message, Id)
return
End if
elseif
send _GPRS(message, addr_serv)
…
End function
```

/* The connection protocol, encryption and mailing equipment is managed by the GPRS and GSM operator and management of shipments. That leaves just a few lines of code to write on the port where the modem is working and GPRS function GPRS.send(message,CNX) that uses AT commands to send the message */

```
Function send _GPRS(message, addr_serv)
Start function
CNX=modem_GPRS.connect(port)
…
GPRS.send(message,CNX)
…
End function
```

B. Example of AT commands to GPS modem of a phone Nokia [Nokia, 2010]

To send a message between devices using GPRS mode, we can use one of two modes:

i) Mode Text[DevHome, 2010] :

AT+CMGW="+85291234567"

> A simple demo of SMS text messaging.

ii) Mode PDU [GSMPDU, 2010] :

AT+CMGS=23 //Send message, 23 octets (excluding the two initial zeros)
>0011000B916407281553F80000AA0AE8329BFD4697D9EC37

An example is given in the appendix at the end of this paper to illustrate this realization.

C. Running The Tool For Reading The GPS Position (Screenshots)

The tool (program) scans the available communication ports and puts them in a dropdown menu. In our case, COM5 is the GPS port.

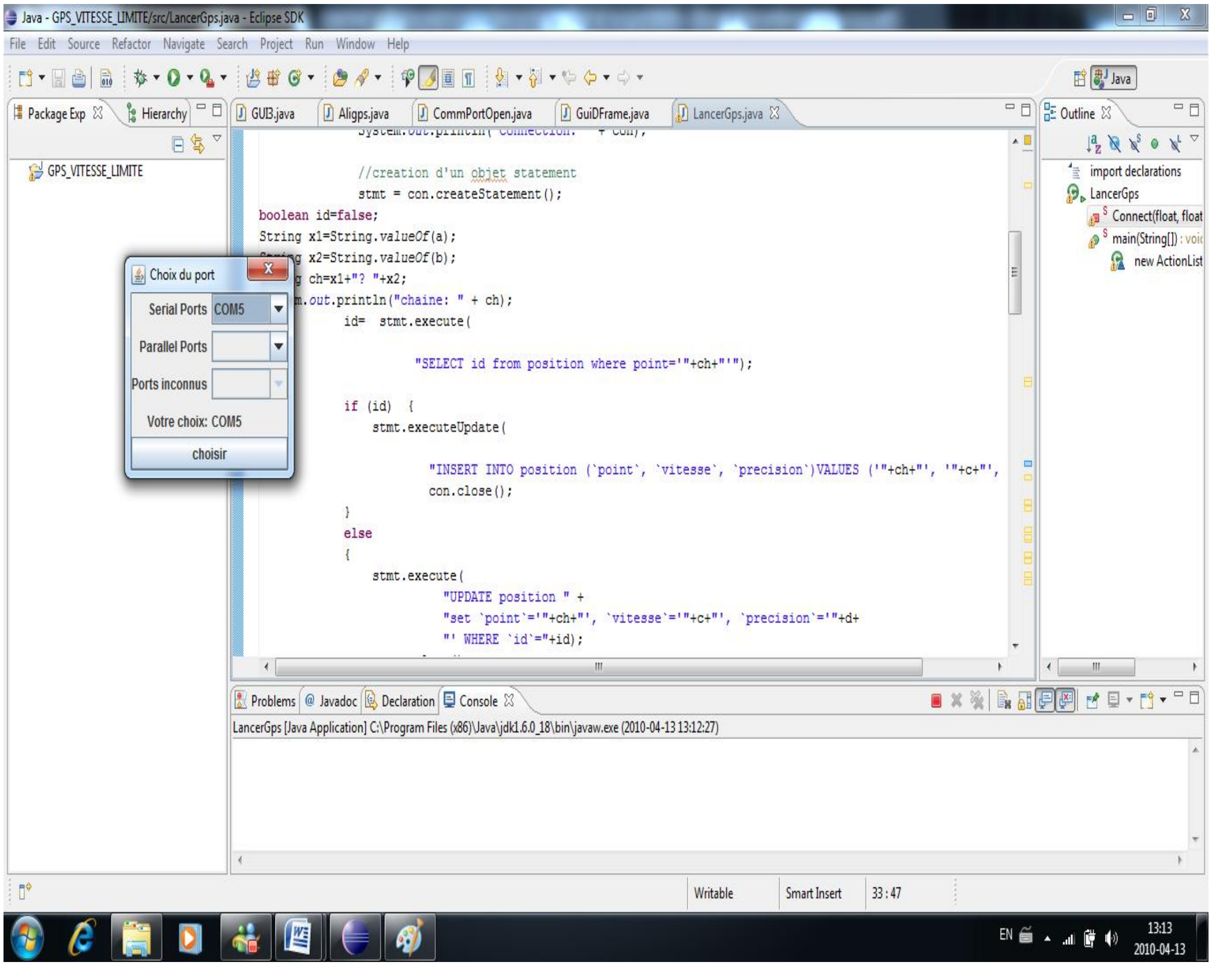

Fig. 5. Running the programme to read the positions on the GPS.

After logging on COM5, our application communicates with the GPS using Trimble TAIP protocol. The information

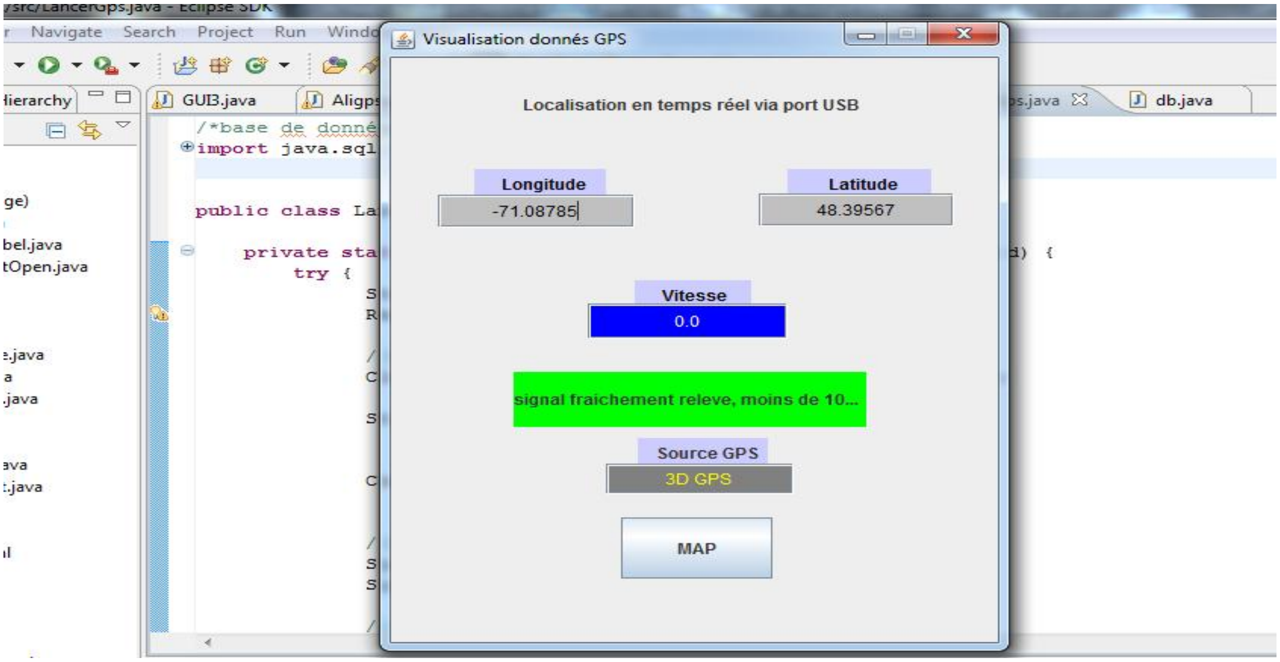

Fig. 6. Locating mobile objects in real time via a USB port.

Web Page generated via Google Map. On the server side, we have a database that contains the positions received from our GPS, a table in our database named field, contains the area (road) as a polygon that is associated with a speed limit. In this case, we have put this part of the street " Rue Rabelais" in a polygon format:

(48.396275? -71.089984,48.395657? -71.085987, 48.395714? -71.085832,48.396157? -71.085674,48.396161? -71.085505,48.395664? -71.085684,48.395523? -71.085969,48.396143? -71.090032,48.396275? -71.089984)

Then, we have limited the speed to 45km / h. The gray points are points that belong to any area in our database and therefore are outside the road. The green point is a point which is located in the rue Rabelais, whose speed is less than the speed limit. The red dots belong to the road but they exceed the speed limit.

Fig. 7. Web Page generated via our PHP pages using GoogleMap API.

V. Conclusion

