Escola Politècnica Superior de Castelldefels
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TREBALL DE FI DE CARRERA

TÍTOL DEL TFC: GPS GPRS System for Kids Location

TITULACIÓ: Enginyeria Tècnica de Telecomunicació, especialitat Sistemes de Telecomunicació

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Resum

El treball de fi de carrera que es presenta a continuació té com a propòsit oferir un sistema, que podria ser implementat, per a localització de nens mitjançant un dispositiu que inclou un localitzador GPS i un telèfon mòbil GPRS. Aquest tipus de dispositius actualment es troben en un bon moment de comercialització. En aquest document es mostra la situació actual d'aquest tipus de dispositius: la demanda i l'oferta que s'ofereix actualment en tots els productes que s'han comercialitzat en aquest país. També mostra la situació de la cobertura GPRS en el nostre país ja que aquest dispositiu està pensat, bàsicament, per implementar-se a Espanya.

Tot i que actualment, com s'ha dit abans, ja existeixen dispositius que s'utilitzen per a la localització de nens, les especificacions que es detallen en aquest document són úniques pel sistema plantejat, que és diferent a qualsevol dels sistemes actuals per a localització de nens i que podria ser implementat. Aquest document ofereix totes les especificacions tècniques necessàries per a la implementació d'aquest sistema.

Mitjançant el programa creat per aquest treball es pot obtenir informació sobre la utilitat que pot oferir aquest sistema depenent de l'entorn on es trobi el nen habitualment. Aquest programa, creat en llenguatge JAVA i utilitzant la plataforma Netbeans (detallada a continuació en aquest document), permet crear qualsevol escenari o entorn mostrant la qualitat de la comunicació GPRS en cas de que es pugui donar. Així és com permet veure realment la utilitat d'aquest sistema abans de decidir-se a implementar-lo o no en un entorn determinat.

Finalment, al final d'aquest document, es mostren les dificultats que s'han anat creant durant l'elaboració d'aquest treball de fi de carrera així com la feina que s'ha anat realitzant durant tots aquests messos per tal de crear un sistema que permet localitzar nens i el seu programa de simulació.

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Date: December, 17th 2007

Overview

The final work that is shown below has such as final purpose to offer a system, that could be easlily implemented, for kids location using a GPS locator and a GPRS device cell phone device.

This sort of devices are currently in a good moment to be sold. This document shows the current situation of these devices and the demand and offer of these products (in Spain) It also shows the GPRS coverage map in Spain because this system has been thought, mainly, to be implemented in Spain.

Although currently, as has been said before, these kind of devices already exist, in this document the technical specifications explained are only thought for the system explained in this document and they differ from the other specifications from the other similar products/systems.This document offers the necessary information and specifications to enable the system creation and production.

Using the created program for this final work, we ca obtain information about the utility that this system can offer depending on the kid usual environment. The program, created in JAVA language and using the Netbeans platform (explained below in this document), allows to create any scenario showing the GPRS communication quality whenever the communication can be possible and this is how the program shows the utility of the system for the kid environment.

Finally, in the end of this document, are shown the difficulties that have been appearing during the creation of this final work and the job done every month to create this system that allows to locate kids and its simulation program.

A toda mi familia, a Javi y a mi amigo Dani por las innumerables horas de trabajo juntos, ya que sin ellos no habría sido posible.

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Objectives

This Final Career Work pretends to study, analyze and simulate a particular system for kids location. During the last time this devices have created a lot of expectation on the population probably because of the current kids disappearances (currently probably the most commented cases are Madeleine McCann disappearance in Portugal and Yeremi Vargas in Canarias). These 2 particular cases have created a lot of insecurity on many parents who are looking for some devices to keep their children under control. Some of these devices allow to control the kid on a short control area (like the one developed by a company from Sevilla to keep the children on a 10m radio range) or other systems developed by other companies: chips that are introduced under the kid skin (probably under his/her arm skin) that allow to know anytime where the kid is.

In this work will be studied the features of a particular and commercialized system: GPS+GPRS. The objectives are:

·**Study** the system: understand how it work there will be given a complete description of the system that will allow to understand the main features of the system.

Analyze the system: calculate and characterize its features.

·**Simulate** the system: for different scenarios will be simulated the most important features of the system. The possibility to configurate many and different scenarios allows to decide the effectiveness of the system for each particularly kid environment.

System Features

First of all will be explained the devices we already have offering this service. Although there are many devices which can be used to find somebody by using different systems and protocols in these papers will be studied and simulate a system based on GPS+GPRS (mainly used on kids location). This system needs a GPS device connected to a GPRS one. It is commercialized in just one device that can be barely differentiated with a cell phone. When the kid presses an alarm or emergency button from the cell phone/GSM modem, the GPS satellite finds the kid coordinates (communication 1) and then the cell phone or GSM modem makes a GSM/GPRS connection to the wireless network provider (communication 2). In the following picture, **Fig.1** , is shown how a GPS for kids location system works:

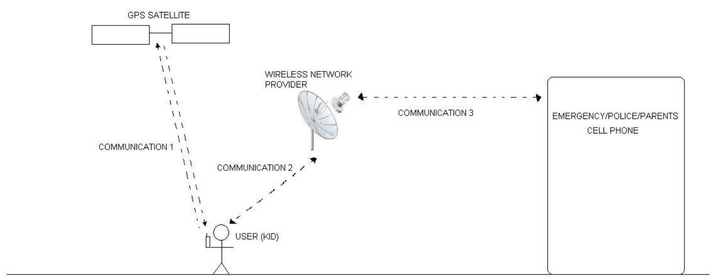


Fig.1 Scheme of a GPS for kids location system

As shown in **¡Error! No se encuentra el origen de la referencia.** there are three communication types to study in this system:

-Communication 1:
The purpose of this communication is to get the position coordinates of the kid. This coordinates are saved inside the cell phone memory.

*Features:
half duplex.
satellite link.

-Communication 2:
The purpose of this communication is to send the data of the kid's position to the wireless network provider (to the antenna). This system needs a wireless service from a GSM/GPRS network provider. In Spain there are (mainly) three different GPRS providers: Telefónica Móviles, Movistar; Vodafone; France Telecom, Orange.

*Features
full duplex
GPRS/GSM link (nowadays, GPRS link)
GPRS uses Internet Protocols (20kbits transm.)

To send this data is necessary to have coverage from the cell phone operator

-Communication 3:
The purpose of this communication is to send the information sent by the kid to the antenna which was providing the cell's phone coverage to an emergency service (police...) or to the parents cell phone.

In these papers will be mainly studied the communication 2 features.

CHAPTER 1. THE GPS GPRS SYSTEM FOR KIDS LOCATION

1.1 Introduction

This chapter pretends to explain how the proposed system works and the system parts. Finally, this chapter will show the current situation of this system and the current costs.

1.2 System functionality

This is a marketed system first thought on 2003. In this system there are two different and separate parts: a GPS locator and a GPRS cell phone.

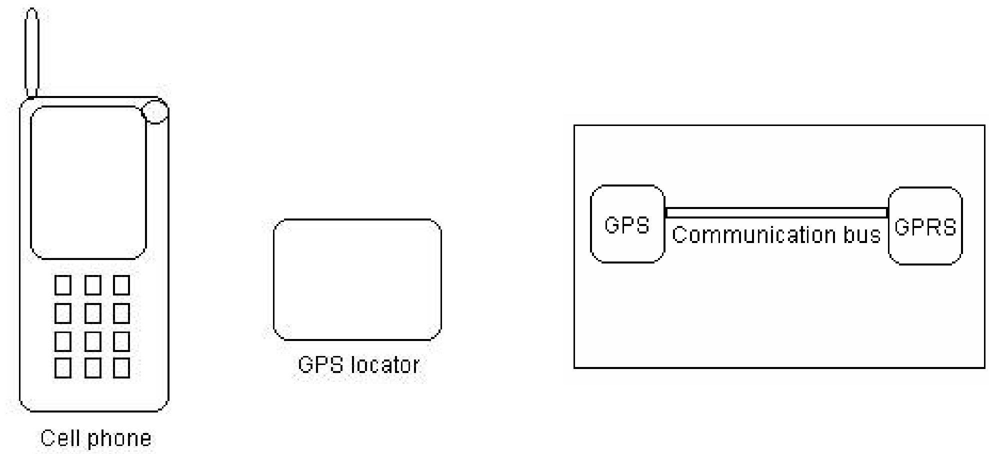


Fig. 1.1 The GPS GPRS system for kids location parts. Both of them are integrated in one cell phone.

In Spain this is a technology, designed by a Spanish company using the system A-GPS (assisted GPS), that allows the kids, ancient, psychiatric patients,…to be found whenever they feel on a dangerous situation (in this final work will just be mentioned the system as a kids locator system). The Spanish astronaut, Pedro Duque, the director of Deimos Imaging and Joaquín González, general director of Deimos Technological Applicatons (DAT), which is a Spanish technology company, presented in Madrid (25th of April of 2007) a system that allows to locate people. The system is marketed in one device: NOKIA E65. Nevertheless, this system can be marketed in many other cell phones.

Fig. 1.2 Nokia E-65. This cell phone contains a GPS locator ‘inside’ of it.

Whenever the kid feels on a dangerous situation can press a button and the GPS locator will find the kid and later starts a GPRS communication sending the data obtained from the GPS locator to a GPRS Base Station (explained in chapter below, chapter 2). So this button makes the process start: the GPS module will start a link with the closest satellite (as has been said before, this final work will consider that anywhere the kid is place he will have GPS coverage); when the GPS gets the coordinates will be packeted (as explained in section 1.4) and sent to the GPRS module. This module will start a communication with the Base Station (explained in chapter 2). After this the data is supposed to be sent to an emergency service and, finally, this one is the one who has to make decisions with the received data. This system does not allow parents to track their kids at any moment, only when the kids feel on a dangerous situation the system will start to work.
This section shows the marketed devices currently in Spain (it is important to say that in other countries this system is being marketed with other cell phones, not only with this model).

1.3 The system current situation

This system requires to pay for an emergency agency. This means that, although the device allows the GPS location and the GPRS connection, an agency must be paid to receive the data sent by the kid, processing it and sending it to the police, parents or whatever. This agency costs are close to 50€/month and the cell phone price (depending on the future GPRS operator) is around 500€.

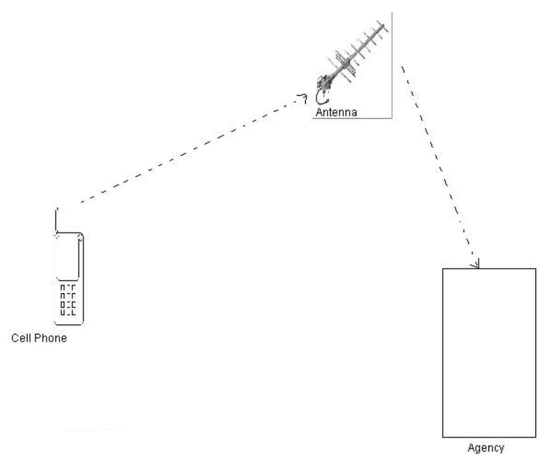


Fig.1.3 The sent data way.

On the one hand it is obvious to think that this system will have a lot of connected parents to it. The current society makes think that this system will be hard marketed the following years, because of this, the most modern applications of the system also allow parents to know everytime where their kids are, adding to this system a tracking software. On the other hand there are many studies that show the dangerous effects of the cell phones on kids (and on adult people but specially on kids). These effects can probably cause the current slow marketing and evolution of this product.

1.4 Technical Specifications of the GPS GPRS for kids location system

1.4.1 Device Specifications

1.4.1.1 The GPS device

The device GPS receiver is provided of 16 channels and this receiver does not suppose a high increment of power consume. All the inputs and outputs are digital and the functionality and code are reprogramables from the base (in case that somebody wants to receive some different data than the standard one). This receivers also have a µC from 16bits and 22MHz. The GPS receiver has a 10m error.

1.4.1.2 The communication Bus features

This device uses the I^2C bus (which is a serial communication bus). Its name comes from Inter-Integrated Circuit. The 1.0 version is from 1992 and the 2.1 from 2000, its designer is Philips. The bus speed is 10Kbits/s on the standard mode, although enables speeds until 3.4 Mbits/s. This bus is commonly used on the industry, mainly to communicate µC with its peripherics on Embedded Systems and generalising more, to communicate integrated circuits between them that normally are on the same circuit. The main characteristic of I^2C is that only uses two wires to communicate the information: on one of them data is travelling and on the other the clock signal that is used to synchronise them. Is also necessary a third wire, but it is just the reference (mass) and on circuits normally they use the same mass, because of this often is not necessary this wire. The wires are called

SDA: Data

SCL: Clock

GND: mass

The devices connected to the I^2C bus have only one direction for each of them. They can be masters or slaves. The master device starts the data transfer and also generates a clock signal, but it is not necessary that the slave is always the same device, this characteristic can be turned by the different devices that have this capacity (in our case, the circuit from the GPS receiver and the one from the GPRS). This feature makes the I^2C be called multimaster.

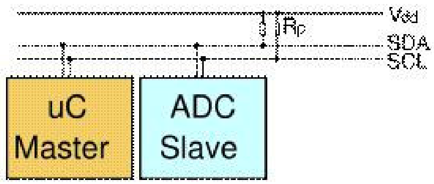


Fig. 1.4 an schematic view of the I^{2}C bus

1.4.1.3 The GPRS device features

On the other hand, the GPRS cell phone uses the standard protocol TCP/IP and in SMS datagrama messages to send on a real time all the required information. This device sends either GPS bursts (position and time) and the bursts generated from the cell phone in order to send a SMS (sensor modules, data terminal...). In section below, section 1.4.1 the GPRS features are explained with more detail.

1.4.1.4 The protocol used on the GPS GPRS transmissions

CAN is a communication protocol developed by the German company Rober Bosch GmbH, based on a topology bus for the message transmission on distributed systems. The CAN communication protocol gives the following profits: is a communication protocol standardised (because of this, simplifies the subsystem communication tasks from different companies on a common network or bus); the host processor gives the communication charge to an intelligent peripheral, so the host processor has a higher time to develop its own tasks. CAN is a protocol oriented to messages. It assigns to them an ID and they are encapsulated on bursts to their transmission. Each message has a unique ID. Nevertheless, CAN was developed for the internal communications inside the cars, because of this, it does not offer always the best solutions when a communication using this bus is being done.

1.4.1.5 Data sent by the GPS receiver

The GPS receiver uses (like any GPS receiver) 4 satellites in order to find out the user's coordinates. Nevertheless, for this application is not necessary to store inside the mobile phone any map because the purpose of this application is not to use the GPS receiver as a way guide. The GPS receiver sends the info got from the satellites (high, latitude and longitude) to the GPRS module. The info is packeted as shown in section 1.4.1.6 (below) and sent using the bus explained before (in section 1.4.1.2) and the protocol explained in 1.4.1.4.

1.4.1.6 Communication between the GPS module and the GPRS device: the packet fields.

As has been explained in this chapter (**Fig. 1.1**) a communication between the GPS device and the GPRS one has to exist in order to convey the data obtained with the GPS module to the GPRS device. Otherwise the information could not be sent. The communication bus that will be used in this case will be the one explained before, in section 1.4.1.2. The GPS receiver generates a packet with the data obtained after the research (see section 1.4.1.5) and the packet generated has the fields shown in the figure below.

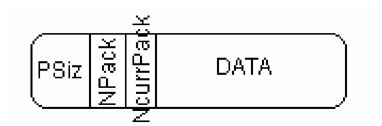


Fig. 1.4 Packet generated by the GPS module.

Where

PSiz is the packet size (in bytes)

Npack is the total number of packets (the ones necessary to convey all the data)

NcurrPack is the number of the current packet (if there are 3 packets and this is the first one this field will have the value ‘1’)

DATA are the coordinates that the module has received and processed. And the maximum size that this field

The communication time spent is considered 0s (because no propagation time will be considered on this communication).

The maximum length of this packets is 1kB and the size of each field is:

-Psiz:2Bytes (the maximum size is 99bytes)
-Npack:2Bytes (because the maximum number of packets is 99)
-NcurrPack:2Bytes (because the maximum number that this field can have is 99)
-DATA:1018Bytes (the rest of the packet can be used for the data)

This size is related to the necessary bytes to represent an hexadecimal numer: The numer 9 in binary is represented by the following chain: “00001001” and the size of this chain is 1Byte. To represent the maximum number of our application, which is 99 are necessary 2 Bytes. This is the reason of the different sizes of the fields of the packet. Only 2 Bytes are necessary to represent the numbers that these fields are representing.

This communication does not have any ACK (and acknowledgment packet) because considers that the possibility of failure is close to 0%.

The info sent by the GPRS receiver to the Base Station uses the following structure:

Example
Scenario:

-The kid presses the button at 19:32h

-Data obtained from the GPS receiver: 6kB (this data is storing info about the high, latitude and longitude; this data is stored on the cell phone memory) 19:34h.

-Data received on the GPRS device: 7kB 19:35h

-Data received on the Base Station: 35kB 19:37h (time necessary to process the info related to the authentication of the kid user).

