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Proyecto de final de carrera:

Study of Localization in Spain

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Sommario

Introduction

The objective of the analysis is the study of the trend of logistic curve of location services, from data expressed as Hits / month, provided by the Spanish company Genasys.

Genasys is a leading provider of location services for mobile devices and solutions for the management of geographic data.

The company's main customers are telephone operators located in Spain, such as Vodafone and Telefonica.

It 'been through analysis of the data held and the functions that generated them.

The analysis is divided into six chapters.

The *first chapter* describes the location services provided by major mobile operators in Spain. Operators that are considered specifically are Movistar, Orange and Vodafone. For each of these was drawn up a description of its characteristics and location solutions available to customers. The *second chapter* describes the Genasys company that offers location services to mobile operators in Spain and worldwide. It also shows the data expressed as Hits / month, which are related to location services company Genasys. These data represent the starting point of our analysis.

In the *third chapter* are applied to real data in our possession, methods of prediction such as linear regression, Moving Averages, Simple Exponential Smoothing, Holt's Method. By evaluating the mean square error and using the Chi-square test, we found the method that provides the best estimate from the standard input data related to location services for Genasys.

In this chapter we also implement the ARMA, ARCH and GARCH models in order to understand what is the model that generated the data.

1 Telephone operators in Spain

In this chapter we will first give an overview on the main operators in Spain. The information which will be discussed will be:

- general characteristics of each operator
- location services provided by each mobile operator to its customers.

The companies that we are going to analyze are: Telefonica Movistar, Orange and Vodafone.

1.1 Movistar Telefonica

Movistar is a major mobile phone operator owned by Telefónica Móviles. It operates in Spain and in many Latin American countries. Many Movistar networks were acquired from BellSouth Corporation, who is an American telecommunications holding company based in Atlanta, Georgia. The Movistar name has been in use in Spain since the launch of GSM services in 1995. After purchasing BellSouth mobile operations branch in South America, the name became effective worldwide on April 5, 2005. After the purchase of O_2[1] in 2005 by Telefónica S.A., the company announced that the O_2 brand would continue to be used in the UK, Germany and the Republic of Ireland, as a separate branch with its own board and management structure.

It is the biggest carrier in Spain with 22 million customers (cellphone services only) and it also has the widest coverage in Spain.

It offers GSM 900/1800 MHz (2G), UMTS 2100 MHz (3G) and HSDPA (3.5G) services.

Countries where Telefónica Móviles operates wireless networks under the Movistar brand

- Argentina (formerly Telefónica Unifón and Movicom BellSouth)
- Chile (formerly Telefónica Móvil and BellSouth)
- Colombia (formerly BellSouth)
- Ecuador (formerly BellSouth)
- El Salvador (Formerly Telefónica Móviles or Telefonica MoviStar)
- Guatemala (formerly Telefónica MoviStar and BellSouth)
- Mexico (formerly Cedetel, Bajacel, Movitel, Norcel and Pegaso)
- Nicaragua (formerly BellSouth)

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[1] Telefónica O2 U.K. Limited (previously Cellnet Limited and BT Cellnet Limited and branded as O2) is the second largest provider of broadband internet access and telecommunications in the United Kingdom. Its national headquarters are located in Berkshire and it is a privately owned subsidiary of Telefónica.

- Panama (formerly BellSouth)
- Peru (formerly Telefónica Móviles and BellSouth)
- Spain (formerly Telefónica MoviStar)
- Uruguay (formerly Movicom)
- Venezuela (formerly Telcel BellSouth)

Countries where Telefónica Móviles has networks under other brands

- Brazil (formerly under Movistar in some places, now under the Vivo brand through a joint venture with Portugal Telecom)
- Morocco (under Meditel Telecom brand) brand through a joint venture with Portugal Telecom, BMCE Bank and others

Countries where Telefónica has networks under other brands

- Czech Republic (under the O_2 brand)
- Slovakia (under the O_2 brand)
- Germany (under the O_2 brand)
- Republic of Ireland (under the O_2 brand)
- United Kingdom (under the O_2 brand)
- Isle of Man (under the Manx Telecom brand)

1.1.1 Movistar and Localization

The operator Movistar offers two general types of location:
- ✓ GSM location (by cell)
- ✓ GPS Location (AVL or Automatic Vehicle Tracking)

1.1.2 GSM location (by cell)

Location is the possibility of knowing the location of the mobile phone company by sending a text message.

This service uses positioning technology based on GSM cellular networks. This location is done by taking as a reference the location of radio base on which is the phone at the time be located. The motive may find indoor, outdoor. Location service can be used from Movistar or from a PC.

Location solutions are used to:

- Logistic Companies
- vehicle and people tracking
- Control of goods or objects
- Handling of courier services
- Security
- Utilities

1.1.3 GPS Location (AVL or Automatic Vehicle Tracking)

It allows geographical positioning of mobile assets such as objects and / or individuals. The location is acquired through satellites that provide GPS (Global Positioning System) service.
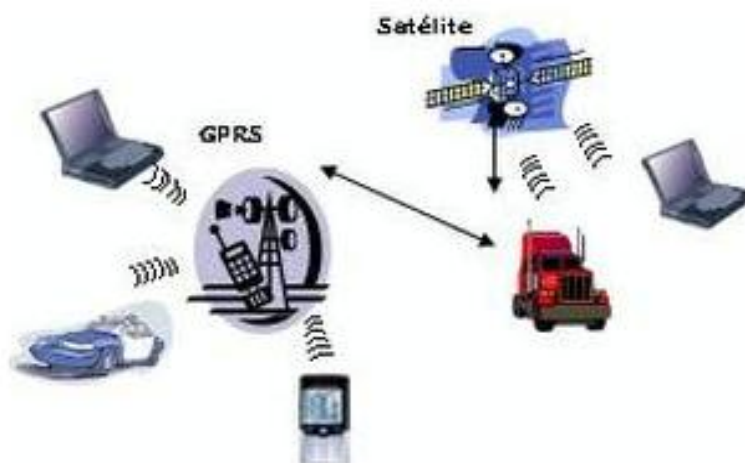
The GPS receiver interprets signals from these satellites and deliver the latitude and longitude coordinates to a specific hardware send this information through the cellular network to Movistar data to a central server where these coordinates are represented in a mapping system.

Application Type:

• Distribution and Logistics Solutions

This solution is used for fleets with advanced logistics requirements such as:

    - Fleet Management.

    - Location of mobile assets on a map.

    - Localization for logistics or security work.

    - Route planning for groups of mobile assets.

    - Calculation of optimal routes.

    - Alarms and diversions routes.

    - Dynamic Roadmaps.

    - Geomarketing

• Fleet Management "A.S.P."

Lets get the location of a fleet on a digital map, accessing it via the Internet.

• Fleet Management In-House "

Lets get the location of a fleet on a digital map, installed in your central monitoring station.

Both types of Fleet Management may carry out:

    • Records of events: opening doors, detention of vehicle yaw

     route, panic button, release.

    • Delivery of action: opening of the van, fuel cut.

    • Analysis of information: routes, delivery, speed limits,

     mileage, downtime.

Advantages:

    • Reduced costs.

    • Increased Security.

• Reduction of errors.

• Control of resources.

1.1.4 Range of localization services

The operator Movistar offers a wide range of localization services to its customers.

- *Movistar Fleet Location*

  Fleet Location Movistar will have all the information of the vehicle without being in it, only to access the service from any PC with Internet. Giving us a high level of control and safety on the fleet. The service is very simple and intuitive, you do not need any technical knowledge to manage, plus it has options for all commands support and telephone support and information 24 hours a day 365 days a year.

- *GPS personal navigator*

  "Your mobile is now also your co-pilot". By voice instructions and moving maps, your phone will indicate the route you should follow to reach the destination you choose, the best route in the fastest time. You can pre-plan trips and create list of favorite locations, POIs, etc.In addition to guide you, the service will give information on current speed, average maximum, distance and travel, weather.

- *Portable Location Movistar*

  This innovative service allows localized to a person or an object with a small GPS. The position, course and other features can be seen both from a PC with internet, or from a cell phone Smartphonebe able to access historical data or real time, and set up alerts via email or SMS. Configurable alerts, apply to entry and / or exit from an area, excessive speed, motion and low battery.

  When purchasing a user service delivery manager, with which you can create other users with visibility into a select group of devices to distribute in different sectors of the company. The technology used is GPS positioning, taking as reference the location of different satellites and triangulation to determine the position of the track team.

1.1.5 Movistar España

LOCALÍZAME[2] is a location service that shows your approximate position or the position of others Movistar's users, without the use of additional devices for wireless equipment. This service is available for all GSM Movistar with SMS services.

You can access the service through two interfaces that offer different features: SMS and web.

The location is given by a text or phrase that indicates the approximate position of the user through the street that is, town and zip code and others with a margin of error that can vary from 200 meters to 5 kilometers town in rural areas . It can be used anywhere in Spain whenever the phone is switched on and within range.

Localízame offers the following options:

- You can find and be found by people who define.

- To locate a person it will need to give you permission.

- You can set a schedule to be located.

- You can activate or deactivate at any time going from one state to another easily.

Only Movistar customer can now use this service. Its availability is immediate.

- Main Page: Free for the first 30 sec. And 0.25 euros per minute thereafter

- Locate person: $ 0.30 (premium content)

- Trip: 6 locations during the defined period of 3.6, or 12 hours at $ 0.45 / location

Every mobile phone user is located at any time via GSM antennas or via GPS satellite. Telephone operators Movistar, Amena and Vodafone are already offering the service to locate mobile users. The service "Localizame" allows to know the position of mobiles that allow and facilitate our position to other phones.

1.2 Orange

France Telecom España S.A., more commonly known by its trade name Orange España, is a mobile network operator in Spain. It was previously known as Amena until 2005, when it was bought by France Télécom. France Telecom Orange is a major global player in the mobile, fixed and Internet markets. With consumer businesses in 32 countries, Orange is the number three mobile operator and

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[2]Page Web: http://www.movil.movistar.es/media/descargas/localizacion/ManualUsuarioClienteSymbian.pdf

number two provider of broadband Internet services in Europe. It is also a leader in emerging markets, particularly in Africa, where the brand is experiencing sustained growth. Under the Orange Business Services brand, the Group is a global leader in telecommunications services for multinational companies.

Orange España is the third mobile phone provider of the four Spanish providers (Movistar, Vodafone, Orange and Yoigo). In fact, its competitors are Movistar, Vodafone Spain and Yoigo. Its legal headquarters are in Pozuelo deAlarcon, near Madrid. The company has 11 million customers and offers TV internet, television and mobile services in the majority of countries where the Group operates.

Orange offers GSM 900/1800 MHz (2G), UMTS 2.1 GHz (3G) services and HSDPA (3.5G) services. Its network radio access serves to the following Mobile Virtual network Operators (MVNOs, or "Operador Móvil Virtual" in Spanish): MasMovil, Happy Móvil, Carrefour Móvil, Jazztel Movil, Día Móvil and Simyo.

1.2.1 Location

The Orange Location API (Application Programming Interface) will allow you to query the Orange network to establish the location of a subscriber's handset. Location-based technology can be used to contextualise and enhance SMS, wap, voice, MMS and video services to make them more relevant to the user.

The service can be used for telemetry and handset positioning, as well as permission-based location targeting for marketing applications.

Orange will provide an application interface for your service to query the location of an Orange subscriber.

When the user requests your service, your application logs the MSISDN, Mobile Station International Subscriber Directory Number. MSISDN is a number used to identify a mobile phone number internationally. It is defined by the E.164 numbering plan. This number includes a country code and a National Destination Code which identifies the subscriber's operator.

Orange supplies you with the user's location and provides the user with location-contextualised content.

1.2.1.1 Location API - Geolocalization in mobiles devices

The location API allows a mobile device to be geolocated directly from application and the mobile device owner's autorisation is necessary for each geolocation request.

This API is compatible with any mobile device and returns the GPS coordinates of the mobile device.

Some applications are:

- Organise events in real time

- meetings

- assistance in the event of problems

- improve the performance of existing services.

The Location API is a web service which allows mobile devices to be geolocated. This service exposes a REST-RPC style interface and the request can be made using GET and POST methods in HTTP or HTTPS mode.

1.2.2 Informations about Orange Location API Based Service Interface

How do Location based services work: when you "ping" a phone via our Orange Location API service, we request the phones last known location from the Orange network. This is returned to Orange as a Latitude / Longitude fix along with a degree of accuracy. This information is then available on a secure web based mapping application, or can be relayed via the Internet to another corporate application.

Kind of devices can be located: Any kind of Device can be located as long as it has a Orange UK Sim card in it. This includes Mobile phones, Data collecting device, Tracking devices etc.

Accuracy of the service: the networks determine the phones position relative to two or more phone cells. The greater the cell density the greater the accuracy. Within an urban area accuracy can be within 100-200m whereas in a remote area accuracy is measured in km's.

Safeguards to protect people's privacy: RingTrack ensures that its LBS customers are compliant with all necessary regulation. The networks own checks are also very stringent to ensure that the service cannot be abused.

What happens if the phone is inside a building?: This makes no difference, because the "ping" does not contact the phone itself it does not matter if the phone is inside.

What happens if the phone is switched off?: The response differs by network. Some return no fix whereas others return the last known position. The Orange system remembers the last known position and this passed back in response to the request.

Payment options: Subject to status, we offer Location API plan customers account terms with payment by Credit Card,BACS,cheque or Direct Debit.

How Does it Work?: After submitting a request to locate a certain mobile number, the Orange location platform provide a result that contains X, Y and Z values. The X and Y are coordinates and the Z value is a radius in metres from point represented by the X and Y. The size of the area depends on the size of the cell, which tends to be smaller in urban areas and larger in less densely populated areas. If you are hosting your own application, The RingTrack Location API can then return the X, Y and Z coordinates to you via the Internet using our simple interface.

Sort of Location Applications: Potential Location applications cover nearly every attractive wireless demographic market, including: parents, teenagers, singles, students, online communities and businesses. Certain businesses depend heavily on mobile voice and/or data communications to operate, such as companies with significant numbers of field employees, and businesses dependent on knowing the location of their assets at any moment, such as transportation by heavy goods vehicles and rail. Beyond this, LBS applications cover nearly every aspect related to human mobility: Convenience, Entertainment, Health/Security/Emergency, Navigation, Travel Aids and so on.

Categories of Location Based Services:

- "Passive" or "Push" Services - "Passive" or "Push" services are those where a user may consent to have their location requested by the service multiple times by the application or by another user following only one demand. For example a user may subscribe to a "Find My Family" type service, where they give consent to have their location requested on an ad hoc basis in order to be located when somebody else (e.g. a permitted member of their family) wishes.

