MASTER THESIS

TITLE: A viability plan of a unit of research in applications of new telecommunications technologies

MASTER DEGREE: Master in Science in Telecommunication Engineering & Management

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DATE: June, 15th 2009

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Overview

This project is about to develop a plan to create a dedicated unit in order to monitoring of emerging technologies in the field of telecommunications. The main objective is to combine models based on numerical methods and estimation techniques with these technologies for an intelligent use of efficient space transparent to the user at the local area and even personal.

This unit is part of the structure of the International Center for Numerical Methods also know as CIMNE (International Center for Numerical Methods) is an autonomous center dedicated to develop and promote advances in the development of numerical computing method and application techniques. CIMNE is a consortium between the Polytechnic University of Catalonia (UPC) and the Generalitat of Catalonia to boost R&D&I applied for numerical methods in engineering.

This project is based on analysis of research centres that are developing technologies from wireless sensor networks and new companies based on this technology and consultation to people with extensive expertise in research and the query to research experts with an overview of industry needs, we can outline a plan, in general, based on differential elements of CIMNE to compete with other centres, to create synergies with other groups and to be able to launch competitive products demanded by the productive sector through the intensive use of numerical computation in distributed networks such as wireless sensor networks in order to generate alarms, create decisions support systems and act in a manner transparent to the user in different environments.

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Resumen

El presente proyecto consiste en desarrollar un plan para la creación de una unidad dedicada al seguimiento de tecnologías emergentes en el ámbito de las telecomunicaciones. El objetivo principal es el de combinar las simulaciones basadas en métodos numéricos y las técnicas de cálculo con estas tecnologías para el uso inteligente de espacios eficaces, de forma transparente al usuario a escala local e incluso personal.

Esta unidad se enmarca dentro de la estructura del Centro Internacional de Métodos Numéricos también conocido como CIMNE. Es un centro autónomo de investigación y desarrollo dedicado a impulsar los avances en el desarrollo y aplicación de los métodos numéricos y técnicas de cálculo por ordenador. CIMNE es un consorcio entre la Universidad Politécnica de Cataluña (UPC) y la Generalitat de Cataluña para impulsar la I+D+i de los métodos numéricos aplicados en la ingeniería.

El proyecto se basa en el estudio de la prospectiva tecnológica, en el análisis de los centros de investigación que están desarrollando tecnologías a partir de las redes de sensores sin hilos y de nuevas empresas basadas en esta tecnología y en la consulta a personas con amplios conocimientos en materia de investigación y con una visión global de las necesidades de la industria y la sociedad en su conjunto. Todo ello para esbozar un plan, basándonos en elementos diferenciales del CIMNE para competir con el resto de centros, crear sinergias con otros grupos y poder lanzar productos competitivos demandados por el sector productivo haciendo uso intensivo del cálculo numérico dentro de redes distribuidas como las redes de sensores sin hilos para poder generar alarmas, crear sistemas de apoyo a la decisión e incluso actuar de forma transparente al usuario en diferentes entornos.

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INTRODUCTION

This project will study the viability of creating a new research unit in CIMNE to promote the intensive use of calculations in emerging technologies.

The idea of promoting the creation of a department aimed at emerging technology monitoring was born from the positive experience of the ICT group where the use of technologies is been promoted, now development stage. The main objective is to combine simulations based on numerical methods and calculating techniques with new technologies such wireless sensor networks or even Geographic Information System (GIS) in order to be able to develop tools and Decision Support Systems (DSS).

First of all a prospective analysis of emerging technologies have been carried out. This analysis considers which technologies will have an important impact in the society with the aim of detecting which are the challenges that we will face during the implementation of this technology.

Experts in new technologies have been asked about topics related with wireless sensor networks, in order to have an overview of new coming challenges and those sectors where it is supposed that an extensive use will be carried out.

A comparison of R&D activities, experiences, services and work processes in research centres have been done. Benchmarking has been carried out based on products, services and work processes that belong to research centres. It has been focus on transferring the knowledge and its application.

After this, a plan based on CIMNE differential elements has been draft in order to be competitive with other organisations, to make agreements with other groups and to be able to launch competitive products demanded by the productive sector.

Afterwards, the objectives has been specified to make the unit competitive with other research groups that are working in the same line making an estimation of which resources has been needed and which projects may have a bigger scientific or application impact.

A growing plan has been designed. I have been defined long-term objectives based on a prospective analysis function and on the advice from experts.

Finally different ways of public financiation has been considered for analyzing the economic and financial viability of the unit.

CHAPTER 1. PROSPECTIVE

The prospective study has been limited in a first approach to two technologies that can bring more benefits to meet the goals of the group like wireless sensor networks and RFID (Radio Frequency Identification).

Reports and studies from Gartner Inc. have been consulted. Garner is working in research, consultant and assessment to ICT. Also has been consulted other sources including the MIT (Massachusetts Institute of Technology).

1.1 Prospects for wireless sensor applications

Increasingly, the objects in the real world (physical) contain not have the process capability, due to the decreasing size and cost of microprocessors, but they are also able to interact with their environment through the monitoring and detection capability the network [1].

The emergence of this new concept also known as the Internet of things will give greater autonomy to the Web, which today is perceived as a virtual place for the user but it will become increasingly difficult to distinguish the real from the virtual.

This effect will have a big impact in the technologies described below:

Positioning technologies like Global Positioning System GPS (GPS), assisted GPS (A-GPS), Enhanced Observed Time Difference (EOTD), Enhanced GPS (E-GPS), and other technologies like the mobile phone network. It will be reach mature enough in less than two years time. Users should evaluate the potential benefits that personal navigation devices may add to business processes (for example TomTom or Garmin), or other GPS receivers, as well as the placement of WLAN equipment may help to automate complex processes, like those ones logistic and maintenance related.

The adoption period of applications derived from technologies mentioned below will be from 2 to 5 years. Increasing numbers of organizations have focused their business model to mobile business applications, mostly based on GPS, such support to activity processes, vehicle and logistic management, etc. The market is now in an early stage of adoption and Europe is taking advantage in front of the United States due to the higher maturity in their mobile networks.

Market for wireless sensor networks still in an early stage and is quite divided. There are not too many standards and it makes that providers are making a continuous evolution, doing that the equipment is suffering very quickly. Thus, this field should be considered as a risk in investment due the adoption is not expected before than in about 10 years time [1].

Wireless sensor networks will be one of the technologies that will revolutionize the industry [2]. They are able to communicate without any kind of wires or

cables and is one of the fields were the research is putting more effort nowadays. Through them, an integration of functionalities can be done in order to achieve the highest efficiency in fields like consumption and power management. These functionalities before used to work independently.

Wire sensor networks are not new and they have functions like temperature, level liquid, humidity measurement, etc. Many sensors places in industrial environments have their own network connected to a computer or to a control box through a wire. When an anomaly is detected, they send a warning message to the control box. The difference between well-known sensors and new generation ones is that new ones are smart. It means that they are able to enable an action based on the accumulated information and they are not limited by the drawbacks of a wire.

The progress in radiofrequency microchips manufacturing, combined with routers increasingly faster and new computer applications liked with networks are achieving the elimination of wires from sensor networks and creating a higher potential.

Wireless sensor networks may be based on different technologies like IEEE 802.11, wireless LAN, Bluetooth, Zigbee and radiofrequency identification.

The most recent researches point out that smart sensor networks technology is growing. These networks will gather lots of information and will make possible an improvement in factories, studies, construction monitoring, domestic duties, work organization and natural disaster prediction.

If the technological advances in this field continue at the same speed than have been in the recent years, wireless sensor networks will revolutionize the capability of interaction between humans and world.

Based on Gartner analysis [3], the main element to take into account when integrating information, operation and consumption technologies will be the Real World Web.

Most of the research related to the interface between information and public consumption technologies and the interface of information and operation technologies say that both problems should be handled in a different way. However in certain fields like local government o public service companies, this problem should be treated together.

From this study, operation technologies will have a role every time more important in fields leaded by local government like environmental preservation, traffic management, health and medical fields. This technology will interact with information technologies, as well as with hardware devices and software components. Its interoperability will be an issue needed to be solved.

It is an information technology customization call. It is based on how companies can be affected and how can they use it to take profit in order to create new business models.

In some industrial sectors, like manufacturing, another important trend is the growing interconnection between information and operation technologies. The last ones are used to guarantee the system integrity facing technical limitations of real time operations of company assets.

They are real time events of software applications or devices with software embedded, in which the control is carried out through sensors for production management or delivering processes. Governments, especially at local level, depend on this kind of processes to guarantee the public security, traffic tolls and management and environment monitoring.

Something similar happens with interfaces between consumption and information technologies.

The emergence of Real World Web with the presence of sensors and actuators having local transformation and network capabilities, will promote the operation technology adoption in new fields. The ability of borrowing services or carrying out critic processes will depend on the capability to find a balance between information, operation and consumption technologies. This will be especially true in sectors like transport and environment preservation. Current previsions say that in 2013 more than 20% of local government investments will go towards this direction.

1.2 RFID technology prospects of application. (Radio Frequency Identification)

From Gartner report [3], RFID technology will have a bigger impact in solutions pointing to control the stock in storages and vehicle monitoring. There also are many new markets to discover like information points or entry point control in events or services.

This report also talks about market speed adoption and position and says that now is at the point of the disappointment curve and now the scope and benefits is starting to be well considered. Currently only a small percentage around 25% of local business have been tested it out. Only a very few of them took profit of the technology to carry out a wider deployment. It means that in the early future (2-3 years time) the number of local business will not grow significally. Another aspect to consider is that the number of pilot projects has been decreased. However some companies like Alien Technology or Motorola still researching and promoting the spreading of RFID in the market.

From Gartner, pilot projects should be focus on supplying chains for example to be able to evaluate the availability of a product and optimise the scheduling.

The impact that it will have over the companies will the tracking improvement referring to the customer availability. Something that needs to be considered is that the technology is in a early stage of transformation and new actuation fields can be found yet, due to is not mature enough and the penetration objectives are only from 1% to 5%.

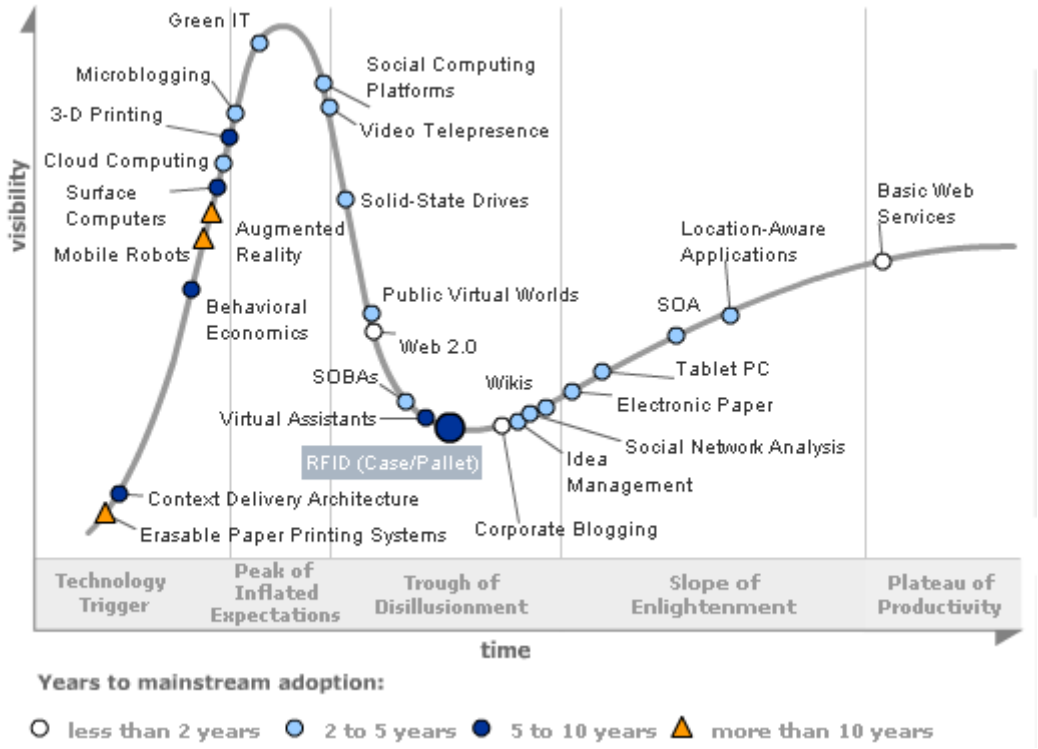

Figure 1.1 Hype Cycle for Emerging Technologies, Gartner, ID Number: G00159496, Publication Date: 9 July 2008.

benefit	years to mainstream adoption			
	less than 2 years	2 to 5 years	5 to 10 years	more than 10 years
transformational	Web 2.0	Cloud Computing Public Virtual Worlds SOA	3-D Printing Context Delivery Architecture RFID (Case/Pallet)	Mobile Robots
high		Electronic Paper Green IT Location-Aware Applications Service-Oriented Business Applications Solid-State Drives	Behavioral Economics	Augmented Reality
moderate	Basic Web Services Corporate Blogging	Idea Management Microblogging Social Computing Platforms Social Network Analysis Tablet PC Video Telepresence Wikis	Surface Computers Virtual Assistants	Erasable Paper Printing Systems
low				

Figure 1.2 Priority Matrix for Hype Cycle for Emerging Technologies, Gartner, ID Number: G00159496, Publication Date: 9 July 2008.

The most recent paper published by Gather about Hype Cycle [3] point out that industry seems that is leaving the disappointment valley referring to RFID technology. After a sceptic period, the industry already is starting to believe in the benefits that this technology provides. This study also predicts that prevision

plan of market participation and RFID previsions will grow from $504 millions in 2004 to $3,000 millions in 2010.

As it is has been discussed before now is the time when true benefits are coming out and industry will start to believe in innovative applications using this technology. This will also accelerate the adoption by the industry. Annex A and B explains in detail how the Hype Cycle and the Priority Matrix are analyzed.

1.3 Interview to experts

In this part of the project the goal has been to gather information from new technology experts, especially in which is relevant in relation to wireless sensor networks, to know the most important challenges of coming years and those sectors where it is suppose that a intensive use will be carried out.

This information clarifies which sectors and which applications may be interesting once included the added value that CIMNE provides with its numerical methods, Decision Support Systems and simulations.

A brief explanation of asked experts is introduced below:

- Jordi Berenguer: Doctor in Telecommunication Engineering. ETSEIB (Escuela Técnica Superior de Ingeniería de Telecomunicaciones de Barcelona) in 1988. Used to work for Mier Comunicaciones until February 1992, when he became a professor at University School for the Signal Theory Department. He was the sub director of laboratories at the Escuela Universitària Politécnica del Baix Llobregat since it began until 2000. He was also the project director of the Secretaria de la Sociedad de la Información (DURSI) from 2000 until 2003. From June 2006 is delegate of the director in the Campus del Baix Llobregat. Since January 7th 2008 is the director of the Escuela Politècnica Superior de Castelldefels.

- Rafael Vidal Ferré: Telecommunication Engineer since 1997 and PhD student in Telematics Engineering. Lecturer since 2000 in the Telematics Engineering Department at Universidad Politècnica de Catalunya (UPC) assigned to Escola Politècnica Superior de Castelldefels (EPSC). Since 1998 works for Wireless Network Group.