When the kid presses the button the process starts: the GPS device “switches on” and the GPS starts to receive some info (Communication 1, look **Fig.1** on Introduction). The info is being stored on the cell phone memory. When the GPS has received ALL the info about the kid position starts packing. This process takes 1minute. Then the info is sent to the GPRS module. The elapsed time used on the transmission between the GPS module and the GPRS one is considered 0seconds. When the GPRS module receives the info prepares a SMS to send the info, using the GPRS protocols, to the Base Station (Communication 2, look **Fig.1** on Introduction). It takes 30 seconds. In 1min 30seconds the info is received on the Base Station and the Communication 3 starts (look Fig.1 on Introduction).

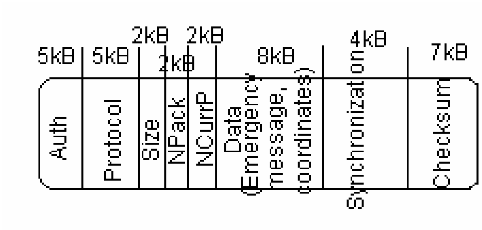


Fig.1.6 packet structure and fields

Where:

Auth: users authentication. This field contains info of the user (like the phone number) and info of what the user is going to send: packets from a message or packets from a call, in order to allow to start the communication if the user has not enough money to spend for one of these things.

Protocol: Protocol and version used. This field contains mainly info about the LLC protocol. LLC defines the logical link control layer protocol to be used for packet data transfer between the MS and serving GPRS support node (SGSN). LLC spans from the MS to the SGSN and is intended for use with both acknowledged and unacknowledged data transfer. The frame formats defined for LLC are based on those defined for LAPD and RLP. However, there are important differences between LLC and other protocols, in particular with regard to frame delimitation methods and transparency mechanisms. These differentces are necessary for independence from the radio path.

All LLC layer are in frames of the following format:

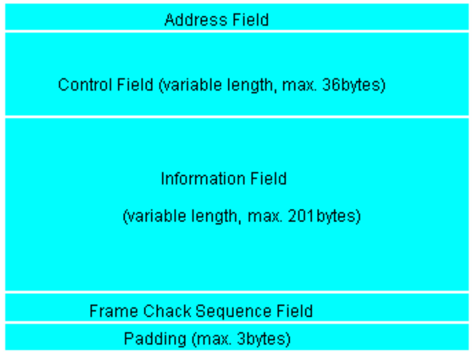


Fig. 1.6 LLC frame format

Size: Packet size.

NPack: Number of packets. This field probably will have always the ‘1’ value because it is considered that in 8kB all the emergency info can be sent (8kB is the size of the info sent).

NCurrP: Number of the current packet. This value will be probably ‘1’ (because of the same reason explained before on the NPack).

Data: Data sent.

Synchronization: necessary info to make the synchronization.

Checksum: Error controls. This field allows the communication to make an error control of the system.

The total packet size is 35kB and the maximum time necessary to make this transfer is 30s so the minimum transfer speed is 1,2kB/s.

With all of this information the message transference is possible.

1.4.2 Short message service in GPRS

This service enables the possibility of sending/receiving short text messages through a cell phone. The maximum length of the messages is 160 characters. This service includes the images and sounds transfers.

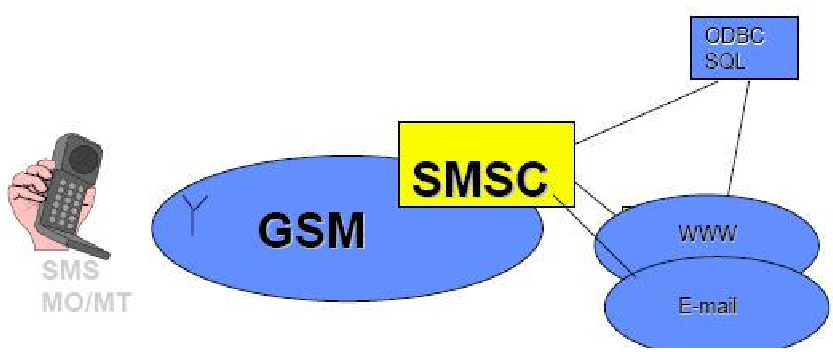


Fig.1.7 service platform.

There are three kinds of bursts:

- Normal bursts
- Specific bursts
  - *Uplink*
    - Frequency correction burst
    - Synchronization burst
  - *Downlink*
    - Access burst
- Dummy bursts

In this final project understanding that the most possible burst to be used in this situation, only the Normal Bursts will be explained.

1.4.3 Normal Bursts

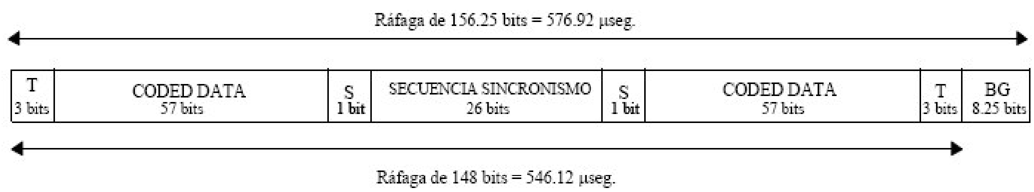


Fig. 1.8 Normal burst

The 3 bits from the beginning and the end (T bits) are used to initialize the igualator.

S (Stealing flag) indicates whether the burst is an urgent control information burst instead of user information.
There are 8 different synchronization bursts.
The following figure, **Fig. 1.9**, shows more characteristics from these bursts:

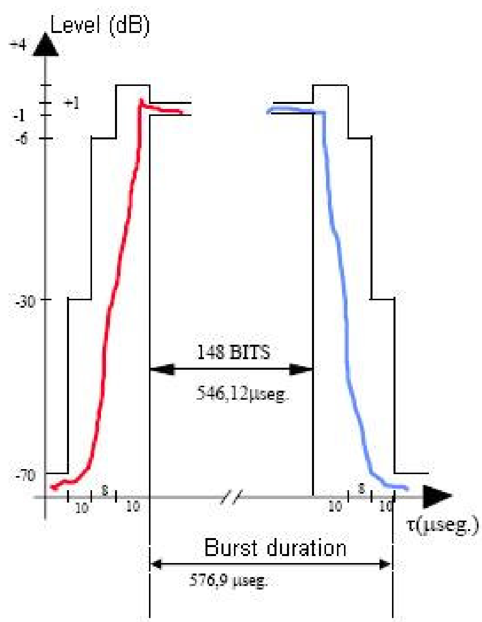


Fig.1.9 the technical specifications of normal bursts.

Hence, the guard period of 8.25 bits is 30.4 μs aprox. which is the same as the power transitory time. During this time the ascending transitory time from a new burst and the descendent transitory time from the old burst cannot happen at the same time. During the transitory time no information is sent.

1.4.4 Channels in GPRS

In GSM/GPRS system exist two different kind of logical channels:
 TRAFIC channels
 CONTROL channels
And on the control channel are 3 different channels:
 RADIODIFUSION channels (BCH)
 CONTROL channels (DCCH)
 COMMON CONTROL channels (CCCH)
These are the channels used in GSM/GPRS system when a communication has to start.

Finally, to understand how this system works probably a brief final explanation must be given:

The system uses some of the details explained below, mainly in chapter 2 and this system, currently, does not reserve any specific channel to ensure this communication. This means that the message sent by the kid will not have any special treatment to be sent.

1.4.5 The Emergency Message Transmission

This system is oriented to connection as shown in the following lines and figures The primitives that the system uses are the following ones:

-T-Connect: used to start the connection establishment.
-T-Disconnect: used to disconnect a session and to notify the user that a session cannot be possible.
-T-Resume: used to ask for the session restore.
-T-Exception: used to notify the events that are not assigned on a particular transmission and do not cause a disconnection.
-T-Invoke: used to start a new communication
-T-Abort: used to abort a communication

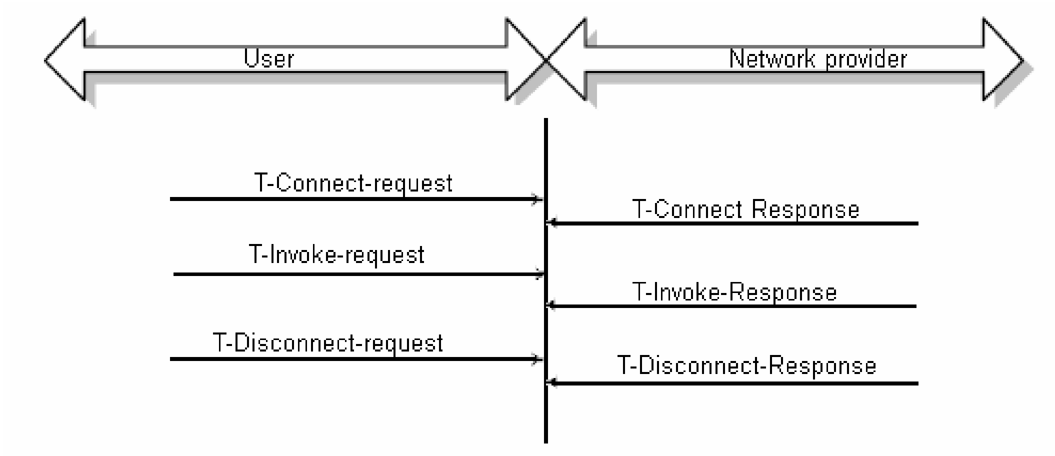


Fig. 1.10 a normal transmission

When the message has been created and it is ready to be sent the cell phone starts a communication with the network operator shown in **Fig. 1.10** and after the invocation the sent packets are the following ones:

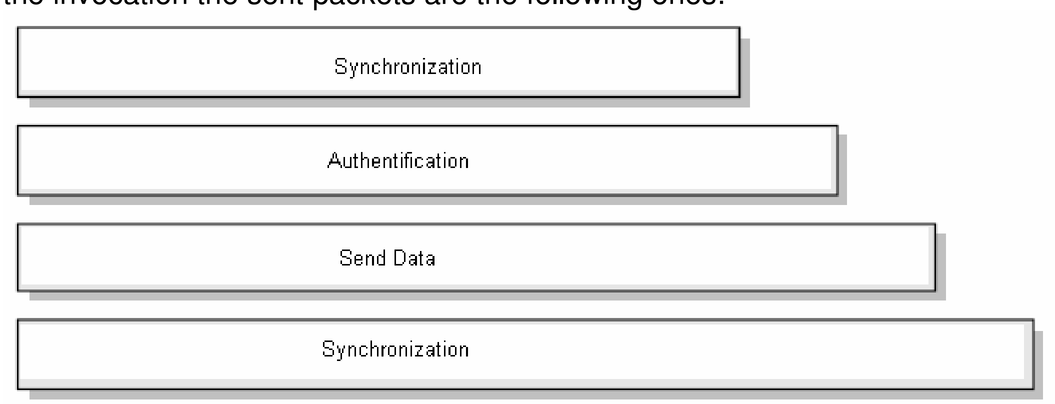


Fig. 1.11 Packets sent by the cell phone.

All these packets are the possible information that the cell phone can send.

The synchronization packets are used to start and end the communication.

The Authentification that is sent to the provider allows the cell phone to be identified on the network.

The Send Data packet shows the 1.4.1.6 data transmission

The network provider creates some other packets in order to stablish the communication:

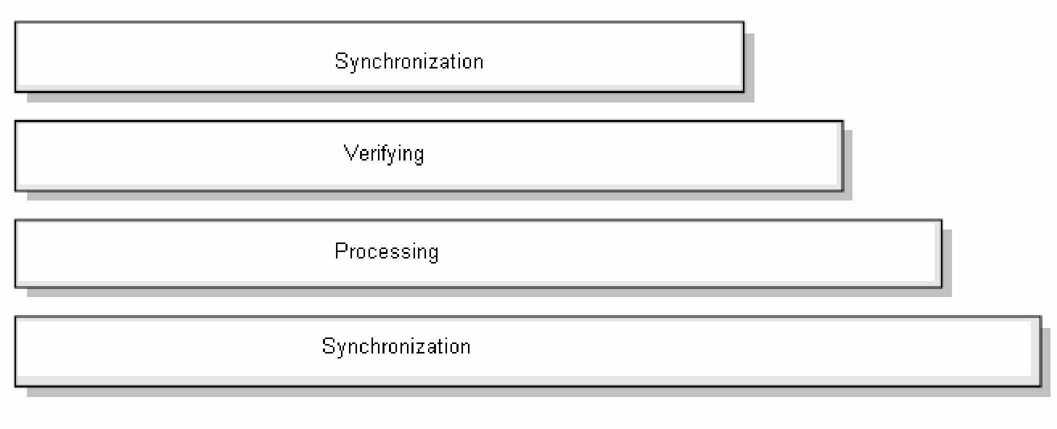


Fig. 1.12 Packets sent by the provider to make the connection

All these packets are the packets that the network provider can send (synchronization packets explained before in this section):

-Verifying: used to verify the user.
-Processing: used to process the information sent by the user.

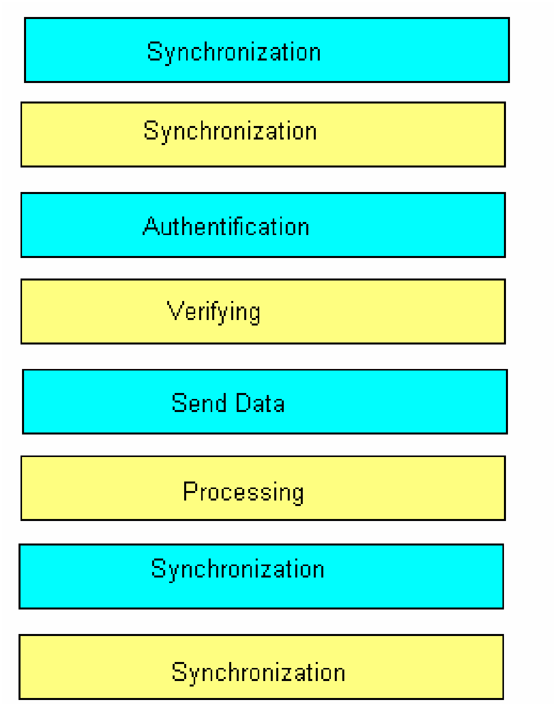


Fig. 1.13 The packets transmission: Blue: coming from the cell phone; Yellow: coming from the network provider.

1.6 The GPRS situation in Spain

1.6.1 Introduction

Although this final work has not used the GPRS expressions but the GSM after studying the last scenarios and understanding the conclusions extracted after the results view, there are some features that the system needs to work independently of the kid environment. In order to keep the coverage, the mobile phone makes connections to the BS checking whether the received power is enough to make the communication. Whenever the kid wants to start the communication, the mobile must have coverage, if the mobile does not, the kid will not be able to contact. In Spain there are no special GPRS channels intended for this system although it is an emergency system. Nevertheless, there are some channels intended for emergency in general (like the ones used for 112 emergency calls). To work, this system needs, at least, mobile coverage. This coverage will depend on the cell's phone operator that the mobile has (the more coverage, the better). Although the simulation program has not exactly worked with all the GPRS features (and, because of this, only some of them have been used in this work), ideally this system needs GPRS to work. Because of this, the following part of the chapter makes a breaf view of the GPRS situation in Spain currently.

1.6.2 Spain's Situation

In the following lines is explained the GPRS coverage in Spain currently for the main operators: Telefónica Móviles, Movistar; Vodafone; France Telecom, Orange. For each operator the coverage map changes.

<u>1.6.2.1 Movistar</u>

In the following figure, **Fig.1.14** is shown the Movistar coverage map.

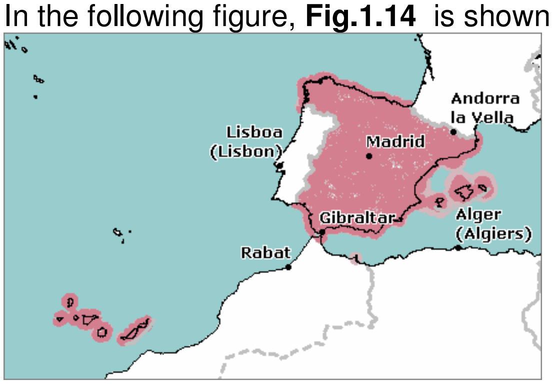


Fig. 1.14 Movistar coverage map

Movistar is probably the main GPRS operator in Spain. It offers coverage almost everywhere on the country and communication can be possible almost everywhere. There are some small areas that are not covered by this operator (probably rural areas). But almost all the territory is covered by Movistar. Movistar is a national company that offers GPRS service in Spain.

1.6.2.2 Vodafone

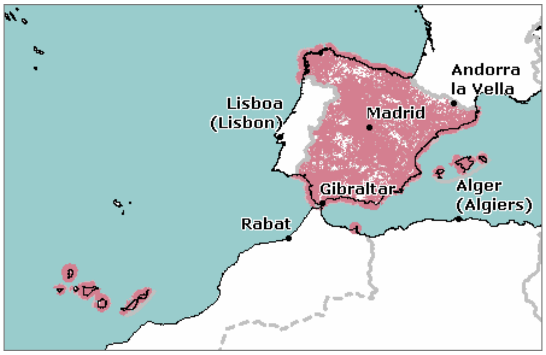


Fig. 1.15 Vodafone coverage map

Comparing with Movistar coverage map (which is probably the main operator of Spain) are visible some white areas where no Vodafone service is offered. Nevertheless, Vodafone is probably the second operator in Spain.