By comparing the different approaches to localization, we argue that the fine-grained methods can provide very good accuracy. The problem with these methods is that they rely on physical infrastructure rather expensive because it will install multiple sensors to cover a large area. The GPS satellite network offers the opportunity to provide the location without additional hardware with a reasonable accuracy in the range 5-10 meters which can be enhanced with WAAS or A-GPS.

The WAAS system is not available all the time; we have proposed a model where a long range antenna will broadcast the correction signal over a wide area (up to 50KM). Our system allows you to benefit from the increased accuracy of GPS improved by A-GPS. The data download can be done without cost, via radio communications, to our server. The system supports mobility, accuracy and implementation with a lower cost since it uses radio waves to communicate data without recourse to a complex communication infrastructure.

To strengthen the system, we have added communication via cellular networks where the radio communication fails.

To summarize, our system offers the following advantages:

1- Free exchange of data via radio waves.

2- Global vision of different types of objects detectable with better resource management and better coordination of field teams.

3- Moving Objects cooperative. The short-range devices may require long-range devices to relay their messages to the server.

4- Facilitate the process of detection and rapid response (in cases of speeding in cars, medical emergency related to mental or physical health such as heart or for people with Alzheimer's, etc.).

For future research, we suggest i) the use of an encryption algorithm for secure radio data. The algorithm must be light enough not to take a fairly limited bandwidth with the radio systems. ii) Add a device WiMax for long range wireless communication. This technology allows to achieve very high flow rates. Vehicles equipped with this device can centralize a greater number of radio data from several objects at short range. A large amount of data will be transmitted much faster than Wi-Max connectivity classical radio. Wi-Max is natively secured via encryption keys using WEP, WPA and WPA2.

Appendix

This appendix is used in section IV realization.

A. Communication With GPS on a port COM

To allow communication with GPS devices via with specific configuration through a serial COM port, it is necessary to specify each parameter using Java code as the following:

// we import the classes javax.comm that manage the communication

// we create our class to open the communications port