- Jordi Jiménez del Hierro: Computer Engineering from Universitat Politècnica de Catalunya. MBA at the Fundació Politècnica de Catalunya. Since 2006 coordinator of the department of R & D in Information Technologies and Centro Internacional de Métodos Numéricos en Ingeniería. His main line of research is the integration of smart wireless sensor networks with ICT in areas like environmental, construction, health, tourism, aviation and naval. He has coordinated and worked in several research projects, both in Spain and in Europe. All related to Information technology and communication: WSN technology, GIS technology, artificial intelligence (AI), development of collaborative

web tools (Virtual centre of CIMNE), platforms and Decision Support Systems.

- Pedro Arnau: Ph.D. in Oceanography from the Universidad Politècnica de Catalunya. He is an expert in remote sensing, object programming and GIS. Authored over 20 papers published in journals, Pedro Arnau has presented over 10 communications in conferences. In his research, he has participated in 35 projects of national R & D (17) and international (18) in different fields like oceanography (physics, biology, chemistry and geology, and 3 with ESA and Space Agency ERSDAC. He has worked on 13 contracts with companies. He has participated in 9 oceanographic cruises with ships Hespérides, 'García del Cid', 'Vizconde de Eza' and 'Arraix'. Since 2004, he is a professor and tutor of master UNIGIS at the Universitat de Girona. He received in 2001 an award from the Foundation AGBAR for his doctoral thesis. Since 2002, he has recognition by the Board of the UPC for their research work.

Prevision of New Information Technologies and Telecommunications Impact

This part will summarize the information and analysis of the experts consulted by separating the technological scope sectors that may have new information technologies and telecommunications, especially wireless sensor networks, combined with methods calculation by computer.

Environment

Recently the fact that the environment affects our quality of life in a fundamental way is concerning the society. In a country like ours, every time more populated and industrialized, the preservation of the environment must be one of the pillars of our system of R & D and, in particular, new technologies must be developed within the field of ICT to control and monitor in real time those environmental parameters that define our environment and therefore our quality of life.

The noise generated by industrial activities, traffic and leisure activities is one of the main environmental problems in developed countries. Noise pollution is growing day by day and it does not have received yet the necessary attention by the government. The noise problem is basically an urban problem but may also affect the rural or natural areas (if they are nearby to a major infrastructure such as airports or motorways).

Urban noise affects clearly to the citizens health. Recent studies have demonstrated that urban noise is directly related to cardiovascular diseases [9], and hypertension problems. It also generates high levels of stress (which particularly affect children [10]). In addition to this, it also has been shown that part of the public exposed to noise generated by an airport has lower health quality than the standard average [11].

Despite the existing laws and regulations in different countries of European Union, the number of European citizens harmed by noise pollution still growing. Due to the increase of urban areas and especially the increase of mobility, the areas where you can enjoy a quiet atmosphere is decreasing. Achieving a sustainable mobility is a major social and political challenge in Europe. Mobility promotes economic growth, but also tends to increase the traffic congestion and harms the sustainable development of Europe. Noise is one of the obvious effects of the transport industry. The traffic is often the most important source of problems and actually it has shown that noise may cause serious health problems (cardiovascular, nervous ... etc).

Thus, developed countries are pushing for research into new technologies for real time monitoring of environmental pollution, not only to know the state of the environment at all times, but to make predictions, environmental maps and to take measures to preserve the environment.

The measurement and monitoring of environmental noise will allow checking the noise levels of the territory. These maps are the main tool to identify the most affected geographical areas by noise pollution and are the basis for decision making by administrations. The noise of tourist cities increases excessively during summer due to tourism and it seriously affects the residents and tourists quality of life.

The creation of noise maps allows also studying the impact on the area of large infrastructures such as airports or motorways. It offers a scientific basis on which to make political decisions (such as noise barriers to minimize the impact of that infrastructure).

Real time monitoring technologies are needed to check the status of noise pollution. These technologies also allow making a diagnosis of noise in each point, generating environmental databases that can be used to make predictions. Then it makes possible to provide an empirical basis in the creation of maps and acoustic capability maps. It is important to begin the creation of environmental databases to fight environmental pollution.

The creation of an acoustic information system involves research and development in wireless sensor technologies, acoustic measurement system, GIS technology, predictive models (statistical and differential equation algorithms) and finally in real time interactive display systems.

The Spanish tourist industry faces many challenges and opportunities that will define its future. Competitive challenges, among others, will require growing and management models of tourist supply and demand more innovative, balanced and sustainable.

Improving the quality of tourist destinations, products and services, with diversification of supply and deseasonalisation, may constitute the fundamental basis of a tourist strategy in which promotion and applied research also provides essential elements to achieve the goals set from the administration in a model where there should coexist tourism and environmental preservation. It

also needs to adopt measures to enhance the attractiveness and facilitate the integral restructuring and repositioning of tourist pioneering and outdated areas.

In this context, a key factor is the combination of wireless sensor technology in weather stations, GIS technology and the integration of information from external content repositories from the public sector, in order to control and monitoring of geographical, weather, environmental, healthcare and tourism data in real time, with special attention to the environmental warning spreading (for example jellyfishes, spillages, storms, etc).

Aviation sector

In the aviation industry the parachute features prevents the use of measurement standard systems of the market and require the development of high sensitivity wireless sensors, capable of measuring positioning, aerodynamic and structural data for the design, implementation and validation of an information system for monitoring and controlling the operation efficiency and structural integrity of a parachute during the spreading out and flight stages, combining wireless smart sensors, computer simulation techniques and artificial methods of intelligence based on artificial neural networks for decision making in quasi-real time.

The research should focus on the study and development of sensors such as accelerometers, load cells, pressure transducers, meters and inertial navigators (accelerometers, gyroscopes, GPS, etc), temperature and strain sensors to control the movements, stress and deformation in the parachute structure and the knowledge of their position during the flight.

The use of new analytical and simulation environments from a collection of on-line data, using wireless smart sensors is an interesting aspect for many aviation companies due to the allowance to carry out a structural analysis of tissues and cords that make up the parachute.

Naval sector

In the naval sector and especially in competition sailing boats they have realised the there are important benefits obtained from the development and validation of innovative methods, based on computational engineering techniques to develop and integrate Decision Support Systems for assistance in the design and sail manipulation.

The constant monitoring of a competition sailing boat and the predictive ability of the measurement system enables its use as a warning. Thus, it is possible to encode the sailing boats information loads and translated into specific messages that users can understand easily. This would help in preventing accidents like the one on the boat taking part in the Spanish 1999 edition of the Copa America, "Bravo España". In this accident Martin Wizner died when a support piece broke and hit him.

Another aspect to take into account is that it is possible to identify a technological purpose which is development of a methodology for economic and advanced sensors of the rigging and aloft of a sailing boat through the use of suitable easy mounting wireless sensors.

Enological industry

The development of new technologies on the agro-production infrastructure in order to monitor enological processes integrating wireless smart sensor networks, simulation methods, predictive calculations, the Internet and mobile communication technologies is one of the greatest challenges for the coming years.

Monitoring stages of cultivation and production of wine is essential to control the quality, as well as to be able to be aware of defects and situations that may risk the product integrity leading the industry to make a huge loss.

One of the actual challenges is to develop platforms that incorporate new methods, new techniques and tools to achieve better quality, efficiency and safety of food processes, in the enological field production. The combination of wireless sensor networks, as the key for monitoring and remote control via Internet and mobile devices, allows making an online control. At the same time, incorporating a system for real time predictive data calculation through the sensor network enables the creation of an advanced system that helps to adjust the parameters that optimize the service level.

CHAPTER 2. BENCHMARKING

2.1 Investigation Groups

In this section a comparison of R & D activities, experiences, services and work processes in research will be carried out. The benchmarking will have the aim of comparing the products, services and work processes that belong to research institutions that is demonstrate best practices with the aim of transferring the knowledge of their application their application.

Table 2.1 Comparative of Investigation Groups

	R & D Activities	WSN Experiences	Number of European projects	Number of national projects
Telecom and System Engineering Dept. (UAB)	Wireless communications: - Physical layer - MAC layer - Signal processing - Information theory - Optimization	Channel analysis. Relay selection Power optimization. Design fair design algorithms spending battery technologies based on port-folio.	2	10
Communication Group, Signal and Communication Theory Dept. (UC3M)	Sensors, telecommunications and network security (eValues) Biometrics and smart card test. (IDTestingLab) Treatment of socio-political security.	Analysis and WSN simulation Efficient transmission Algorithms.	3 (€7.5 millions worth)	1
Universidad de La Salle	Traditional communication systems of electrical companies Networks of low and medium voltage in which now communications are not used widely.	Modelling, development, and validation of the architecture for communications in smart networks. Specifications of communication networks and devices to support smart electricity networks of the future.	1 (Proposal)	0
Centre Tecnològic de Telecom. de	Providing end-to-end QoS. Communications subsystems.	Self-organized networks	2 (€3.7 millions worth)	2

Catalunya.	Radio communications. Access technologies.			
Instituto Tecnológico de Galicia	Mobile Wimax (IEEE 802.16e): Study of standard implementation to specific areas. Vehicle Ad-hoc networks.	Efficient techniques for implementation of standards. IP Connectivity (IPv6), routing and mobility in adhoc LoWPAN networks (IEEE802.15.4). Integrating sensors with radio technology.	0	1
I2CAT		Internet Engineering Task Force (IETF). Small size TCP/IP stacks.	3 (€0.375 millions worth)	19 (€0.232 millions worth)
Electrical Engineering and Computer Sciences (UC Berckley)	Artificial Intelligence (AI). Biosystems & Computational Biology (BIO). Communications & Networking (COMNET). Computer Architecture & Engineering (ARC). Control, Intelligent Systems, and Robotics (CIR). Database Management Systems (DBMS). Design of Electronic Systems (DES). Education (EDUC). Energy (ENE). Graphics (GR). Human-Computer Interaction (HCI). Integrated Circuits (INC). Micro/Nano Electro Mechanical Systems (MEMS). Operating Systems & Networking (OSNT). Physical Electronics (PHY). Programming Systems (PS). Scientific Computing (SCI). Security (SEC). Signal Processing (SP). Theory (THY).	Inertial systems based on MEMS. System of sensors for aviation and other vehicles		12

Networks and Mobiles Systems (MIT)		Prevention and control of interferences. Spread Spectrum wireless sensor networks. Cabernet: content distribution using WiFi. Coding symbols for wireless mesh sensor networks. Use of mobile sensor network for traffic monitoring. TCP Stream Normalization.		6
Aalborg University	Sustainable energy, environment and construction. Global production, innovation, knowledge development and consistency. Information technology and embedded software. Nanotechnology and nanoproduction. Technology and experience design.	PHY and MAC for WSN. WSN security	4 (WSN related)	

2.2 Benchmarking Competition (Companies)

In this section a comparison of the number of products, sales systems, after-sales service, R & D lines and spreading results of companies that sell products or services related to wireless sensor networks.

Table 2.2 Comparative of Companies

	Number of products and /or services	**Sale systems**	**After-sales service system**	**R & D**	**Outcome spreading**
Libelium	3	On-line.	Using a Wiki and exceptionally by telephone.	Two lines: -Wireless Sensor Networks. - Mesh Networks	Website with information of projects developed and under development.
TST Sistemas	5	Custom.	Custom	Deployment of emerging	Only reported

				technologies in retailing	the awards given.
Dexma	1	Custom. They have a pre-sale system that consists of pilot testing to customers free of charge	Training and support	Collaboration with universities and research centers.	Only reported the awards given.
WorldSensing	0	Its funding comes from the collaboration in R & D projects		Acoustic systems, seismic, electromagnetic and magnetotellurics.	Do not have precise information on their projects.
Signatelitcs	15	Custom.	Custom.	Design of the occupant of a vehicle equipped with smart technologies, which are able to detect the behaviour of the driver.	The results are regularly published on its Web site.
Adevice	8	Custom.	Custom.	Its lines are in fields like: -Industrial Monitoring and Control. -Energy Efficiency. -Telemetry. -Domotics.	Report their activities via their website.

Indra	Consulting, project development and systems integration applications. Outsourcing of information systems and business processes.	Custom.	Custom.	Second Spanish company that invests more in R & D. Has submitted a total of twelve patents in the Spanish office of patents and trademarks associated with the sensors.	Internal Publications.

[7]

CHAPTER 3. GROUP ESPECIALIZATION DEFINITION

After the prospective study, analysis of research centres that are developing technologies from wireless sensor networks and new companies based on this technology and consultation to people with extensive expertise in research and the query to research experts with an overview of industry needs, we can outline a plan, in general, based on differential elements of CIMNE to compete with other centres, to create synergies with other groups and to be able to launch competitive products demanded by the productive sector.

To guarantee that the new unit is successful, it is supported by the strengths of CIMNE, which will be analyzed in this chapter.

3.1 Prospective analysis

The study of prospective technology has been necessary to identify emerging technologies that will produce the greatest economic and social benefits and then assess the ability of the new unit of CIMNE based on its experience to integrate the calculation methods and to develop applications that match with what the society is demanding.

The prospective analysis tells that next step of Internet evolution will be the connection of identified and smart objects capable of exchanging information. This is the expected evolution after several years of platforms, networks and Web 2.0. We are approaching to a ubiquity that allows linking real and virtual objects, services and products in a smart way. Ubiquity is the integration of technology in the environment of the person, so that the computing units are not perceived as separate objects. To enable this interaction it will be required that objects with large processing capacity, become smaller and more economic and which are connected to sensors and actuators placed in the user environment and are forming a network. This answer the call from companies that make decisions on their value chain from multiple variables analysing data from different perspectives and carrying out information projections to predict what may happen in the future.

The challenge of the new unit is supported by the experience of CIMNE that has been working for over twenty years in the study and development of predictive models to make decisions in real time.

This challenge is the application of these models in distributed networks that are capable of capturing information from environment variables. These models should be able to act or to generate alarms so that the computing capacity is high but with an easy integration in any environment.

Wireless sensor networks are wireless networks of spatially distributed and autonomous devices using sensors to obtain information from physical variables such as temperature, sound, vibration, pressure or movement. The ease and

flexibility in the deployment is one of the key strengths that make possible that these networks can be integrated into a wide variety of applications.

In addition to sensors, each node is usually equipped with a radio transmitter or other wireless communications devices, a microcontroller and a power supply source, usually a battery. The expected size may vary although there are researches from groups such as the University of Berckley that suggest in future the dimensions can be microscopic.

The size and cost are directly related to power management, memory, computational power and speed of data transmission.

3.2 Analysis of Benchmarking Research Groups

The benchmarking was carried out in order to compare the R & D activities, experiences, services and work processes in research centres. It has been useful to know what others centres are doing so that we can determine which is our position in the market and see if we can be competitive if we can differentiate ourselves from other groups to be a national reference point in that technology and able to compete with universities and other international companies.

Wireless sensor networks are made to play a crucial role in many fields of application. The platforms, middleware and protocols evolution have been important in recent years both in industry and research. In fact, the enormous capacity for sensing and control over the physical world is what makes the wireless sensor networks a key technology for this type of environments.

After studying in depth the partners involved in developing projects related to this technology we realise how big the requirements are so that a wide knowledge in a large number of fields is required.

There are a large number of units that focus on design and analysis research of hardware, software, algorithms, structures and evaluation of data from sensor networks.