Vodafone Global Enterprise is a new business set up by Vodafone with the sole purpose of enabling 142 of the world's leading multinational companies to develop and control their entire mobile communications networks. Find out how we are changing the way global businesses communicate.

1.6.2.3 Orange

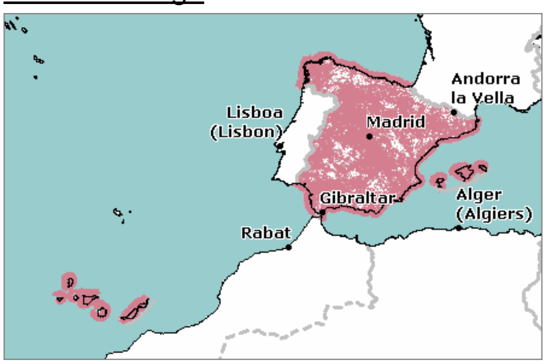


Fig 1.16. Orange coverage map

Comparing with the other operators, Orange is the one which offers less coverage in Spain (but it is probably the cheapest company and the one which offers the best offers). Looking at the France Telecom website, the information (that allows to create a view of the group) extracted about the France Telecom group is that “since the France Telecom Group, a global communications operator, resolutely implemented a policy of responsibly to ensure ‘Responsible Growth’, as part of a plan strengthen and ensure the consistency of actions undertaken over the years by the various entities in the Group”. After reading this information, the conclusions that can be extracted, are that France Telecom is a well known group in France (currently the Apple has designated France Telecom as the only operator which can offer the IPhone in France) is trying to grow in other countries (with competitive prices and competitive services).

CHAPTER 2.CELLULAR SYSTEM OPERATION

2.1 Introduction

What we may ask first would be why do we need a cell system instead of a non cellular system? The final objective consists on maximize the coverage area. With a non-cellular system (**Fig. 2.1**) the base station power would have to be higher and so the cell phone power. So there was a problem with the efficiency: a high users number would require a high bandwidth.

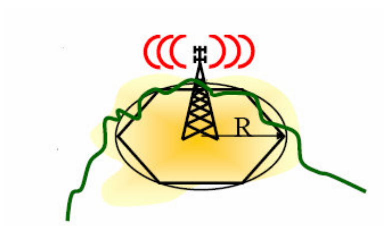


Fig. 2.1 non-cellular system

If we use a cellular system(**Fig. 2.2**), we'll need to fragment in cells the different areas to coverage, the base station and mobile station power are reduce comparing with the non-cellular system, the interference between channels will be reduced but it requires an efficient handover and frequency assignation.

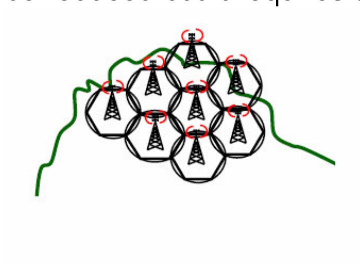
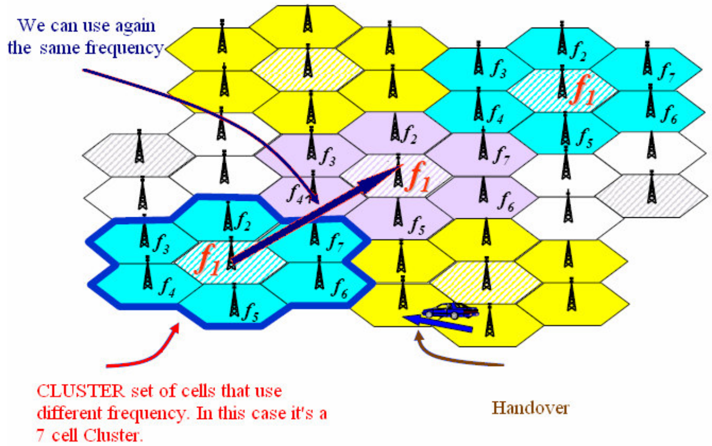


Fig. 2.2 cellular system

With this configuration frequency can be reused in different cells (sufficiently separated to no create problems during the telecommunication). The simulation program (created after this study) works considering this reuse is made



correctly.

Fig. 2.3 Cell system scheme

2.2 Basic components on a cellular system

The basic components of a cellular system are the Mobile Station (MS), the Base Station (BS or fixed station FS), the Mobile Switching Centre, the Public Switched Telephone Network, shown in **Fig. 2.4**

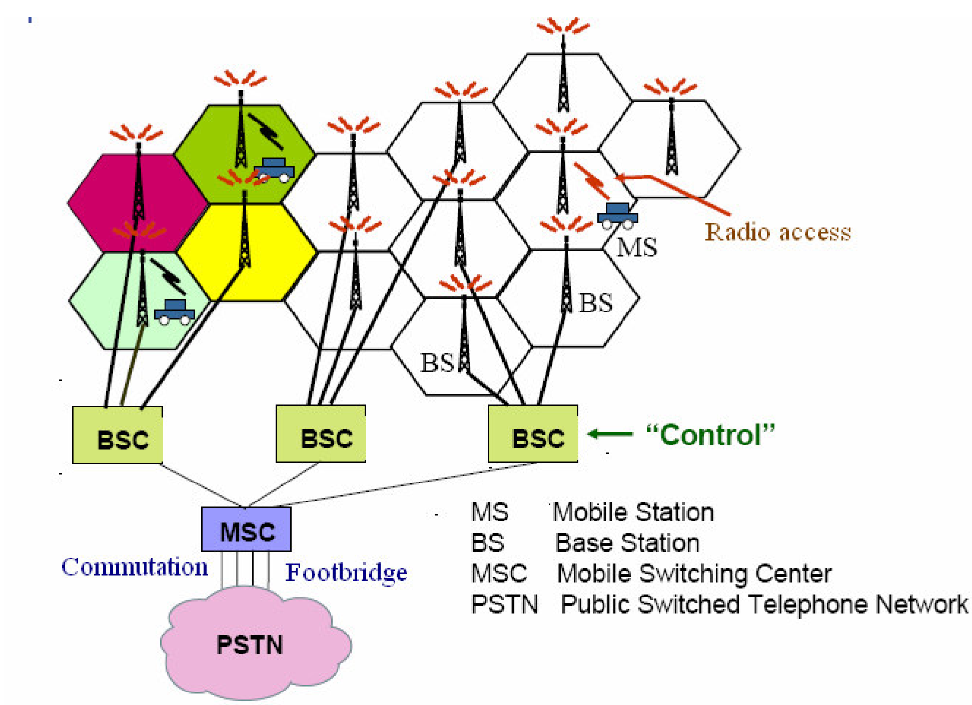


Fig. 2.4

Mobile Station: It has two basic components: on the one hand the mobile phone and on the other the SIM or Subscriber Identity Module. The SIM is a small intelligent card that allows the network to identify our terminal features. This card is placed inside the mobile phone and allows the user to access to all the available services offered by the operator.
Without the SIM card our device will not work and will be useless.

Base Station or Fixed Station: The radio electrical spectrum is limited and the available frequencies are not infinite, because of this, we must **reuse** frequencies more than once in different clusters (multi-access network).There is a fact that we may know when we talk about these systems which is called the interference produced in another channel (when we have different frequency channels an interference can appear from the next and the previous channel).

We use to call these systems trunking. Anyway these systems can be totally independent or have links with other different public systems, mobile or not.
The main characteristics of the TDMA service are:

-The mobile phones have a radio link with the radio stations (base stations) which are placed everywhere where the network offers coverage. Phones are automatically synchronized to the base station

2.3 Power Balance

In general terms we have to use the following expression to calculate the received power on a mobile or on a fixed station:

$$Prx[dBw]=Ptx[dBw]+Gtx[dB]+Grx[dB]-Ltotal[dB] \qquad \textbf{(2.1)}$$

Where:

- -Prx= Received power.
- -Ptx= Transmitted power.
- -Gtx= Transmitting antenna gain.
- -Grx= Receiving antenna gain.
- -Ltotal= Losses.

If an emergency SMS has to be sent, the first we have to check is the received power on the MS using the general expression (2.1) and data obtained on the following table

	Downlink	**Uplink**
Gtx	**14dB**	**-3dB**
Grx	**-3dB**	**9dB**
L	**(antenna) 5,7dB**	**Variable**
Ptx	**38dBm**	**Variable**

Table 2.1

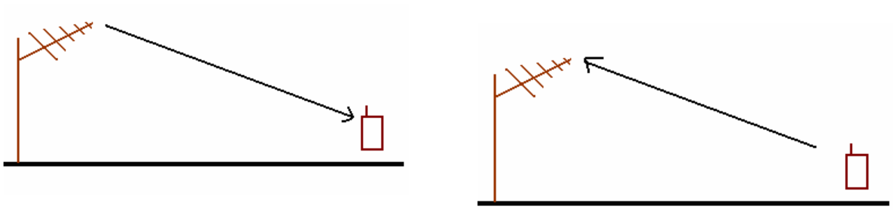


Fig. 2.6 Downlink and uplink.

The received power on the mobile station must be at least -85dBm. If the mobile station doesn't receive this power no emergency SMS will be sent.

When the mobile station receives at least -85dBm the communication between the MS and the FS will be possible and the SMS can be sent. Using the general expression *1.1* we will calculate the received power on the FS antenna and the probability of receiving OK the SMS (on a Rayleigh environment).
It happens when a travelling signal loses power because of the absorption, reflection or diffusion. For example, if we introduce an electrical signal with a P1 watts on a passive circuit, like a cable, its power will suffer an attenuation and the final power will be P2<P1 watts. The received power at the mobile station is also influenced by attenuation.
In the following graph, **Fig. 2.7**, is shown how the received power at the mobile station (MS) in dBm suffers attenuation within the distance in an urban environment:

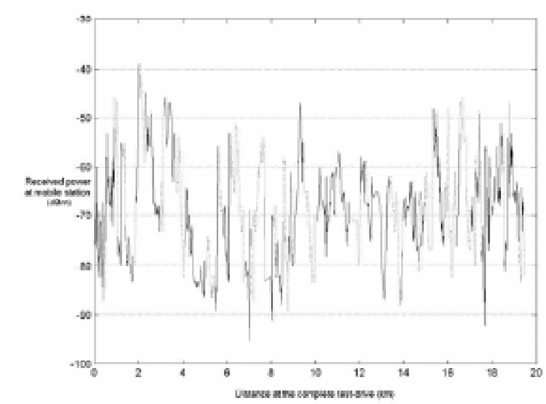


Fig. 2.7 Power of the signal (dBm) at MS.

In these papers will be studied the attenuation in a rural and urban environment starting by the distance attenuation (Ltotal=Lrural+ Lurban+ Lbasic+Lother).

2.3.1 Distance attenuation

The general expression used to calculate the 'basic' attenuation (the distance attenuation) is:

$$Lbasic[dB]=A+B+C \qquad \textbf{(2.2)}$$

Where:

$$A=32{,}45+20\log f+20\log d \qquad \textbf{(2.3)}$$

where:

- f=frequency [MHz]
- d=distance between the FS and the MS [km]

B makes reference to the slow fading. Slow fading arises when the coherence time of the channel is large relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The amplitude change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the Log Distance Path Loss Model. To calculate this expression will be used the lognormal function with m=0 and σ =1.

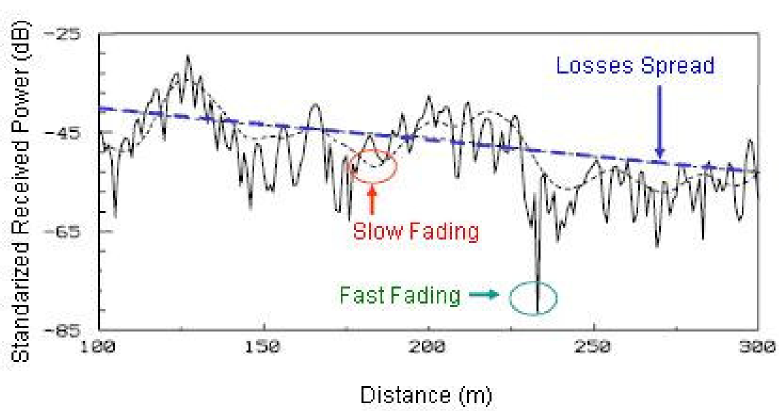


Fig.2.8

Finally, C makes reference to the fast fading. Fast Fading occurs when the coherence time of the channel is small relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel varies considerably over the period of use. To study this parameter will be used the Rayleigh distribution.

2.3.2 Rural attenuation

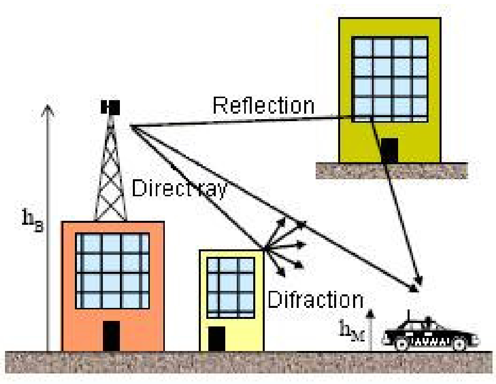


Fig. 2.9

To calculate the Rural attenuation expression this final work will use the Okumura-Hata expression for rural places:

$$69{,}55 + 26{,}16\log f - 13{,}82h_b - ((1.1\log f - 0.7)h_m - (1.56\log f - 0{,}8)) + (44{,}9 - 6{,}55\log(h_b)\log d \quad \textbf{(2.4)}$$

Where h_m and h_b are shown in **Fig. 2.9**.

2.3.3 Urban attenuation

The Urban attenuation expression has been obtained based on an empirical study made in Oporto (Portugal). The measurements were taken during a test-drive made in the main business and commercial zone of Oporto, named *Centro,* **Fig. 2.10**.

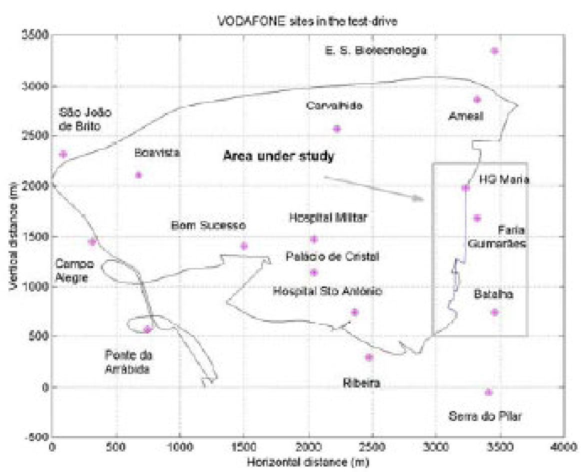


Fig. 2.10

The take of the measurements was made in collaboration with a Portuguese mobile operator. It was used a MS, a GPS receiver coupled to a laptop running TEMS from ERICSSON. This last one integrates all the components in the setup. The complete test-drive path illustrated in **Fig. 2.11** was reconstructed in MATLAB environment from the GPS's coordinates.

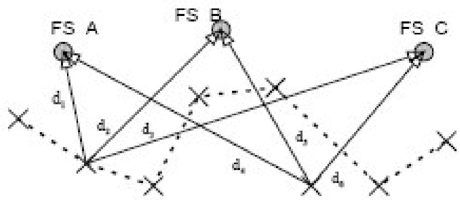


Fig. 2.11 Method used to combining all FS.