- "White List" Services and "White Label Map" services - "White List" services are generally business applications where the owner or administrator of a batch of mobile handsets gives consent for multiple, ad hoc location requests on that batch. Example applications are sales force location or asset tracking. Proof of authority over the list of mobile numbers will be required.
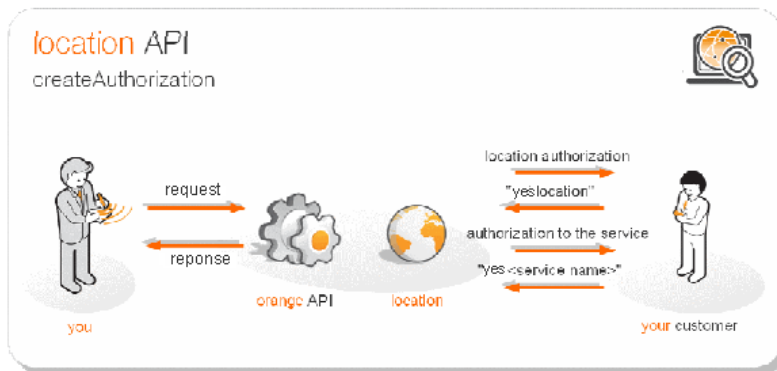
There are two stages involved in using the API:
- authorisation (for your service and for the platform)
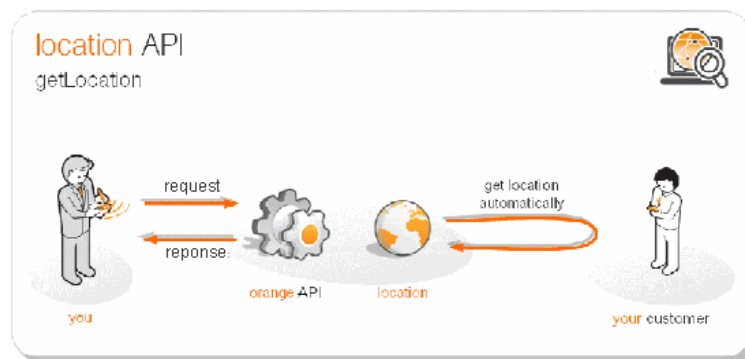
- the actual location request

Methods

1. **createAuthorization**: retrieve the user's authorisation to be located

2. **getLocation**: locate the mobile. In fact this method returns the GPS coordinates of the mobile.

1.2 SMS API- send and receive sms in the world

This API is used to create own SMS application. This could be a new web application or a component which could be integrated into your existing IT systems.

Using the SMS API you can:

- send SMS in push mode.

- create an interactive SMS service.

- use this API to bill your clients. Special short codes could be used for tax purposes.

This API is not exclusively available for Orange customers. It can be used by anyone.

Some applications are:

- improving business to client relationships
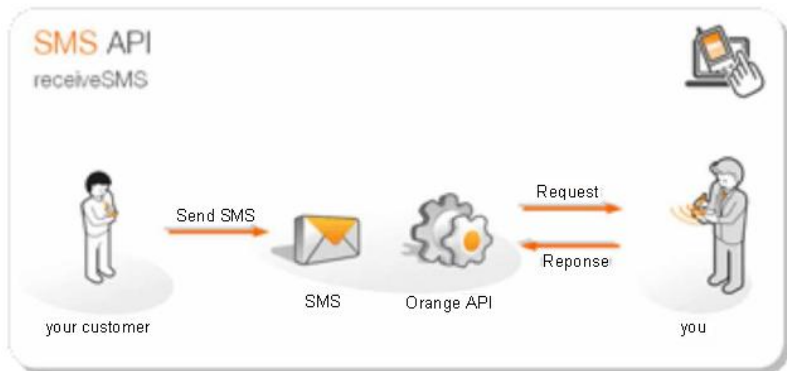
- more interactive meeting tool.

The SMS API is a web service for sending and receiving text messages (maximum 160 characters). The requests use GET or POST in HTTP or HTTPS mode and the service exposes a REST-RPC style interface.

Methods

1. **sendSMS**: send SMS to a mobile using HTTP request
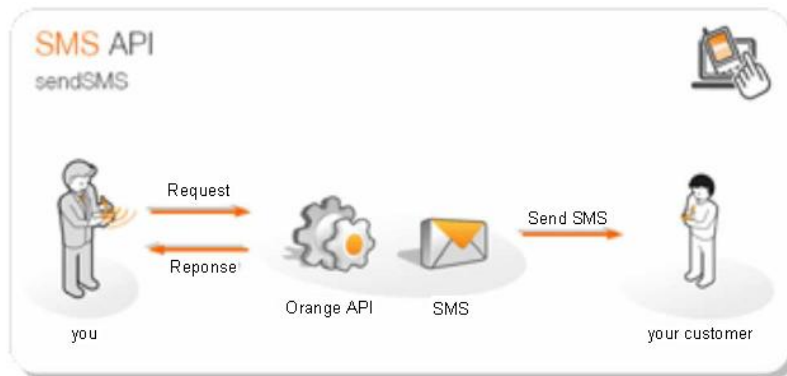
2. **receiveSMS**

You will need to specify a few configurations under the my account tab before using the receiveSMS method. These include:

- Your keywords (upto 5), which are used to redirect the SMS you receive to your application.
- The SMS and MMS keywords are shared.

Reception mode: email, to a URL (script), or both.

By e-mail

Once you have registered your e-mail address the receiveSMS method will forward the SMS directly to your inbox in this form:

```
From: apache@orange.es
To: email address
Date: Wednesday 01/07/09 18:34
Subject: Sms from [mobile number] to [short code] on 2009-07-01 16:34:09.733?

[keyword + body of the message]
```

Through a URL

Once you have registered the URL of your script, the receiveSMS method will forward the SMS to that URL using an HTTP GET request.

The SMS sent using a mobile phone should be in the following format:

- your keyword (example: orange)

- a space or a new line

- the body of the SMS.

Email API- *send and receive e-mails through your website or application*

This API is used to create own email application on the Web or for integration into your IT systems. Using the e-mail API you can:

- send and receive emails

- manage your inbox

- count and list your emails

The API is not reserved exclusively for Orange customers but it could be used by anyone.

Some applications are:

- send emails from a business application

- combine the email API with the SMS API to stay in closer contact with your customers.

The email API is a web service which allows you to send and receive emails. Orange provides you with a 500 MB. The requests use GET or POST in HTTP or HTTPS mode and the service exposes a REST-RPC style interface.
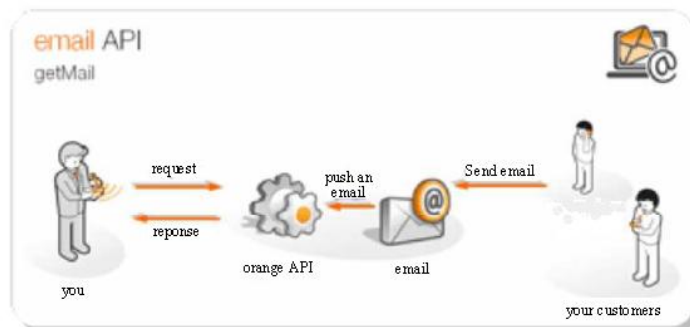
Methods

1- **sendMail:** this method is a simple function which allows you to send an email using HTTP request.
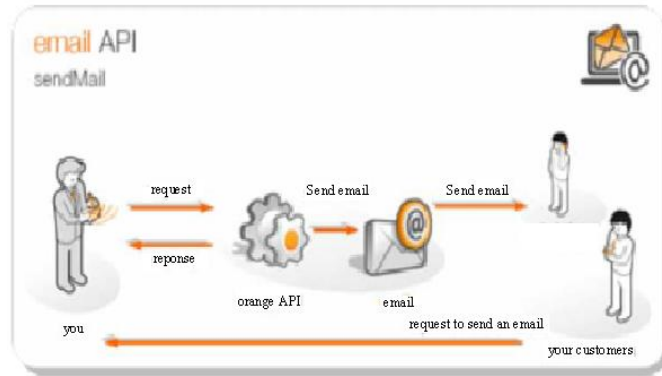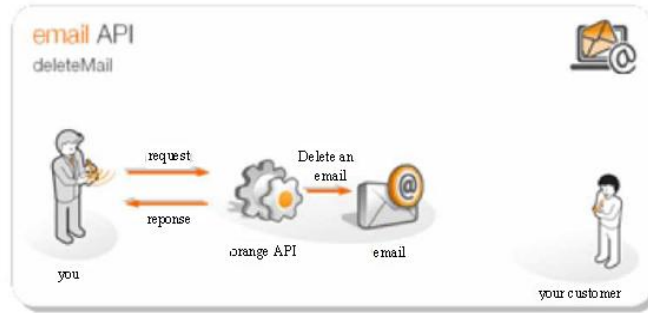
2- **getMailList**- read email method. The GetMailList method provides a list of all e-mails from the inbox. Each e-mail is assigned a number in chronological order. This is not the unique identifier to the e-mail.
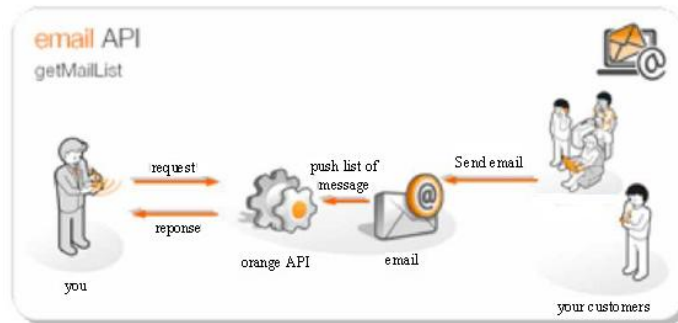
3- **getMail:** read email method. This method provides the content of an email

4- **deleteMail:** manage inbox method. This method deletes an email from your inbox.

5- **markMailRead**: manage inbox method. This method marks an email in your inbox as "read".
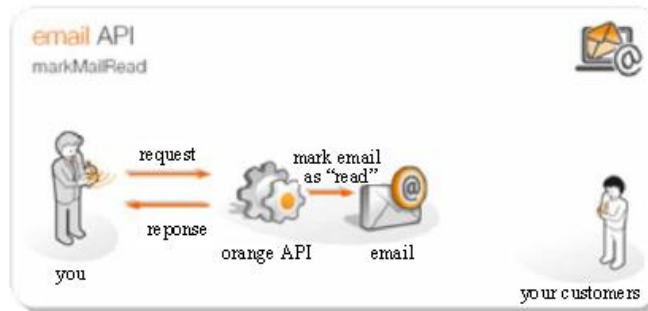
6- **markMailUnread**: manage inbox method. This method marks an email in your inbox as "not read".

7- **countMail**: manage inbox method. This message returns a total of the numbers of emails and unread email in your inbox.

1.2.3 Wifi localization

This development is a complete indoor localization system for WiFi device users. It is a client/server application that can be integrated by service providers and telecom operators, or even directly used by corporate customers, to localize users of WiFi - enabled devices, such as PDAs or mobile phones. It consists of a WiFi localization client and a server middleware.
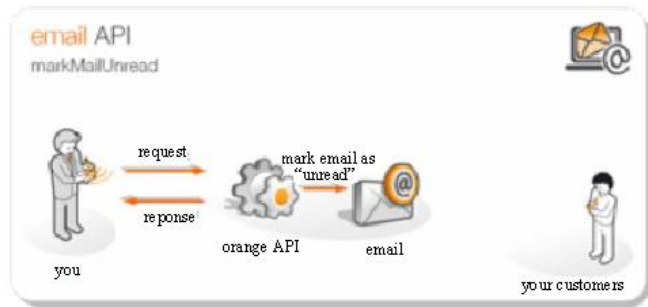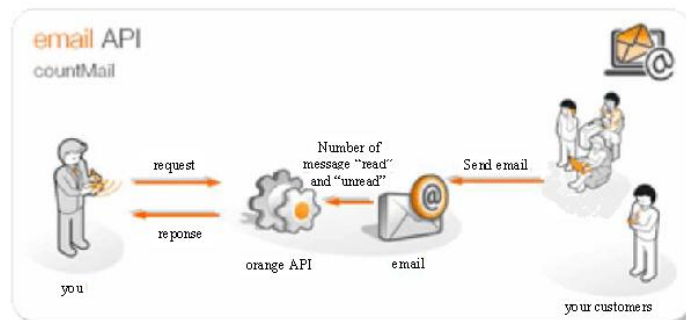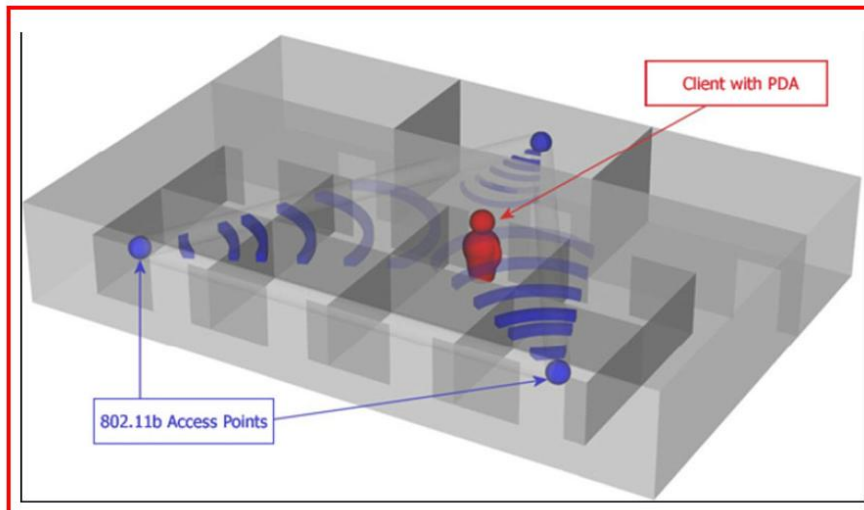

Working

The client collects and transmits the access point reception power measures to the server middleware ; the server middleware calculates the client location and updates the location database.

This software package provides a fairly accurate localization of WiFi users (nearly 3 meters) without additional infrastructure investments; it is very efficient inside buildings, where other localization systems (like GPS) would be problematic.

It can be integrated in communication or navigation services used in corporate or mass market environments.

Main advantages

The application can be used on multiple OS environments, which makes it available to a wide range of devices. It is easy to integrate in a complete localization system, thus speeding up its development.

It embeds a proprietary mechanism that permits simple and fast localization inside multi-room segmented buildings, and it is very robust to external perturbations such as weather conditions, client hiding, etc., even if the rooms are very small.

Moreover, it is a very reactive system which allows localization of even fast walking people.

Environment

Client: ported on windows (XP & mobile), LINUX (Nokia 770).

Middleware: developed on LINUX.

1.3 Vodafone Group

Vodafone is a world leader in providing voice and data communications services, including voice calls, SMS text messaging, MMS picture and video messaging, internet access and other data services. It offer integrated mobile and PC communication services, wirelessly through 3G and HSPA services, and via fixed line broadband.