At the end of the nineties most of the investigations were aimed at developing small size hardware platforms capable of communicating via the radio channel. One of the pioneering groups was the Electrical Engineering and Computer Sciences, from University of Berckley. They developed platforms especially designed for MEMS-based inertial systems (Nano Electromechanical Systems), and for sensor systems of sensors for aircraft and other vehicles. Currently, they follow the same line of work but adapting the devices for all types of applications. Consumption of resources is another of the problems that we are considering in relation to devices to be deployed on a massive scale (monitoring of large areas, control and sensors for smart environments, etc.). The more resources required (CPU, RAM, flash, etc) the more expensive is the cost per node and the competitiveness and viability of solutions based on networks of sensors are reduced. The group of the Electronics of La Salle is also working on

optimizing the consumption of system resources specifically on the modelling, development, and validation of the architecture for communications and specifications of communication networks and devices to support smart electricity networks.

All wireless sensor network nodes must carry out the routing data functions from other neighbouring nodes. It is therefore important to develop protocols that manage the routing in an optimal way. There are many groups running their lines of work for this purpose. The Communications Group, Signal Theory and Communications Department at the Universidad Carlos III de Madrid base their activity in the simulation and analysis of such networks and they develop algorithms for smart transmission. Instituto Tecnológico of Galicia is working on efficient techniques for standards implementation, specifically IP connectivity (IPv6), routing of mobility of ad hoc LoWPAN networks (IEEE802.15.4) and the integration of sensors with radio technology. In that field the competition is quite strong because there are other groups like i2Cat that are also developing algorithms to provide quality service. The ENTEL group from Universitat Politècnica de Catalunya is also working in this line.

Networks and Mobile Systems is a group from MIT dedicated to the prevention and control of interferences using Spread Spectrum codes and to the encoding of symbols for wireless sensor networks.

The data transmission in the air has opened up new security risks. The exposure of the waves outside the security border exposes data to potential intruders that could obtain important information. The ICT group at the University of Aalborg is conducting studies to these security issues.

In summary the most important American and European level have covered the most important aspects to make the wireless sensor networks a competitive technology to be integrated into what is known as ubiquitous computing.

However there are no groups specialized in the integration of numerical methods for the wireless sensor networks in order to make them capable of being sensitive and to respond appropriately to the presence of users in those networks, carrying out actions like the creation of alarms or real time decision making.

On the other hand, the energy becomes a very important point to take into account. Usually devices are powered by batteries that have a limited period of life and although most of protocols and algorithms take into account the consumption that represents the wireless data transmission, it does not solve the problem of replacing the batteries every so often.

In these last two points is where the new unit can make intensive use of the calculation methods developed by researchers to integrate them in those networks.

3.3 Strengths of New Unit

The new unit is supported by the strengths of CIMNE, which will be analyzed here.

CIMNE is an autonomous research and development centre dedicated to promote advances in the numerical methods development and application and computer calculation techniques for solving engineering problems with presence in several countries.

The research activities of CIMNE that can contribute with added value to wireless sensor networks are divided into the following areas:

- Pre-and post-processing.
    - Development and integration of data entry techniques for large size computer simulation programs.

- Artificial Intelligence.
    - Development of artificial neural networks for problem optimization, analyzing and quick decisions making.
    - Integration of networks or artificial neural systems to support the decision combining wireless sensor networks, methods of computer simulation and artificial intelligence techniques.

- Information Technology and Communications.
    - Methods for integration and management of wireless sensor networking platforms in the Internet.
    - Systems development and integration with geographic information systems to support the decision.

CIMNE has extensive experience in the development and integration of technical data entry for simulation programs. Considering that the hardware requirements of wireless sensor networks are very limited compared to the numerical calculation of equipment currently in use it is very important to optimize the technology to enter the data and the memory space of these codes. CIMNE's experience is an important key because it has the resources and the knowledge needed to achieve these challenges.

The experience of CIMNE in artificial intelligence may have a strong impact on network nodes. Nodes can sense their environment through sensors and act as agents. They can also process these perceptions with the calculation methods developed by CIMNE that are able to act on the environment to maximize the expected result.

The CIMNE has extensive experience in the use of information and technologies in the civil and environmental engineering fields. In particular it developed various systems to support decision (DDS) under the R & D national and international projects. Those systems allow the user to define, interactively, the required information and how to combine it. Its main feature is the ability to

multi-dimensional analysis that enables further information to the level of detail. It also analyzes the data from different perspectives, making projections of information to predict what might happen in the future, trend analysis, prospective analysis, etc.

DSS combine collection and database management, information systems and online calculation and artificial intelligence models. Examples of SAD developed by CIMNE include applications for risk prevention and flood emergency management, for the management and monitoring of marine spillages, for the structural assessment of buildings, for the design of service networks in neighbourhoods, for city council power management and for supporting the detection and treatment of cardiovascular diseases.

CIMNE also develops real time optimization systems. Those systems actively interact with a well-known dynamic environment in relation to their inputs, outputs and time constraints, in order to give the right operation and optimum resource management. CIMNE has developed genetic algorithms, one of the most innovative techniques applied to structural optimization, which are born of the need for more robust methods to maintain a good balance between efficiency and reliability and can be applied to a many different of problems. Genetic algorithms can be applied successfully to the optimization of typical civil engineering structures. These algorithms can be redesigned to be integrated in the processing of wireless sensor networks. In addition to the wide knowledge of CIMNE in the development of this kind of algorithms it allows CIMNE to adapt to a wide variety of applications and industries.

CIMNE also has extensive experience in collaborative projects coordination. Since 1987 it has coordinated about 50 European projects (from 180 European projects where it participated) and 32 projects of the R & D National Plan.

In summary CIMNE has great potential for management, handling and data analysis.

3.4 Unit definition

Taking into account the strengths of CIMNE, the prospective analysis, the opinion of experts and the benchmarking we have the tools needed to make decisions in order to decide which should be the group specialization within the structure of CIMNE.

Primarily the group is able to develop tools for numerical methods integration to make wireless sensor networks capable of being sensitive and responding appropriately to the presence of users in carrying out specific actions like the creation of alarms or the real time decision making.

The group also could determine which parameters are the most important in the battery consumption to generate methods lifetime prediction and to create structures to increase the lifetime of the batteries.

One option is that the group specializes in the integration of numerical simulation algorithms for sensor networks with wireless interfaces through bi-directional transmission of data between the networks of wireless sensors and modules calculation considering this code optimized for applications with limited hardware.

In addition to creating advanced systems for monitoring and prevention there is a system adjusted to the needs of measurement and prevention requirements. It is able to independently measure and excluding cables, as well as erroneous behaviour predict by numerical simulation.

This seems most appropriate in relation to competitors because it provides calculation tools for wireless sensor networks which allow them to achieve high levels of ubiquity and transparency. Moreover, there are no other groups that work on wireless sensor networks on the same line of work. Therefore we have a differentiating element in one of the key points to facilitate the Internet evolution which means that the creation of the unit would make CIMNE even more competitive.

This may allow CIMNE to be a pioneer in the definition and development of activities for numerical simulation field with real data from wireless sensors by integrating a hardware tool capable of enhancing and complementing the numerical simulations of the current codes in CIMNE.

I will also allows to identify new actions with the industry to focus on static and dynamic processes monitoring supported by numerical analysis with the DSS so that it the physical world could be attacked in order to be able to obtain the data in real time. Besides being able to make decisions, we can act with this physical world (turn off lights, open dams). There would be a feedback of the simulation results with real time data, making possible an automatic correction and being able of carrying out information projections and to predict what might happen in the future.

Other alternatives are the creation of communication protocols or algorithms in order to create optimal routes based on minimizing the battery consumption and to increase the throughput (relationship between packets sent and received correctly) in the network. The computation methods and artificial neural networks are two very important tools when the implementation of this type of algorithms needs to be done. However there are already groups like the Signal Theory and Communications Department at the Universidad Carlos III, the Instituto Tecnológico de Galicia, i2Cat and ENTEL from the Universitat Politècnica de Catalunya that they have been developing algorithms in this area for some time and probably CIMNE will have a disadvantage with respect to them as referring to position in the domestic market. Maybe it can be more convenient to use the protocols developed by others and to optimize them using tools developed by CIMNE.

There is also the option to develop an own sensor network platform. This would provide a great technical control of the modules to incorporate calculation techniques and to be independent from foreign suppliers. However there are

many companies and groups developing this type of platforms. There are many types and there are already some platforms such as the Crossbow Technology and free hardware like Arduino that provide the needed hardware resources to incorporate the entire process that CIMNE can have. Besides the time needed to develop a new wireless sensor platform would allow that other groups specialized in computing techniques to take advantage within this sector.

3.5 Risks when undertaking this research unit

There are risks that must be taken into account before making the final decision to create this new research unit.

Based on the benchmarking, real benefits offered by technology developed by these groups are uncertain. Considering the unit specialization to make the right decisions when choosing a platform or other sensors is the key point.

Progress in leading companies may cause a radical change in the market for wireless sensor networks, as it has happened with the technology of radio frequency identification (RFID).

There may be restrictions on the hardware that affect the implementation of certain modules calculation.

Without the proper technology it is possible that some platforms do not have direct access to the control codes and wireless sensor networks data processing.

CHAPTER 4. UNIT PROJECTS

The experience that CIMNE would like to acquire in wireless sensor networks includes the WSN technology control and the addition of new R & D strategies.

CIMNE aims to develop wireless sensor networks able to monitor the present and future status of a certain environment with real information from sensors and with advanced numerical simulation models.

To achieve this objective, CIMNE is considering the creation of a new working group of professionals in the field of electronics, computers, telecommunications and industry.

4.1 Objectives

This unit must consider some challenges to be competitive with other research groups that have units working in this line. The most important challenges on the basis of the technology foresight study, consultation with experts in technology and analysis of benchmarking are:

- Implementation of a management system based on the UNE 166002: To make sure activities that are able to generate own and patent technologies are not missed out. From these technologies additional benefits can be obtained by technology transfer or tax breaks.

- Integration of sensors with wireless smart communications platforms: It consists in developing the interface between the sensor output and input channels of wireless smart communication platform.

- Integration of numerical simulation algorithms to WSNs: It consists in creating interfaces for bi-directional data transmission between the WSNs and computation modules, taking into account that this code should be optimized for applications with limited hardware.

- Communication protocols integration and handling: Learn how to adapt protocols for wireless communications to achieve high efficiency of packets sent, an optimization of energy consumption and the ability to disconnect and connect nodes in the ad-hoc network.

- Creation of advanced monitoring and prevention systems: A system that matches with the necessities of measurement and prevention required. It is able to independently measure and to exclude wires, as well as to predict wrong behaviour by numerical simulation.

- Creation of networks capable of communicating with them from multiprotocol nodes: One of the greatest challenges of this type of

network is to be able to integrate with each other in order to interconnect a large number of nodes that can share each other information.

- Development of high autonomy supply systems: Creating power supply systems capable of providing a high autonomy to the nodes of the network.

4.2 Tasks

To accomplish all the challenges above mentioned a list of tasks will be defined. Each one will be link to a scheduling plan based on the technical difficulty and the workload can generate or the difficulty in finding or supplying tools or suitable work equipment.

Implementation of a management system based on the UNE 166002

The model is based on monitoring and prospective technology, internal creativity and benchmarking of competitors and customers. It follows a structured and logical management system based on the cycle of continuous improvement also known as PDCA (Plan, do, check and act).

- Plan: establishing the objectives according to the technological strategy and market requirements.
- Do: Systematization process implementation.
- Check: Monitoring and process control
- Act: Make decisions to continue improving of the process.
- Technology monitoring: Systematic to capture, analyze, spread and operate useful technical information.
- Technology Forecast: Reflection to detect new ideas which allow guiding the development of future products and processes.
- Creativity: Giving up the structured ways of thinking to come up with ideas that can solve a problem.
- Internal Analysis: Inventory and cataloguing of human skills and materials, success factors analysis and failure of projects.
- Internal Analysis: Knowing what competition is doing and looking at that situation we are facing.
- Integration of sensors with wireless smart communications platforms

The main requirements to accomplish this challenge are:

- Knowing the market for wireless sensor platforms: It is important to know which wireless sensor platforms already exists in the market and what are their most important features.

- Studying physical parameters which are most relevant in sectors that experts believe that wireless networks will have greater impact: In this task is important to know what are the parameters that may affect the

performance of applications, services or products of sectors where the incorporation of this kind of networks in their value chain.

- Knowing the different sensors that are capable of measuring directly or indirectly any of the parameters studied in the previous task.

- Establishing decision criteria for the use of sensor platforms: Once we know the market for wireless sensor platform, which parameters we will measure and which sensors that can measure the criteria for choosing one or the other depending on the application or the requirements of the measurement.

- Development of conditioning circuits for signal adaptation: Each sensor has an output depending on the input physical parameter being measured. This output does not need to match with the platform monitoring input channels, so it is necessary to develop systems that conditioning the signal from the sensors so we can get a real measurement.

- Develop high autonomy power supply systems: One of the main challenges of the wireless sensors is to achieve reduced consumption, which allows a high usage time. How they affect one another lifetime, information sent and frequency will be studied.

Integration of numerical simulation algorithms to WSNs

- Processing capacity: The current trend is the incorporation of new processors with greater computational power without increasing consumption. This task will assess the needs of local processing of applications in monitoring infrastructures and the possibility of distributing the calculation between the remote and base station, without overloading the potential for transmission of network information.

- Integration of wireless technology with simulation programs: The information provided by sensors can be used as input for advanced computer simulation predictions.

Communication protocol analysis

- Study of wireless communications protocols: Evaluating which protocols are more suitable for using them in mesh networks, taking into account their bands of operation, network topology and security.

- Data transmission: currently, wireless sensors are limited for receiving and sending data, especially in a sustained way, which disables the system, in many cases, for the transmission signal. New schemes should be analyzed for transmission of large information flows in an effective way, without making a large consumption of energy, taking as starting point the optimization of existing protocols.

Creation of advanced monitoring and prevention systems

- Development of expert systems: This task includes developing systems for managing information that comes from the network of sensors and simulation codes in order to help the management, control and monitoring processes.

- Integration of artificial neural networks for decision-making: Information received from sensors and simulation codes can be integrated to train an artificial neural network (ANN). ANN is able to make decisions in quasi-real time during the management of a system.

Creation of networks capable of communicating with them from multiprotocol nodes

- Network integration: The integration of wireless sensor networks, Internet and Web 2.0 will allow approaching the ubiquity (networks and systems transparent to the user) which allows to link real and virtual objects, services and products in a smart way. It will require devices to a gateway between networks and others. The aim of this task will be to know which are devices and technologies to integrate sensor networks with other wireless sensor networks and even local area networks or the Internet.

- Development of high autonomy supply systems

- Scavenging energy systems: Analysis of processes in which energy is obtained from external sources (for example solar energy, thermal energy, wind energy, salinity gradients and kinetic energy) and then this energy is stored.

- Design of power systems: Developing DC-DC conversions using different switch regulators, its operation mode and control circuits.

4.3 Projects

After talking to experts in technology we are going to analyse the state of the art and the technical limitations of three projects that can have a major impact on society by introducing technological innovations in sectors which require a technical improvement of their systems products or services.

4.3.1 Systems for enological monitoring processes

The objective of this project would be to develop new technologies for agro-production infrastructures in order to monitor enological processes by integrating wireless smart sensor networks, simulation methods, predictive calculations, the Internet and mobile communication technologies.