The results obtained from this study are shown in the next table, **Table 2.2**

FS	Regression Lines (RL)
2828	$PL(d)$=-34.92-34.06$\log_{10}(d)$
H271	$PL(d)$=33.00-58.27$\log_{10}(d)$
H2026	$PL(d)$=389.97-194.1$\log_{10}(d)$
Three FS	$PL(d)$=-33.41-29.09$\log_{10}(d)$

Table 2.2

The final expression used on our simulation program is the Three FS expression:

$$Lurban[dB]=33{,}41+29{,}09\log d \quad \textbf{(2.5)}$$

Where:
·d= distance between the FS and the MS in [km]

2.4 Bit Error Rate in GMSK

GMSK is the modulation used in GSM/GPRS systems (which is a particular case of FSK where the modulation index is 0,5).The following expression is used to calculate the probability of receiving an erroneous bit when we use a GMSK modulation:

$$Pe(x) = \frac{1}{2} - \frac{xJ_o(2\pi f_d T)}{4(x+1)} \left\{ 1 + \frac{\cos 2p_1}{1 - \frac{1}{2}\left(\frac{x}{x+1}\right)^2 J_o(2\pi f_d T) sen^2 2p_1} \right\} \quad \textbf{(2.6)}$$

Where $J_0(x)$ is the 0 order Bessel function and p_1 is:

$$p_1 = \frac{\pi}{2} \frac{\left\{ Erf(2kT) - Erf(kT) + \frac{1}{2kT\sqrt{\pi}} \left\{ 1 - \exp\left[(-kT)^2\right] + \exp\left[-(2kT)^2\right] \right\} \right\}}{Erf(kT) + \frac{1}{kT\sqrt{\pi}} \left\{ \exp\left[-(kT)^2 - 1\right] \right\}} \quad \textbf{(2.7)}$$

and k is

$$k = \sqrt{(2/\ln 2)}\pi B_b \qquad \textbf{(2.8)}$$

2.5 The Grade of Service

2.5.1 Grade of Service

In these papers the Grade of Service (GoS) will be the medium percentage of the admitted calls that would be lost during a defined period. This quality objective can variate between 0% and 100%, where 0% will mean that no calls will be lost and 100% that all calls will be lost. To calculate the Grade of Service (GoS) is necessary to use the Erlang Function (B):

$$\frac{\left(\frac{A^N}{N!}\right)}{\left(\sum_{k=0}^{N}\frac{A^k}{k!}\right)} \qquad \textbf{(2.9)}$$

Where: A is the expected traffic intensity in Erlangs and N is the number of circuits in group. To calculate A *1.9*: UsersxMxN/3600 where M=Average of calls (on a ‘full’ hour) and N= the average duration in seconds and 3600=number of seconds that an hour has. To calculate N 1.9: this value depends of the BS and the operator, if an area has. The number of circuits is the aviable number of channels of the BS. One BS has X Slots and each slot has 16 channels. The number of slots depends on the possible number of calls of this BS, on the operator.
The simulation program uses this expression, 2.9, to calculate the GoS of a system. The system is changeable by the program user, almost all the features are variable to show the different results for different scenarios. The program allows to study how the different features of a system can change the result of the final link.

2.5.2 Example

The following example is to understand what this expression allows to calculate:

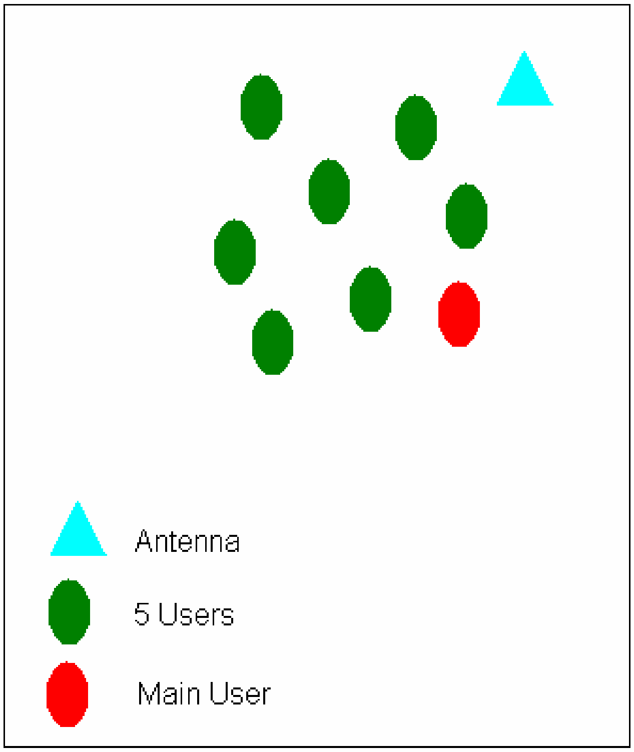


Fig. 2.12

Number total of users: 36
Number of circuits: 128
Number of calls in 1h: 100
Number of seconds for each call (average): 120s
Number of seconds of 1h: 3600s

$$A = \frac{100 \cdot 120}{3600} \cdot 36 = 120$$

Using the expression 2.9 will be calculated the GoS of the system for this scene:

$$GoS = \frac{\frac{120^{128}}{128!}}{\sum_{K=0}^{k=128} \frac{120^k}{k!}} = 0{,}0347 \rightarrow 3{,}47\%$$

This result shows the probability of failing links for this situation: the antenna (because of its number of circuits) is probably placed on a rural place (where the expected traffic is probably no more than these users).

The simulation program allows to create many different scenarios changing almost all these features. Sometimes the difference is barely appreciable and the results do not show the real difference.

2.6 Coverage

2.6.1 Introduction

In this section will be explained the lognormal distribution in order to understand the system coverage. Coverage is not a fixed and preset feature. It depends on the lognormal distribution, the received power, the average power, and some other variables. The expression used in this section is necessary to calculate how probably is to have coverage in some place.

In probability and statistics, the log-normal distribution is the single-tailed probability distribution of any random variable whose logarithm is normally distributed. If *Y* is a random variable with a normal distribution, then *X*=exp(*Y*) has a log-normal distribution; likewise, if *X* is log-normally distributed, then log(*X*) is normally distributed.

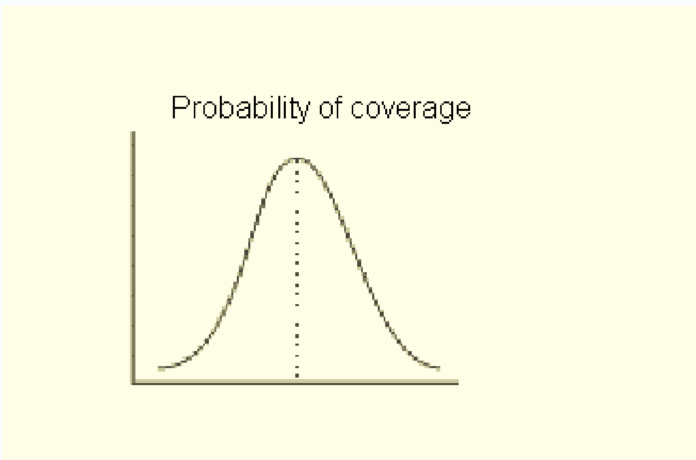


Fig. 2.13

Although the received power would be enough to make a communication, the lognormal distribution affects to the probability of coverage.

This probability is not calculated by the simulation program.

2.6.2 Probability of coverage

The following expression is used to calculate the probability of coverage:

$$prob(P > P_{th}) = \int_{P_{th}}^{\infty} f(P)dP = \frac{1}{2} - \frac{1}{2} erf\left(\frac{P_{th} - P_{average}}{\sqrt{2}\sigma}\right)$$ (everything in dBs) **(2.10)**

Where

P is the average received power. ($P_{average}$)

P_{th} is the threshold power

2.7.2.1 Example 1

Data:

-For this application the average power, $P_{average}$, is -65dBm
- The σ value is 10dB
- For this application the probability must be higher than 95% (the 95% of the times is necessary to make the connection when the received power allows it).

$0{,}95 = \frac{1}{2} - \frac{1}{2} erf\left(\frac{P_{th} - 65}{\sqrt{2} * 10}\right)$;Applying some of the function *erf* properties, $erf\left(-\left(\frac{P_{th}}{14{,}14} - 4{,}6\right)\right) = 0{,}9$; looking at table 1.3 and taking the closest value to 0,9, which is 0,880, the value of x=1.1. That means that: $1.1 = \frac{-P_{th}}{14{,}14} - 4{,}6$; and, finally, $P_{th} = -80{,}6dBm$. The interpretation of this result is that all the places thathave an average power of -65dBm the 95% of the time the received power is higher than the threshold power (-80,6dBm).

2.6.2.2 Example 2

(Using the same data from Example 1, section 2.7.2.1).

If we reduce the probability to another value, for example, 80% the threshold value changes:

$0{,}80 = \frac{1}{2} - \frac{1}{2} erf\left(\frac{P_{th} - 65}{\sqrt{2} * 10}\right); 0{,}6 = erf\left(\frac{P_{th} - 65}{\sqrt{2} * 10}\right)$; taking the closest erf function value to 0,6, which is 0,67, the value of x=0,7. That means that $0{,}7 = \frac{-P_{th}}{14{,}14} - 4{,}6$; and, finally, in this case, $P_{th} = -79{,}9dBm$ which is a logical result comparing with the previous one because in this case the threshold power is 'less' restrictive because the probability condition is less restrictive too.

CHAPTER 3. SIMULATION PROGRAM

3.1 Introduction

The final purpose of this program is to simulate any scenario showing different results in order to show the possibility of a communication like the received power and the probability of receiving OK a SMS on a Rayleigh channel, using the GPRS physical layer, for example. The parameters to study have been calculated using the expressions explained previously (2.1,2.6,2.9). The program only shows the uplink specifications, nevertheless what the program makes first is the calculation of the coverage (i.e if the downlink power is higher than the threshold power, which is -85dBm). This program pretends to be useful when this system wants to be used at any scenario, because of this, the program allows to generate any scenario showing the most important characteristics of the system, and allowing to know whether the system will be useful or not for a personal and a particular situation. The program has been created in Java because Java offers many applications in cell phones.

3.1.1 Java Language and the Java Virtual Machine

Java is an oriented object programming language developed by Sun Microsystems on the 90's. Its syntaxes is similar to C and C++ but it has a simpler object model. Java applications are typically compiled on a bytecode, although the compilation in assembler code native is possible. During the execution time, the bytecode is normally compiled by a native code for the execution, although the direct execution by hardware of the bytecode using a Java processor is possible too.

Fig.3.1 The Java Symbol

The original implementation and the compiler reference, the virtual machine and the classes libraries of Java were developed by Sun Microsystems on 1995. Since then, Sun has controlled all the specifications, development and evolution of the language through Java Community Process. Meanwhile, other have developed alternative implementations of these Sun technologies, some of them with free software licenses.

During the period of November of 2006 and May of 2007, Sun Microsystems made free the most part of their Java technologies using the GNU GPL license, in agreement with the specifications of the Java Community Process and practically all Java of Sun is now free software (although the classes library of Sun that is required to run Java programs is not free software).

Java	
Main Feature:	Object Oriented

Created in:	1990s
Designed by:	Sun Microsystems
Influenced by:	Objective-C, C++, Smalltalk, Eiffel
Has influenced:	C#, J#, JavaScript
Operative System	Multiplatform

A Java Virtual Machine (JVM) is a set of computer software programs and data structures which implements a specific virtual machine model. This model accepts a form of a computer intermediate language, commonly referred to as Java bytecode, which conceptually represents the instruction set of a stack-oriented, capability architecture. This code is most often generated by Java language compilers, although the JVM can also be targeted by compilers of other languages. JVMs using the 'Java' trademark, may be developed by other companies as long as they adhter to the JVM specification published by Sun.

The JVM is a crucial component of the Java Platform because is available for many hardware and software platforms. Java can be both middleware and a platform in its own right (hence the expression 'write once, run anywhere')

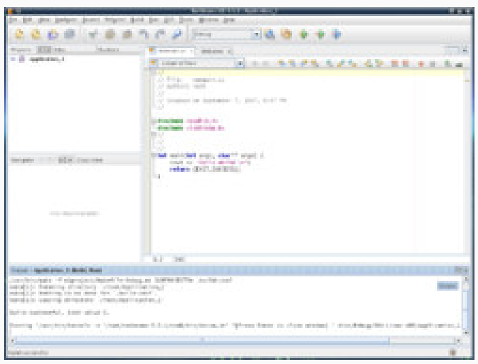
3.1.2 The Programming Platform: NetBeans.

Netbeans is a platform for the desktop applications using Java and an integrated develop environment (IDE) developed by the NetBeans Platform.

Fig. 3.2 Initialing NetBeans

The NetBeans platform allows the applications to be developed from a group of software components called *modules*. A module is a Java file which contains Java classes written to allow the communication between the NetBeans APIs and a special file (manifest file) that identifies it with a module. The constructed applications from the modules can be extended adding new modules. The modules can be developed independently and because of this the based applications on the NetBeans platform can be extended easily by other software developers.
NetBeans is a big succeed open code project with a big users base, a community in constant growing and with 100 members in the whole world. Sun MicroSystems created the open code project NetBeans in June 2000 and it continues being the main sponsoring of the projects.

NetBeans



Netbeans 5.5.1 running a program griten in C++, over Slackware Linux.

Developer:	Sun Microsystems
Last Version	5.5.1 (24/05/2007)
S.O.:	Multiplatform
Kind:	Java SDK | Java IDE
License:	CDDL
Web Site:	http://www.netbeans.org/index_es.html

The NetBeans Platform is a modular base and extending used by an integration structure to create big desktop applications. Independent companies associated, specialized on the software development, provide additional extensions that are easily integrated in the platform and that can be used to develop their own tools and solutions.

The platform offers common services to the desktop applications, allowing to the developer to focus on the specific logic of its application. The features of the platform are:

Administration of the users interfaces (like menus and tool bars).
Administration of the users configuration.
Administration of the storage (keeping and loading any kind of data).
Administration of the windows.
Framework based on assistants (step by step dialogues).

When running NetBeans the main and first window that appears is:

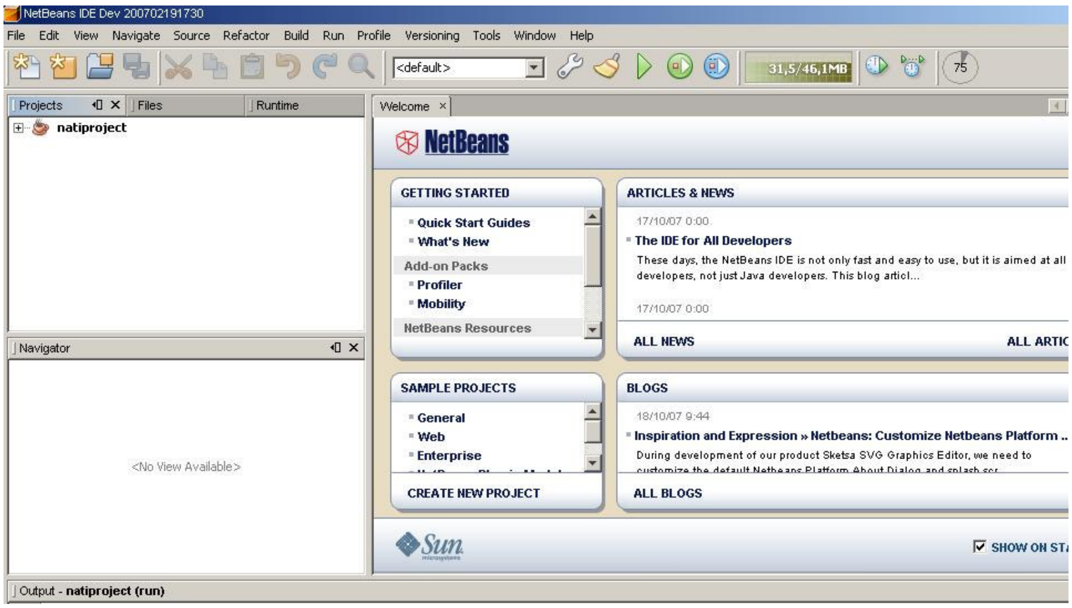


Fig.3.3 NetBeans working window

3.2 Program Structure

3.2.1Program diagram

Using the NetBeans programming platform the program has been created. The program structure is shown in the next figure, **Fig. 3.4**.

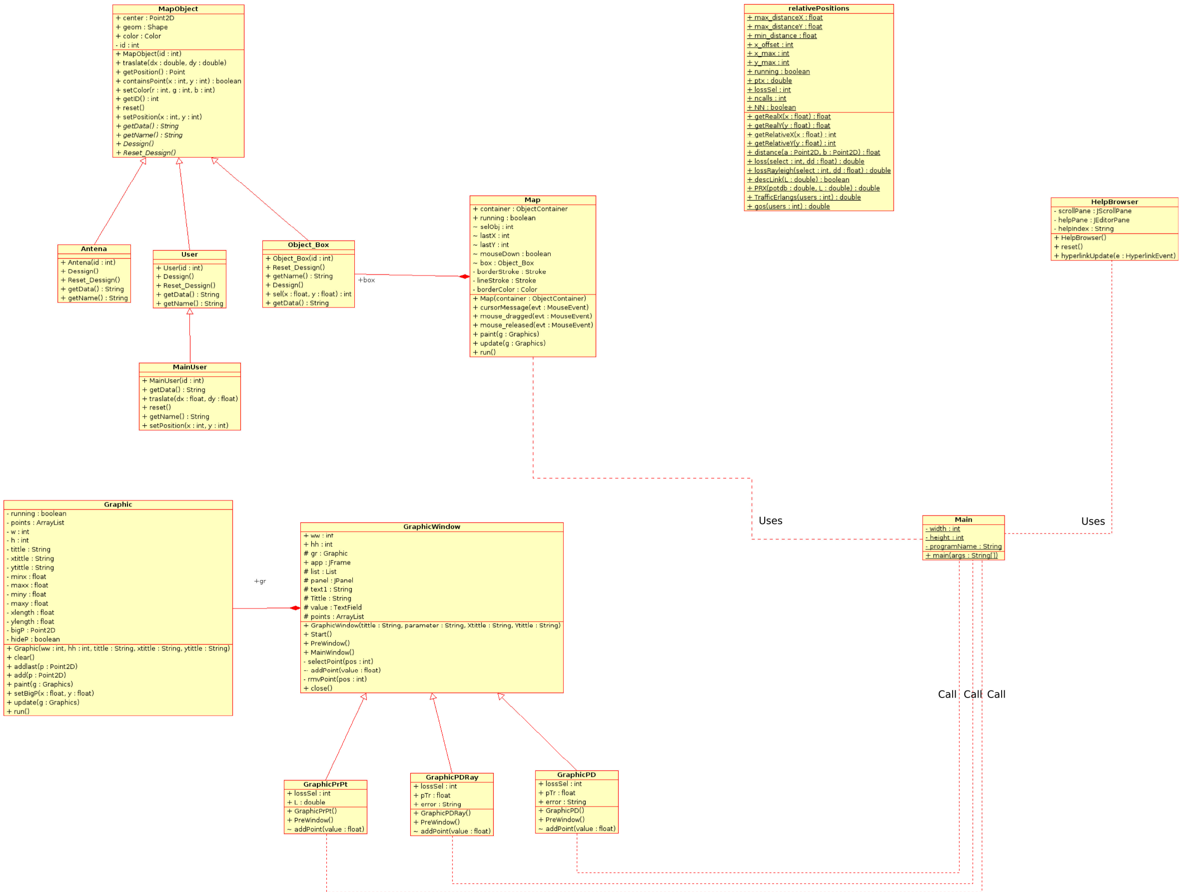


Fig. 3.4 The simulation program structure

Fig.3.4 shows the simulation program structure. As this figure shows the program needs some classes (all these classes will be explained in section 3.2.2) to work. The first square shows the main screen that allows to move some figures on a map. The figures are Antennas (because of this Antenna is related to it) and Users (because of this are related to it; users can be normal users or the Main User). All these figures can be moved inside a map which is featured by Object Box (because of this Object Box needs Map to work). All the other parts of the structure represented on **Fig. 3.4** are the different variables and data necessary to create the visual applications from the program, updating the data in a few words: the program working (like the *getReal(x: float): float* for example).