```
public class OuvrePort {
```

/** This is our read buffer from a specific port that we define later in this code */

```
protected BufferedReader is;
```

/** variable contains the message to send to our system */

```
protected PrintStream os;
```

/** Here, we create an ID of the port */

```
CommPortIdentifier PortId;
...
```

/* Chosing physical port COM1 */

```
portId=CommPortIdentifier.getPortIdentifier("COM1");
…
SerialPort port;//create a serial port
```

/* Open our port with the message GPS_Appli and a timeout of 30s */

```
port=(SerialPort)portId.open("GPS_Appli",
TIMEOUTSECONDS);
...
```

/* configuration of a serial port for communication */

```
        try {
        port.setSerialPortParams(BAUD,
        SerialPort.DATABITS_8,
        SerialPort.STOPBITS_1,
        SerialPort.PARITY_NONE);
        }
catch(UnsupportedCommOperationException e)
{}
```

/* to communicate with the device, we use our variables (is and os): */

```
        os = port.getOutputStream();
        is = port.getInputStream();
```

/* we send our command by writing on the port via println */

```
 os.println(msg);
```

/* to retrieve the message from the device we must read through our port variable (is) */

```
is.readLine();
…
```

B. Positions Stored in Databases Via GougleMap

The following PHP code creates the points representing the geo-localization places retrieved from our database which has previously saved the positioning data of different mobile devices. This points are displayed on a browser using the GoogleMap API.

```
<?php
// we create a link to connect to the database
$link = mysql_connect("ServerAddr", "myLogin",
"myPass");
```

...

// pointInPolygon is an imported function that tests if a point is included in an area as a polygon, the polygon can be a road or area of any number of sides. This function is available on many internet sites and does not need to be rewritten.

```
include_once("pointInPolygon.php");
```

/* if the point belongs to a zone and that the velocity of the point exceeds the speed limit of the area, it generates AJAX code using GoogleMap API, and puts the point in red via in the map with the function createMarkerR() */

```
 if(($inclus==1)                                      and
($row1['vitesse']>$row2['limite'])) {
  echo   "var   point   =   new   GLatLng("   .
$coord['x'] . "," . $coord['y'] . ");\n";
  echo   "var   marker   =   createMarkerR(point,
'vitesse:"   .  addslashes($row1['vitesse'])  ."
<br>  Source:".  addslashes($row1['precision'])
.   "   <br>   date:".   addslashes($row1['dat'])
."<br>     _____________________________
<cite><em>Copyright
A.Goundafi</em></cite>');\n";
```

...

// if the point belongs to a zone and that speed does not exceed the speed limit zone, we generate AJAX code that puts a green position point with the function createMarkerV as we did for the red point in the previous function (...)

…

Etc.

ACKNOWLEDGMENT

This work is sponsored by NSERC (Natural Sciences and Engineering Research Council of Canada) and by the University of Quebec at Chicoutimi (Quebec).

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BIOGRAPHIES

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