State of the art

The enological industry should implement a self-control production system, based on the Hazard Analysis and Critical Control Points (HACCP). HACCP is defined as a preventive control system of food whose main objective is the safety and the harmless of food. It also tries to identify the risks involved in a process to identify critical control points (CCPs), which can be controlled such dangers and to establish systems based predominantly on physical and chemical tests and assessment or visual observation, through which the effectiveness of control can be monitored.

Control systems for processes based on computers and PLC units (programmable logic control) are incorporated into modern manufacturing of food products and are important elements for the proper plant operation. They guarantee economic production with little loss of product at a high level of quality. Continuously monitoring in real time the integrity of an enological process may improve and ensure the quality of results. Particularly the awareness of the management aspects of the enological industry that affect the overall quality of the products that it produces are in the process of quality wine: vineyard, vintage, young or aging wine production, processes involved in the brandy, vinegar and other derivatives, or whether the controls during the bottling or quality in the finished product. Thus the objective is to monitor and evaluate the organoleptic, physico-chemical and microbiological properties to ensure a stabilization and preservation of the product.

The use of sensor networks will be needed to investigate local and global quality risks. The number of cables, optical fibres or other physical transmission medium can be a problem, even forbidden, depending on the place where the monitoring will take place. Therefore it is essential to develop new ways of wireless communication that can provide low cost and use of dense detection networks.

This new technology combined with predictive simulation models, may improve the knowledge of the enological environment in real time. At the same time it can predict potential risks, such as temperature problems in fermentation stages in wines and champagnes. This is due to the sensor networks can provide the input for the calculation engine and a tool to validate the prediction with the real evolution measured and to act on the environment in case of anomalies. It will achieve a new technological platform that significantly improves quality, efficiency and security of an infrastructure for food production.

Innovation technology and project scope

The key line in the R & D project would focus on the development of wireless sensor technology, together with the implementation of a monitoring platform via the Internet and mobile communications, which integrated into a system for predictive calculating, make an expert system capable of controlling and improving the quality and the service level and maintenance processes in the enological environment.

It would operate and develop the capacity of data acquisition systems to set new sensors for specific applications, such as temperature control in liquid (wine cellars) using wireless technology.

New wireless sensors are equipped with a microprocessor that allows an interactive operation mode. Algorithms for communication among sensors, sensors themselves and mechanical actuators in a network will be studied and developed.

Finally simulation codes and neural networks would be studied and developed. They can enable the expert system to be able to predict the environment from the information obtained by sensors in real time, getting a tool that optimizes the level of food service infrastructure.

The application of WSN technology in the enological sector is a topical subject. There is a clear opportunity for the development of WSN technology in Spain and be pioneers in implementing this technology in the sector and particularly for monitoring, controlling and managing the elaboration and conservation process of enological products, due to the great value that in these tasks may be the wireless sensor networks.

WSN networks lead to the overcoming of the traditional concept of sensing and telemetry, as the GPS has changed the field of topography.

Smart infrastructures can no longer be static devices for the acquisition of dynamic, adaptive properties more sensitive to context and interaction with their managers and users to define new concepts of service.

Project tasks

The project development would be organized into the following tasks:

- Study and definition of sensor models: The objective of this task would be the technical study and the operational definition of variables to capture, the computational models (queries processing and storage, distributed in the WSN network), the data post processing, the sensor system interface with numerical models, the system to support the decision, etc. This set of tasks depends on the nature of the enological process, its physical, environmental and geometric parameters and the type of phenomena to be controlled to improve the quality, efficiency and safety of the process.

- WSN network specifications: The objective of this task would be to define WSN network specifications, defining the hardware and software specifications required, as well as where it will be applied to evaluate the viability of wireless sensor networks in the enological sector. The expert system would be specified for data management that users of the system would use as a monitoring and industrial process control tool.

- WSN network configuration: This work package would take into account the configuration and starting up operation of the motes in the WSN network and the identification and configuration of all protocols for exchanging information communication system for monitoring and control of data from real time experiments. It will also be carried out the development of algorithms for sensor network communication.

- Development of an expert system for enological processes monitoring: The main objective of this task would be to develop a system for enological processes monitoring integrating smart sensors, predictive simulation methods and the Internet, facilitating the decision-making activities for control, monitoring and management of these processes. This system would integrate data from monitoring processes and it would transform into classified information by predictive and decision-making algorithms. A methodology for the modules assembly for receiving and transmitting in the WSN network will also be created, as well as interaction with simulation methods, Internet and mobile devices.

- Implementation of an expert system for monitoring enological processes: Implement a expert system prototype for monitoring food processes, the enological sector using the results of the system that would be developed in the previous task in order to evaluate the potential and efficiency for prevention and management of risk parameters that could alter the integrity of the quality, efficiency and safety of the process, in anticipation of possible defects or accidents that could endanger the outcome of the product.

- Prototype Validation: Validate the monitoring prototype developed and implemented in the previous task.

4.3.2 Acoustic Information System

The project's overall objective is the creation of an acoustic information system. This system would allow the acoustic and environmental noise real time monitoring which will be integrated into a geographical information system. In addition to creating a dynamic environmental database, it would serve to produce and display acoustic maps, being a tool to support government decisions on the noise impact of major infrastructures (roads, airports ...), leisure areas, industries, etc.

State of the art

In Spain there are currently no commercial systems for environmental monitoring geo-referenced and incorporated into GIS. The technologies involved in developing an acoustic information system are very diverse.

- With regard to the state of the technology of wireless sensor networks, the rapid advances in smart sensors, wireless communication, Micro Electro Mechanical Systems (also known as MEMS) and information

technologies, have great potential to be applied in the environmental sector, specifically for the study of noise pollution. To manage the large amount of data that would be generated by a monitoring system, a processor-level sensor should be incorporated in order to enable a part of the calculation is made locally. Such a process provides a smart and adaptive sensor, which reduces the amount of information required to be transmitted on the network.

- Referring to GIS technology, it is of important relevance that GIS are widely used today to manage information related to the environment, because its structure can store both alphanumeric data and spatial data. In addition, there are commercial programs on the market for simulation and decision making that can transfer their results to commercial GIS systems, but have the drawback that the end user should be familiar with more than one system. This is because the tasks performed have to run in several steps, then the simulations should be performed in simulation and visualization systems in a GIS system, with all the complexity associated that those steps represent. Specifically, GIS that would be developed in this project would be a system for the integration, management and visualization of environmental and acoustic data captured in real-time by embedded sensor networks and sound stations. At present, there is no system on the market that is able to offer what is proposed in this project in the same environment and in a simple and friendly way.

- For the project development, it would also be needed to have acoustic simulation technologies for outside areas. Geometric methods (inherited from the computer graphic community) approximate the propagation of sound waves through rays. That approximation is valid for all frequencies above a certain threshold. Among the most popular geometric methods, it is important to mention the Image Source Methods, the Ray Tracing algorithms. Their main features are the relatively computational low-cost and the good performance of the results that makes them convincing. On the other hand, they are unable to reproduce the diffraction phenomenon, very common at low frequencies and responsible that not visible sound sources are audible (an important phenomenon in the prediction of noise levels).

Innovation technology and project scope

These are the main R & D activities to be carried out in the project:

- Development of WSN technologies adapted to acoustic monitoring.

- The improvement of existing acoustic simulation algorithms will be investigated.

Project tasks

The development of the project would be organized into the following tasks:

- Study and definition of sensor models: Define the basic requirements of the acoustic information system. It would be considered the appropriate location of monitoring stations, the communication protocols between the different measure sensors, data post processing and the final system interface.

- Design of environmental and acoustic capture system design: Technical study of the microphones and sound level meters suitable for the acoustic information system. Analysis of the integration of acoustic sensors with other components of the system: other sensors, motes, etc. Define protocols for acoustic measurement protocols for noise maps and acoustic capabilities.

- Advanced embedded wireless sensor systems sensors and communication systems in real time: The goal of this stage would be the technical, design, analysis and configuration network study to be integrated into the information system. It should accomplish the requirements detailed in the first task, as well as the analysis of protocols for communicating data and the collaboration of the necessary components: sensors, motes, electronics, etc. This task will also carry out the specification, design, development and tests of a communication system for real time access to information captured by the ad-hoc network sensor embedded in the environment to the end user through Wi-Fi technology, radio transmission, public mobile networks (GPRS, 3G-UMTS) or landline-based (Internet) and its advanced display via Internet browsers.

- Advanced display GIS system: The objective of this phase would be to create a geographic information system to manage, display and integrate via Web the data captured by embedded sensors networks, which are transmitted by the real time communication system.

- Integration and operation tests: The main objective of this task would be to integrate all the technologies involved in creating the system.

4.3.3 Creation of a communication system of local information based on web

The main line of research and development of this project will focus on the combination of WSN wireless sensor technology in weather stations, GIS technology and the integration of information from external repositories content from the public sector, in order to implement control and monitoring real-time geographical, weather, environmental, healthcare and tourism data with special attention to the environmental warning spreading (for example jellyfish, spillages, storms,..).

State of the art

The objective of the promotion of a line of environmental monitoring is to take advantage of the 'call effect' that this type of information generate on the citizen to establish a channel of communication between authorities and citizens that may be useful in situations of potential risk to the public (floods, storms, jellyfish, occasional spillages) and promote the natural and heritage values of the area for tourist purposes.

The system is integrated into a web environment of tourist information and communication (Tourist Internet portal). It would be a key tool to create and enhance the modernization of tourist information services. In addition, it could facilitate the monitoring and accomplishing of the objectives of a program to monitor and report the status of the beaches due to the incorporation of real time wireless technology and its incorporation into GIS web-based spreading.

In particular, it could affect the monitoring of indicators related to the sanitary quality of beaches and those environmental indicators that can interfere with the development of leisure activities and general public use of beaches. In terms of market it could potentially contribute to the achieve quality certificates that may positively distinguish a swimming area. In this way, service providers will specify which destinations are more suitable for the tourist needs. Thus, this platform would be a communication between institutions, citizens and tourists to the continuous improvement of the beach.

Innovation technology and project scope

The system would incorporate the following technical innovations:

- Advanced sensing of environmental, meteorological and assistance variables through the integration of embedded wireless networks of sensors, able to send the captured information in real time to the stationary base without wires.

- Visualization and integration of spatial and mapping information from data captured by the sensor network using GIS technology allows analyzing spatial data using spatial queries, image processing, thematic mapping configuration (for example temperature, radiation solar and wind directions maps), etc.

- System integration with other data from different repositories and databases provided like data on the sanitary quality of water, tourism, socio-cultural, which might be overlapped with the geographical and environmental data using GIS technology.

- Real time access to information via Wi-Fi, radio transmission, use of public mobile networks (GPRS, 3G) and landline-based (Internet) and its advanced display across browsers and general purpose tools in the Internet context.

- Research and development of a robust and efficient architecture for large-scale integration of micro sensors and infomechanic actuation systems.

Project tasks

The project development would be organized into the following tasks:

- Study and definition of sensor models: This task will define the basic requirements of the land information system, the basic parameters of the system (environmental, meteorological, geographical, etc..), the communication protocols between the different sensor systems and between them and the information system, the data post processing with GIS technology and the interrelationship with other repositories of information (health, tourism, cultural, etc.) and finally the interface of the final system.

- Advanced embedded wireless sensor system: This aim of this stage would be the technical study, design, analysis and configuration of the wireless sensor network that would integrate the information system and that should accomplish the requirements detailed in the first task.

- Advanced display GIS System: The objective of this stage would be to carry out a geographic information system to manage, display and integrate via Web, the data captured by the sensor networks, which are transmitted by the communication system in real time.

- Integration and operation tests: The main objective of this task would be the integration of all the technologies involved in creating the system.

4.4 Unit structure

This part of the unit structure will be defined both human and material resources. The number of members, their skills and knowledge that each one must have on their roles, the functions and the physical location of the group will be taken into account. Also scheduling of unit tasks as well as other tasks that will be carried out will be quantified.

4.4.1 Human resources

The group will need the support of R & D management unit: At present CIMNE has a group of members who are able to:

- Managing the R & D project portfolio.
- Managing the transfer of technology.
- Managing the protection and operation of results.

In addition, the interaction with other groups within the organization will be needed. Groups like ITC (Information Technology and Communications), GID (the group of developers of software for geometric modelling and display of results for all types of programs for numerical simulation) or Group of Numerical Simulation and Engineering:

- GID Group: It is important to agree with the GID team which bi-directional communication protocols will be between the networks and the GID. It is also important to define in which ways is possible to connect data from sensors to GID pre-processing. Thus it is important to define communicating ways to the sensor network the GID data post-processing. The aim of this is to be able to have action mechanisms on the environment that will be measured.

- Group of numerical simulation codes in engineering: This partnership tries to identify in which areas of engineering is possible to monitor with the integrated wireless sensors network and the modules for numerical simulation. The scope of the system can estimate and also define new calculation algorithms that are properly optimized to be used in wireless sensor networks.

- ICT Group: The objective of the ICT Group is to provide data display tools, which can be easily controlled by users and also managed from the Internet. It is important to emphasize that the integration of WSN with GIS technology can be especially relevant.

At first the group must be integrated at least by 3 engineers with the objective of activating the tasks and to create a dynamic work. 6 months later the two internships would be integrated as a support.

Project Leader (Engineer 1):

The duties that project leader will carry out are defining and managing the strategic lines of work according to the proposed objectives, and coordinate the tasks are executed according to some technical and economic requirements to generate a product or service.

Electronic Engineer (Engineering 2):

The duties that electronic engineer will carry out are designing the hardware that integrates a wireless sensor network. This includes the selection of the optimal electronic components according to the best offer of market. Tasks are specified as:

- Integration of sensor platforms with wireless smart communications.
- Develop high autonomy systems.

Telecommunication Engineer (Engineer 3):

The duties that the telecommunication engineer will carry out are designing the controller hardware. It will be based on network topologies, as well as the protocols and data processing. This also includes the interface between the wireless sensor network, the numerical calculation modules and display tools. Tasks are specified as:

- Integration of numerical simulation algorithms with wireless sensor networks.
- Integration and communication protocols handling.
- Creation of advanced monitoring and prevention systems.
- Creation of networks capable of communicating one to another from Multiprotocol nodes.

Internship position (student of Electronic Engineering):

- To support the electronic engineer once the tasks of the projects are ready.
- Internship position (student of Engineering in Telecommunications).
- To support the telecommunication engineer once the tasks of the projects are ready.

4.4.2 Material Resources

At this point we will assess the needs that we would have to achieve all the goals we set in previous sections and to carry out all the tasks and challenges of the projects.

We will begin with the hardware definition that would be used to make the sensor network for capturing and transmitting the information via wireless. It also includes some sensors that would be used to test integration with the wireless platform:

- Motes are hardware platforms based on radio processing cards (MPR: mote processor radio), commonly known as motes. These devices are powered by batteries and operate the open-source operating system TinyOS. Gateways and interface cards for motes (MIB) allow developers to connect to PC motes, a PDA, Internet or other types of wireless

networks. Finally, the sensor cards and data acquisition (MTS and MDA) are connected directly to the motes. The support of a wide range of sensors includes sensors embedded as well as interfaces for external sensors.

- External sensors: sensors that would be integrated into the system:
    - Air temperature and relative humidity.
    - Wind speed and direction.
    - Solar radiation (ultraviolet and infrared).
    - CO_2.
    - Barometer.
    - Water temperature.
    - Salinity.
    - Dissolved oxygen in water.
    - Turbidity.
    - Sonometer.
    - Microphones.
- Operating Systems: Software that is used both for programming and for data exchange between network nodes:Operating system: TinyOS
    - Query tool: TinyDB
    - Programming language: nesC
    - Monitoring software: MOTE-VIEW
- UNIX Environment: CYGWIN
    - GiD application for graphic pre and post-processing application.