Customers can use a range of devices to access products and services, including handsets, fixed line telephones, laptops and desktop computers.

302.6 million are divided between private consumers and corporate customers around the world.

In 2008/09 they reorganized the way manage the business to reflect their increasing focus on growth in emerging markets. The business is now divided into three regions, each with its own CEO:

- Europe
- Africa and Central Europe
- Asia Pacific and Middle East.

In addition to their 20 local operating companies, they also have joint ventures, associated undertakings, other investments and partner market agreements in a number of other countries worldwide.

Vodafone is a global telecommunications company headquartered in Newbury, United Kingdom.

It is the world's largest mobile telecommunications company measured by revenues and the world's second largest measured by subscribers (behind China Mobile) with 347 million proportionate subscribers as at 30 June 2010. It operates networks in 31 countries and has partner networks in a further 44 countries. It owns 45% of Verizon Wireless, the largest mobile telecommunications company in the United States measured by subscribers.

The name Vodafone comes from **vo**ice **da**ta **fone**, chosen by the company to "reflect the provision of voice and data services over mobile phones".

Its primary listing is on the London Stock Exchange and it is a constituent of the FTSE 100 Index. It had a market capitalization of approximately £80.2 billion as of August 2010, making it the third largest company on the London Stock Exchange. It has a secondary listing on NASDAQ.

1.3.1Vodafone and Localization

Location Based Services or LBS seek to offer a personalized service to users based on geographic location information thereof. In order to operate technology used geographic information systems, some positioning technology either client side (eg GPS) or server side (eg positioning service provided by the network operator) and networking communication technology to transmit information to an LBS application that can process and respond to the request. A constant definition updates on Location Services may be consulted for details.

LBS Typical applications seek to provide real-time geographic services. There are basically two scenarios for location-based applications: a user may require an information service center or management may require trace-to-real-time tracking.

In either scenario, through some mechanism determines the user's current position, this location along with other relevant parameters, is transmitted to a processing center. There, the service requirements are analyzed by an infrastructure supported by geographic information systems to deliver the response to the user. There are two ways of working, active and passive LBS system.

Technologies such as GPS, mobile networks and WiFi hotspots can create location-enabled services that bring many benefits to mobile users.

Vodafone classifies location-enabled services into *active and passive services.* Active location services are those that are initiated directly by the mobile phone user. An example of such a service is: "Where's my nearest chemist/cash machine/cinema etc?". A response from the location service provider would supply this information to the customer in the form of a map or directions, for example, based on the customer's location. Passive location services enable the location of one user to be tracked by another, once the service has been enabled.

The policy on location-based services aims to minimise the risk of unauthorised location surveillance, ensuring customers cannot be tracked by another person or application without their prior consent. It includes guidelines on how consent should be obtained, used and managed to ensure clarity, transparency and fairness to the person being located. Their periodically review their

policy in light of recent market developments, most recently, for example, the increased market penetration of mobile with <u>GPS technology</u>[3].

GPS uses satellites and works by calculating the time it takes a signal to travel from a satellite to a receiver on a handheld device. Accuracy to within a few metres is achievable using differential GPS.

However this approach can be time consuming and unreliable as the GPS receiver needs to be able to communicate with at least four satellites before location can be found. In addition the receiver must maintain a line-of-site transmission with the satellites. As a direct consequence GPS does not work well in built-up areas such as large cities and is not accessible indoors. An alternative method for determining user location is by using the cellular/mobile telephony GSM system and the known location of base station cells. This approach estimates location using a range of different techniques based on signal transmission between the base station cell and the mobile device. This approach is not as accurate as GPS and is dependent on the coverage size of the cell stations used with typical accuracy limited to 200m in urban areas. Examples of the use of this type of approach are becoming more commonplace e.g. I-Mode Streetmap and Vodafone Live Find and Seek service.

1.3.2 Vodafone España

Vodafone Spain has launched a new service location, *Mensa-Red*, business-oriented. The system, which uses the technology platform Autodesk Insight terrestrial geographic location, allows companies to know the location through the mobile phone of its employees at all times and manage the distribution of these resources according to service needs and business at all times. Aimed at couriers and transport, equipment maintenance and service and sales forces, the new service to optimize the use of these human resources, improve speed and quality customer care, minimizing downtime and dispersion of costs of labor.

Autodesk Insight technology platform includes a geographic information system associated with another location, enabling companies to:

- Planning routes
- Easily modify the route of its teams based on the changing needs of service

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[3] The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

- Optimize resources, giving an effective response to emergency services and adapting to changes in service plans.

Thanks to this monitoring system, using SMS text messaging for communication, companies can manage real-time service requirements and submit to the professionals who are at all times closer to the destination. Additionally, the system can provide information to customers on time delivery of goods and on meetings and / or pending appointments or more accurately immediate notification if a delay occurs.

Vodafone Spain also implemented this year Autodesk LocationLogic ™ platform, which like Autodesk Insight, allows fast delivery service and a flexible location with minimum cost to the customer, in terms of equipment, training and maintenance. Customers who have a PC, Internet and mobile device Vodafone Spain can start using the service without requiring any additional equipment, which does not happen with other management solutions.

Vodafone introduces *Mensa-Red Location* a particularly useful tool, which allows employees to coordinate on the move, knowing the location in which they find their handsets. Mensa-Red Location is a web tool that locates individuals or groups of people, working with a company, the location of their terminals and thus optimize the allocation of visits and routes.

Mensa-Red Location is a web tool that lets employees know where they are (by locating their mobile handsets Vodafone) and communicate with them via SMS, thus being able to manage and coordinate the staff of the company.

Mensa-Red Location is a tool designed to facilitate the daily work of companies and professionals who need:

- Request the location of a person or group of persons, to know where they are due to the location of your mobile phone.
- Avoid annoying calls to find out where they are.
- Submit persons located, by SMS, itineraries and instructions to get directions from where it is situated to another destination.
- Locate points of interest located near the person to send this information by SMS.

You can access Mensa-Red Location from any computer with Internet connection, and you do not need download any software.

Mensa-Red Location allows you to:

- Locate mobile terminal employees.

- Add and edit up to 100 mobile employees.

- Generate maps and driving directions.

- Send SMS text messages to one or more phones.

- Edit, create and organize users into groups.

- Show locations of interest located near the mobile users.

- Create personalized sites of interest: their own offices, customer ...

- Have a user with administrator profile to manage users with access to the application and locate terminals.

2   The Company Genasys

Genasys is a leading provider of solutions and services based on the location of mobile units and solutions for the management of geographic data.

Genasys offers a combination of experience, products and services that are common to these areas of activity, while maintaining a remarkable level of innovation and a strong commitment to customer satisfaction.

Regarding the Mobile Location Services Unit, Genasys offers a complete set of intermediate products (product family Genasys Positioning Platform "GPP", currently in version 5.0) among the different location technologies based on terrestrial or satellite networks and the many Applications that use location information. Genasys also provides a full range of location-based applications. The proposed Genasys on Geographic Data Management services include the instrument of Geographic Information Systems (GenaMap), currently at version 9.0.

Genasys II in Spain, S.A.U. (Below Genasys) is the main component of a group of predominantly Spanish-owned companies, which operates internationally.

Genasys was founded in 1994 as a subsidiary of Spanish Genasys II Pty Ltd, based in Sydney, Australia. Genasys began its work by distributing GenaMap and its family of products in various parts of the world, and offering design services, design and build solutions for these products.

2.1 Sectors

With his experience in various fields of management of geospatial information, Genasys is able to provide solutions for a wide range of business sectors.
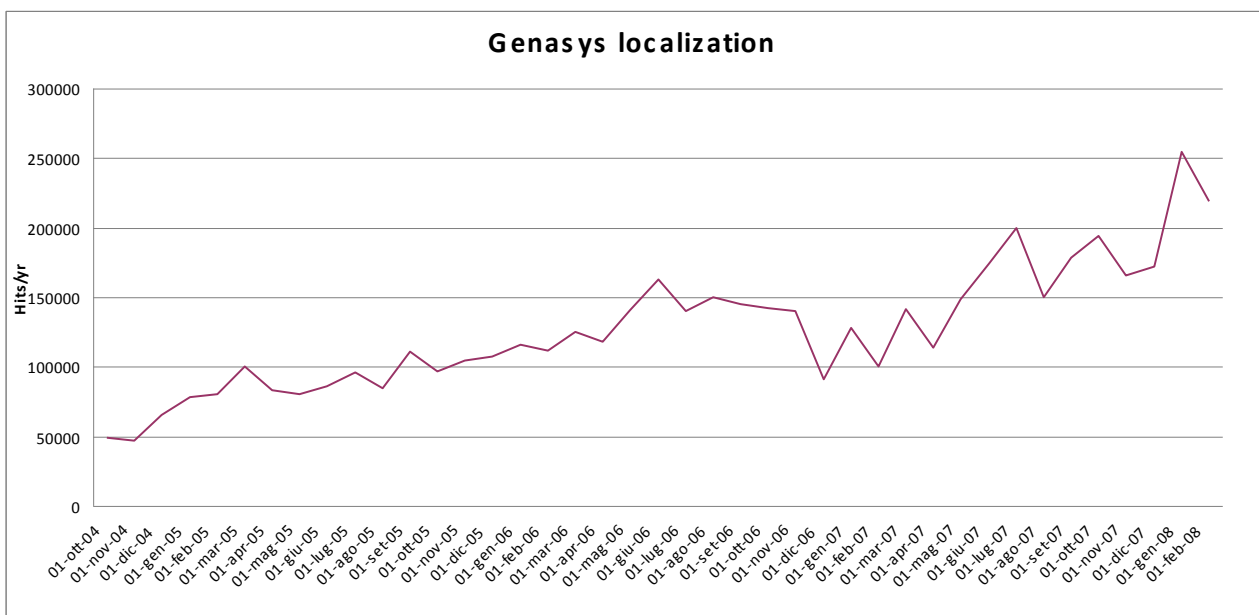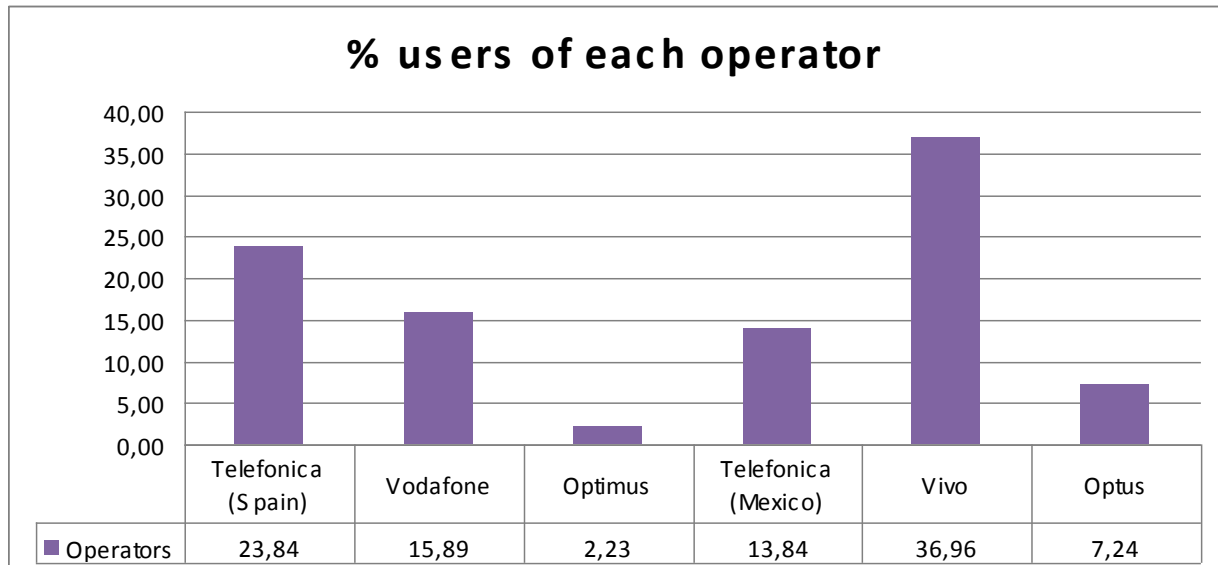
Genasys localization (Hits/yr)

Data	Cm	Hits/mes	Data	Cm	Hits/mes
15-ott-04	7,80	48750	15-lug-06	22,4	140000
15-nov-04	7,5	46875	15-ago-06	24	150000
15-dic-04	10,5	65625	15-set-06	23,2	145000
15-gen-05	12,5	78125	15-ott-06	22,8	142500
15-feb-05	12,8	80000	15-nov-06	22,4	140000
15-mar-05	16	100000	15-dic-06	14,6	91250
15-apr-05	13,3	83125	15-gen-07	20,5	128125
15-mag-05	12,9	80625	15-feb-07	16	100000
15-giu-05	13,8	86250	15-mar-07	22,6	141250
15-lug-05	15,4	96250	15-apr-07	18,2	113750
15-ago-05	13,5	84375	15-mag-07	23,8	148750
15-set-05	17,8	111250	15-giu-07	27,9	174375
15-ott-05	15,5	96875	15-lug-07	32	200000
15-nov-05	16,7	104375	15-ago-07	24	150000
15-dic-05	17,2	107500	15-set-07	28,5	178125
15-gen-06	18,5	115625	15-ott-07	31	193750
15-feb-06	17,9	111875	15-nov-07	26,5	165625
15-mar-06	20	125000	15-dic-07	27,5	171875
15-apr-06	18,9	118125	15-gen-08	40,7	254375
15-mag-06	22,5	140625	15-feb-08	35	218750
15-giu-06	26,1	163125			

User Data

Operator	Country	Users	%
Telefonica (Spain)	Spain	21.600.000	23,84
Vodafone	Spain	14.400.000	15,89
Optimus	Portugal	2.020.000	2,23
Telefonica (Mexico)	Mexico	12.538.000	13,84
Vivo	Brasil	33.484.000	36,96
Optus	Australia	6.560.000	7,24
Total		**90.602.000**	100