3.2.2 Program classes

In order to understand the fig 3.4:

·**Map Object**: This class is the father of all the objects that appear on the main map, and contains all the abstracts methods of drawing, painting and object location.

·**Antenna**: Inherits from MapObject. This object contains the user definition and the graphic which features the antenna on the map.

·**User**: Inherits from MapObject. Map object that contains the user's definition and the graphic which features it.

·**Main_User**: Inherits from User. Map object that represents the main user, contains the necessary methods to describe and to write it different from other users.

·**Oject_box**: This box appears on the left side of the map and allows to create new users and antennas, depending on where we click with the mouse.

·**ObjectContainer**: Container of the dynamic objects that appear on the map. Contains just one main user and a list of MapObjects to store the antennas and users that appear on the map and the methods to create and eliminate them.

·**Map**: Is the map that appears on the main application, it contains an instance of ObjectBox and another of ObjectContainer. It inherits from a JComponent Runnable to allow the graph updates. For each refresh loop (when an object moves), this class makes all the necessary calculations to show the data on the screen (distance, Received Power, GoS,…). This class has to 'listen' the different entrances from the mouse and sends the position the MapObject (which is in contact, if it does not touch to any MapObject, it does not make anything).

·**HelpBrowser**: navigator for the help menu of the main window.

·**Main**: Main class that creates the application window and all the menus that appear on it. Contain instances from Map and HelpBrowser.

·**Graphic**: Class which contains the methods to draw the graphics and to localize the points inside the graphic.

·**GraphicWindow**: Abstract class that generates the windows and the graphics with the corresponding menus. It has an instance from graphic.

·**GraphicPd**: Inherits from GraphicWindow. Generates the transmitted power-distance graphic.

·**GraphicPdRayleigh**: Inherits from GraphicWindow. Generates the transmitted power-distance with slow and fast fading effects graphic.

·**GraphicPrPt**: Inherits from GraphicWindow. Generates the received power-transmitted power graphic.

3.2.2.1 The relative positions class:

Relative positions contains all the necessary calculations for the received power, fading effects, non fading effects, GoS... This class uses the 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8 and 2.9 expressions.

·**Relative Positions**: static class (keeps the methods and attributes from the global application). This class allows to make all the necessary calculations to show the information on the screen and it turns the virtual coordinates from the map to real coordinates. Main methods necessary to emphasize:

distance (Point2D a, Point 2Db): Returns the distance between 2 points.

loss(int select, float dd): Return the attenuation caused by the distance between the antenna and the different attenuation applied for each case.

lossRayleigh(int select, float dd): Makes the same than *loss* but adding the fast and the slow fading effects.

descLink(double L): returns true or false depending on the losses.

PRX (double potdb, double L): Returns the received power for a transmitted power and for particular losses.

TrafficErlangs (int users): For a number of users, it returns the traffic in Erlangs.

gos(int users): Returns the GoS for a number of users connected to the analyzed antenna.

The following lines show the Java code created for this class (relativePositions.java) with all the methods created on it:

```
public class relativePositions {

   //all in meters; main screen size
   public static float max_distanceX= 36000;
   public static float max_distanceY= 23263;
   public static float min_distance= 500;
   public static int x_offset =50;
      public static int x_max = 618;
   public static int y_max =299;
      //data for map (in main window)
   public static boolean running = false;
   public static double ptx;
   public static int lossSel;
   //necessary data to calculate the GoS
   public static int ncalls;
   public static boolean NN;

//the following methods are related to get the position fixed on the graph

public static float getRealX(float x){
      return (max_distanceX*(x-x_offset))/(x_max-x_offset);
   }

   public static float getRealY(float y){
      return (max_distanceY*y)/y_max;
   }

   public static int getRelativeX(float x){
      float r =(float)( (x_max*x)/max_distanceX);
      return (int)r+x_offset;
   }

   public static int getRelativeY(float y){
```

```
      float r =(float)( (y_max*y)/max_distanceY);
      return (int)r;
   }

public static float distance (Point2D a,Point2D b){
     Point2D tmpa =new
Point2D.Float(getRealX((float)a.getX()),getRealY((float)a.getY()));
     Point2D tmpb =new
Point2D.Float(getRealX((float)b.getX()),getRealY((float)b.getY()));
     return (float)tmpa.distance(tmpb);
   }
//the following method has been created to calculate the loss: basic loss, urban
//loss and rural loss
public static double loss (int select, float dd)
   {
      float d = dd/1000;
      double Lnormal = (32.45+10*Math.log10(900)+20*Math.log10(d));
       switch(select)
       {
          case 0:
               return Lnormal;
          case 2:
               return Lnormal+(33.41+29.09*Math.log10(d));
          case 1:
               return Lnormal+(32.45+20*Math.log10(d));
       }
       return 0;
   }
//the following methods are is used to calculate the received power when
//fading affects to the system (low and fast fading); to calculate the coverage of
//the system and to check the values //introduced by the user
public static double lossRayleigh (int select, float dd);
public static boolean descLink(double L);
public static double PRX ( double potdb, double L);

//the following method calculates the Traffic in Erlangs (expression 1.9)

public static double TrafficErlangs (int users)
   {
      double pas1 = (ncalls *120*users);

      return pas1/3600;
   }
public static double gos(int users)
   {
      try
```

```
    {
      int n;
      double Fn;
      if ( NN)
      {
        n=128;
        Fn =(Math.pow(10,215)*3.856204824);
      }
      else
      {
        n=192;
        Fn =(Math.pow(10,306)*7.257415615);
      }

      double A= TrafficErlangs(users);

      double gostmp= (Math.pow(A,(double)n))/Fn;


      double gostmp2=0;
      double kfact=1;
      for ( int k =0; k<= n; k++ ) //to calculate the factorial
      {
        if( k != 0)
        kfact= kfact* k;
        gostmp2 += Math.pow(A,k)/kfact;

      }
      double result =gostmp/gostmp2;
      }
      catch(Exception e){return 1;}
  }

//and, finally, the following method uses the expression 1.6, 1.7 and 1.8 to
//calculate the Pe
public static double pex(double f, double prx);
```

3.2.2.2 Flux diagram

In this section are represented some of the methods and the program flux diagram. This diagram allows to understand how some of these methods work and the way the program works.

The first diagram shows how the program generates the power-distance graphic.

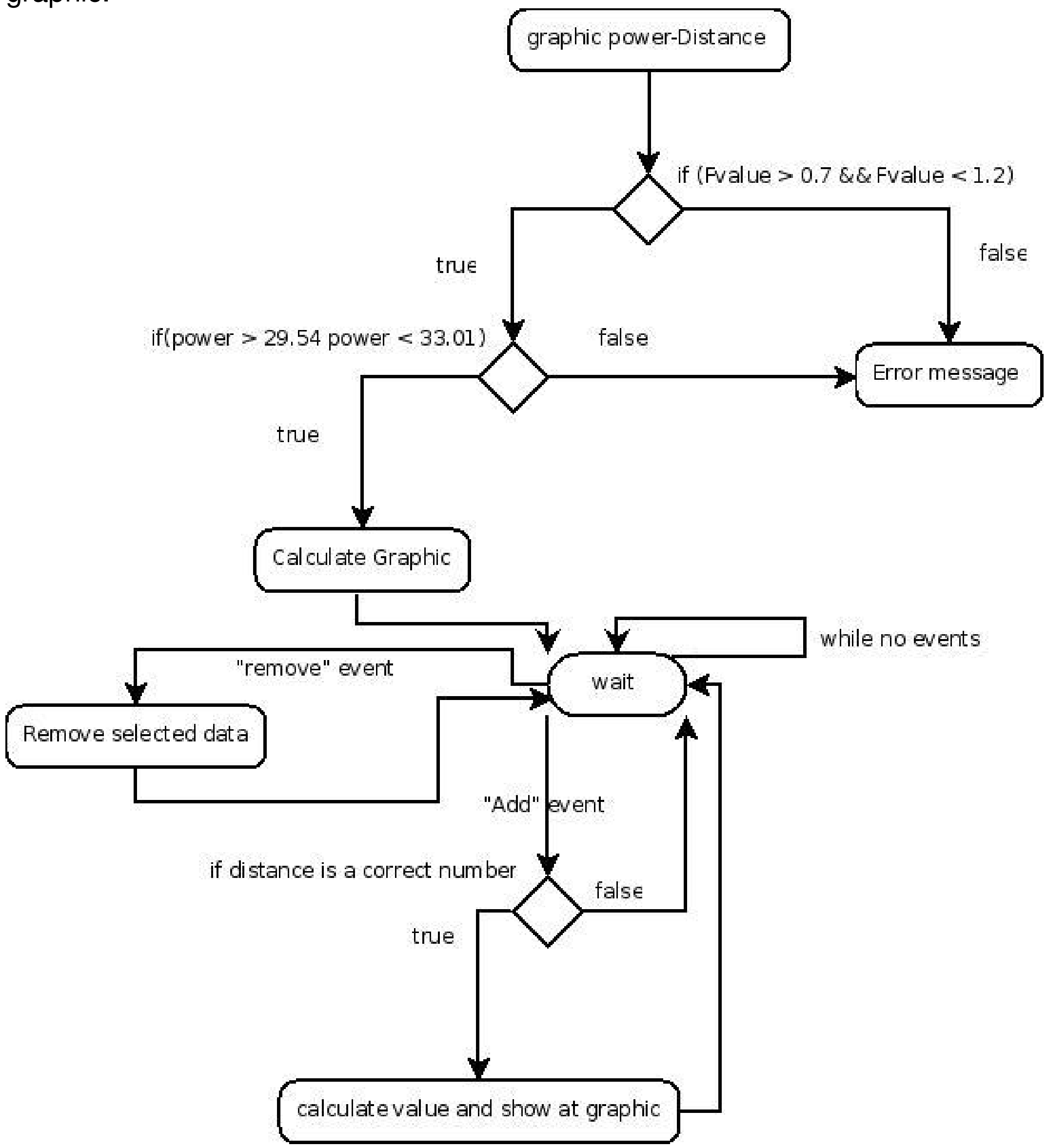


Fig. 3.5 the graphic power-distance flux diagram.

This diagram shows how the program generates this graphic (which is probably the most used graphic in this program). The first the program checks is the Noise Factor on the receiver, this value must be between 0.7 and 1.2dB If this value is correct, the program goes to the next conditional situation: the transmitted power. In this case there is again a condition: this power must be between two values. Nevertheless it is important to consider that the recommended transmission power by some of the most popular cell phone companies is set between 29.54 and 33.01dBm. In both cases, when the condition is not accomplished the program will show an error message. When both conditions are accomplished the program generates a graphic using the methods explained before (in section 2.2.2 and 2.2.2.1). Whenever the user wants to add a value the program asks the user the data to calculate the receiving values: received power and BER. The conditions must be accomplished to generate the results. It is important to remember that many studies have been done on this telecommunication field that conclude that, probably, the highest power that the human head (and human brain) can be exposed to for this frequency and this features (the GPRS features) are close to 2w (33.01 dBm). Nowadays scientific are investigating to reduce the transmission power used on this communication links. In order to make a range of the most common values, the simulation program has been programmed to make possible the communication links between this values (i.e, 29,57 dBm, 30dBm or whatever).

The second graphic shows the GoS application.

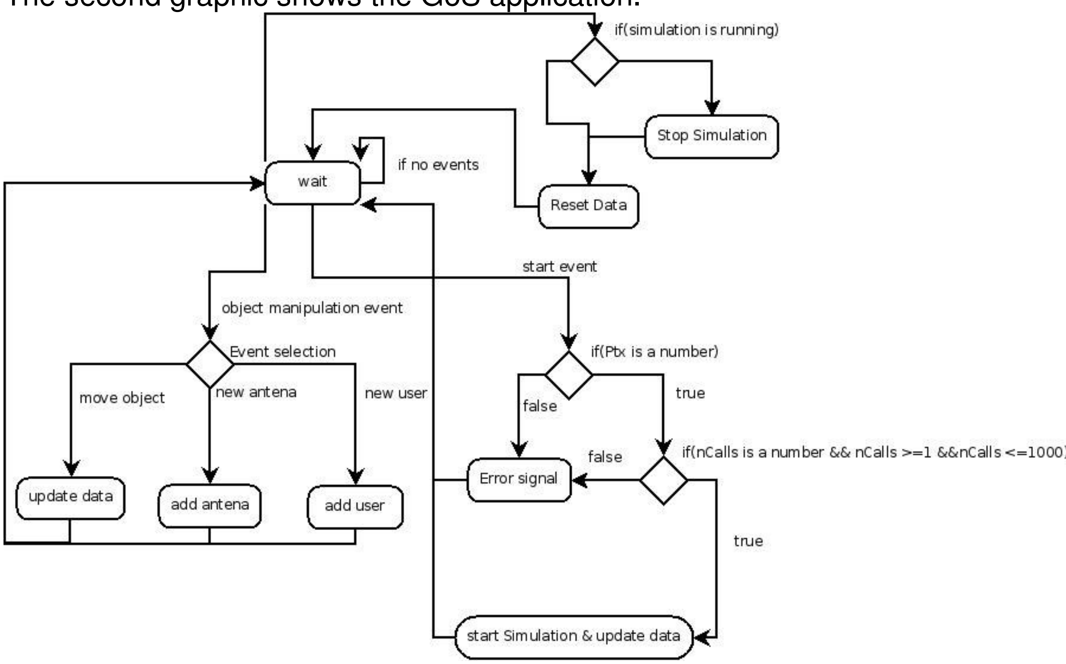


Fig.3.6 The GoS flux diagram.

In this diagram is shown how the GoS application works inside the simulation program. Like in the other case, there are many conditional cases that must be accomplished to the correct working program. This application starts with a 'wait' situation that will remain until no events happen. Whenever an event happen the simulation program checks out what the event is: if Ptx is a number goes to nCalls and checks the same. If any of this variables are not a number an error signal happens and the simulation program will go to the beginning again. If both of these conditions are accomplished, using the expressions mentioned in chapter 1 and on the methods explained on the beginning of chapter 2, the simulation program will calculate the necessary calculations and will update the data. On the other hand, the event is not necessary a number introduced, it can be an object movement. First of all the program will recognize which object is and will move it on to the place. In this case, if it is a new object, the program will add the new object on to its memory. If it is jus moving, the program will update the data and keep it inside its memory. The other event that can happen is related with the simulation time: if simulation is still running or not. If it is, it will stop the simulation, if it is not, it will reset the data and start again with the wait situation.

These two diagrams have been considered the most significant graphics to understand how the program gets the simulation view (but not the calculations, which have been specially explained in chapter 3.2.2.1) because they show the different screen views.

These flux diagrams have been created using a program named Dia which is a gtk+ based diagram creation program released under the GPL license; it is inspired by the commercial Windows program 'Visio', though more geared towards informal diagrams for casual use. It can be used to draw many different kinds of diagrams. It currently has special objects to help draw entity relationship diagrams, UML diagrams, flowcharts, network diagrams, and many other diagrams. It is also possible to add support for new shapes by writing simple XML files, using a subset of SVG to draw the shape.

It can load and save diagrams to a custom XML format (gzipped by default, to save space), can export diagrams to a number of formats, including EPS, SVG, XFIG, WMF and PNG, and can print diagrams (including ones that span multiple pages).