The following computer resources would be needed:

- ORIGIN 2.000 computer server calculation with 8 processors R 10.000 and 2 GB RAM memory.
- 5 high performance graphic workstations from Silicon Graphics (3 Indigo y 2 O2).

4.5 Infrastructure Projects

Once the tasks are defined and human and material resources are quantified, it is very important to define a good strategy for the information management systems that includes elements such as networks, communication lines, telephones, workstations, servers, printers, operation systems, mail services, web, databases and computer security mechanisms.

Firstly the unit would be placed in one of the new offices available in the new building of the C3 Escuela Politècnica Superior de Castelldefels where will be located the five members who will develop the group tasks.

The building has already the infrastructure for Internet access and VoIP telephony to reduce costs in phone calls. CIMNE also has an e-mail and webmail service.

A workstation to manage the machine printed circuit boards will be needed. It must be prepared to work in an environment of design, engineering and advanced analysis with Wi-Fi card to connect to the Internet via wireless. The workstation can be Dell Precision 7300 with an operating system Windows XP.

An FTP server will be needed in order to centralize all development, documents and articles generated by the unit, as well as software for monitoring and data centralization from sensor networks.

The software will be the MoteView from Crossbow for Windows based computers. It provides an intuitive graphical interface for monitoring and managing wireless sensor networks. MoteView allows the user to understand the data from sensors and network allowing an easy configuration of sensor nodes. This is achieved because the program shows the network topology, graphs, tables, sensor readings from a very intuitive way. The MoteView client application will be able to measure in real time keeping a track of results of previous measures. It also provides a command interface for sensor networks, the ability to export data, the topology map, etc…

It will also require the software platform MoteWorks from Crossbow, which allows the development of applications of sensor nodes. It is specially designed for networks with low battery power and provides support for:

User Interface: Client application for analysis, local and remote monitoring and the sensor network configuration.

Sensor devices: The stack of network protocols and operating system, support of standards (802.15.4) and development tools.

Gateway servers: A middleware to connect wireless sensor networks making possible the interpretation of management and information systems.

The software is free and available on the website of Crossbow but it can only be used to develop networks based on its technology.

The software will be installed in a Dell PowerEdgeTM 2900 running Windows 2003 server. It is allowed adding RAM memory, hard disks and backup tapes. The disks will be configured in a raid disc mode because if one of the disks stop working can be replaced by another one and there is no need to reinstall all software and operating system.

In addition to the server and the workstation for circuit boards printing, we will have five workstations for the three engineers and two internships.
On the other hand we will use the HP StorageWorks D2D Backup Systems to make the backup from other computers. Backups will be done in differential way for the six workstations, the ftp server and monitoring. Backups will be done daily for servers and weekly for workstations. Incremental backups will be done on tapes for the server.

In case of failure of the server hardware a copy ready to change will be provided in the shortest time possible.

A pack of Panda Internet Security will be acquired in order to keep the information from workstations and servers secure. It will provide antivirus, anti-spam, anti-spyware and firewall so that the group information will not be compromised.

To be on the Internet and to spread the progress a wiki will be created by members of CIMNE Castelldefels. It will be used to post and to share unit experiences.

Server will be located in a room for the purpose that will be in the same building with other servers of CIMNE Castelldefels. The space has a proper air conditioning and fire prevention system.

CHAPTER 5. GROWING PLAN

There are different alternatives in terms of unit growing plan and should be taken into account the future expectations in order to decide.

Research on issues related to power management and the development of systems that make better use of power sources that are in the environment according to [12] will revolutionize the design of embedded systems including wireless connectivity.

Miniaturization of the devices can do according to [12] that networks of sensors can be placed in special sectors such as health. The smaller and lower-consumption of the device the easier will be to introduce it in that field. At CIMNE there is a group that develops biomedical simulation codes to predict and prevent diseases. Their knowledge in that field may be the key to develop useful applications for the industry.

A line of future work may be the design of positioning systems using wireless sensor networks due to GPS technology does not work for indoor positioning. Dr. Jordi Olivella, director of this project, believes in the advantages and benefits of this technology in some sectors. It also says that it will make possible to trace the paths in the interior of industrial places, warehouses, logistic companies, etc. For example this information can be useful to analyze the process strategy of a particular company. CIMNE could incorporate calculation systems or artificial neural networks where the system could learn from the experience.

The more ambitious option would be to create a spin-off based on the outcome from R & D projects outlined in the chapter of the unit.

Alternatives will be analyzed in detail and an accurate strategy will be outlined based on the future state of wireless sensor networks, the technical developments that are expected to achieve in the unit, the knowledge and know-how of CIMNE. Furthermore, the developed benchmarking described in previous chapters will be analyzed in detail in order to assess whether or not to launch a spin-off.

After the analysis of prospective and the reading from [13] and before the wireless sensor network nodes can be deployed on a large scale there is a need to improve power systems of these devices.

The idea of replacing the batteries periodically in a large number of wireless devices in the whole area, where they will be applied, may be a drawback for companies that could choose this technology.

The research and development activities in the design of new power supply systems should be designed to obtain power sources from the environment to keep permanently running the wireless sensor networks.

This is a very interesting field of research towards a future. It should be taken into account that that one of the possible researching lines might be the prediction of the optimal time to change the batteries. This could be a further step towards the improvement of power systems. However, based on CIMNE experience, it seems too risky to invest in aspects related with electronics.

Looking carefully at health sector, the caring in some cases especially in rural areas is very poor due to increased costs, reduced staff, medical errors and the difficulties in reaching the hospital within a reasonable time.

The ubiquity concept of individual welfare monitoring regarding to physiological, and biochemical parameters monitoring in any area without the activity restriction, may become a reality due to the progress in the area of wireless sensor networks.

The progress in key areas like miniaturization of power systems, battery life increasing, power consumption reduction and the development of the systems analyzed above for the use of energy flows into the environment is still necessary for the improvement of power systems.

Until now, general sensor applications in clinical environments are designed to sensors that are implanted externally positioned in the body in a static.

However, blood vessels, the ventricles of the brain, spine, lymphatic system and venous system are those ones that offer a better opportunity to detect the processes of acute disease and control chronic diseases more quickly and efficiently.

The insertion of sensors inside these cavities may become a reality in the future due to recent advances in nanotechnology.

If we include numerical methods for modelling and simulation of biomechanical problems, simulations of cardiovascular behaviour developed by the CIMNE biomedical group, in addition to fluidynamic study of veins and arteries, a study of the mechanics of the urological system and the study of the dynamics of heart we have the tools needed to create sensor networks personal area for the control and prevention of diseases and the creation of alarms in extreme situations.

This is an area of great scientific interest and CIMNE has the necessary tools for the analysis of data obtained from this new generation of sensors.

On the other hand, bearing in mind that wireless sensor networks are an instrument to measure the time-space characteristics of many phenomena, the acquisition of relative or absolute spatial information from measurement point is an aspect which is implicit in such networks. The article on [3] describes the development and deployment of a wireless sensor network carried out by the Queensland Centre for Advanced Technologies (QCAT) for indoor tracking and position of people. The nodes are equipped with inertial sensors embedded in people moving inside the buildings. They use a real time algorithm to determine

the indoor location. CIMNE has an added value in that field. It can contribute with roads and paths simulations from the data provided by sensors and determine the optimum route for each case. Neural networks can be used in order to make each device learn based on data and the experience making an improvement of the strategy processes based on environmental changes.

Another line to follow may be the creation of a spin-off if the project results are satisfactory. Benchmarking has been done to analyze actual companies working with wireless sensor networks and in which is the sector are they involved.

One interesting point to take into account is the fact that most companies that sell products or services based on wireless sensor networks were born as spin-offs from universities and in many cases they were supported by the public sector or loans at zero interest.

Companies with more experience like TST Systems or Signatelics diversify the offer with different services, developing products based on different technologies (RFID, WSN, NFC, etc.). They do not give details about the research are carrying out and they do not make public the results obtained in these cases. They only thing they show are the awards obtained or the significant successful projects.

Indra's case is exceptional, is a multinational which is pushing for monitoring systems based on WSN, but in a more extensive range of products and services offered. Indra is one of the Spanish companies that spend more money on R & D.

On the other hand start-ups as DEXMA or WorldSensing have a business model based on a single product based on a single technology (WSN), but open to multiple applications. Their projects are turnkeys and also offer consulting services. DEXMA uses pilot projects as advertising tool for companies who already know your product but they are not decided in terms of WSN technology. Worldsensing has a philosophy very similar although they have not commercialized products yet. Currently they are seeking funding for their R & D projects trying to get a product in the field of geophysics but useful for different applications like acoustic models, seismic, etc…

In terms of sales systems, companies work in open projects and budgeting each independently. The case of Libelium is different. They are hardware-based and sales are conducted via web. The case of Traza Indentificación combines the classic system with the innovation for this kind of services. They use a system of technology renting.

In terms of after-sales services, some companies like Libelium have a very poor service based telephone or on private forums for their customers. On the other hand Indra provides software updates, maintenance of its implemented solutions and they even adapt its technology to new standards.

Some of these companies, especially Indra or Dexma have products where

software for monitoring and control networks by alarms is included. On the other hand is worth to mention that none of the previous companies use computing systems in their applications. They do not derive part of the processing nodes in to the network nodes, which makes the central node of the network handle large volumes of information and this is reflected in the speed results. If calculation systems are included we can generate alarms and we will be able to predict what might happen and we will anticipate the events to avoid potential damage.

Taking into account the strengths of CIMNE there is a clear business opportunity.

Considering all the above mentioned and the initial plan, the creation of a spin-off may be a good strategy, but a deeper market study and well-defined business plan would have to be done. However the resources from CIMNE could be used to progress in the development of applications in some sectors like health and in the development of networks for closed environment positioning. We should keep in mind the evolution of sensor technology and power supply systems to see if it is technologically possible to create BSN (Body Sensor Networks) for clinical applications.

CHAPTER 6. FUNDING SOURCES

An initial investment will be needed in order to face the cost of human resources and materials for the first few months. CIMNE is a consortium between the Universitat Politècnica de Catalunya and the Generalitat de Catalunya, so it seems that the best option is to seek funding from public funds.

The following table shows the calls for public funding to promote research.

Table 6.1 Funding Sources

National Level: Programa Nacional de Proyectos de Investigación Fundamental	Application	Calls	Objetives	Eligible costs	Budget
Subprogram of non-focus Fundamental Research		Different calls according to the thematic	Mobilizing the fields of scientific knowledge for solving problems in society.		
Subprogram TRACE	CIMNE	First: 7th January to 26th February Second: 2nd March to 8th September	Fundamental research aimed at knowledge transfer.	Marginal costs: personnel, consumables, travel etc. It further includes 21% indirect costs	€10,000000, €8,000,000 first term and €2,000,000 second term
Subprogram of non-focus research Acciones complementarias	CIMNE or company	First: 12th January 2009 to March 31st. Second: 1st April to 9th July.	Mode A: the organization of congresses, seminars..., Mode B: transfer of knowledge between science-technology company,	Marginal costs. It will not be eligible personnel of the entity.	€24,000,000. €16,000,000 fist term, €5,000,000 second term and €3,000,000 third term

		Third: 10th July 10 to 29th October	Mode D: Preparation of proposals for the Marco Program for R & D in the European Union		
Subprogram Proyectos de Investigación fundamental orientada a tecnología agrarias en coordinación con las CCAA	Public centres of agricultural and food research.	Since 7th January, 2009 until 12th February	Individual or collective projects.	Expenditure on personnel specifically recruited for the project implementation costs, indirect costs (20% of direct costs).	
Complementary actions (Resources and Recursos and agricultural technologies)	CIMNE and other nonprofit centres	Actions 1, 2, 3 and 4: from 09/01/09 until 31/03/09, from 01/04/09 until 15/07/09, from 16/07/09 to 31/10/09.	1. Actions to promote the Spanish participation in international programs, with special reference to the Marco Program of the European Union. 2. Organizing conferences, seminars, workshops and courses, national or international science and technology. 3. Support the concerted actions of scientific and technical in order to promote the	Expenditure on staff costs and implementation	€12,48 millions. The maximum amount eligible for private R & D non-profit will be 50%

			exchange and transfer of knowledge.		
Nacional Level: Programa nacional de Contratación e Incorporación de Recursos Humanos					
Ramón y Cajal					
Juan de la Cierva					
Technical support (graduates of higher level of R & D Projects and FP2)	CIMNE	February 2 to March 3. Duration of one year to three maximum.			320 grants: €10,000,000. Grants for graduates is €18,900, and the contract will be €23,625 gross salary. For undergraduates will be €16,380 and a contract of €20,475
Torres Quevedo	Companies	First: 15th January to 30th April Second: 1st May until 30th September Maximum duration of three Additional support may be reques			1.300 grants to hire doctors and technologists -€30,000,000 The grant goes from 75% to 25% depending on the type.

		ted for contracts that started from 30th September 2008			
National Level: Ministerio de Asuntos exteriores y de cooperación. Congresos Seminarios					
	CIMNE	Ends 9th February 2009			Total approximate budget €400,000
Autonomy Level: Línea de préstamos para proyectos de investigación industrial					
CIDEM	Companies				

[14]

TRACE is the most interesting subprogram for CIMNE due to its objective is to promote basic research to knowledge transfer. Choosing this type of program would not be appropriate to launch a spin-off because part of the investigation would be transferred to companies that may be our competition. Even this, exploitation agreements can be signed.

The Acciones sub programme is of complementary non-oriented research programme that would also be interesting because grants the transfer of knowledge between science and technology within the company. In addition the program provides support for the European Union Marco program.

Within the National Program: The Programa Nacional de Contratación e Incorporación de Recursos Humanos (National recruitment and placement of Human Resources) may be obtained through grants from subprogramme Personal Técnico de Apoyo (Technical Support Personnel) to hire high or intermediate technical qualified staff (graduates of higher level of R & D Projects and FP2).

Within the autonomous region some programs can be applied like those ones based on the cooperation and assistance to companies to encourage the use of information technology in SMEs.

The financial plan will specify the programs to which they submit grant applications.

CHAPTER 7. FINANCIAL-ECONOMIC STUDY

The purpose of this chapter is to present viable alternatives for financing the unit.

First of all, the cost of resources required for the starting of the unit based on the unit project chapter will be quantified.

7.1 Initial investment plan

In this part are included all those expenses related to the physical place where the activity, tools and machinery, facilities, elements of transportation, facilities, computer equipment, software, furniture, stocks, etc…

Investment in fixed assets

This section will analyze those assets that will not vary significantly during the period of unit activity.

Premises

The investment associated with the acquisition of the premises would be made by the UPC through funding from the Generalitat de Catalunya. The group would begin the activity in one office in the C3 building of the Mediterranean Technology Park CIMNE reserved.

Facilities

Facilities, those relating to electricity, water and telephone will be also provided by the UPC.

Machinery

The unit will need a machine for manufacturing printed circuits of power systems and circuits for the integration of sensor to wireless sensors technology.

The only company that distributes this type of machinery in Spain is Laser & Electronics. The most suitable machine is for the circuits that we will design will be the LPKF ProtoMat ® S62. Its cost is € 15,720.