% users of each operator

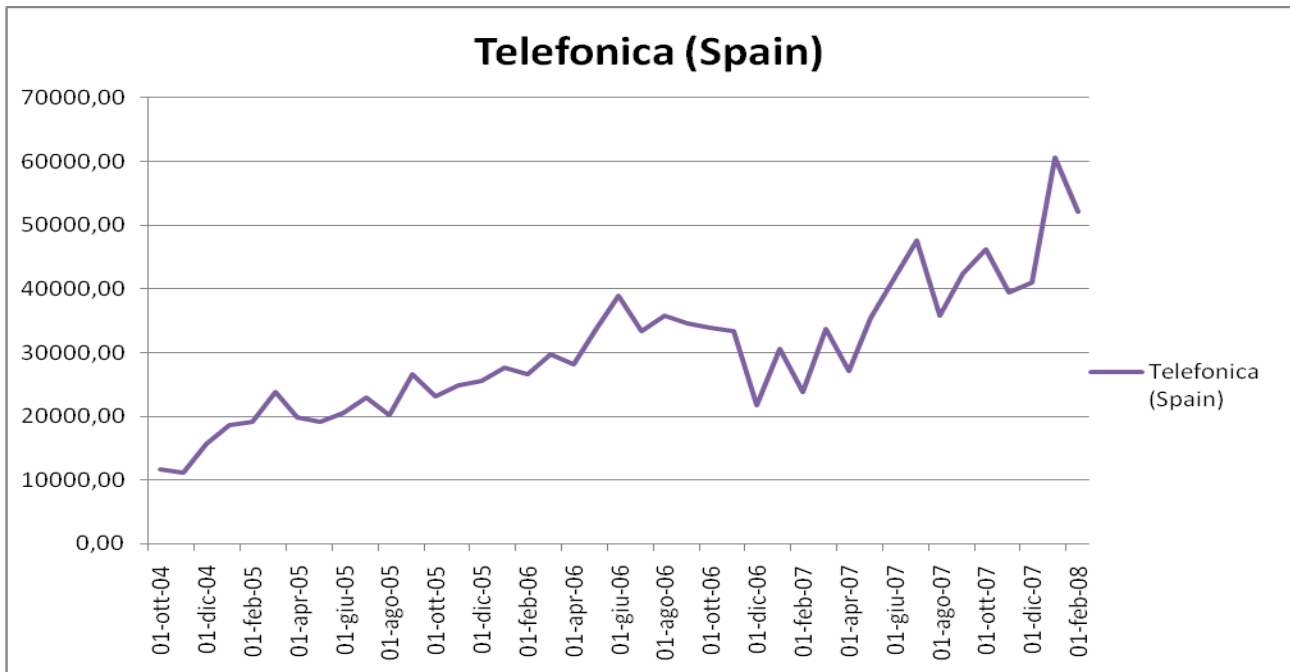| Operators	Telefonica (Spain)	Vodafone	Optimus	Telefonica (Mexico)	Vivo	Optus
	23,84	15,89	2,23	13,84	36,96	7,24

2.2 Telefonica (Spain)

We report data on the telephone company based on the percentage of the total data of the company Genasys.

	Tot Genasys	Telefonica			Tot Genasys	Telefonica
15-ott-04	48750	11622,26		15-lug-06	140000	33376,75
15-nov-04	46875	11175,25		15-ago-06	150000	35760,80
15-dic-04	65625	15645,35		15-set-06	145000	34568,77
15-gen-05	78125	18625,42		15-ott-06	142500	33972,76
15-feb-05	80000	19072,43		15-nov-06	140000	33376,75
15-mar-05	100000	23840,53		15-dic-06	91250	21754,49
15-apr-05	83125	19817,44		15-gen-07	128125	30545,68
15-mag-05	80625	19221,43		15-feb-07	100000	23840,53
15-giu-05	86250	20562,46		15-mar-07	141250	33674,75
15-lug-05	96250	22946,51		15-apr-07	113750	27118,61
15-ago-05	84375	20115,45		15-mag-07	148750	35462,79
15-set-05	111250	26522,59		15-giu-07	174375	41571,93
15-ott-05	96875	23095,52		15-lug-07	200000	47681,07
15-nov-05	104375	24883,56		15-ago-07	150000	35760,80
15-dic-05	107500	25628,57		15-set-07	178125	42465,95
15-gen-06	115625	27565,62		15-ott-07	193750	46191,03
15-feb-06	111875	26671,60		15-nov-07	165625	39485,88
15-mar-06	125000	29800,67		15-dic-07	171875	40975,92
15-apr-06	118125	28161,63		15-gen-08	254375	60644,36
15-mag-06	140625	33525,75		15-feb-08	218750	52151,17
15-giu-06	163125	38889,87				

**Telefonica (Spain)**

2.3 Vodafone (Spain)

We report data on the telephone company based on the percentage of the total data of the company Genasys.

	Tot Genasys	Vodafone		Tot Genasys	Vodafone
15-ott-04	48750	7748,17	15-lug-06	140000	22251,16
15-nov-04	46875	7450,17	15-ago-06	150000	23840,53
15-dic-04	65625	10430,23	15-set-06	145000	23045,85
15-gen-05	78125	12416,94	15-ott-06	142500	22648,51
15-feb-05	80000	12714,95	15-nov-06	140000	22251,16
15-mar-05	100000	15893,69	15-dic-06	91250	14502,99
15-apr-05	83125	13211,63	15-gen-07	128125	20363,79
15-mag-05	80625	12814,29	15-feb-07	100000	15893,69
15-giu-05	86250	13708,31	15-mar-07	141250	22449,84
15-lug-05	96250	15297,68	15-apr-07	113750	18079,07
15-ago-05	84375	13410,30	15-mag-07	148750	23641,86
15-set-05	111250	17681,73	15-giu-07	174375	27714,62
15-ott-05	96875	15397,01	15-lug-07	200000	31787,38
15-nov-05	104375	16589,04	15-ago-07	150000	23840,53
15-dic-05	107500	17085,72	15-set-07	178125	28310,63
15-gen-06	115625	18377,08	15-ott-07	193750	30794,02
15-feb-06	111875	17781,06	15-nov-07	165625	26323,92
15-mar-06	125000	19867,11	15-dic-07	171875	27317,28
15-apr-06	118125	18774,42	15-gen-08	254375	40429,57
15-mag-06	140625	22350,50	15-feb-08	218750	34767,44
15-giu-06	163125	25926,58			
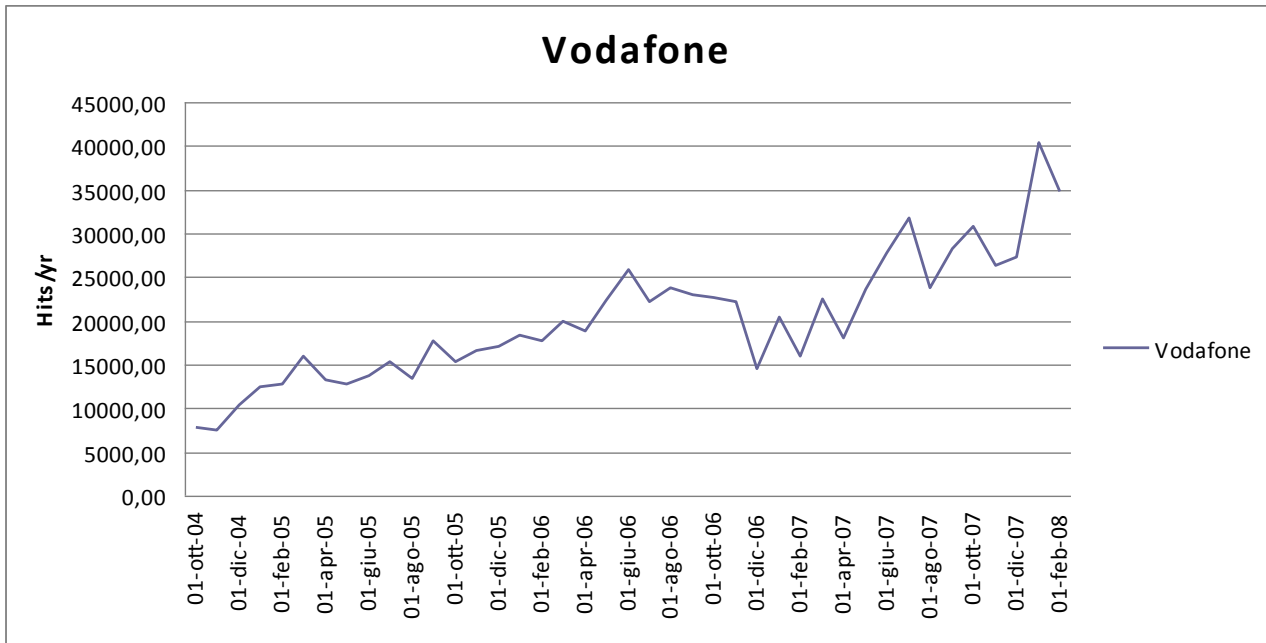
2.4 Genasys, Telefonica, Vodafone

We report data on the all telephone company based on the percentage of the total data of the company Genasys.
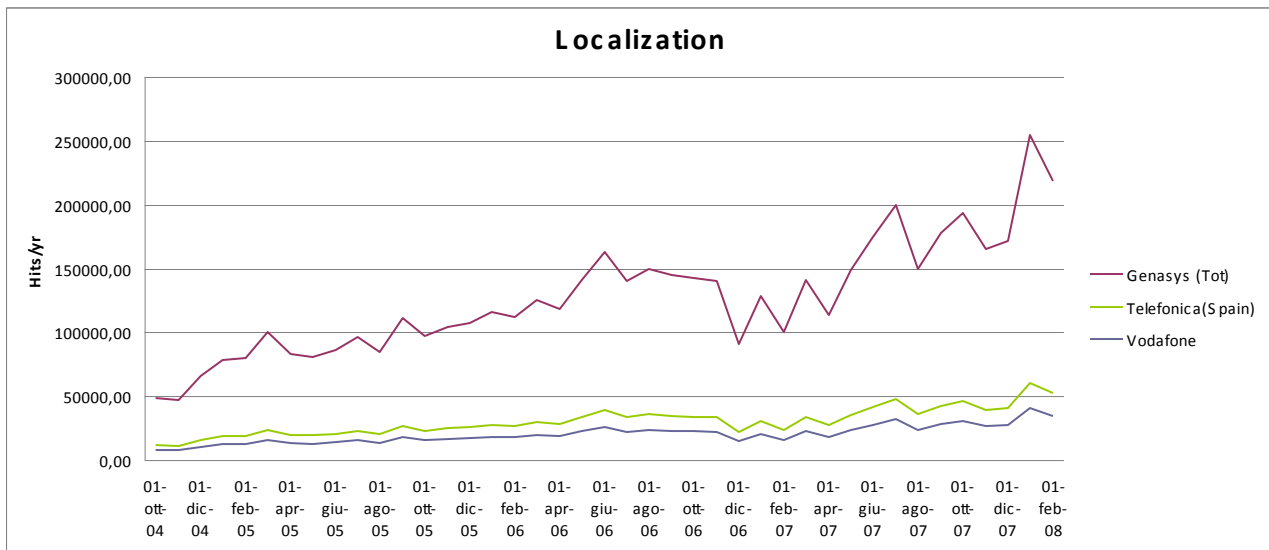
2.5 Localization Solutions

Genasys offers a wide range of products and applications that are location-based solutions for mobile operators to ASP.

It also provides full-service consulting and support for all products, so as to meet the specific needs of each client.

Genasys try to exploit the current market positioning, technology and experience to become the leading provider of platforms, applications and solutions for mobile operators, enterprises and consumers.

Solutions proposed by Genasys:

• <u>LBS Hosting</u>: a reliable and safe way to allocate the applications based on location.

• <u>LBS Platform</u>: A family of servers that offers value-added solutions for interoperability and roaming LBS. For virtual operators, the solution "hosting"is a fast and inexpensive way to provide location services to their subscribers.

• <u>LBS Applications</u>: A wide range of practical solutions and entertainment for mobile operators and other companies.

• <u>Application development</u>: The company provides technology design and systems integration.

3 Forecasting methods applied to real data

In this chapter we provide a detailed analysis of available data of location services provided by the Genasys for telephone operators. Such analysis is based on methods for forecasting demand as linear regression, moving average method, method of Exponential Smoothing, Data analysis with the Chi-square test and analysis methods Arch – Garch.

In general we suppose to have a mixed model:

$$F_{t+l} = \left[L_t + (t+l) \cdot T_t\right] \cdot S_{t+l}$$

where:

- L_t = respect of the level (asks destagionalizzata) period t
- T_t = respect of the trend (increase or decrement asks) period t
- S_t = respect of the factor seasonal period t
- D_t = question real observed period t
- F_t = forecast of the question period t

3.1 Data Analysis: Linear Regression

Through the method of linear regression we try to identify the characteristics of our system.

It is assumed that there is a linear relationship of the form y = a + bx between two physical quantities x and y, which is have the set of measurements xi and yi.

The purpose of linear regression is to determine the values of the parameters a and b for which the relationship between x and y give the best possible interpolation of n experimental determinations (xi, yi). The procedure involves determining those coefficients a and b for which the minimum sum of squared differences _yi = yi-(a + bxi).

This is also what makes Excel through LINEST; this function by taking incoming data makes an estimate of the coefficient and the intercept of-hand.

What we get from this function is:

	T	L	
coeff angolare	3289,6341	57548,78	intercetta

Going to graphics obtained as:
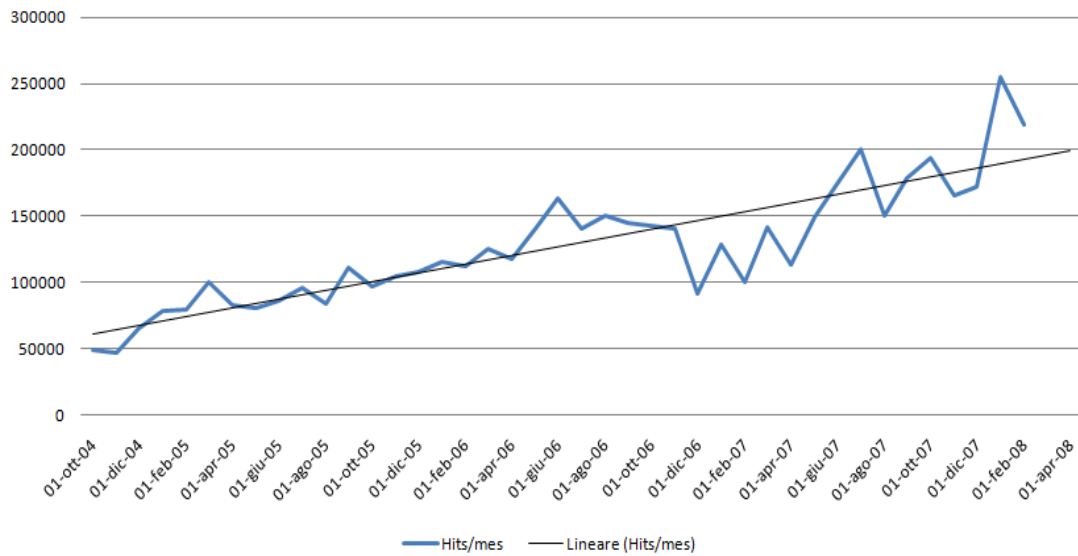
3.2 Data Analysis: Moving Averages

Through the equations of the moving average method, we try to identify the characteristics of our system.