3.3 User's Manual

3.3.1 Introduction

This program allows to create any environment in order to simulate the features shown in chapter 2. This tool has been created using the Java language explained before and the Netbeans platform shown in chapter 3 section 3.1.2. This section will show the program functionality and the program features to make it easier to use.

3.3.2 Main screen

When the program is opened the following screen appears (**Fig.3.7**)

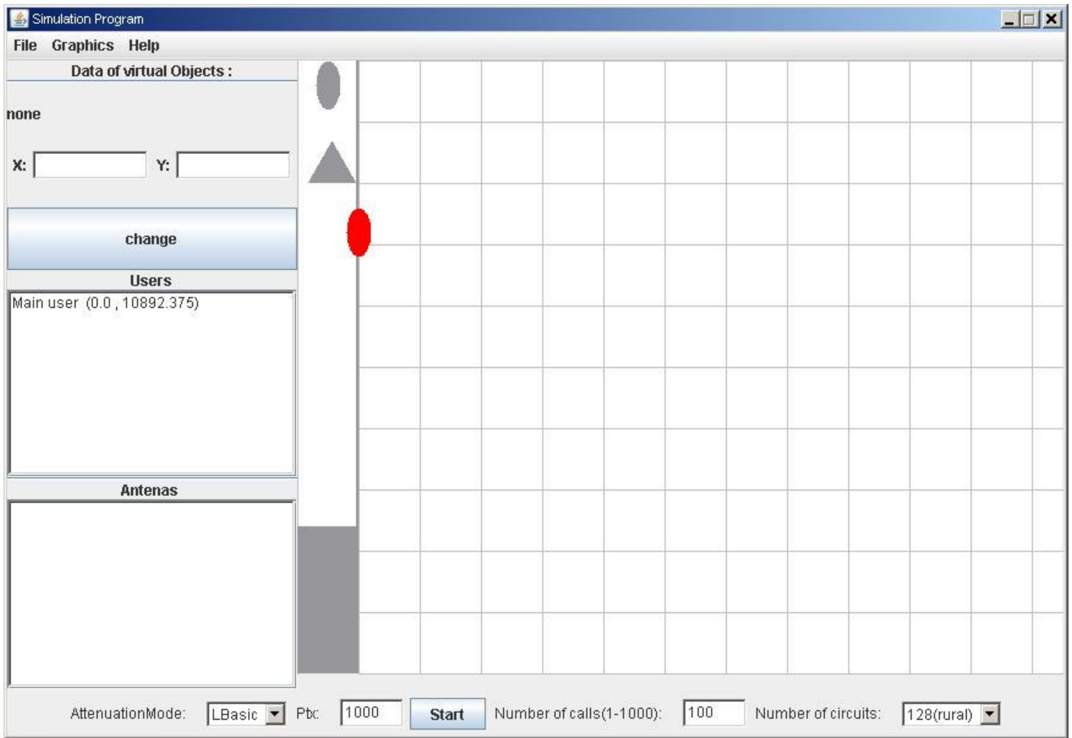


Fig. 3.7 The main (and first) screen of the simulation program

The screen shown in Fig. 3.5 shows all the options that the program has: on the tool bar, the File menu (where we can choose if we want to quit from the program or we want to reset it) ; the Graphics menu (where we can choose the kind of graphic that we want to see and selecting its features, see section below); the Help menu (in this part the program gives a little explanation of the program utilities and the program author).

3.3.3 The Graphics menu

This part of the program allows to calculate the received power on the antenna (uplink) when a communication has started and the BER. The program generates three different kind of graphics, shown in **Fig. 3.8**.

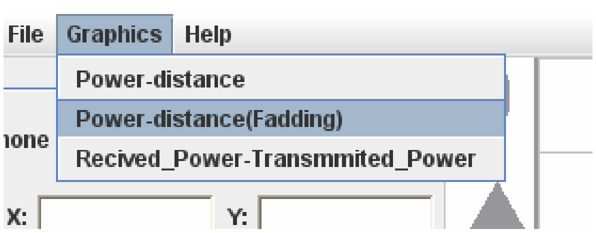


Fig. 3.8 the different options of the Graphics menu.

We can choose the graphic we want to generate just clicking over it. The first and the second graphics shown the relation between the received power on the antenna and the distance, the only different is that in the first case the program is generating an ideal situation (with non fading effects, just attenuated by the distance) but in the second one the program generates a more realistic graphic. The third graphic generated is just an error controlling graphic where the received power on the antenna and the transmitted power by the cell phone relation is shown. Although this graphic does not show any new information that the other ones show, this graphic allows to ensure that the expressions shown in chapter 1 are well used. The following figure, **Fig.3.9** shows the next screen generated after selecting a power-distance graphic.

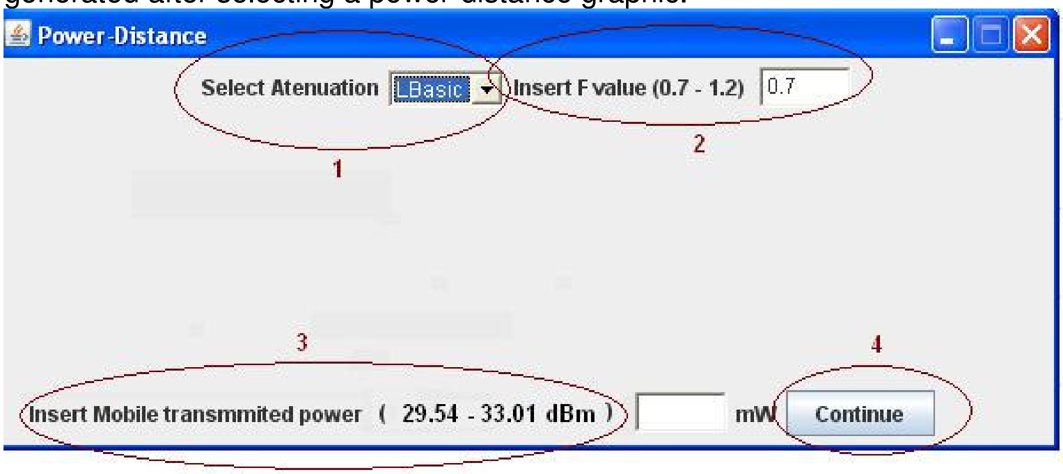


Fig. 3.9 the asked information marked by simple steps.

The first the program asks the user to select in order to create an environment is the attenuation that the user environment has: Basic attenuation (this situation is not realistic but allows to understand the next two attenuations); Rural attenuation (it must be selected when the user's environment is a village or close to the country); or, finally, Urban attenuation (which has to be selected whenever the kid's environment is a city). When we have selected any of these attenuations the program asks you to introduce the Noise Factor on the receiver value. In order to create a more realistic simulation program, the program has fixed that the Noise Factor on the receiver must be between these two values after checking out the values on some of the typical cell phone brands: Nokia, Sony Ericsson and Siemens mobiles. The next step asks the user to introduce the cell phone transmitted power. Again, the values that can be chosen are the ones that Nokia, Sony Ericsson and Siemens companies have chosen on their cell phones. When all of these steps have been completed the next thing to do is to press the continue button.

<u>3.3.3.1 Example</u>

This example shows the generated graphic after selecting (on the Graphics menu) a Power-distance (fading) graphic and, on the next screen, configuring on the step 1 the basic attenuation, on the step 2 0.7dB and on the step 3 29.54dBm. The following figure, **Fig.3.10** shows the graphic that the program generates

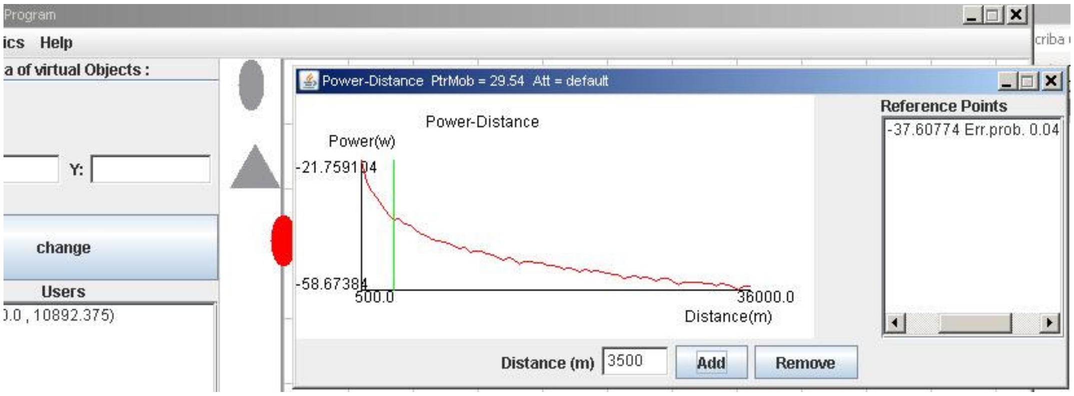


Fig. 3.10 The graphic generated for this example (see features on the beginning of this section, 3.3.3.1).

Do not forget that this menu, “Graphics”, also generates the received power in function of the transmitted power.

3.3.4 The GoS simulation

Over the main screen different scenarios can be created in order to calculate the GoS. If we take a look on to the main screen we can see a triangle (which represents many different antennas), a grey ball (which represents the other users that the system can have) and a red ball (which represents the main user: the kid user). All these elements can be moved over the screen (with the left button of the mouse) and can be placed anywhere. The only element that cannot be repeated is the main user (or red ball). All the elements allow to create a particular scenario. The program also needs to know the average number of calls and the number of circuits (in order to calculate the GoS (expression 2.9) and allows the user to introduce these values (although the program has default values). When a whole scenario is created is just necessary to press the start button and the GoS will be calculated.

<u>3.3.4.1 Example</u>

This example allows to understand the GoS simulation explanation described in 3.3.4. **Fig. 3.11** shows a created scenario (which has 36 users and only one antenna, because, is important to remember that the system considers that only one antenna affects to the kid environment and all the users that affect to the kid when calculating the GoS must be using the same antenna, because of this, only one antenna is simulating this example; nevertheless the program enables to select more than one antenna but the difference is that when more than one antenna is selected the users will have more possibilities of using other antennas and they will not be affecting to the kid environment when calculating the GoS).

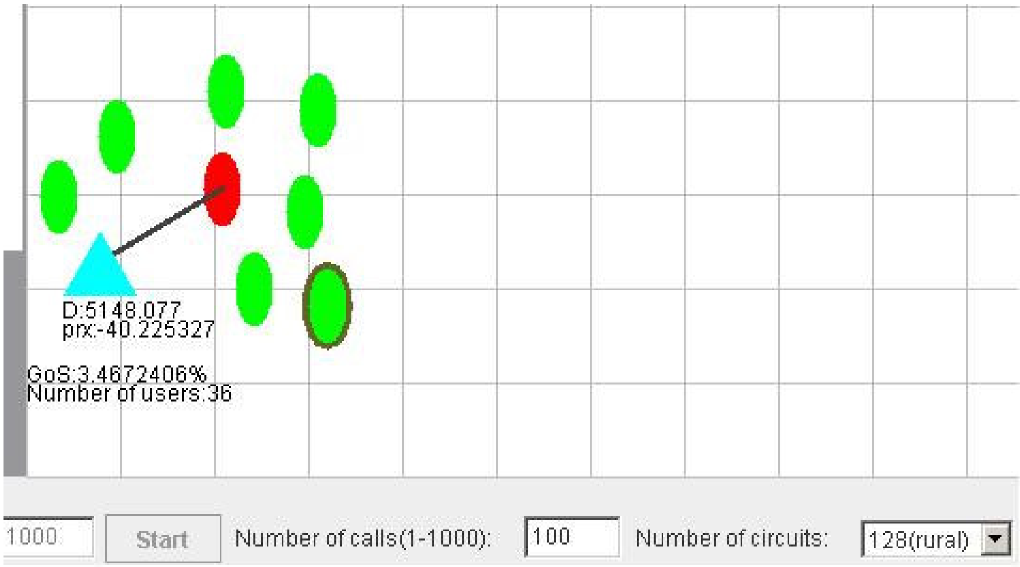


Fig. 3.11 The GoS calculation

CHAPTER 4. STUDY-CASE SCENARIOS

4.1 Introduction

In this chapter three scenarios will be characterized in order to classify the utility of the GPS+GPRS for kids location system. The created program allows to simulate for a particular situation or environment the utility of the system, and for the three situations characterized in this chapter, the program will show the grade of utility of the system. On a real situation more than one antenna is affecting to the system. Nevertheless in this case all the scenarios will suppose that no interference between the different base stations exists.In this final work will be also considered that the BS are well designed and the frequency reuse is well planned. To sum up, the scenarios and the simulation program will consider that no interference is produced by the near antennas.
Because of this, only one antenna will be significant for these scenarios and only one antenna will be featured in these applications. Nevertheless, is important to consider that on a real application probably more than one antenna would be affecting to the system. All this scenarios will consider that the downlink communication has been possible and that all the users are inside the cover area.

4.2 Scenario 1:

4.2.1 Introduction

This scenario pretends to study an ideal situation that probably we will not find anywhere. Nevertheless this scenario allows to understand fading effects that are going to be characterized in the following scenarios. Furthermore, in this section no urban or rural attenuation will be applied. The attenuation in this case will only be affected by the distance.

4.2.2 Features

· Basic environment.
  -Number of circuits: 192
  -Attenuation using the expression 1.2.
· NO Fading effects (neither slow and fast fading effects)
· Transmitted power 29,54dBm.
· Noise Factor on the Receiver 0,7dB.
· Number of users connected to the same antenna that the main user 35.
· Total number of users 36.
· Average number of calls made at the time charged by all the users 100.
· Average time for each of these calls: 120s
· Kid distance to the antenna: 3500m
· Fixed probability of coverage: 95%
· Size X axis=3500m
· Size Y axis= 500m
· Users are distributed randomly and uniformly
· The situation will suppose that users do not move in the coverage area

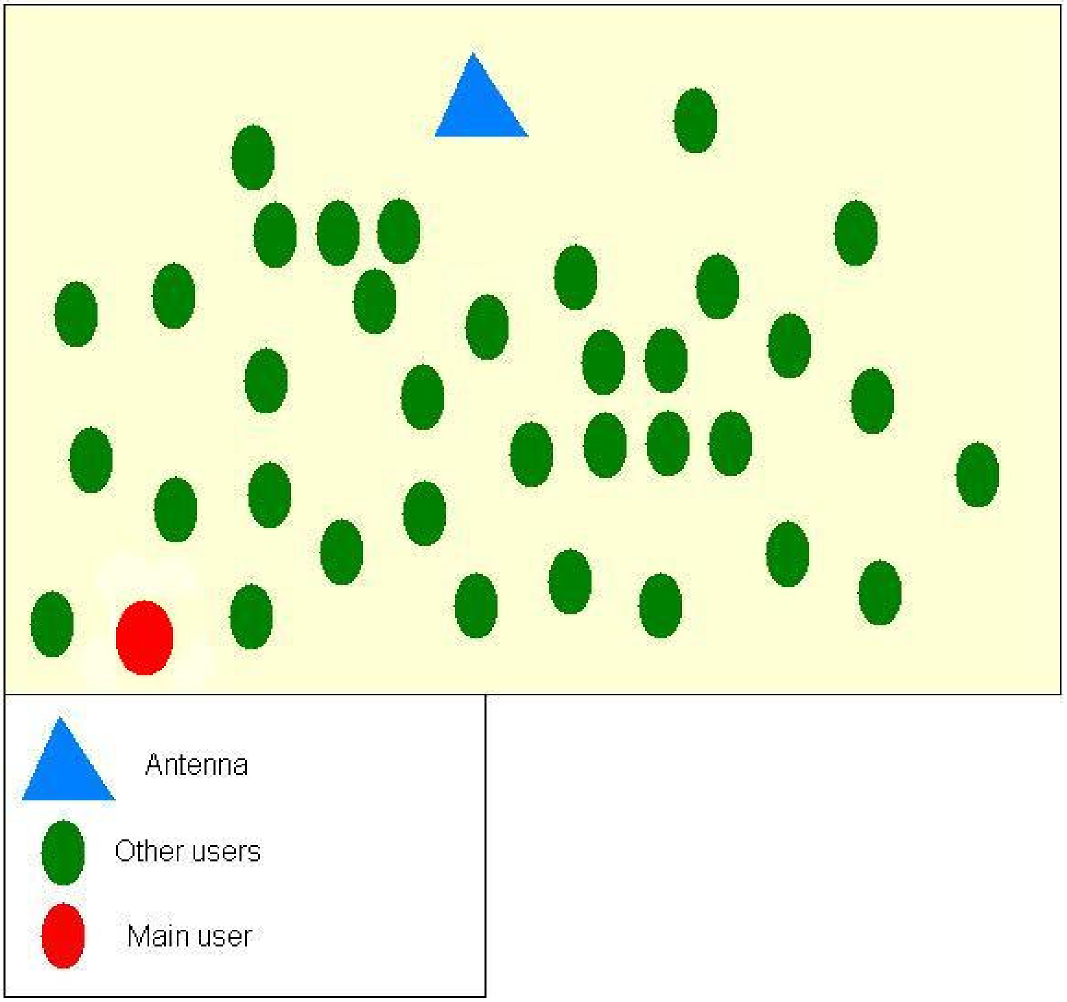


Fig. 4.1

4.3 Scenario 2:

4.3.1 Introduction

This scenario pretends to show probably a normal situation in a city like Oporto or any other big city. This system is so claimed on these environments because of the possibility of loosing a kid or kidnapping. The features described in this scenario pretend to be as realistic as possible.