On the other hand it will also require a drill machine to install a measuring system developed by the unit. The cost of a drill machine that meets all our requirements amounts to € 1800.

Furniture

The furniture will consist of the same elements as other offices of the building, tables, frames, lamps and cabinets, valued at € 4000 for 5 members of the group.

Computer equipment

The following table shows the number and costs of computer equipment.
The total cost of hardware resources is € 12,500.

Table 7.1 Computer Equipment

Type of equipment	Units	Cost/unit	Total cost
Workstations	6	1000 €	6000 €
Server	3	2100 €	6300 €
Print	1	200 €	200 €

Meter equipment

Equipment to monitor signals from sensors and systems designed by the unit will be required.

Table 7.2 Meter Equipment

Type of equipment	Units	Total cost
Osciloscope	1	1200 €
Multimeter	1	120 €
Power Supply	1	400 €

The total cost of resource measurement equipment is € 1720.

Welding equipment

Tools to weld electronic components on printed circuit boards will be needed.

Table 7.3 Welding Equipment

Tool	Units	Total cost
Welder	1	50 €
Third Arm	1	40 €
Support Welder	1	10 €
Magnifying glass	1	15 €
Consumables	1	10 €

The total cost of the tools needed for welding is 125 €.

Forecasting depreciation of fixed assets

Table 7.4 Forecasting Depreciation of Fixed Assets

Element	Acquisition value (€)	Expected lifetime (years)	% Amortization	Annual amortization cost
Máquina PCB	15720 €	10	100	1572 €
Taladro	1800 €	6	100	300 €
Workstation	1000 €	5	100	200 €
Server	2100 €	5	100	420 €
Print	200 €	5	100	40 €
Osciloscope	1200 €	6	100	200 €
Multimeter	120 €	6	100	20 €
Power Supply	400 €	6	100	66 €
Soldador	50 €	5	100	10 €
Tercer Brazo	40 €	4	100	10 €
Apoyo Soldador	10 €	5	0	0 €
Lupa	15 €	10	0	0 €

7.2 Investment on current assets

In this part we will include those assets required for the development of projects.

Table 7.5 Investment of Current Assets

Stocks	Units	Cost/unit (€)	Total cost (€)
Crossbow transmitters (micas)	10	150 €	1500 €
Data Acquisition Cards (Crossbow)	10	220 €	2220 €
Gateways (Crossbow)	2	200 €	400 €
Nodes Arduinos	12	80 €	960 €
Sensors	20	10 € (average)	200 €
Printed circuit boards	10	5 €	50 €
Electronic components	200	3 € (average)	600 €
GPRS transmitters	2	70 €	140 €
Solar panels	5	200 €	1000 €
Batteries	5	70 €	450 €
Voltage regulators	5	25 €	125 €

The total investment in assets is € 7645.

7.3 Human Resources

The group should have at least 3 engineers working in tasks to create a dynamic work and in 6 months time the 2 internships would be integrated.

Table 7.6 Human Resources Costs

Position	Salary (€)	Insurance (€)
Project leader	30000 €	7200 €
Electronic Engineer	26000 €	6240 €
Telecommunication Engineer	26000 €	6240 €
Internship 1	15000 €	0 €
Internship 2	15000 €	0 €

The total cost of human resources amounts to € 131,680.

7.4 Total expenses

The following table shows the total cost of the first year of the unit.

Table 7.7 Total Expenses

Concept	Cost
Machinery	17520 €
Furniture	4000 €
Computer equipment	12500 €
Meter equipment	1720 €
Welder equipment	125 €
Fixed assets	7645 €
Human resources	131680 €
Total	175190 €

7.5 Financial plan

The financial plan will define the source of the budget needed for investment: whether the initial investment is made by the partners (Government and UPC), banks or government programs of funding for research.

The unit will seek funding through public financing programs. Subprogramme Trace is based on providing grants to eliminate the risk associated with the development of projects whose long-term recovery is very uncertain. In this call

will be destinate to the salaries of three engineers and two interns for the first two years as well as costs associated with equipment and assets (systems and materials used for the development of projects).
To cope with the costs associated with measuring equipment, machinery and welding equipment, will seek funding through Acciones subprogramme for non-oriented research.

In case of failure obtaining the funding for staff recruitment it would be requested to the national recruitment and placement of human resources.

Finally, the investment required for the cost of the furniture should be assumed bye CIMNE through one of its two partners in the consortium (UPC or Generalitat).

CONCLUSIONS

The prospective analysis tells us that, in the next evolutionary step through Internet, identified and smart objects capable of exchanging information will be connected. This is the expected evolution after several years of platforms, networks and Web 2.0 and we are approaching to a ubiquity that allows linking in a smart way objects, services and products both in the real world as in the virtual. Ubiquity is the integration of technology in the environment of the person, so that computing units are not perceived as separate objects. To enable this interaction, objects will be required to have a large processing capacity, be smaller and more economic and be connected to sensors and actuators placed in the user environment that makes a network. It answer the necessity of companies to make decisions on their value chain from multiple variables, analyzing data from different perspectives and making projections of information to predict what might happen in the future.

In that way CIMNE has great potential for the management, manipulation and analysis of data and has been working for over twenty years in the study and development of predictive models to make decisions in real time. The new challenge is the application of these models in distributed networks that are capable of capturing information from environment variables, which are able to act or to generate alarms and consequently having a high capacity computer, but are easily integrable in any environment.

In this way, the unit would be able to develop tools for integrating numerical methods for the wireless sensor networks to make capable of sensing and responding appropriately to the presence of users with the creation of alarms or decision making systems in real time.

We must also take into account the risks due to the uncertainty of real performance offered by wireless sensor networks and consequently we should be aware of the results from other research groups working in this line.

To make the unit's first steps an initial investment in order to meet the costs of human resources and materials for the first few months will be needed. CIMNE is a consortium between the Universitat Politècnica de Catalunya and the Generalitat de Catalunya, so it seems that the best option is to seek funding from public funds.

There are different alternatives in terms of the growing plan of the unit and it should be taken into account the expectations of the future in order to decide.

Research on issues related to power management and development of systems that make better use of power sources that are in the environment will revolutionize the design of embedded systems including wireless connectivity.

The miniaturization of devices opens the possibility of their integration in some special sectors such as health. I will be based on smaller size and low consumption requirements. CIMNE has a group that develops biomedical

simulation codes to predict and prevent diseases. Their knowledge of the sector may be a key to develop useful applications for the industry.

Finally CIMNE is pushing for a unit of research of new technologies for the use of numerical methods with the aim of creating smart environments transparent to the user (ubiquitous environments). It can put CIMNE as one of the leaders in the research and development of smart applications.

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ANNEXES

ANNEX A. CYCLE HYPE

Hype Cycle is a model that represents the evolution of the expectations of an emerging technology over time. It is the graphic representation of the level of adoption, maturity and application of new technology. Gartner is a research and advisory consulting technology since 1995. It has used hype cycles to characterize the state of over-enthusiasm and subsequent disappointment that typically happens with the emergence of new technologies. The aim is to separate the hype from reality and decide whether a technology is ready for the approval of the business.

According to the interpretation of the Gartner hype cycle has five phases:

1."Technology Trigger" — The first phase begins when the product or service generates the interest in the media.

2."Peak of Inflated Expectations" — In the next phase, an excess of enthusiasm and publicity generated unrealistic expectations.

3."Trough of Disillusionment" — The technology comes into a state of disappointment because the expectations are not met and the media generally leave the subject and technology.

4."Slope of Enlightenment" — Although the media left the information technology, some companies are continuing the investigation to reveal the real and potential benefits.

5."Plateau of Productivity" — A technology reaches the "plateau of productivity" when the benefits are prove and accepted. The technology becomes increasingly stable and evolves in second and third generations. The final height of the plateau varies according to whether the technology is broadly applicable or benefits only apply to a niche market.

Figure A.1 Gartner's Hype Cycle Special Report for 2008, ID Number: G00159853, Publication Date: 11 July 2008.

The Hype Cycle is a useful tool for businesses because it allows an analysis on the temporary role of technology in the same state to avoid the excesses of euphoria because of unrealistic expectations that can make companies discard a technology without counting the benefits and impacts.

Summarizing:

- Provides an overview of the maturity of a technology in a particular segment of information technology (IT).

- Hype Cycle is a simple and clear message. Companies should not invest in a technology just because it is receiving a great deal of praise, nor should be ignored until it knows its true scope.

ANNEX B. THE MATRIX PRIORITY

Matrix priority is a tool to prioritize the emerging technologies that force planners to look beyond the advertising and assess the opportunities of technology in terms of their relative impact on the company.

The horizontal axis groups the technologies according to the ratio of time required to enter the stage of adoption in the Hype Cycle. It is a simple measure of risk based on the projections of the rate of maturation of the technology. High-priority investments in the top left of the priority matrix, which are technologies that can potentially have a major impact and have a high level of maturity.

benefit	years to mainstream adoption			
	less than 2 years	2 to 5 years	5 to 10 years	more than 10 years
transformational	**Invest aggressively if not already adopted**	Conservative (Type C) investment profile	Moderate (Type B) investment profile	Aggressive (Type A) investment profile
high	Conservative (Type C) investment profile	Moderate (Type B) investment profile	Aggressive (Type A) investment profile	Invest with caution
moderate	Moderate (Type B) investment profile	Aggressive (Type A) investment profile	Invest with caution	Invest with extreme caution
low	Aggressive (Type A) investment profile	Invest with caution	Invest with extreme caution	Invest with extreme caution

Figure B.1 Gartner's Priority Matrix Gartner's Hype Cycle Special Report for 2008, ID Number: G00159853, Publication Date: 11 July 2008.

The Priority Matrix answers the questions:

- ¿How much value can an enterprise gain from a technology?
- ¿When will the technology be mature enough for an enterprise to derive this value at an acceptable level of risk?

[1]

ANNEX C. Europeans Projects Partners

To apply a proposal to one of the calls of the Séptimo Programa Marco IDT, every European project must meet certain criteria, such as lasting more than one year, the demonstration effect (nature of innovative projects to address problems in relation to European policies), and transnationality / European added value (usually it is necessary to involve partners from other countries). It is also true for the Programa Marco de Investigación. Here are the partners in European projects of some research discussed in the benchmarking.

Partners of Network of excellence in wireless Communications++ (NEWCOM++) Project

Organization name: NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS
Contact person Address
Name: CHRISTOU LADA 6
10561
ATHINA
HELLAS
Region: ATTIKI
Tel:
Fax:
E-mail:
URL:
Organization Type:
Education

Organization name: GROUPE DES ECOLES DES TELECOMMUNICATIONS
Contact person Address
Name: 46, RUE BARRAULT
75634
PARIS 13
FRANCE
Region: ÎLE DE FRANCE Ile de France Paris
Tel:
Fax:
E-mail:
URL:
Organization Type: Education

Organization name: ECOLE SUPERIEURE D ELECTRICITE SUPELEC
Contact person Address
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Project Partners of Power Aware Communications for Wireless Optimised personal Area Network

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ANNEX D. BENCHMARKING INVESTIGATION CENTERS

D.1 Universidad Carlos III de Madrid

Groups or work units of the university who dedicate part of their activity to study and develop wireless sensor networks are:

- Communications Group, Department of Signal Theory and Communications.
- Centre for Technological Innovation for Security and Space.

Research & Develop Activities

The group activities focus on:

- Sensors and Telecommunications
- Networks Security (eValues)
- Biometric and Intelligent Targets Test (IDTestingLab)
- Socio-political treatment of the security

Wireless Sensor Networks Experience

Their experiences in these areas are:

Simulation and analysis:

The most important in this regard is the publication of the article 'CRUISE research activities towards Ubiquitous Intelligent Sensing Environments "in IEEE Wireless Communications in October 2006 on ubiquitous systems to achieve smart environments.

Efficiency Transmission Algorithms:

It publication of the article "An Energy-Efficient Adaptive Modulation Suitable for Wireless Sensor Networks with SER and Throughput Constraints" in the EURASIP Journal on Wireless Communications and Networking in May 2007 on energy efficiency in transmission systems devices wireless sensor networks.

[7]

Nationals and Europeans Projects

In this section we will analyze the projects have been financed by national or European organisms.

Europeans

Creating Ubiquitous Intelligent Sensing Environments

This European project began in January 2006 with the participation of 32 partners coordinated by the Swedish University of Aalborg. The project ended in December 2007.

They justify the need for this project to face the fragmentation and weakness of this field in Europe and had little awareness that at the time the benefits that introduces this technology in many sectors.

Project Goals:

- Make a significant contribution to the coordination and effectiveness of research.
- Evaluate, update and communicate the status of wireless sensor networks to the technical community.
- Change the current state of technology to a long-term vision by defining the intermediate steps in a vision based on the work plan.
- Stimulate the exchange of researchers and keep them informed of the needs of industry and research.
- Promote integration and sharing of tools and test research in more effective ways.
- Organize and participate in events that promote research on the development of sensor networks and the integration of the various initiatives of European research.

Financing:

The estimation costs of the project was 3,800,000 € of which were funded by the European Union 1,900,000 €.

Project partners can be found in Annex C.

[8]

Network of Excellence in Wireless Applications and Technology

Is a European project on Wireless Communications, with a duration of 18 months beginning in September 2002 and ended in December 2004. Its aim is to provide a proof of concept for a new kind of network of excellence in light of specified goals and priorities of the Sixth Marco Program.

The purpose of NEXWAY is to create a team based on a group of academics and independent R & D organizations with an international reputation in the field of wireless communications in order to serve the society and industry.

Project Goals:

- To strengthen academic research, eventually leading to the activity of joint programs.

- To encourage educational activities in the area of Wireless Communications.

Financing:

The estimation costs of the project was 12,146,680 € of which were funded by the European Union 998,877 €.

Project partners can be found in Annex C.

[8]

Power Aware Communications for Wireless OptiMised personal Area Network

Is a European project aiming at developing enabling technologies for Personal Area Networks. It is coordinated by Imeca, that is an independent research center in nanotechnology.

The project aims to provide the necessary tools for designing wireless security (IPv6) in a personal access network, as part of the image 4G. It will consist of physical layer / MAC that enable low-power operation and scalability (especially in the bit rate and complexity of the device), advanced networks to optimize the loading of the communication, security concepts, which contrasts with the "openness" of wireless technology, communications and gateway to the outside.

The link between all these tools is done via an optimization approach based on obtaining Pareto curves (optimal curves linking points) applied to the design of communication nodes and links. This approach allows the design of networks can be optimized for different objectives.

Objetives:

- The system will provide a solution for low power, offering local and global wireless access to the user with the speed of 100 bps to 10 Mbps without the need for infrastructure. The focus is on optimization of the device from the RF to the network layer and on the optimization of the network itself.

- The project's main objective is to conduct the necessary research, development and optimization of all layers of the ISO, which allows a

design of low cost and low power flexible. The project is based on advanced architectures in all layers and to integrate them with the help of Pareto optimization for low power devices and to provide a efficient system based on cost (in euro / bits).

Financing:

The estimation costs of the project was 4,500,000 € of which were funded by the European Union 2,700,000 €.

Project partners can be found in Annex C.

[8]

Nationals

Optimization of Wireless Personal Area Networks for Flexible Services

Project funded by Plan Avanza.