The moving averages method is an adaptive method, is used when the data held lack of trend and seasonality. This model consists of the following equations:

• Estimation of the level at time t N as an estimate of more recent periods:
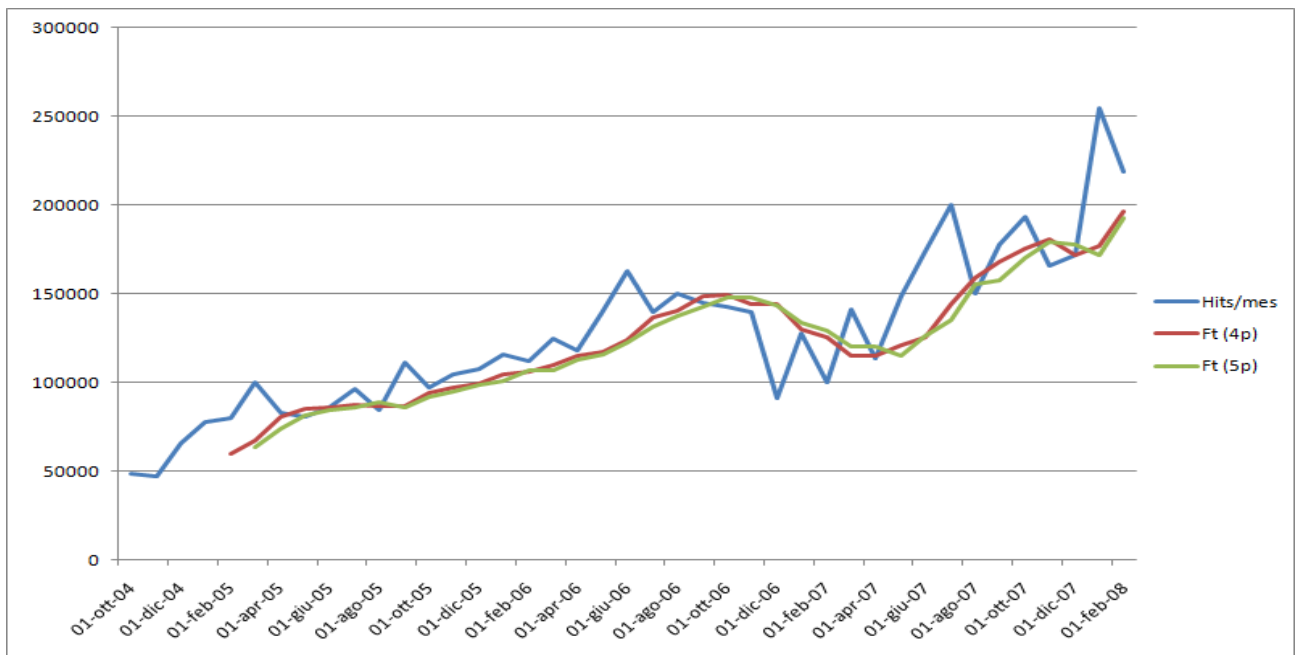
$$L_t = \frac{\sum_{i=0}^{N-1} D_{t-i}}{N}$$

• Forecast at time t depends only on Lt:

$$F_{t+1} = L_t \qquad F_{t+n} = L_t$$

• After observing the demand in period t +1, we revise the estimates as follows:

$$L_{t+1} = \frac{\sum_{i=0}^{N-1} D_{t+1-i}}{N}$$

31

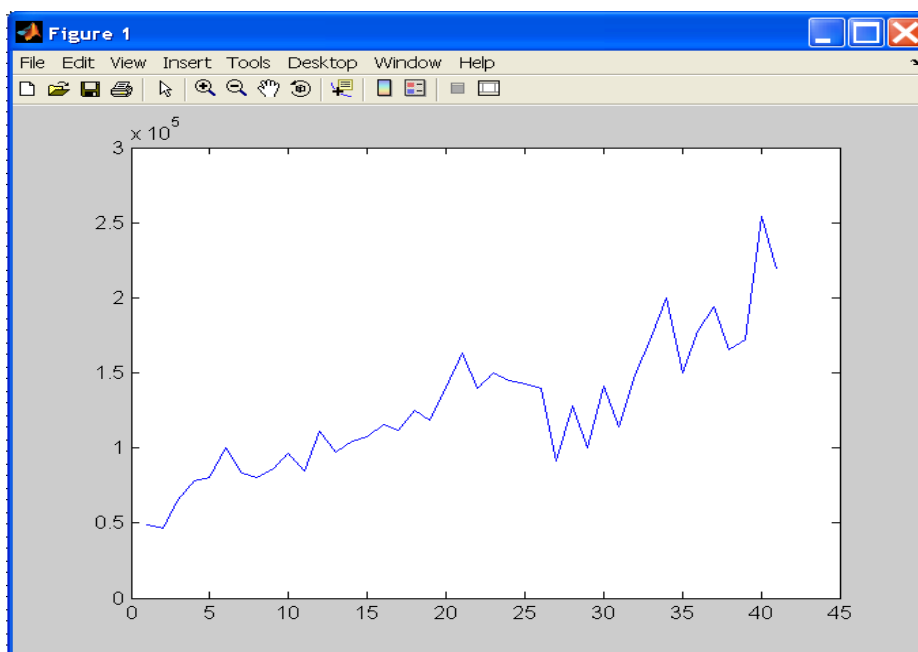What we obtain by the following study is the following graph:

The study Moving Average has been carried out by going to consider two types of time windows: window of 4 values and the time window of 5 values.

3.2.1 Implementation matlab

The time series of hits / month was loaded in Matlab.

dati=xlsread('Genasys.xls', 'C19:C59');

From the plot of this series we observed this trend.

We applied the function 'tsmovavg' to calculate simple moving average.

The function syntax is:

```
output = tsmovavg(tsobj, 's', lag)
```

`tsobj`: Financial time series object.

`Lag`: Number of previous data points.

The function has been implemented with lag=4 and lag=5 respectively.

The result is stored in the variable 'output' as follows:

1- output = tsmovavg(dati, 's', 4)

We get the following values for the prediction of demand at time t:

```
output =

  1.0e+005 *

  Columns 1 through 12

     NaN      NaN      NaN    0.5984   0.6766   0.8094   0.8531   0.8594   0.8750   0.8656   0.8688   0.9453

  Columns 13 through 24

   0.9719   0.9922   1.0500   1.0609   1.0984   1.1500   1.1766   1.2391   1.3672   1.4047   1.4844   1.4953

  Columns 25 through 36

   1.4438   1.4438   1.2969   1.2547   1.1484   1.1516   1.2078   1.2594   1.4453   1.5922   1.6828   1.7563

  Columns 37 through 41

   1.8047   1.7188   1.7734   1.9641   2.0266
```

2- output = tsmovavg(dati, 's', 5)

We get the following values for the prediction of demand at time t:

```
output =

  Columns 1 through 10

     NaN      NaN      NaN      NaN    63875    74125    81375    84375    86000    89250

  Columns 11 through 20

   86125    91750    95000    98625   100875   107125   107250   112875   115625   122250

  Columns 21 through 30

  131750   137375   142375   147750   148125   143500   133750   129375   120375   120125

  Columns 31 through 40

  114875   126375   135625   155625   157375   170250   179250   177500   171875   192750

  Column 41

  200875
```

Plotting the results obtained by implementing the function with lags=4 and lags =5, these trends are observed:
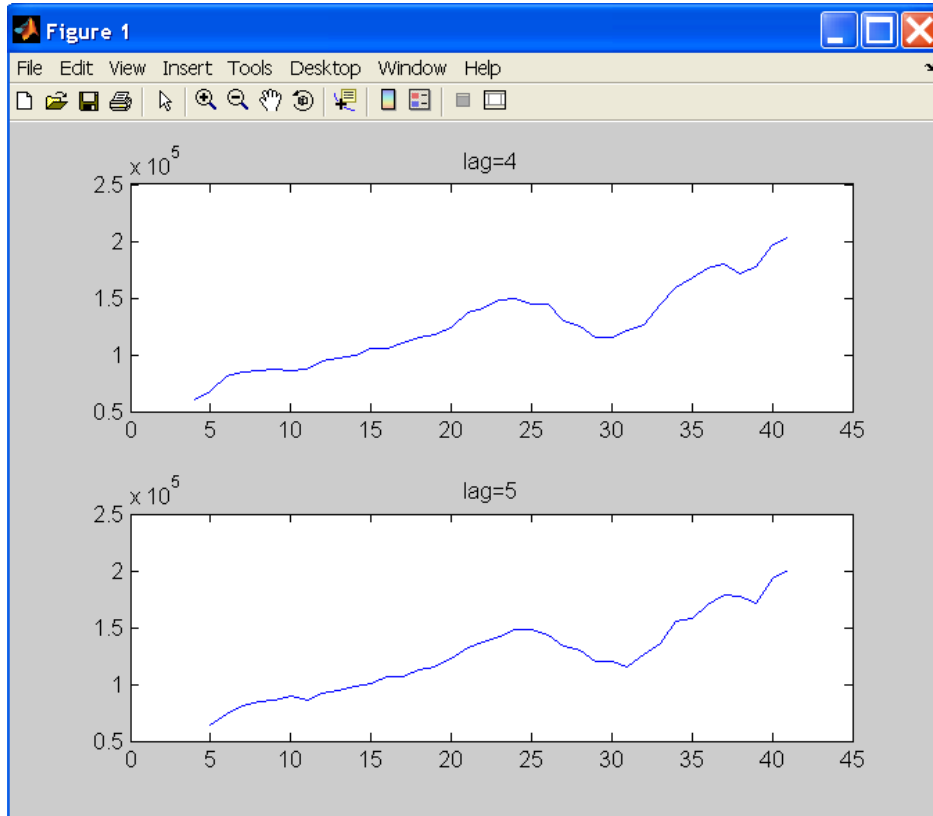
3.3 Data Analysis: Simple Exponential Smoothing values.

Through the equations of the simple exponential smoothing method, we try to identify the characteristics of our system.

The simple exponential smoothing method is a method of adaptive, is used when the data held lack of trend and seasonality, so:

<u>*Systematic component = Level*</u>

• Il The initial value L_o is taken as the average of all historical data available:

$$L_0 = \frac{\sum_{i=1}^{n} D_i}{n}$$

• Forecast at time t depends only on Lt:

$$F_{t+1} = L_t$$

• After observing the demand in period t +1, we revise the estimates as follows:

$$L_{t+1} = \alpha \cdot D_{t+1} + (1-\alpha) \cdot L_t$$
$$0 \leq \alpha \leq 1$$

α is the damping constant of the layer. The value of the revised level is a weighted average of the observed value of the level in period t +1. (Dt +1) and the prediction of the level made with data from the period t (Lt).

What we obtain by the following study is the following graph:
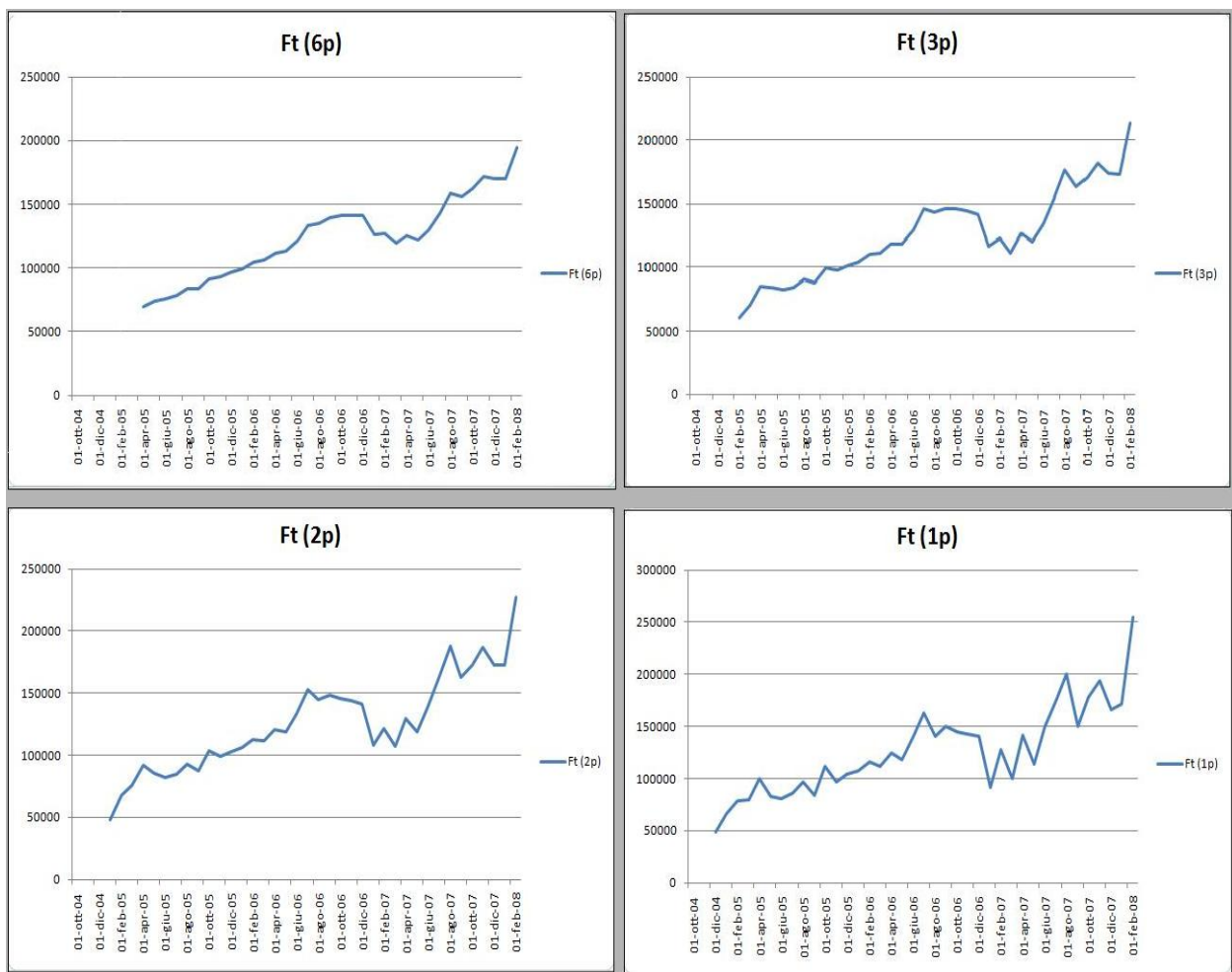
The study with Simple Exponential Smoothing was carried out by going to consider four types of time windows: a window of 6 values, 3-time window values, time window and time window values at 2 to 1 value.