4.3.2 Features

- City (urban) environment.
    - -Number of circuits: 192
    - -Attenuation using the expression 1.5.
- Fading effects (slow and fast fading effects)
- Transmitted power 29,54dBm.
- Noise Factor on the Receiver 0,7dB.
- Number of users connected to the same antenna that the main user 35.
- Total number of users 36.

· Average number of calls made at the time charged by all the users 100.
· Average time for each of these calls: 120s
· Kid distance to the antenna: 500m.
· Fixed probability of coverage: 95%
Size X axis=1000m
· Size Y axis= 250m
· Users are distributed randomly and uniformly.
· The situation will suppose that users do not move in the coverage area

In section 2.4.2 is shown the attenuation expression that will be used to make these calculations. This expression, which has been extracted empirically, is using the GSM/GPRS frequency (although there are three different bands, this final work will use a 900MHz frequency) and all the data extracted from the experiment explained on that section. In this case, because of the attenuation caused by the city environment, the area size is smaller (the received signal is decreased more rapidly than in the other ones).

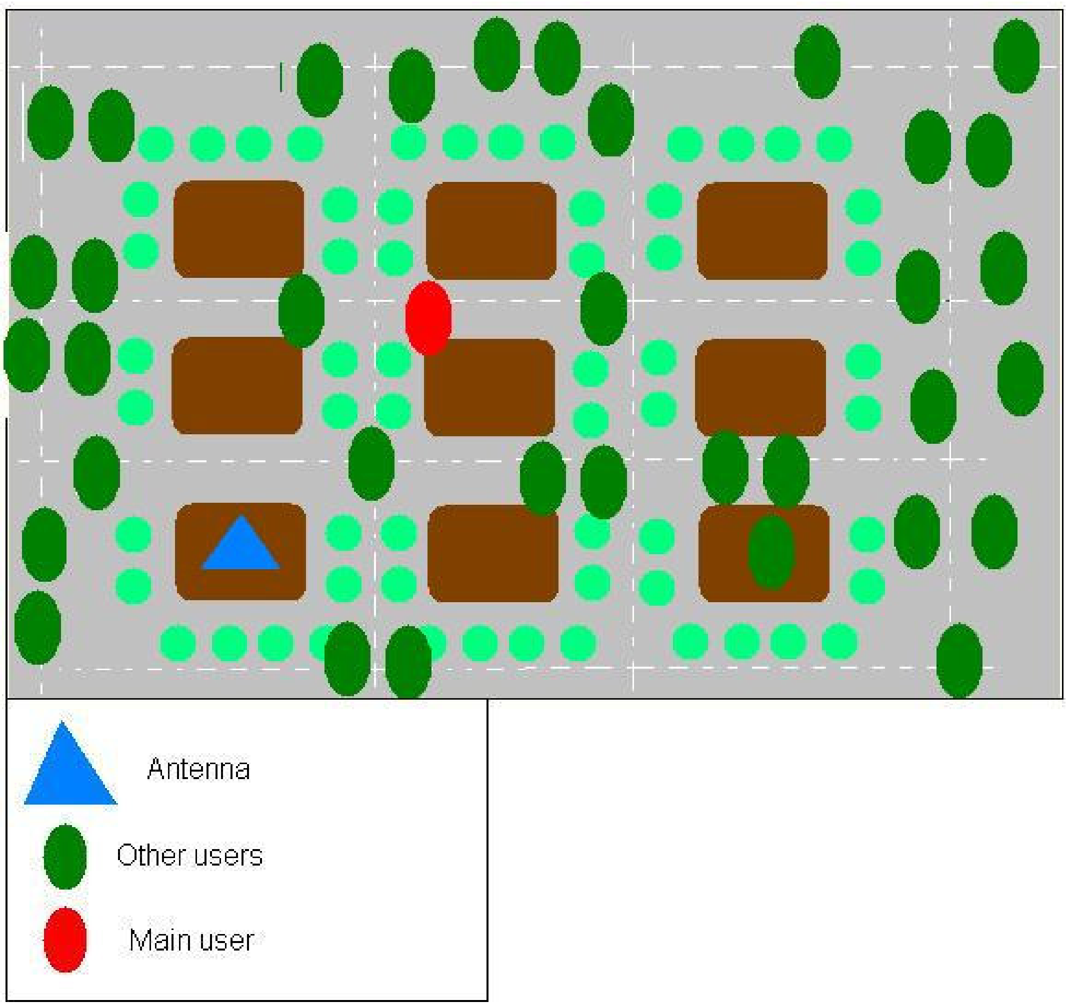


Fig. 4.2

4.4 Scenario 3:

4.4.1 Introduction

This scenario is related to a rural environment where the kid close to the countryside or living in a small village. In these places antennas use to be close from the villages because one antenna provides service to more than one village and the antenna is located between these villages.

4.4.2 Features

· Rural environment.
  -Number of circuits: 128
  -Attenuation using the expression 1.4.
· Fading effects (slow and fast fading effects)
· Transmitted power 29,54dBm.
· Noise Factor on the Receiver 0,7dB.
· Number of users connected to the same antenna that the main user 25.
· Total number of users 26.
· Average number of calls made at the time charged 50.
· Average time for each of these calls: 120s

· Kid distance to the antenna: 3500m
· Fixed probability of coverage: 95%
· Size X axis=3500m
· Size Y axis = 500m
· Users are distributed randomly and uniformly.
· The situation will suppose that users do not move in the coverage area

The attenuation expression is following the Okumura-Hata model explained in section2.4.3

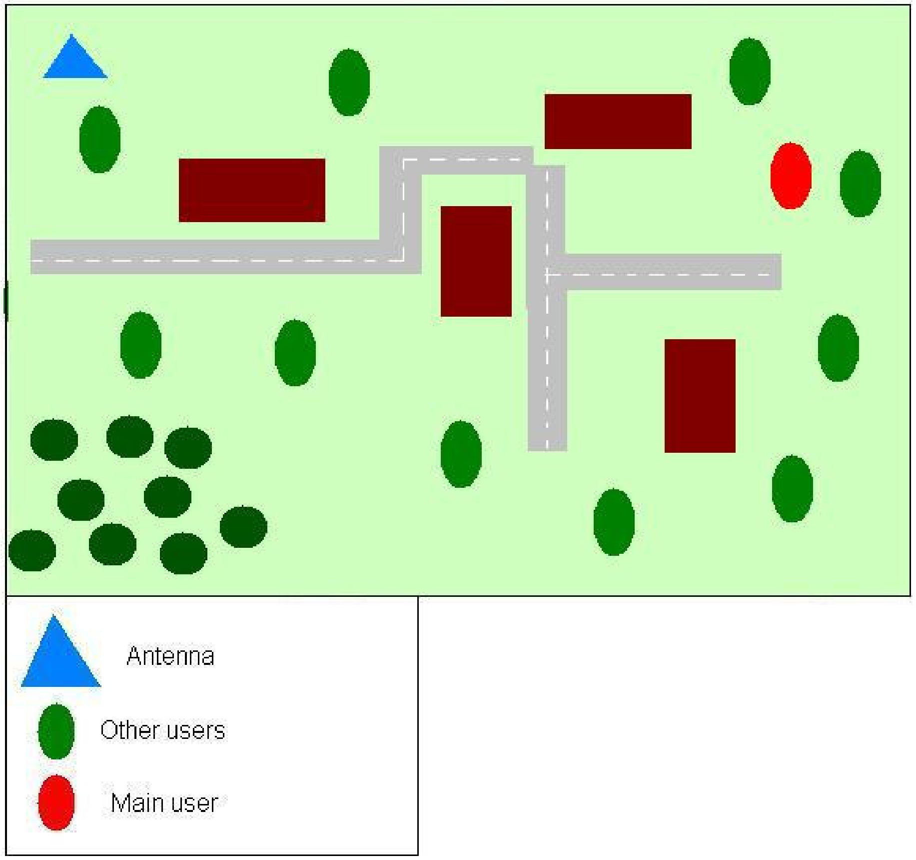


Fig. 4.3

CHAPTER 5. PERFORMANCE EVALUATION

5.1 Introduction

In this chapter will be calculated the received features for each scenario shown in chapter 3. To make this calculations the expressions, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9 and 2.10 will be used. The obtained results will be necessary to decide, for each situation, the necessity of the system. The accepted probability of coverage to start this communication is fixed to 95% (95% of the times the system must offer coverage for a given and acceptable received power). The transmitter and receiver gains are shown in table 2.2. This results will consider that the downlink communication has been possible (the users are placed inside the coverage area, as has been said in the previous chapter, chapter 4). Nevertheless a breaf view of the calculations on the downlink will be shown in this chaper in order to show an example of the situation (because of this, it is important to know that the treshold power that the mobile can receive to keep its funcitonality is -85dBm; it the recived power is lower than this value the receiver BS will not be able to 'understand' the message). This example will be shown on Scenario 2 because the antennas are further than on the other cases and the received power may be lower than in any other environment.

5.2 Scenario 1

Applying the Scenario 1 in the expressions referred in 4.1 the following results have been extracted:

Received Power: Prx (uplink)

To calculate the received power for this scenario the attenuation expression 2.3 will be used.

L=32,45+20logf+20logd

Where f=900MHz and d is 3500m.

Finally to calculate the received power is necessary to use the expression 2.1 and data obtained on table 2.2.

Prx= Ptx+Gtx+Grx-L

Where Ptx is 29.54dBm and, looking to table 2.3, in section 2.3 and 2.4, the following values have been extracted , Gtx= -3dB and Grx=9dB (table 2.2).

Prx=-37,33dBm

Bit Error Rate

To calculate the BER the expressions 2.6, 2.7 and 2.8 (from chapter 2) will be used. The result obtained on section 4.2 Prx wil be used too and the tables from chapter 2.

Pe=0,001→0,1%

GoS

The GoS is calculated like in 2.6.2 example (using the expressions from 2.6 section from chapter 2) and using the data from 4.2.

Number of circuits: 192
Number of users: 36
Average of calls: 100
Average of time for each call:120s

GoS=3,47%

Probability of Coverage and P_{th}

The probability of coverage will be fixed in 95% (or 0,95, taking a look on chapter 4 where this feature has been specified).To calculate the P_{th} value will be used the expression 2.10 and following the same steps than in examples 2.7.2.1 and 2.7.2.2 the following result has been obtained.

P_{th}=- -52,88dBm

5.2.1 Conclusions

Taking a look to these values but not considering that this scenario is not a real situation, we may say that this system would work ok for this place or scenario.
Considering that the receiver sensibility is close to -85dBm we can say undoubtedly that this received power is more than acceptable. More than this, we would say that the received power is higher than the probably expected power. Following the same way, the BER or the Error Probability, Pe, has an exceptional value. This is a logical result if we consider that no loss expressions are applied to this scenario, besides the expression 2.3,.With this result, we may suppose that no bit will be lost in this case. On the other hand, the GoS does not understand about received power neither transmitted. It does understand about the number of users and, in this case, the GoS has an acceptable value but not an excellent value. GoS=3,47% means that the 3,47% of the times that the kid needs to start a communication because he/she is on an emergency situation will not be able to make it. This is a high value related to an antenna city and probably to a city antenna users.
To sum up, we can say that this system would work fine for this scenario.

5.3 Scenario 2

Applying the Scenario 2 in the expressions referred before the following results have been extracted:

Received Power: Prx (uplink)

To calculate the received power for this scenario the attenuation expression 2.5 will be used.

33,41+29,09logd

Where d is 500m

Where f=900MHz and d is 3500m.

In this case, the fading effects are affecting to the system. This effects follow a Rayleigh distribution and a Lognormal distribution. The values used to calculate this effects are explained in section 2.4.1 and in **Fig.2.11**.

Finally to calculate the received power the expression 2.1 and data obtained on **Table 2.2**.

Prx= Ptx+Gtx+Grx-L

Where Ptx is 29.54dBm, Gtx= -3dB and Grx=9dB

Prx=-45,23dBm

Bit Error Rate

To calculate the BER the expressions 2.6, 2.7 and 2.8 (from chapter 2) will be used. The result obtained on section 5.2 Prx wil be used too and the tables 2.4 and 2.5 (from chapter 2).

Pe=0.032→3.2%

GoS

The GoS is calculated like in 2.6.2 example (using the expressions from 2.6 section from chapter 2) and using the data from 4.3.

Number of circuits: 192
Number of users: 36
Average of calls: 100
Average of time for each call:120s

GoS=3,47%

Probability of Coverage and P_{th}

The probability of coverage will be fixed in 95% (or 0,95, taking a look on chapter 4 where this feature has been specified).To calculate the P_{th} value will be used the expression 2.10 and following the same steps than in examples 2.7.2.1 and 2.7.2.2 the following result has been obtained.

P_{th}=- -60.85dBm

5.3.1 Conclusions

In this case, comparing with the previous one, the thing that we can realize about is the received power, it has decreased. Nevertheless, this value is an acceptable value for this situation. On the other hand, the error probability has been incremented if we compare with the scenario 1. As we would expect, these results are worse than the ones from Scenario 1 but this is a logical observation. In this case the attenuation follows the expression 2.5 and, as normal, 2.3 and because of this the results are worse. The GoS result is exactly the same than in scenario 1, because the GoS depends on the number of users, on the average of the number of calls on a full occupied hour and on the slots of the antenna (that allows to calculate the number of circuits of the system). Although this is a city antenna, the number of users calling at the same time affects to the system. In addition, the loss path used in this scenario makes the system to need more antennas because, the farther the user is, the less the received power is but we only have to take a look on to the kid distance to the antenna. It is 500m. On the other case, it was 3500m. Anyway and to sum up, we may say that this is an useful system that can be perfectly used on a city environment. This is not strange because the GPRS coverage is currently working fine in these environments. Cities are full of citizens who are used to have these comforts because when GPRS started, it started in cities and its more developed on them.

5.4 Scenario 3

Applying the Scenario 3 in the expressions referred before the following results have been extracted:

Example: calculations of the received power on the BS (downlink)
As has been introduce on the introduction of this chapter (chapter 5, section 5.1) in this Scenario will be shown a breaf example of the downlink necessary calculations in order to check out that the received power on the BS is sufficiently to start the communication:

To calculate the received power for this scenario the attenuation expression 2.5 will be used.

$$69{,}55 + 26{,}16 \log f - 13{,}82 h_b - ((1.1 \log f - 0.7) h_m - (1.56 \log f - 0{,}8)) + (44{,}9 - 6{,}55 \log(h_b) \log d$$

Where d is 3500m, h_b is 16m, h_m is 1.65m and f is 900MHz

In this case, like in 5.3, the fading effects are affecting to the system. This effects follow a Rayleigh distribution and a Lognormal distribution. The values used to calculate this effects are explained in section 2.4.1 and in **Fig.2.11**
Finally to calculate the received power the expression 2.1 and data obtained on table 2.3. In this case the BS introduces losses because of its internal connectors and circuits: L_{BS}=5,7dB (shown in table 2.2). The final attenuation will be the BS attenuation+ the attenuation caused by the environment described on chapter 4.4.

Prx= Ptx+Gtx+Grx-L

Where Ptx is 38dBm, Gtx= 14dB and Grx=-3dB

Prx=-82,33dBm

This result shows that the downlink communication is possible on this environment.

Received Power: Prx (uplink)
To calculate the received power for this scenario the attenuation expression 2.5 will be used.

$$69{,}55 + 26{,}16 \log f - 13{,}82 h_b - ((1.1 \log f - 0.7) h_m - (1.56 \log f - 0{,}8)) + (44{,}9 - 6{,}55 \log(h_b) \log d$$

Where d is 3500m, h_b is 16m, h_m is 1.65m and f is 900MHz

In this case, like in 5.3, the fading effects are affecting to the system. This effects follow a Rayleigh distribution and a Lognormal distribution. The values used to calculate this effects are explained in section 2.4.1 and in **Fig.2.11**
Finally to calculate the received power the expression 2.1 and data obtained on table 2.3.

Prx= Ptx+Gtx+Grx-L

Where Ptx is 29.54dBm, Gtx= -3dB and Grx=9dB

Prx=-81,95dBm

Bit Error Rate

To calculate the BER the expressions 2.6, 2.7 and 2.8 (from chapter 2) will be used. The result obtained on section 5.2 Prx wil be used too and the tables 2.4 and 2.5 (from chapter 2).

Pe=0,173→17,3%

GoS

The GoS is calculated like in 2.6.2 example (using the expressions from 2.6 section from chapter 2) and using the data from 4.4.

Number of circuits: 128
Number of users: 26
Average of calls: 50
Average of time for each call:120s

GoS=0,0%

Probability of Coverage and P_{th}

The probability of coverage will be fixed in 95% (or 0,95, taking a look on chapter 4 where this feature has been specified). To calculate the P_{th} value will be used the expression 2.10 and following the same steps than in examples 2.7.2.1 and 2.7.2.2 the following result has been obtained.