D.2 Universidad Autónoma de Barcelona (UAB)

Groups or work units of the university who dedicate part of their activity to study and develop wireless sensor networks are:

- Department of Telecommunications and Systems Engineering

Wireless Sensor Networks Experience

Their experiences in these areas are:

- Analysis of performance against imperfect channel knowledge.
- Selecting relays.
- Power Optimization.
- Design of algorithms equitable cost-based techniques for battery-port folio.

Results:

- 20+ magazine articles.
- 100+ conference articles.
- PhD Thesis (1 finished in 2006, several in curs).
- 2 patents in use.
- Relationship with equipment manufacturers and service providers at the Spanish and European.

Nationals and Europeans Projects

In this section we will analyze the projects have been financed by national or European organisms.

Europeans

In this moment are working in two projects:

- DINGPOS: Signal Processing Techniques and Demonstrator for Indoor GNSS PosiKoning, Programa TRP de la European Space Agency, 2007-2009. Participantes: Thales Alenia Alcatel Space, GMV, Nemerix, Advanced Digital Institute, Skyson, Nokia, UAB.

- RF/Microwave Communication Subsystems for Emerging Wireless Technologies (RFCSET) 2008-2011.

Nationals

Projects financed by national public entities:

- Algorithms for CDMA acquisition and tracking signals from the Galileo Receiver Mission Band C, Agreement with Mier Comunicaciones SA, 2007-2008.

- Design of digital telemetry receiver, Agreement stipulates with Tinytronic, SL, 2006-2007.

- POSTIP: Positioning Technologies IntegraKon PlaVorm, Agreement with Center Tecnològic amb l'Aeronàutica I l'Espai of Barcelona (CTAE), 2006-2009.

- Fast Re-Acquisition for GPS Receivers, Agreement stipulates with GMV, 2008-2009.

- Application of Technology Leader to unmanned aircraft for the Research and Development in ATM, CDTI - CENIT Project, 2007-2011. Partners: Boeing, Indra, Atos Origin, TCP, GMV, Altran, TTI, Aernnova, Isdefe, Aertec, IDS, Integrasys, AVA, IBERIA, Caton, QUALITAS.

- Research in Technologies for Migration Management - Project CENIT 2008-2012.

- Design of Link Layer and Physical Systems with Cooperative Communications Position Information Project R & D Department of Science and Innovation.

- Rural Internet Through heterogeneous networks and Itinerant People, CDTI - PROFIT Project, 2007. Partners: Iber-X, Telefónica I + D, Gigle, Hispasat, UAB.

- Quantum Communications Satellite, ESP2006-26372-E, Supplemental EXPLORA Action, Ministry of Education and Science, 2007.

[7]

D.3 Universidad de La Salle

One of the lines of specialization research La Salle-Universitat Ramon Llull is the telecommunications networks to support electricity networks.

Research & Develop Activities

The group activities focus on:

- Traditional communication systems of electricity companies: fiber optic, radio systems, carrier wave. Usually only deployed at sites of high tension.

- Focus its efforts on networks of low and medium voltage networks in which communications are now in place shortly.

Wireless Sensor Networks Goals

The goals of this unit are focus on:

- Define, model, develop, implement and validate the architecture for communications in intelligent networks.

- Define the specifications of communication networks and devices to support intelligent electricity networks of the future.

- Combine WSN, RFID and other wireless technologies.

- Coordinating the various technologies from the viewpoint of QoS (Quality of Service), admission control, security, etc ...

- Coordinating the various technologies from the viewpoint of QoS (Quality of Service), admission control, security, etc ...

- Development of products, processes, algorithms that allow an adequate communication network for the smart grid.

Nationals and Europeans Projects

In this section we will analyze the projects have been financed by national or European organisms.

Europeans

At the moment only a proposal submitted to the European Commission:

INTEGRIS (INTlelligent Electrical GRId Sensor communications)

The key technologies promoting the research are those related to the future of the Internet, the Internet of things and the smart electricity networks.

The three topics are related and have challenges in their combinations. They also need a significant research.

The mode that combines WLAN, WSN, RFID and PLC's is still not resolved and it is a challenge we intend to address through this project.

The challenge is to ensure and provide security for communication among the millions of devices for a specific application. In addition they also have intelligent networks that connect users.

D.4 Centre Tecnológic de Telecomunicacions de Catalunya (CTTC)

Centre of Excellence to drive long-term research and engineering projects.

- Staff: 72 persons.
- Centre of R+D+I research and engineering components.
- 6 º Classified in the returns of the projects FP6/IST (Source: CDTI).
- Founded in 2001
- 40 reserch projects developed
- More than 450 publications between 2001-2007
- Mainly devoted to the layers OSI 1,2 y 3.
- 3 researchers and industry / year
- 11 PhD, 14PhD Students, 2 post-PhD.
- 8 de patents.
- Increased number of researchers

Cumulative Investments

The following data refers to the cumulative investments since its founding:

- 4,500,000 € in headquarters
- 4,500,000 € in equipment and infrastructure

Research & Develop Activities

The group activities focus on:

- Providing end-to-end QoS
- Communications Subsystems

  - Active Components
  - Passive Components
  - Antennas

- Radiocommunications
  - Signal Processing
  - Communications and Information Theory

- Access Technology
  - Advanced techniques for multi-user wireless Networks
  - Advanced Resource Allocation and MAC Protocols

- IP Technologies
  - Mobile Wireless Networks
  - Self-Organize Networks

- Optical Networks
  - Transparent optical networks
  - Multilayer Networks

Nationals and Europeans Projects

In this section we will analyze the projects have been financed by national or European organisms.

Europeans

Network of excellence in wireless Communications++ (NEWCOM++)

This project has been presented to the first convocation of the Seventh Framework Program.

Its goals are:

- Identify application scenarios.
- Define appropriate performance measures that take into account the wireless channel.
- Analyses of the main theoretical results are available.
- Assess the information about the theoretical limits of performance.
- Design and analysis of transmission / reception of the algorithms and protocols

Financing:

The project began on 1st January 2008 and the date that the project must completed will be in 31st December 2010. It has of €5 million of funding when the cost of the project was expected around €9 million.

Project partners can be found in Annex C.

Physical layer for dynamic spectrum access and cognitive radio PHYDYAS

The expected impact of the project is the migration of wireless systems in a physical layer that is more efficient and responsive to the needs of dynamic and cognitive access.

Financing:

The project began on 1st January 2008 and the date that the project must completed will be in 31st December 2010. It has of €3.7 million of funding when the cost of the project was expected around €4.8 million.

Project partners can be found in Annex C.
[8]

Nationals

Projects funded by nationals organisms:

- TIMI. Intelligent Intermodal Transport of Goods. Draft Contract
- MUMO. Multi-carrier system for power lines. PROFIT

[7]

D.5 Instituto Tecnológico de Galicia (ITG)

It is nonprofits private foundation founded in February 1991 by the College of Architects, Civil and Industrial Engineers of Galicia.

Research and Develop Activities
The activity is based on:

- WMAN Networks: Mobile Wimax (IEEE 802.16e) standard for implementing the study to specific areas like the sea, and their integration with networks of sensors to be hybrid networks.
- Ad-hoc Networks Vehicles. In this area they are working on the study of adaptation of mobile standards to the specific requirements of these

environments (V2V technology, v2i) and in the design of specific services supported by these technologies.

Wireless Sensor Networks Experience

Their experiences in this area are:

- Techniques for efficient implementation of standards (ZigBee). Implementation multihop efficient routing algorithms, such as algorithms or multi-hop planes (Crossbow platform experience, Xmesh).
- Research on Open Connectivity IP (IPv6) routing and mobility in ad hoc networks lowpan (IEEE802.15.4), analysis of standard and protocol LOAD 6LoWPAN by TinyOS.
- Integrating sensors with radio technology.

Nationals and Europeans Projects

Nationals

Projects funded by national organisms:

Wireless Sensor Network for Environmental Alert Rivers and Coasts (ZIGSEA)

Project funded by the Xunta de Galicia.

Partners:

- SATDATA TELECOM – Company TELCO
- Marine Instruments – RadioBuoy Manufacture
- ITG – Technological partner
- GTEC – A Coruña University – Electronical and Systems departmen
- Portos de Galicia – Acces and Facilities
- CETPEC – Fisheries Technology Center

Project Goals:

- Test the technology ZigBee / WSN networks for Measure in Coastal Water Quality.
    - Model WSN Network Communications (Kit Crossbow Technologies)
    - IEEE 802.15.4 sensor node (Radiobuoy): T ª, GPS ...
    - Pilots in PUERTOS DE ARES (A CORUÑA) and CELEIRO (LUGO)
    - Mesh Network formed by a central node and 4 nodes (buoys)

D.6. i2CAT (UPC)

Groups or work units of the university who dedicate part of their activity to study and develop wireless sensor networks are:

- Wireless Network Group

I2CAT Foundation is a non-profit organization whose purpose is to promote research and innovation in advanced Internet technologies.

I2CAT promotes the deployment of services and broadband applications from the communities of research and innovation, both public and private, prompting the deployment of pilot facilities and services for telecommunications operators and management companies.

I2CAT is organized as a center for research and innovation in network distributed to:

- Develop research and innovation projects.
- To promote advanced research in the network environment, applications of high bandwidth and enhance their use.
- Create new platforms for collaboration between business and university research.
- Promote teamwork with institutions from the rest of the world who are in line with the objectives of the Foundation in the field of Internet research.

The I2CAT key model is based on putting research and innovation of the Internet within the reach of society through collaboration between government, businesses and research groups from universities and the educational world.

Organizational Structure

I2CAT foundation is divided into two major areas: research and innovation. It currently focusing their research projects in networking technologies that has 30% of their business and ultimately serves to innovation. Innovation projects represent 70% of the activity and focus on the development of networks, services and applications based on IP technology.

The main objectives achieved by the Foundation I2CAT in research work are:

- 21 publications in international journals and conferences.
- Development of modules and packages free: V-3 of UltraGrid high-definition transmission.
- Participation in four research projects CENIT (i3media, Vision, and Segur Inredis @), funded by the state plan for R&D.

Financing

Funding provided by national and European organisms:

- CIDEM 94,736 €
- Progresses Plan 242,552 €
- European Projects 375,000 €

CENIT

- 4 large projects (the implementation period of 4 years)

Acceptance rate of proposals:

- Nationally 80%
- At European level <50%

Funding regarding subcontracting amounted to 700,000 €.

Wireless Sensor Networks Experience

Their experiences in this area are:

- Internet Engineering Task Force (IETF) or 6LoWPAN WG
- Development of protocol NST-AODV
    - In line with previous proposals as LOAD
    - Co-authorship of the Internet Draft "Routing requirements for 6LoWPAN (http://www.ietf.org/internetdrafts/draft-dokaspar-6lowpan-routreq-06.txt)
- Other lines
    - Stacks or TCP / IP small

D.7 Electrical Engineering and Computer Sciences (UC Berkley)

Research conducted by professors and graduate students in this group contributed to the development of microwave devices, devices, surface acoustic waves, antennas, and lasers. They are pioneers in wireless technology and communications space.

They are currently working on several lines of research including the Wireless Embedded Systems (WEBS) and Micro / Nano Electro Mechanical Systems (MEMS).

Research and Develop Activities

The lines of R & D in this group are:

- Artificial Intelligence (AI)

- Biosystems & Computational Biology (BIO)
- Communications & Networking (COMNET)
- Computer Architecture & Engineering (ARC)
- Control, Intelligent Systems, and Robotics (CIR)
- Database Management Systems (DBMS)
- Design of Electronic Systems (DES)
- Education (EDUC)
- Energy (ENE)
- Graphics (GR)
- Human-Computer Interaction (HCI)
- Integrated Circuits (INC)
- Micro/Nano Electro Mechanical Systems (MEMS)
- Operating Systems & Networking (OSNT)
- Physical Electronics (PHY)
- Programming Systems (PS)
- Scientific Computing (SCI)
- Security (SEC)
- Signal Processing (SP)
- Theory (THY)

Wireless Sensor Networks Experiences

Their experiences in this area are:

Global Leader in Sensory Systems

- MEMS based Inertial Systems
- Wireless Sensor Networks

Sensor systems for aircraft and other vehicles

- Gyros

R&D Projects

Development Projects:

- Optical Transformer for Surface-Enhanced Raman Spectroscopy (SERS)
- Remote neuronal flight control of insect flight
- A Micromechanical Power Amplifier
- A Micromechanical Power Converter
- A Micromechanical RF Channelizer
- Electric Power Industry Applications of MEMS
- Limits to Micromechanical Resonator Performance
- MEMS-Based Oscillators
- Micromechanical Resonant Displacement Gain Stages
- Networked Suite of Mobile Atmospheric Real-Time Sensors (NSMARTS)
- Nanomechanical sensors for chemical transduction

- Phototransistor Optoelectronic Tweezers for Cell Manipulation

D.8 Networks and Mobiles Systems (MIT)

The group was formed in 1998 and is part of the MIT (Massachusetts Institute Technology). Conducts research in the field of wireless networks, specifically in the design of the architecture and communication protocols and network security and network systems.

Wireless Sensor Networks Experience

Their experiences in this area are:

- Prevention and control of interference.
- Spread Spectrum wireless sensor networks.
- Cabernet: content distribution using WiFi.
- Coding symbols for wireless mesh sensor networks.
- Use of mobile sensor network for monitoring of road safety.
- Standardization TCP Stream.
- Normalización de TCP Stream.

R & D Projects

Development Projects:

- CarTel: Development of network protocols, software and services for mobile wireless sensor networks.
- Wireless network coding: Techniques to improve troughput wireless networks using encryption.
- Bit-switched wireless networks: Using the information in cross-layer (SoftPHY) from the physical layer design for wireless network protocols more robust.
- Combating wireless interference: New techniques to overcome interference.
- AIP (Accountable Internet Protocol): Self-certification of Internet addresses and protocols to provide new and improved Internet security.
- WaveScope: Computer system for high data rate applications.

D.9 Universidad de Aalborg

Aalborg University is located in Aalborg, Denmark. With its foundation in 1974 became the fifth University in Denmark. In 1995 the College of Engineering Esbjerg joined the University and established, then the School of Architecture and Design in 1996, the Campus was opened in Copenhagen in 2003 (The Copenhagen Institute of Technology) founded the School of Medicine in 2006 and joined the Research Institute for National Construction in 2007.

Research and develop Activities

The main area of research is the field of engineering. The University has chosen as areas of special interest and Technology Health Sciences and Technology Communications:

- Sustainable energy, environment and construction.
- Global production, innovation, knowledge development and consistency.
- Information technology and embedded software.
- Nanotechnology and nonproduction.
- Technology and design experience.

Wireless Sensor Networks Experience

Their experiences in these areas are:

- PHY and MAC for WSN
- Security in WSN

Europeans Projects

The Institute of Technology Aalborg is developing a large number of Europeans. The following list contains a program that is working with only one site above:

- Power Aware Communications for Wireless OptiMised personal Area Network
    - Partner of Carlos III University of Madrid

- Creating Ubiquitous Intelligent Sensing Environments
    - Manager of the project and partner of Carlos III University of Madrid.

- Network of excellence in wireless Communications++ (NEWCOM++)
    - Partner of CTTC

D.10 Cork Institute of Technology

The main activity of the Institute's research is around three main groups of strategic research. These support group collaboration, multidisciplinary research, postgraduate education and research faculty.

- BioPharmaChem Group:

The members of this group participates are staff and postgraduate students of the Faculty of Science and Engineering Department of Chemical Processes. It incorporates research in the field of bio-analytical and biological control.