For each time window we can associate a value of the coefficient α by the following equation:

$$\alpha = \frac{2}{(Window\ Size + 1)}$$

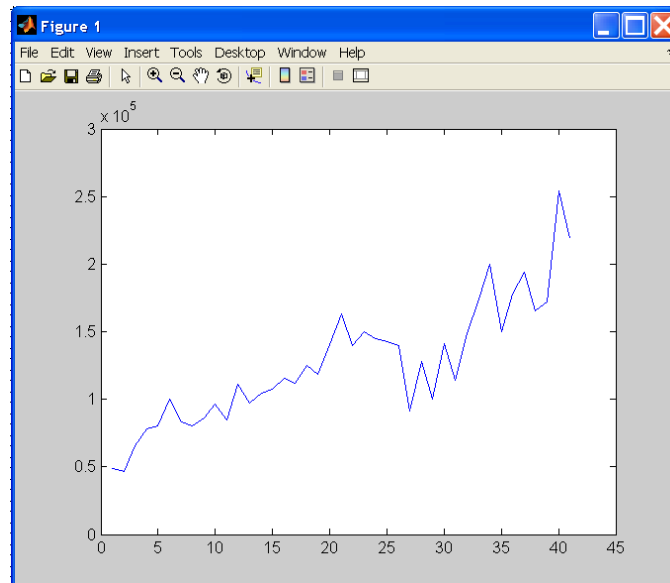So according to set time windows we used the following coefficient values:

Window Size	α
6	0,286
3	0,5
2	0,667
1	1

3.3.1 Implementation matlab

The time series of hits/month was loaded in Matlab.

dati=xlsread('Genasys.xls', 'C19:C59');

From the plot of this series we observed this trend.

We applied the function 'smoothts' to calculate Exponential Smoothing.

The function syntax is:

```
output = smoothts(input, 'e', n)
input: Financial time series object or a row-oriented matrix. In a row-oriented
matrix, each row represents an individual set of observations.
```

`'e'`: (e = Exponential) Smoothing method (essentially the type of filter used).

`n`: For Exponential method, specifies window size or exponential factor, depending upon value.

- `n > 1` (window size) or period length
- `n < 1` and `> 0` (exponential factor: alpha)
- `n = 1` (either window size or alpha)

The function has been implemented with n=6, n=3, n=2 and n=1 respectively.

The result is stored in the variable 'output' as follows:

1- output = smoothts(dati, 'e', 6);

We get the following values for the prediction of demand at time t:

```
output =

  1.0e+005 *

  Columns 1 through 12

    0.4875    0.4821    0.5319    0.6031    0.6594    0.7567    0.7780    0.7861    0.8079    0.8521    0.8497    0.9248

  Columns 13 through 24

    0.9373    0.9677    0.9984    1.0435    1.0650    1.1179    1.1360    1.2132    1.3326    1.3519    1.3942    1.4101

  Columns 25 through 36

    1.4144    1.4103    1.2681    1.2718    1.1942    1.2565    1.2225    1.2982    1.4255    1.5897    1.5640    1.6261

  Columns 37 through 41

    1.7151    1.6983    1.7041    1.9440    2.0136
```

2- output = smoothts(dati, 'e', 3);

We get the following values for the prediction of demand at time t:

```
output =

  1.0e+005 *

  Columns 1 through 12

    0.4875    0.4781    0.5672    0.6742    0.7371    0.8686    0.8499    0.8281    0.8453    0.9039    0.8738    0.9932

  Columns 13 through 24

    0.9810    1.0124    1.0437    1.1000    1.1094    1.1797    1.1805    1.2934    1.4623    1.4312    1.4656    1.4578

  Columns 25 through 36

    1.4414    1.4207    1.1666    1.2239    1.1120    1.2622    1.1999    1.3437    1.5437    1.7719    1.6359    1.7086

  Columns 37 through 41

    1.8230    1.7396    1.7292    2.1365    2.1620
```

3- output = smoothts(dati, 'e', 2);

We get the following values for the prediction of demand at time t:

```
output =

  1.0e+005 *

  Columns 1 through 12

    0.4875    0.4750    0.5958    0.7194    0.7731    0.9244    0.8623    0.8249    0.8500    0.9250    0.8708    1.0319

  Columns 13 through 24

    0.9898    1.0258    1.0586    1.1237    1.1204    1.2068    1.1898    1.3341    1.5322    1.4441    1.4814    1.4605

  Columns 25 through 36

    1.4368    1.4123    1.0791    1.2139    1.0713    1.2988    1.1913    1.3888    1.6254    1.8751    1.6250    1.7292

  Columns 37 through 41

    1.8681    1.7269    1.7215    2.2697    2.2149
```

4- output = smoothts(dati, 'e', 1);

We get the following values for the prediction of demand at time t:

```
output =

  1.0e+005 *

  Columns 1 through 12

    0.4875    0.4688    0.6563    0.7813    0.8000    1.0000    0.8313    0.8063    0.8625    0.9625    0.8438    1.1125

  Columns 13 through 24

    0.9688    1.0438    1.0750    1.1563    1.1187    1.2500    1.1812    1.4063    1.6313    1.4000    1.5000    1.4500

  Columns 25 through 36

    1.4250    1.4000    0.9125    1.2813    1.0000    1.4125    1.1375    1.4875    1.7437    2.0000    1.5000    1.7813

  Columns 37 through 41

    1.9375    1.6563    1.7188    2.5438    2.1875
```

Plotting the results obtained by implementing the function with n=6, n=3, n=2 and n=1 respectively, these trends are observed:
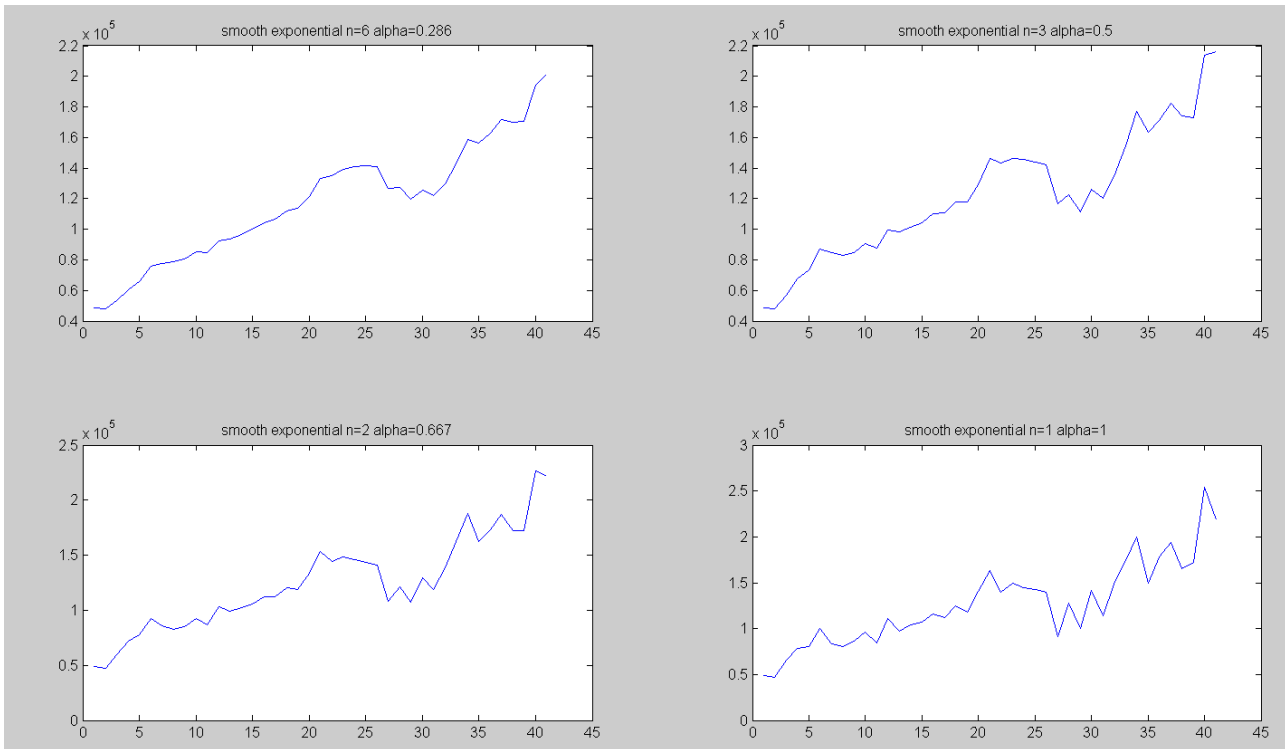
3.4 Data analysis: Trend-adjusted Exponential Smoothing (Holt's Method)

Through the equations of the exponential smoothing method to correct the Trend (Holt's method) try to identify the characteristics of our system.

The exponential smoothing method to correct for the Trend is an adaptive method, is used when data have owned a trend component but lack of seasonality, so:

Systematic component = Level + Trend

• It is estimated the level at time 0, L_0, and the trend to period 0, T_0, by linear regression of the data demand Dt available (no need for seasonal variations since it is assumed the absence of the seasonal component):

$$D_t = a \cdot t + b$$

Where:

$$T_0 = a \qquad L_0 = b$$

• The forecast will be:

$$F_t = L_t + T_t \qquad F_{t+n} = L_t + nT_t$$

• After observing the demand in period t +1, we revise the estimates as follows:

$$L_{t+1} = \alpha D_{t+1} + (1-\alpha)(L_t + T_t)$$

$$T_{t+1} = \beta(L_{t+1} - L_t) + (1-\beta)T_t$$

$$0 \le \alpha \le 1 \qquad 0 \le \beta \le 1$$

α is the damping constant of the layer. The value of the revised level is a weighted average of the observed value of the level in period t +1 (Dt +1) and the prediction of the level that could be done with data from the period t (Lt + Tt).

While β is the damping constant of the trend. The revised value of the trend is a weighted average of the value of the observed trend in period t +1 (+1- Lt Lt) and forecast of trends that could be done with data from the period t (Tt).

What we obtain by the following study is the following graph:
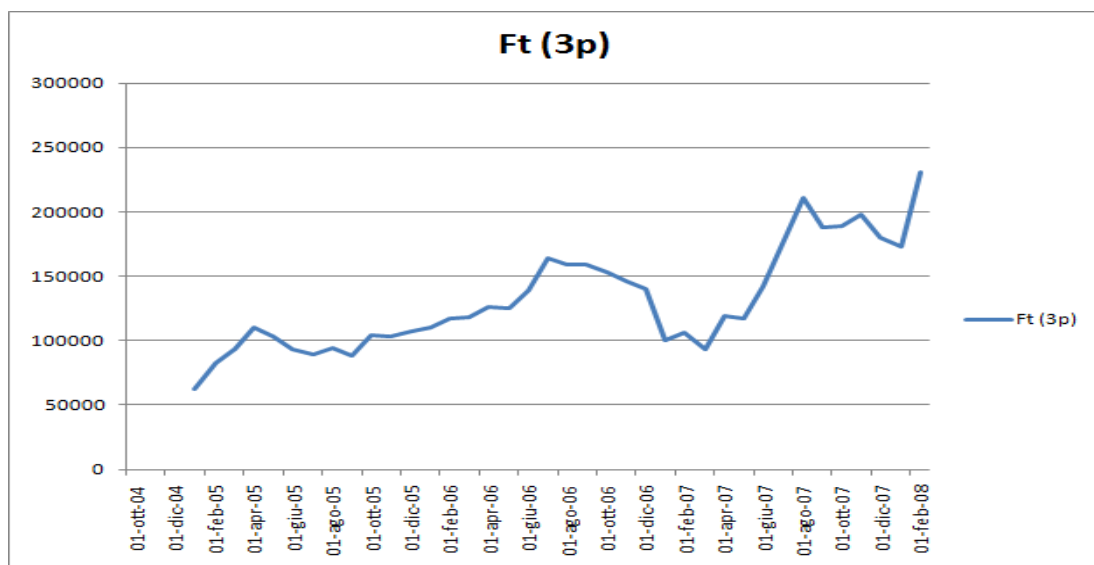
This study was performed with a time window of 3 values.

3.5 Evaluation of the best method applied to the data.

In this part we evaluate the methods when applied to data through the evaluation of mean square error and chi-square test.

3.5.1 Evaluation of the mean square error

The error at period t, E_t, was calculated for the various forecasting methods using the following expression:
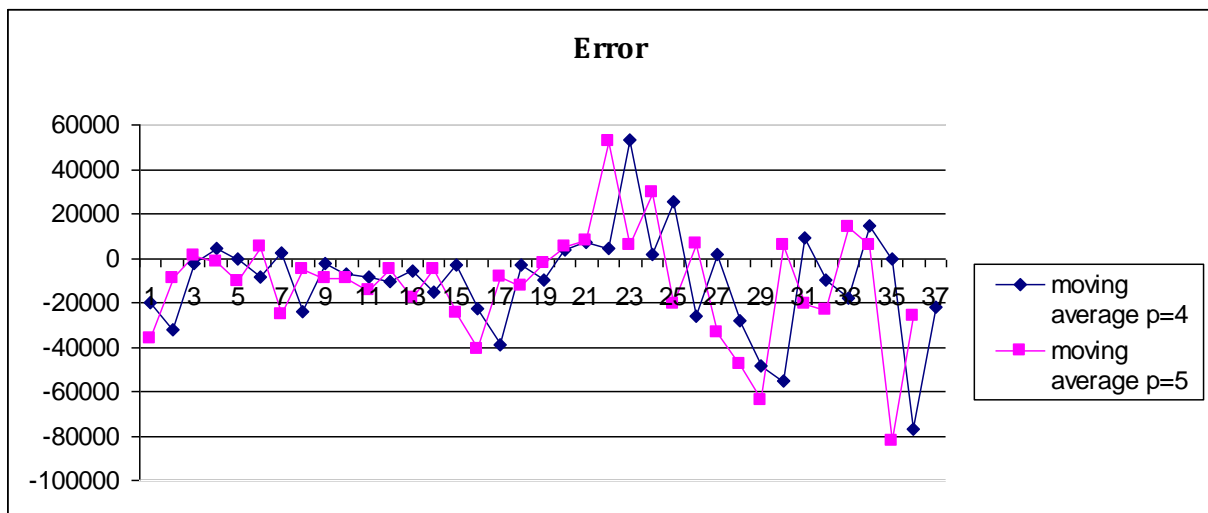
$$E_t = F_t - D_t$$

Where:

- D_t = question real observed period t
- F_t = forecast of the question period t