P_{th}=- -97,50dBm

5.4.1 Conclusions

Taking a look on the received power is obvious that the received power is close to the minimum value it can have to make the communication. Because of this, the error probability grows and reaches this value that hadn’t reached before. Anyway, this is an acceptable value that the system can use and can establish a communication (for Pe higher than 25% the system has difficulties to work but not for this value). We also have to take a look on to the distance between the antenna and the kid. This is a normal distance for rural environments where antennas are scarce. On the other hand, in these environments the number of users related to an antenna is low and because of this, the GoS acquires this value. For this scenario this system would probably work but not as fine as in the other cases.

5.6 Conclusions

For every scenario have been calculated the most important features that are summarized on the following table (Table 5.1).

	P_{rx}	P_e	GoS	P_{th}
Scenario 1	**-37,33dBm**	**0,1%**	**3,47%**	**-52,88dBm**
Scenario 2	**-45,23dBm**	**3,2%**	**3,47%**	**-60,82dBm**
Scenario 3	**-81,95dBm**	**17,3%**	**0,0%**	**-97,50dBm**

Table 5.1

The system can be useful at any of these environments. All the analyzed parameters are acceptable values and the results are probably the expected ones. Nevertheless ,after watching these coverage map (from chapter 1) the conclusion that can be extracted is that Movistar offers a greater coverage service in the whole country. The GPS+GPRS system needs to work coverage and if someone wants to use a cell phone as a GPS+GPRS locator, probably the best choice would be Movistar

This chapter is useful to understand the utility of this system in Spain. Although the simulation program has not used all the GPRS features (in some cases it has used the GSM features and in other the shared features between GSM and GPRS ones) and in this work has not been explained anything about GPRS service before, is useful to know the GPRS situation to understand or to decide whether the system purposed in this work is useful. This final work has been using the GSM expressions because some of the GSM features are similar to GPRS ones (like the reusing frequencies, the frequency work, the antennas features…).

CHAPTER 6. WORK DIFFICULTIES

This project has been made during the last months and from the initial idea until this result many difficulties have been found. In the following table there is a brief view of the job made month by month.

Month	Work Done
March	-The initial idea has been thought. Now I'm trying to organize the ideas and the work I want to do. I prepare a document that allows me to identificate all the parts that the final work must have. -I start the information research.
April	-The information research goes on and I start writing the base of the memory document- -I start the simulation program programmation. First of all, taking Java manuals and Java notes.
May	-The program is being created but there are many difficulties. I don't understand why but some graphs are exactly the opposite from what they have to be. Some methods does not work. Nevertheless the implementation works and I understand how to make many Java utilities.
June	-Although there are still some problems with the graphics now they look the way they have to look. -The memory goes on (adding more research information and the expressions used on the program)
July	-I prepare the first diagram of the program. It shows the structure I am following and I find some problems on it (because of the future methods that I was going to add). I change something from the structure.
August	-Altough there are more implementations I want to add to the program I do not know the expressions I have to use to prepare them. The program is stopped until september. -I add more sections to the memory but it has not the final aspect yet.
September	-After getting all the expressions I have to implement on the program I finish the simulation program. I have many problems with the GoS implementation because I do not know how to use big variables (I cannot use the 'double' neither the 'big decimal' type because the program does not run but with the float the variables are too big, a factorial number is too big; finally I find the way to use the 'double' type and the program runs).
October	-I prepare the flux diagrams and some other information for the memory and finally the memory is finished. -I find some details in the program that I do not like the way

they look and I change them. The program is ready.

Table 6.1
This is the job made month by month and the most significant difficulties found. The following figures show some of the comments made in the previous table, **Table 6.1.**

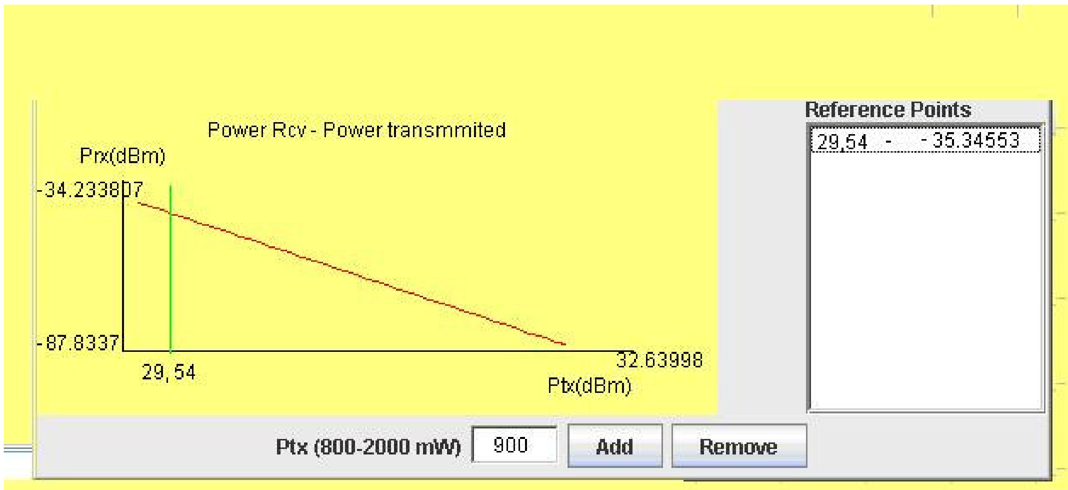


Fig.6.1

There was an error in this graphic. The line must have the opposite pending. The problem was with the representation but not with the used expression. The representation method was receiving the variables with a non correct order and the final result looked like this. At the beginning the program has a yellow fund but I decided to change it because I found it aggressive to watch.

CONCLUSIONS

The final view after studying this system is that the presented system allows parents to find the kid whenever the kid feels on a dangerous situation. Parents only have to provide to the kid a cell phone provided with a GPS locator. This cell phone must be connected to the emergency system and whenever the kid feels like pressing the emergency button.

In this chapter I pretend to explain the final conclusions extracted from this final work. Nevertheless in every chapter are conclusions that try to sum up the most important concepts extracted from each of them that are not going to be summarized again on this chapter.
The simulation program made in this final work is a tool that allows to create any scenario to find out the utility of the system for each environment. The most representative environments have been shown in chapter 4 Every scenario has been thought to create it as real as possible and as representative as possible

in order to obtain the most useful data: the received power, the BER, the GoS and the P_{th}.
Every chapter and section from this final work has been necessary to explain the tool and to understand how this system is. All the examples have tried to be useful to understand the concepts raised before although they were not always showing an specifically GPS-GSM system feature.

Chapter 5 probably is the one which can be the most useful to understand the necessity of this system on an specific environment. As is written on it, it pretends to show the utility of the system and the conclusions extracted on it are:

-Considering a GPS global coverage (this means that the GPS receiver will not have problems anywhere and the signal will be received on any environment) the system needs a GSM network providing working at the specific area. If the system has not this GSM network available the system will have difficulties to work.The system also needs an specific probability of coverage. For this application this probability have been fixed on 95%.

-And, finally, the application also needs an specific GoS (which have been fixed to 5%) to work. If all of these conditions can be accomplished the system will work.

Looking at the proposed scenarios, which have been thought in order to be useful and relevant environments, the system seems to be an useful for the most common situations.

BIBLIOGRAPHY

The following books, notes and web sites have been used while creating this memory and making this final work.

Books:

[1]PRINCIPIOS DE COMUNICACIONES MÓVILES. Authors: Agustí Comes, Ramon;Sallent Roig, Oriol;Valenzuela González, José Luis; Ed. UPC. 2003
[2]COMUNICACIONES MÓVILES. Authors: Gorricho Moreno, Juan Luis;Gorricho Moreno, Mónica. Ed. UPC. 2002
[3] J2ME. JAVA 2 MICRO EDITION. MANUAL DE USUARIO Y TUTORIAL. Agustín Froufe Quintas; Patricia Jorge Cárdenas. Ed. Rama. 12/2003

Notes:

[1]Televés. Yagi Professional TMA 900. Ref. 6576.
[2]Radiofrequency attenuation in urban environments: Observed behaviour of the GSM band in Oporto. J.P.Carmo. Polytechnic Institute of Braganca. Campus de Santa Apolónia.
[3]Redes y Servicios Móviles GSM y GPRS. Ángela Hernández. Profesora de Ingeniería Telemática. Departamento de Ingeniería Electrónica y Comunicaciones.
[4]Sistemas de Comunicaciones Móviles. Tema I, II, III and Colecció de Problemes. EPSC. QP2006.

Web Sites:

[1] http://translate.google.com/translate_t?langpair=es|en
[2] http://es.wikipedia.org/wiki/Sistema_de_posicionamiento_global
[3] http://es.wikipedia.org/wiki/General_Packet_Radio_Service
[4] http://en.wikipedia.org/wiki/Grade_of_service
[5] http://npt.cc.rsu.ru/user/wanderer/ODP/Erlang_tutorial.html
[6] http://math2.org/math/integrals/es-specialfuns.htm
[7] http://gl.wikipedia.org/wiki/Distribuci%C3%B3n_normal
[8] http://www.gsmworld.com/index.shtml
[9]www. televes.es
[10] http://es.wikipedia.org/wiki/Lenguaje_de_programaci%C3%B3n_Java
[11] http://es.wikipedia.org/wiki/M%C3%A1quina_virtual
[12] http://www.netbeans.org/

Escola Politècnica Superior de Castelldefels

UNIVERSITAT POLITÈCNICA DE CATALUNYA

ANNEXOS

TÍTOL DEL TFC/PFC: GPS GPRS System for kids location

TITULACIÓ: Enginyeria Tècnica de Telecomunicació esp. Sistemes de Telecomunicació

AUTOR: Natividad Márquez Nicuesa

DIRECTOR: Luis G. Alonso Zárate

DATA: 17 de Desembre de 2007

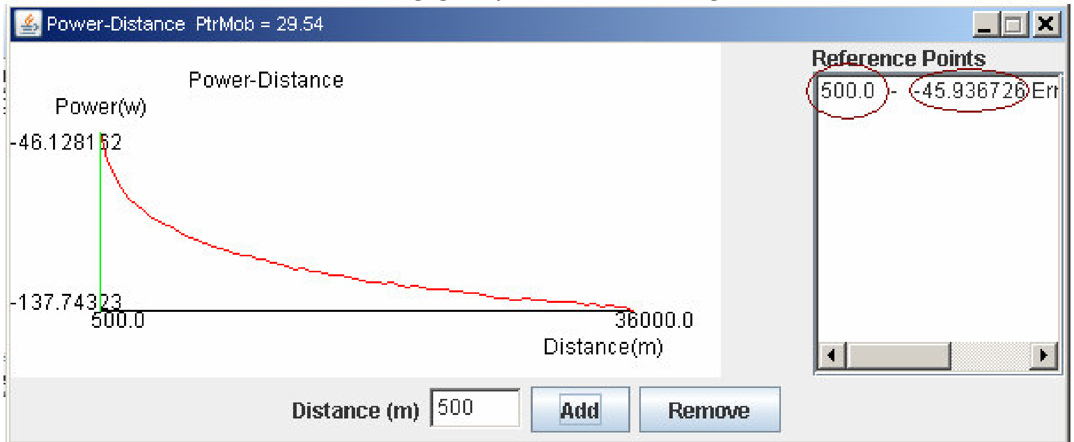
Annex 1: Results for Scenario 2

Introduction

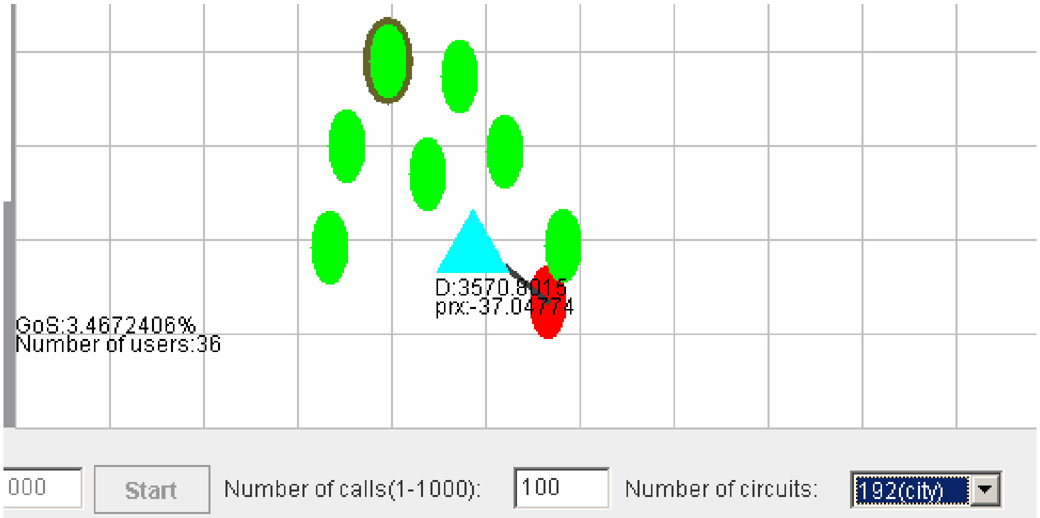
This annex shows some of the results generated by the simulation program. In the following graphs we can see the results obtained from the simulation program created for this final work. This graphs allow to understand many of the concepts explained during the work memory. The graphs have been generated using the executable file from the program.

Graphics generated

For the Scenario 2 the following grahpics have been generated:



In this graphic are marked two points: the distance (500m looking in chapter 4.3) and the received power. Comparing with the results obtained in chapter 5.3 this received power is lower this is because the program calculates this value using the fading effects: following the lognormal distribution and the rayleigh one. The final value is aleatory following the mentioned distributions. Because of this, for the same scenario we can obtain different values. Anyway, this value is 'inside' of the threshold power (it was close to -60dBm). Although the graphic does not seem to show the fading effects it does. What makes to think that the graphic is not showing the fading effects is the screen resolution. This resolution is lower than what it would have to be and the graphic view seems to be wrong; nevertheless, the difference between the results, which are calculated following the lognormal and rayleigh distribution and taking aleatory values, show that the program is really using the correct expressions. At the right side of this graphic is shown the BER result: 0.0351 (3,51%). The BER has increased comparing with the BER obtained in 4.3 and this is because of the received power.



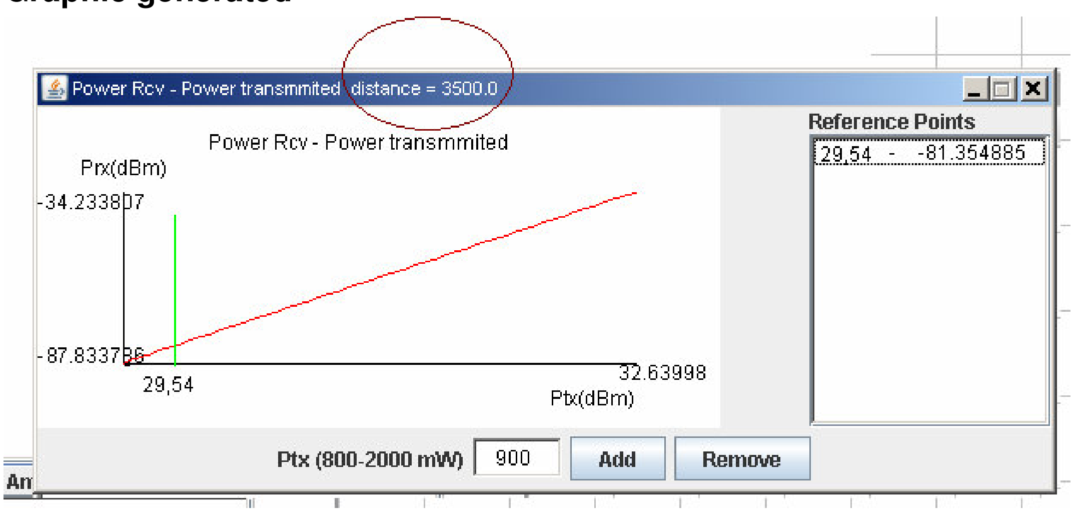
Finally, in this picture is shown the GoS of the system. The result, as expected, must be the same than in 4.3 because the GoS does not depend on any aleatory characteristics. Looking at expression 1.9 we can realise about this: the GoS depends on the number of circuits (192 in this scenario), the number of users (36 in this scenario), the number of calls (100 for this scenario). The program also shows the received power(in this case the features have not been programmed and this result is not showing the result for this scenario).

Annex 2: Results for Scenario 3

Introduction

In this section, the shown graphic will be the received power-transmitted power. The graphic path is the expected path. Nevertheless, as has been explained in chapter 6, the first result did not look like this final one.
For the scenario 3 will be shown the received power-transmitted power while fixing a distance.

Graphic generated



Looking at this graph we can see that the obtained result is the expected one: the received power is similar to the obtained in 5.4.

This graphic is not a useful graphic, it has only been generated to study how the system works featuring it in many ways. This is not an important graphic but gives the confirmation that the study is well done.