- Network embedded systems (NEMBES):

This group performs research, provides learning and allows the transfer of knowledge to the industry in the area of embedded systems. The group focuses on networking of embedded systems, object technology with intelligent wireless sensors to work in what is known as' Internet of things'. It has 45 researchers and is in the process of building a research center.

- Photonics Group

Photonics is the science of generating and harnessing of light, has a great impact in the area of telecommunications, sensors, medical imaging and astronomy.

Europeans Projects

The group of Embedded Systems Networks (Nembo) is developing a large number of Europeans projects. The following list contains programs that are working with only one site above:

- Creating Ubiquitous Intelligent Sensing Environments
    - Partner of Carlos III University of Madrid and Aalborg University in this project.

They are part of the FP-7 program of European Union funded projects related to forest biological diversity and working in 3 workgroups:

- Biodiversity
- Environment and Climate
- Integration of forestry research

ANNEX E. COMPANIES BENCHMARKING

Below a research process will be carried out in search of ideas to carry out methods, practices and processes of adaptation of the positive characteristics of firms or succeed in the fields of wireless sensor networks (WSN) systems and Radio Frequency Identification (RFID). The objective is to obtain information on products, services, sales systems, internal organization, investment in R & D and dissemination of results of these companies to make use of best practices.

E.1 Libelium Comunicaciones Distribuidas

Libelium is a developer and manufacturer of hardware for the deployment of wireless sensor networks (WSN). Leads two research groups: Research and Sensor Networks Wireless Mesh Networks Research Group and the group working RedSens that is within the framework of the Association of Electronic, Information Technology and Telecommunications of Spain.

Libelium was created in 2006 and in 2007 received a rating of Spin Off from the University of Zaragoza. In 2008 received a grant NEOTEC which funded the development and disposal of their products.

Products

Meshlium

It is basically a multi-gateway wireless router capable of connecting to different wireless networks like Bluetooth, ZigBee, WiFi and GPS to communicate in a mesh network topology. It has a modular design, its components can be combined to connect to networks that most interest the customer. Each component can be added separately. It contains management software that controls the functionality of the network through a Web browser so that you can manage from any computer, PDA or mobile device with Internet access.

Waspmote

It consists of a sensor node ad hoc 802.15.4 protocol to which it can connect 10 digital and 8 analogue sensors. It is powered by solar energy and lithium batteries. Contains an SD flash memory format for storing data and contains a Modem GSM / GPRS.

SquidBee

Sensor node is an ad-hoc ZigBee protocol aimed at monitoring the environment, includes temperature sensors, humidity and luminosity.

Sales Systems

All its products are sold directly online through their website. First is required to pay by bank transfer before sending the order by courier.

After sale Service

The service is made exclusively through a Wiki where researchers and developers Libelium make their contributions. Very rarely do a service telephone.

Research & Development

They have two main lines of research:

- Sensory Wireless Networking: They work in all that relates to the nodes that form the network (power systems, transmission systems, node management, etc ....)

- Mesh networks: contains everything related to the interaction of sensor networks with other networks such as local area networks or the Internet, and focuses primarily on security issues.

Diffusion of Results

The results of their research, published on his website where you can view all the projects and those under development.

E.2 TST Sistemas

TST is a technology private company dedicated to developing applications and telematic services and systems integration in wireless environments.

They offer services that are characterized by the use of emerging technologies including radio frequency identification (RFID), methods of payment without contact (Smart Card, NFC), the monitoring of parameters using wireless sensor networks (WSN), interacting with wireless technologies (WiFi, WiMAX, TETRA, MPT1327, GSM / GPRS, UMTS, HSDPA). Offer their services to sectors such as: Environment and Renewable Energy, Health, Public Transport, Logistics, Security and Defense.

TST was founded in 2007 as a spin-off from the University of Cantabria, motivated by the results in the field of networks, telematics systems and services.

Products and Services

Monitoring and Control

It offers remote control and remote management solutions based on wireless sensor networks. Capture physical quantities such as temperature, humidity, pressure, gravity or magnetism, and sent to control centers to manage and monitor.

These solutions include the design, deployment, management and optimization of sensor networks for different applications:

- Prevention and detection of fires.
- Control systems and water management.
- Study of microclimates.
- Control parameters in vineyards.
- Precision agriculture.
- Monitoring and inspection of structures.
- Detection of smoke and fire in buildings.
- Renewable energy (wind, marine, solar).

Security systems and access control

Solve problems in the identification, safe storage of confidential information, access control logic resources (computers, servers or applications), the electronic signature of documents (either locally or online), access to unique resources or establishing secure communications through the use of smart cards.

They use use smart cards for access control to physical resources (buildings, offices, laboratories, equipment and vehicles).

Contactless payments and mobile

Payment systems are done by smart card technology with near field communication (NFC). By bringing the cards to NFC readers are making the transaction so quickly and safely. These cards do not require batteries, because when the card is placed near the reader, it induces an electrical current to the card that allows you to swap small pulse data.

TST offers advanced payment solutions without contacts and mobility. Its services include consulting, deployment, integration and software development.

Communication infrastructures

In the field of communications infrastructures TST provides services to meet the needs of various industries, governments and financial institutions. Offer integrated solutions that combine the concepts of mobility, ubiquitous computing, intelligence and interoperability.

- Design and deployment of advanced infrastructure systems based on IP and wireless technologies (WIFI, WIMAX, TETRA).
- Networks and corporate communications services (VLAN, VPN, VoIP).
- Solutions for interconnection and interoperability between heterogeneous networks.
- Consulting and support to telecom operators in the deployment of new services.

Identification and Traceability Solutions

Comprehensive and integrated solutions based on radio frequency identification technology (RFID) for the entire supply chain: supply and production, distribution and marketing and point of sale.

- Stock and Inventory Control.
- Packaging and storage.
- Quality control.
- Preparation of inventory automatic.
- Traceability

Sales Systems

The services we offer require an initial size and a budget based on client needs. The sales service is very personalized.

After Sale Service

It service is personalized and resolution of incidents according to contract.

Research & Development

There is not information about their research or projects. It only reported the entities that fund their R & D projects.

Difussion of Results

Not disseminate the results of their projects but reported that they get the funding and awards granted to them by different entities.

E.3 Dexma

DEXMA is a company that offers products and expert services in wireless sensor networks (WSN) systems and Real Time Location (RTLS) in the areas of logistics, transport, industry, energy, emergency, health and agriculture.

It is based on expert opinion as Tim Berner-Lee (inventor of World Wide Web), or groups such as Gartner to discuss the evolution of new technologies.

It began their activity at the end of 2006 with the support of the Polytechnic University of Catalonia, in particular with the Department of Computer Architecture of Barcelona School of Informatics (FIB). Dexma has enjoyed the support and assistance of the Innovation Program of the UPC.

Products

DEXCell

It is a software product that allows deploying solutions based on wireless sensor networks and tracking systems in real time.

They have a team of wireless communications, tracking and monitoring, and developing turnkey projects or participate in the development of your solution, working with technicians from the company for services.

Before Sale Service

Configured and deployed without testing pilots for commitments that the customer can see if the solution will bring benefits.

After Sale Service

Provide training and support to its customers as soon as possible become familiar with the technology.

E.4 WorldSensing

It is a spin off of the University of Barcelona was established in June 2008. There were three people, a doctor in physics and electrical engineering student, an engineer and a doctoral student in Computer Engineering and Computer Science.

Products

We do not currently sell any product or offer any services. They are developing a platform for geophysical data acquisition and its development is at an early stage of basic systems of monitoring.

Research & Develop

This is their main means of financing. Currently, in collaboration with the Department of Geodynamics and Geophysics, University of Barcelona, lightweight systems developed for geophysical prospecting systems acoustic, seismic, and electromagnetic Magnetotellurics. It is looking for computational power in the nodes to reduce the volume of information to convey.

It is working on an R & D project to develop a tracking system off mass Andorra.

Goals

Is a company in develop phase and is still developing their potential products.

- Uniform representation of data from heterogeneous sources.
- Development of algorithms for identifying patterns in data.
- Adaptation of advanced signal processing to the system.

They seeking funding through collaborative projects with other organizations and companies to further develop a marketable product that is finally.

E.5 Signatelitcs

They are defined as a company of entrepreneurs in the incubator of Barcelona Activa. Develop signage and security solutions using wireless technology such as RFID, WSN, ZigBee, Wifi, etc…To develop applications for safety signs, road signs, early detection of fires, guiding the blind, etc...

Products

Diversify its products in four areas: Signs, Control, Security and Location.

Signals4all:

Intelligent and accessible signposting:

- Personalization of signposting (as user or environment).
- Ability to locate and point out objects in the environment.
- Discretion, privacy.

It is aimed at users who perform jobs at risk for pedestrians, disabled people and tourists.

It is designed to be installed in public buildings, museums, home automation, large surfaces, intelligent buildings, mobility, stadiums, theme parks and airports.

RoadBeaconSystem [RBS]:

- Road Singpostings onboard for cautives fleets
- Inteligents Singpostings

SignaData:

- Radiobeacon, capable of storing data, placed at points of easy access, allowing the user to access information related to the inspection point where they are located.

Security

MineSafety:

- Safety in mines. Positioning and emergency personal risk environments.
- Communication with bi-directional messaging, announcements and signals.
- Alerts when a person accesses or abandoned hazardous areas.
- Operations in controlled environments, open or closed.
- Alarms, alerts, text messages, events, etc.., Configurable by the administrator.
- Presence and control in emergency evacuation.

FireFly:

Early detection of forest fires:

- Monitoring of large areas. Cities and forests.
- Oversees remotely control points over large areas, forests or fields.
- Alerts unwanted events such as fires, floods, landslides or temperature limits.
- Help the authorities to take decisions.
- Display information instantly on a digital map.
- Get measures and long-term trends (prediction).Control

LightFly:

- Lighting control, environmental control and overall metropolitan location.

It is designed to capture and control of information over large areas. In addition you can also get:

Continuous monitoring of vehicle fleets, and individuals.

- Real time monitoring of environmental variables.
- Detection of emergency alerts and accurate positioning.

TerraBeacon:

Remote control and management of irrigation:

- Remote control of irrigation valves.
- Remote reading of water supply.
- Remote sensing of environmental variables on the plot.
- Location management and graphics via Internet and mobile telephony.Localización

They have a wide variety of products that allow tracking the location of people, objects or vehicles.

SignaMed: Location and emergency medical personnel and support.
SignaGer: Location and geriatric patients and emergency personnel.
SignaCar: Location of vehicles in controlled environments.
SignaRTLS: Location and emergency stop and active people.
SignaServ: Location of vehicle repair or service.
SignaRent: Location hires vehicles in controlled environments.
SignaPsi: Location and emergency psychiatric patients.

Research & Develop

Currently involved in a large project, Cabintec, working with multiple companies, universities and research centers for the design of the passenger compartment of a vehicle equipped with smart technologies professional, able to detect the driver (compared to healthy habits of behavior risk in the context of a safe driving), and the study of the parameters that characterize the vehicle and driver in the moments before an accident.

Diffusion of Results

The results are regularly published on its Web site without going into detail of the work done and without providing documentation, but if you report the most important objectives achieved.

E.6 Adevice

It is a communications specialist engineering wireless sensor networks (WSN) and embedded systems. Its products provide integrated solutions for the monitoring and control in various sectors: industrial control, home automation, energy efficiency, telemetry, health and environment. Develop hardware and software necessary to integrate different sensors and actuators in low-cost nodes. It is emerged as a technology-based company of the University of Seville, promoted by two researchers from the program funded by the campus of the Board of Andalusia.

Products

Adevice provides engineering services and consulting:

- Applications of wireless sensory networks.
- Applications for embedded systems.
- Integration of sensors and actuators in data acquisition systems.
- Walkways between different communication standards
- Hardware and software for communications and control.
- Telecommunications Consulting

- Technology foresight

- Advanced Technology Training.

- Low-cost wireless terminals and high autonomy using IEEE 802.15.4/ZigBee, with different sensors (temperature, humidity, light, accelerometers) and actuators.

- Pathways of communication between different wireless networks and communication standards (CANbus, Ethernet, WiFi, GPRS, GSM).

- Network Management Software.

- Embedded Systems Industrial Control.

- Industrial control systems using digital signal processors (DSP) and programmable logic devices (FPGA).

Research & Development

His research interests are directed at such areas as:

- Industrial Monitoring and Control
- Energy Efficiency
- Telemetry
- Home Automation
- Greetings
- Environment
- Receive public funding for two projects:
- Ecobuilding

It consists of the design and development of a software platform for monitoring, assessment and intelligent control of energy efficiency in construction in collaboration with Works and Contracts, Deum, F. Architect and CEDINT Magdalena.

Access4OSGI

It is a platform based on OSGi technology for management and monitoring of wireless sensor networks for industrial control and energy efficiency. In this project, working with the company Aici.

Diffusion of Results

Report their activities via their website.

E.7 Indra

Indra is a multinational Information Technology. It is the second European company by market capitalization of the sector. In 2007 sales exceeded 2167 M €. It has more than 24,000 professionals and customers in over 90 countries.

Indra is organized in six vertical markets: Defense and Security, Traffic and Transport, Energy and Industry, Telecommunications and Media, Finance and Insurance and Health and AA.PP.

Products

Indra offers customers from consulting, project development and integration of systems and applications to the outsourcing of information systems and business processes. This offer is structured in two main segments: Solutions and Services.

The solution offering includes a range of systems, applications and components for data collection and information processing, transmission and subsequent presentation, primarily focused on control and management of complex processes. Besides Indra has a consulting engagement, including technological consulting, operational and strategic, the latter being supplied by its subsidiary Europraxis.

By offering services, Indra manages and operates systems and solutions (Outsourcing, AM, Maintenance, etc...) as well as certain business processes where the technology is a strategic element and differential (BPO). The Business Process Management technology, which is strategic and differential Indra develops through its subsidiary josuexulo Indra.

Research & Develop

According to the report EU Industrial R & D Scoreboard published by the European Commission, Indra, is the second Spanish company that invests more in R & D, with a growth of investment here in the past 3 years 22%. It stands as the second European company in its sector that more resources devoted to this subject.

Indra in 2007 spent a total of 136.5 million euros on R & D, a 37.6% increase over the previous year. These numbers put the company at the 116 ranking of European companies that more resources devoted to this concept, while in the Computer Services sector, is in second place, close to the first, the company Fujitsu Siemens, which invested 145 million euros, and distance of the next two, Wincor Nixdorf (96.5 million) and TietoEnator (66.9 million).

The report also notes that the cumulative average growth of investment by Indra in the last three years was 22%, well above the average of the leading companies in its sector, which stands at 11.8%.

Patents

Indra has filed a total of twelve patents in the Spanish Office of Patents and Trademarks [1] related to positioning technologies (GPS and location via mobile phone networks), security systems for electronic voting system for sensor networks has two patents related to the capture of biometric data.

The patents relate to a device for Capturing biometric data of a personal agent to the capture, which includes, first, a Plurality of data capture equipment to be operated by the subject to capture, such as a fingerprint reader and a keyboard and one hand facing the former, a Plurality of data capture equipment to be operated by the agent to capture, such as a scanner and a card reader.

Diffusion of Results

For the dissemination of results, Indra made a series of publications which reported on the activities in which you invest in R & D and the results of their projects. In addition to a monthly magazine which includes a technical summary of its activities and to publicize their products and services.