Below is the graph of the error for each method of prediction:
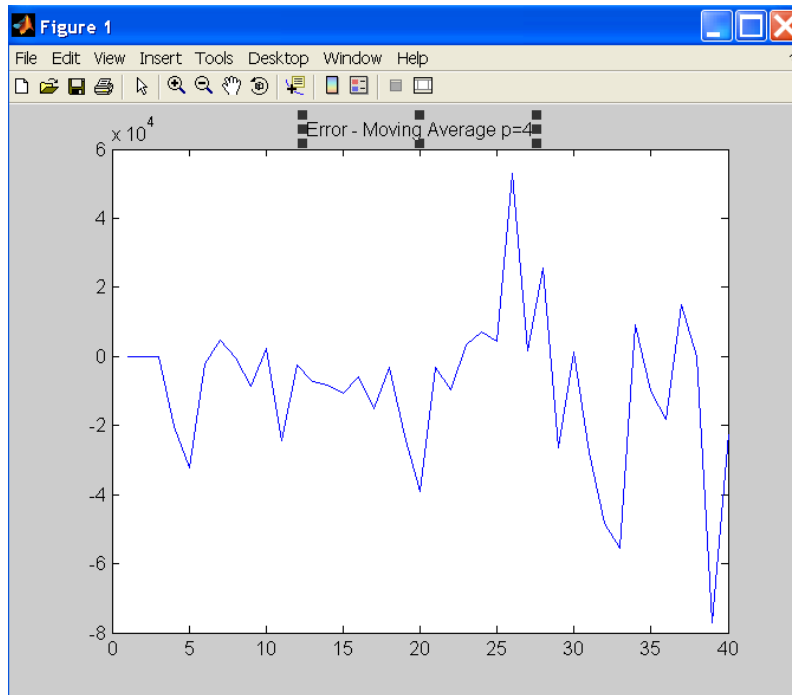
   a- Moving Average

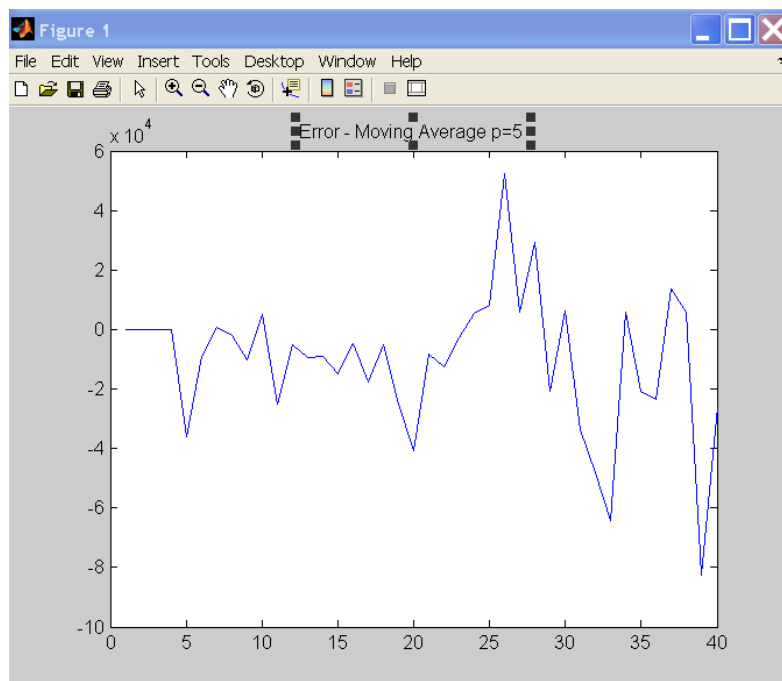The error was also evaluated using Matlab.

Code Snippets:

```
- dati=xlsread('Genasys STUDIO cn METODI.xls', 'C19:C59')
- datiInput=dati'
- output = tsmovavg(datiInput, 's', 4)
- for i=4:40
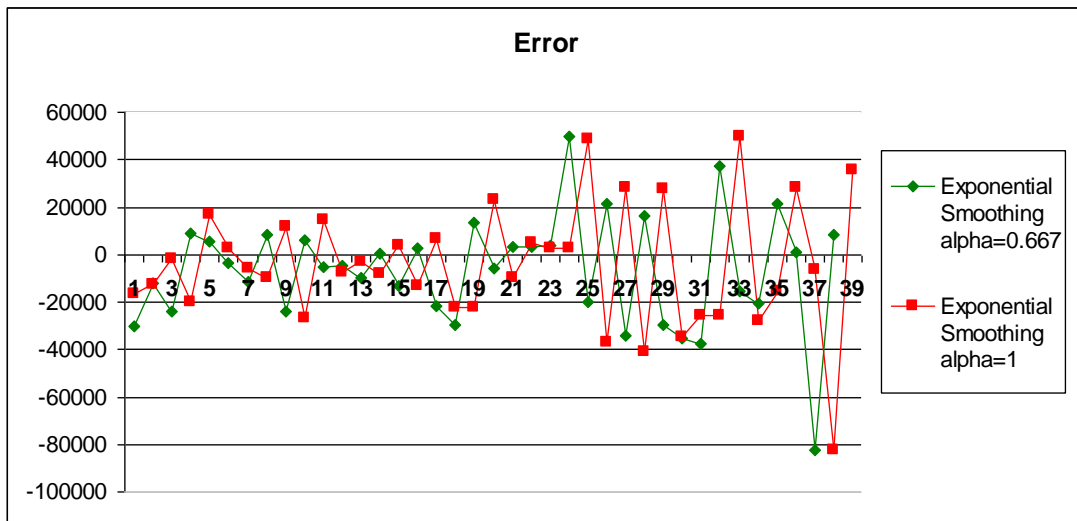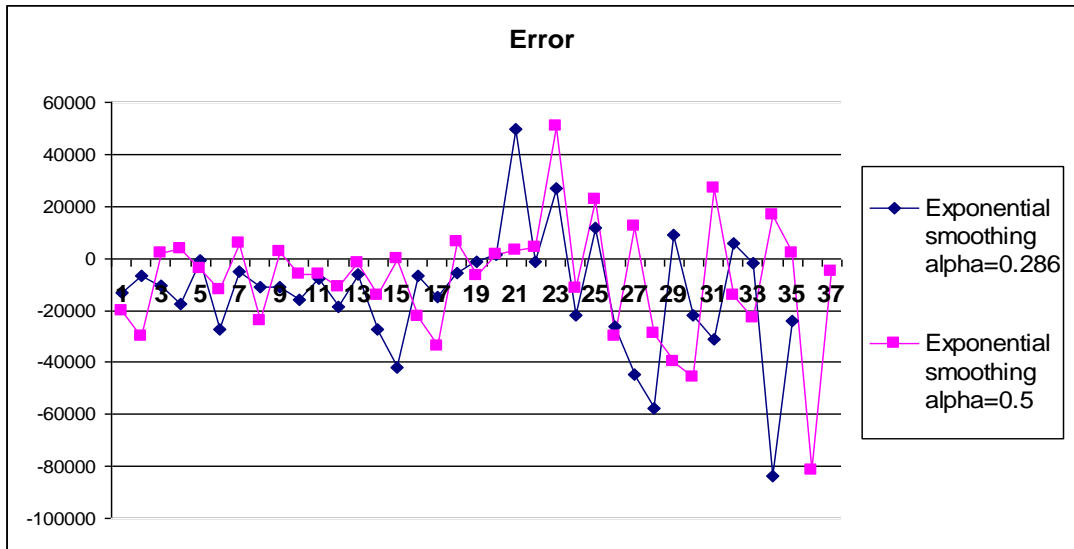```
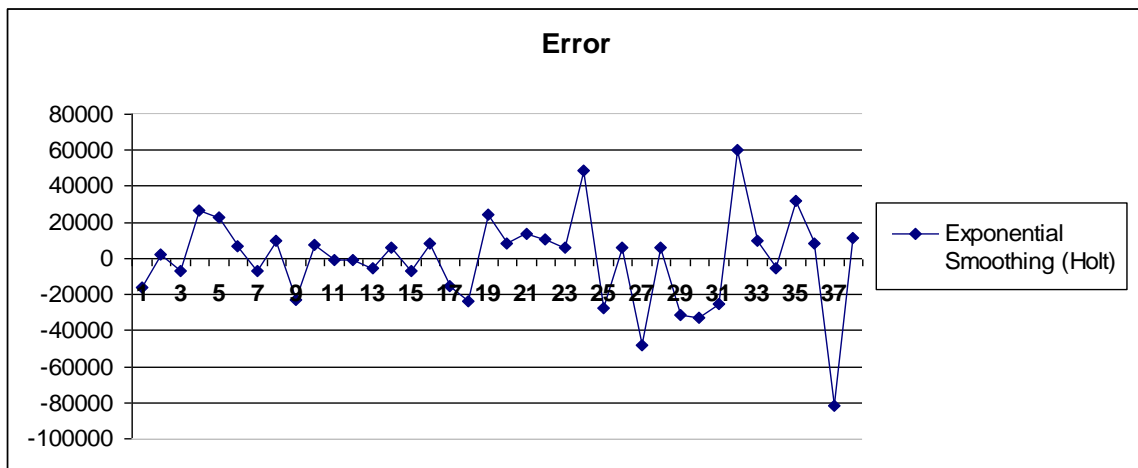
ErrQuad= (output(i)-datiInput(i+1))
end



- dati=xlsread('Genasys STUDIO cn METODI.xls', 'C19:C59')
- datiInput=dati'
- output = tsmovavg(datiInput, 's', 5)
- for i=5:40
  ErrQuad= (output(i)-datiInput(i+1))
  end

b- Exponential Smoothing



c- Exponential Smoothing Holt

The error is calculated to assess, in the next step, the mean square error. The method which corresponds to the minimum mean square error will be the one to choose to make the preview, because it best.

The mean square error was calculated for each method using the following expression:

$$MSE_n = \frac{1}{n}\sum_{t=1}^{n} E_t^{2}$$

The table shows the values of mean square error calculated for each method:

| | Mean Square Error |
|---|---|
| **Moving Average (4 Period)** | 606907860 |
| **Moving Average (5 Period)** | 721116319 |
| **Exponential Smoothing (alpha=0.286)** | 690824120 |
| **Exponential Smoothing (alpha=0.5)** | 580394212 |
| **Exponential Smoothing (alpha=0.667)** | 583942538 |
| **Exponential Smoothing (alpha=1)** | 700285051 |

The method at which one has the minimum mean square error is the exponential smoothing with alpha = 0.5.

## 3.5.2 Chi-Square Test

With chi-square test means a test used in statistical hypothesis testing using chi-square to see if the null hypothesis is consistent with the data probabilistically.

The results obtained in the samples do not always agree exactly with the theoretical results expected according to the rules of probability, rather, it is very rare for this to occur.

Suppose that in a particular sample has been observed that a set of possible events, E1, E2, ..., Ek shows frequencies o1, o2, ... ok these observed frequencies, and that, under the rules of probability, the expectation is that occurs frequently e1, e2, ..., k such theoretical or expected frequencies:

**Event**        $\mathbf{E_1\ E_2\ ...\ E_k}$

Observed frequencies $o_1\ o_2\ ...\ o_k$

Expected frequencies $e_1\ e_2\ ...\ e_k$

The purpose of the $\chi^2$ test is to know whether the observed frequencies differ significantly from the theoretical frequencies.

If $\chi^2 = 0$, the observed frequencies exactly coincide with the theoretical one. However, if $\chi^2 > 0$, they differ. The larger the value of $\chi^2$, the greater the discrepancy between the observed and theoretical frequencies. In practice, the theoretical frequencies are calculated on the basis of a hypothesis H0. If this hypothesis based on the computed value of $\chi^2$ is greater than a certain value, we conclude that the observed frequencies differ significantly from the expected frequencies and we reject H0 at the appropriate level of significance. Otherwise we should accept it, or at least not reject it. This procedure is called a chi-square test of the hypothesis.

$f_0$ and $f_e$ are observed frequencies and expected frequencies.
H0 is the null hypothesis and H1 is the alternative hypothesis.

H0: There is a difference between the observed and expected frequencies.
H1: There is a difference between the observed and expected frequencies.

**Test statistic:**

$$\chi^2 = \sum \left[ \frac{(f_o - f_e)^2}{f_e} \right]$$

The critical value is a value taken from a random variable chi-square with degrees of freedom (k-1), where k is the number of classes in which the random sample is grouped.

*-Step 1: Fix null hypothesis and alternative.*

H0: There is agreement between the data.
H1: There is no agreement between the data.

In our case, the data are:
- values Hits / month for actual location services company Genasys
- values estimated by different methods of forecasting (Moving Averages, Exponential Smoothing,

Holt's method).

Our goal is to apply the Chi Square Test to verify the consistency of the actual data and those estimated in terms of square error.

-*Step 2: Select the level of significance α.*
Let $\alpha = 0.02$

The **level of significance** of a test is usually given by a test of hypothesis testing. In the simplest case is defined as the probability of accepting or rejecting the null hypothesis. The decision in this case is done using the p-value: if the value p (p-value) is less than the significance level, then the null hypothesis is rejected. The lower the p value, the more significant is the result.

-*Step 3: Select the test statistic*

How to use the test $\chi 2$ statistics.

-*Step 4: H0 is rejected if the p-value is less than $\alpha = 0.02$.*

We calculate the test statistic at each forecasting method used.

1. *Moving Average (p=4)*

Sum value $\chi^2 = $ **147108,8093**

This value was obtained by applying the formula:

$$\chi^2 = \sum \left[ \frac{(f_o - f_e)^2}{f_e} \right]$$

Degrees of freedom $= 37\text{-}1 = 36$

The p ($\chi 2 > 147108.8093) = 0$ has been calculated using the method *chi2cdf* ($\chi 2 = X$, $V = $ degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf ).

Matlab code snippet:

*>> chi=1-chi2cdf(147108.8093,36)*

*>> chi =*

  *0*

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level ($\alpha$ = 0.02). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

2. *Moving Average (p=5)*

Sum value $\chi^2$ = **165265,9454**

Degrees of freedom = 36-1 = 35

The $p(\chi^2>165265,9454)=0$ has been calculated using the method *chi2cdf* ($\chi2$ = X, V = degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf ).

Matlab code snippet:

*>> chi=1-chi2cdf(165265.9454,35)*

*>> chi =*

  *0*

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level ($\alpha$ = 0.02). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

3. *Exponential Smoothing (alpha=0.286)*

Sum value $\chi^2$ = **151024,4**

Degrees of freedom = 35-1 = 34

The $p(\chi^2>151024,4)=0$ has been calculated using the method *chi2cdf* ($\chi2 = $ X, V = degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf ).

Matlab code snippet:

```
>> chi=1-chi2cdf(151024.4,34)
>> chi =
   0
```

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level ($\alpha = 0.02$). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

4. *Exponential Smoothing (alpha=0.5)*

Sum value $\chi^2 = $ **140461,6884**

Degrees of freedom = 37-1 = 36

The $p(\chi^2>140461,6884)=0$ has been calculated using the method *chi2cdf* ($\chi2 = $ X, V = degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf).

Matlab code snippet:

```
>> chi=1-chi2cdf(140461.6884,36)
>> chi =
   0
```

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level ($\alpha = 0.02$). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

5. *Exponential Smoothing (alpha=0.667)*

Sum value χ^2 = **150160,9**

Degrees of freedom = 38-1 = 37

The $p(\chi^2>$**150160,9**$)=0$ has been calculated using the method *chi2cdf* ($\chi2$ = X, V = degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf).

Matlab code snippet:

>> chi=1-chi2cdf(150160.9,37)

>> chi =

  0

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level (α = 0.02). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

6. *Exponential Smoothing (alpha=1)*

Sum value χ^2 = **178620,1668**

Degrees of freedom = 39-1 = 38

The $p(\chi^2>$**178620,1668**$)=0$ has been calculated using the method *chi2cdf* ($\chi2$ = X, V = degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf).

Matlab code snippet:

>> chi=1-chi2cdf(178620.1668,38)

>> chi =

  0

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level (α = 0.02). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and

actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

7. Modello Holt

Sum value χ^2 = **163781,5227**

Degrees of freedom = 38-1 = 37

The ***p(χ^2>163781,5227)=0*** has been calculated using the method *chi2cdf* ($\chi2$ = X, V = degrees of freedom) of Matlab, which is likely given the value of the variable (it is the cumulative distribution function, cdf).

Matlab code snippet:

>> chi=1-chi2cdf(163781.5227,37)

>> chi =

   0

It rejects the null hypothesis because the value of the test statistic exceeds the critical value of $\chi2$ and then the p-value of 0 is less than the chosen significance level (α = 0.02). Rejecting the null hypothesis it is concluded that there is no agreement between the estimated and actual data. This performance should be evaluated considering that it is very rare that the results obtained in specimens agree exactly with the theoretical results expected according to the rules of probability.

In summary:

Method	$\chi2$
Moving Average (p=4)	147108,8093
Moving Average (p=5)	165265,9454
Exponential Smoothing (alpha=0.286)	151024,4
Exponential Smoothing (alpha=0.5)	140461,6884
Exponential Smoothing (alpha=0.667)	150160,9
Exponential Smoothing (alpha=1)	178620,1668
Modello Holt	163781,5227

3.6 Data Analysis – Arch and Garch Method

Step 1: The time series of hits / month was loaded in Matlab.

**dati=xlsread('Genasys.xls', 'C19:C59');**

From the plot of this series we observed this trend.
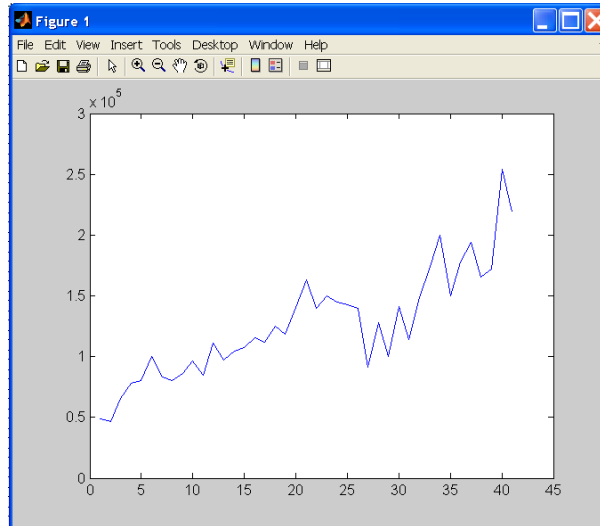
We use the 'autocorr' to calculate the autocorrelation of the series and the series squared. In the first case you must check the presence of correlation between the data given at time t and the previous time, and between the data and innovations. In the second case we consider whether the variance at time t is correlated with the variance to the previous time instants.

We also use the function 'parcorr' to calculate the partial autocorrelation function, from which it may obtain useful information relativity to the structure of the model that generated the series.
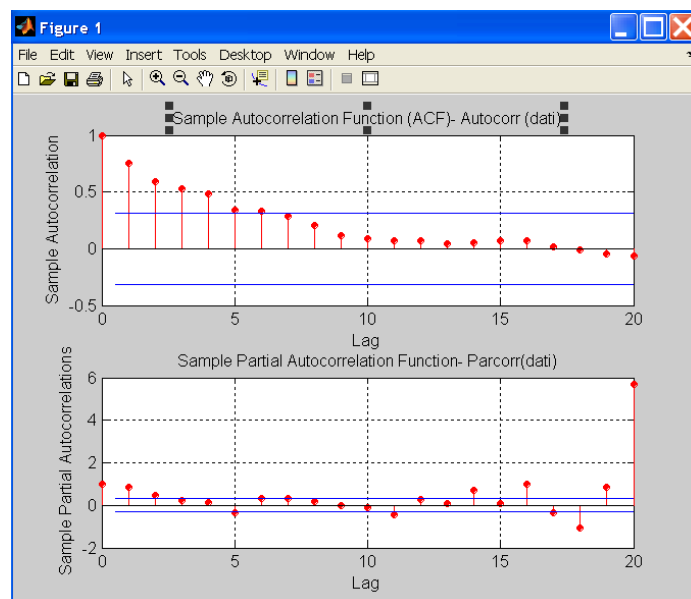
From the figure obtained by implementing the function 'autocorr (data)' can be seen that a significant number of samples of the autocorrelation function is outside the tolerance bands, so there is no correlation between the data series.

The plot on the partial autocorrelation, shows that the function is not significantly different from 0, in fact, only some samples are zero.
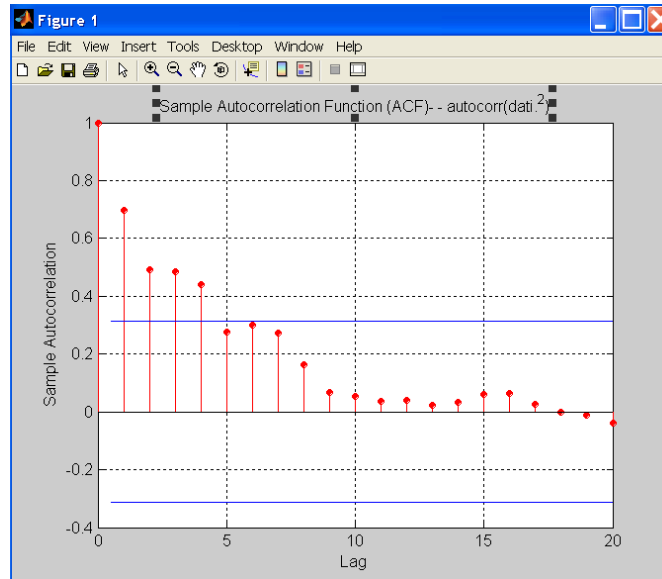
From the figure obtained by implementing the function 'autocorr (dati^ 2)', we look at the samples outside the tolerance bands, which could indicate the presence of arch and garch components. For a further check we use diagnostic tests.

[H,pValue,Stat,criticalValue]= lbqtest (dati,[10, 15, 20]',0.05)

'lbqtest', applied to the 'dati' series, returns a vector of 1, this leads us to reject H0, and then, as also noted in the previous step, there is a correlation between the data.

[H,pValue,Stat,criticalValue]= lbqtest (dati.^2,[10, 15, 20]',0.05)

'lbqtest', as applied to square the series, returns a vector of 1: H0 is rejected, there is a correlation between the data in question.

Use the function 'autocorr' and the implementation of the tests we conclude that there is a correlation between the data.

Step 2 - We first consider the ARMA components, then those related to the GARCH and ARCH models: ARMA model is obtained by putting 0 in the parameters of the variance. Proceed to attempts, we consider first the simpler structures.

ARMA (R = 1, M = 0)

It uses the function 'Garchset'to define and generate the specified pattern. This model is saved in the variable Struct:

Struct= garchset('R',1,'M',0,'P',0,'Q',0);

We use the 'Garchfit' to estimate the structure of the series "dati" and to reconstruct the values of the parameters:

[coeff,errors,LLF,innovations,sigmas,summary]=garchfit(Struct,dati);

Plotting the innovations, which are the residues of the estimated model:
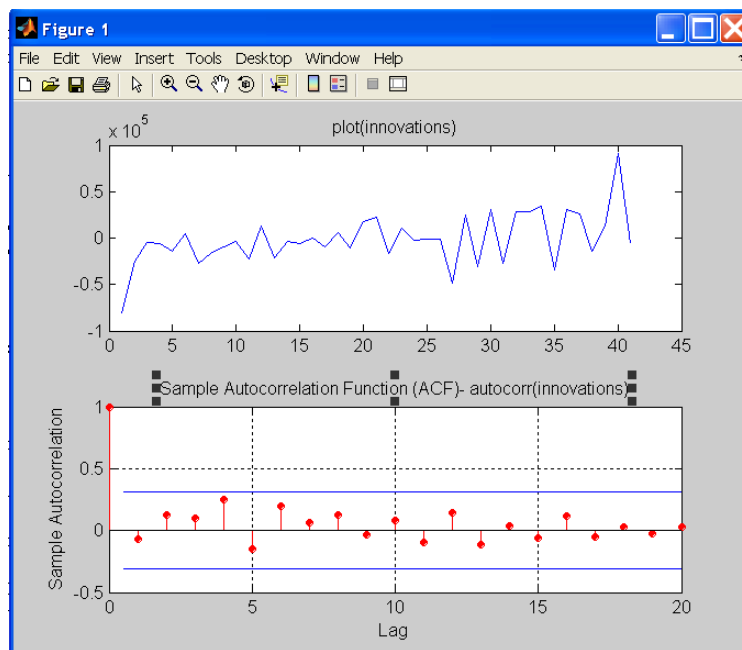
We evaluated the autocorrelation of innovations through the function 'autocorr'. From the figure it is noted that the samples are distributed within the bands, so there is no correlation between the residuals. This structure for the model is accepted as the residuals are uncorrelated with each other.
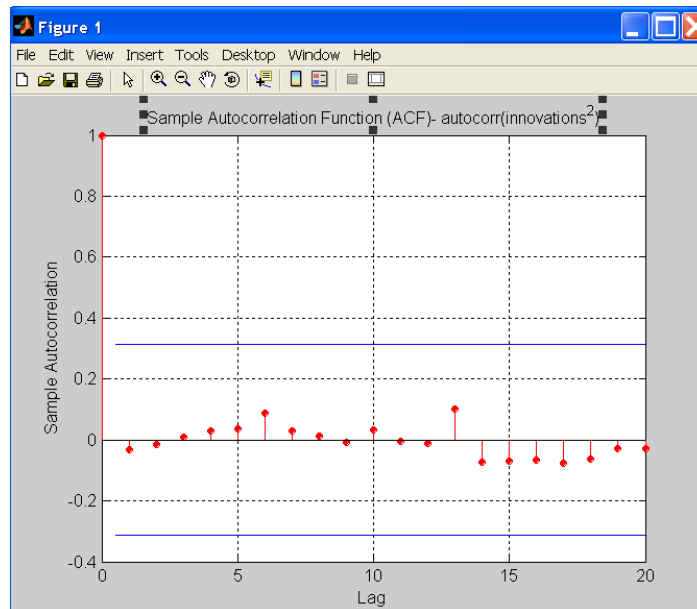
```
>> garchdisp (coeff, errors)

  Mean: ARMAX(1,0,0); Variance: GARCH(0,0)

  Conditional Probability Distribution: Gaussian
  Number of Model Parameters Estimated: 3


                              Standard          T
   Parameter      Value         Error       Statistic
   -----------   -----------   ------------   -----------
           C     35743         15447          2.3139
       AR(1)     0.74183       0.10589        7.0059
           K     6.0101e+008   1.4589         411971437.4869
```

Now we evaluate the autocorrelation of the innovations to the square using the 'autocorr'.

In the plot it is clear that samples of the autocorrelation function of the squared innovations are within the tolerance band then you should not estimate the arch and garch components.

Here is the general structure of our model ARMA (1.0):

$y_t = 35743 + 0,74183 y_{t-1} + \varepsilon_t$

$\sigma^2_t = 6.0101 * e^{+008}$

The coefficients are displayed with the 'garchdisp' function.

garchdisp(coeff,errors)

4 Bibliography

- Forecasting a Logistic Service Demand based on Neural Network
- Forecasting methodology and traffic estimation for satellite multimedia services
- Forecasting the demand for the new telecommunication services
- Forecasting Long-Term Demand for Services in the Residential Market
- Demand forecasting Based on Internet of Things
- A comparison of International ITS Service Architectures and Demand Forecasting of the Korean ITS Services
- Order Prediction of Interactive Service of Cable Television Based on K-means Cluster and Decision Tree
- *ITU*-T Rec. E.*506* (06/92) Forecasting international traffic
- ITU-T Rec. E.507(11/85) - Models for forecasting international traffic
- http://www.itu.int/itunews/manager/display.asp?lang=en&year=2006&issue=03&ipage=radiotelegraphy&ext=html
- Silver, E.A., Pyke, D.F., Peterson, R., "Inventory Management and Production Planning and Scheduling" - Third Ed. - WILEY 1998.
- http://www.mcit.gov.sa/english/Development/SectorIndices/
- http://www.newmediatrendwatch.com/markets-by-country/10-europe/77-norway
- http://www1.american.edu/initeb/as5415a/Israel_ICT/itDiffusion.html
- http://navigators.com/stats.html
- http://www.pewinternet.org/Trend-Data/Internet-Adoption.aspx
- http://www.genasys.com/index.php?lang=en
- http://www.genasys.com/proveedores.php?lang=en&item=localizacion
- http://www.genasys.com/proveedores.php?lang=en&item=plataformas_localizacion&display=1
- http://www.genasys.com/proveedores.php?lang=en&item=gis
- http://www.itu.int/itunews/manager/display.asp?lang=en&year=2006&issue=03&ipage=radiotelegraphy&ext=html
- http://www.netvalley.com/intvalstat.html
- http://www.isc.org/solutions/survey
- http://www.vodafone.es/empresas/es/moviles/servicios-y-aplicaciones/servicios-de-mensajeria/mensared/
- http://www.vodafone.com/content/annualreport/annual_report10/index.html

- http://api.orange.com/en/api/location-api,3
- http://www.orange.com/sirius/RA2009/beevirtua/beevirtua.html#app=307e&adf3-lang=en&ccb3-pageId=0&9557-source=xmlConfs/init.zip
- http://www.mathworks.com/help/toolbox/finance/smoothts.html
- http://www.orange.com/fr_FR/finance/documentation/rapports-annuels/
- http://www.idg.es/computerworld/El-mercado-espanol-de-CAD|CAM|CAE|GIS-en-1992.-Est/seccion-/articulo-40910
- http://www.movistar.com.uy/Servicios/Localizacioacuten.aspx
- http://www.lbsinsight.com/public/templates/lbssearch.aspx?id=172
- http://movil.orange.es/soporte-y-ayuda/herramientas/mapa-de-cobertura/
- http://www.telegeography.com/cu/article.php?article_id=34653
- http://imcellular.org/tag/mobile-internet-profitability/
- http://www.reach-u.com/?op=body&id=13
- http://www.cmt.es/cmt_ptl_ext/SelectOption.do?nav=presentacion