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URJC- ACADEMIC ACTIVITIES AND PROJECTS IN SMART CITIES RESEARCH USING WSN

Julio Ramiro Bargueño PhD.
Rey Juan Carlos University

Smart Wb Madrid training/ 12-14 December 2023

This project has been funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

URJC- ACADEMIC ACTIVITIES IN SMART CITIES RESEARCH

CREATION OF A CHAIR: SMART-E2

SMART CAMPUS: https://chorlito.tsc.urjc.es/smartcampus

COLLABORATION AGREEMENTS WITH SURROUNDING CITY COUNCIL:

FUENLABRADA: IMVF.

ALCORCON

MOSTOLES

COLLABORATION AGREEMENTS WITH TECHNOLOGY MULTINATIONAL COMPANIES: IBM

RESEARCH PROJECTS:

RESEARCHING

- OMEGA (CAM) Website: http://projects.ciemat.es/web/omega-cm

- CHALLENGES 2024. UPM-CIEMAT-URJC. Architecture.

TECHNOLOGICAL TRANSFER

- STULZ https://www.youtube.com/watch?v=e0MlKbTd8Gk

- HISTORICAL BUILDINGS: TAPESTRY FACTORY…

- Transportation: GUIADE, TECOMVEH…

SPIN-OF COMPANIES OF STUDENTS OF OUR UNIVERSITY

MEDIA DISSEMINATION ACTIVITIES: CADENA SER INTERVIEWS

Challenges 2024 Project
https://cadenaser.com/cmadrid/2023/11/13/la-urjc-organiza-en-fuenlabrada-una-jornada-para-conocer-las-ondas-radiomagneticas-con-las-que-convivimos-en- house-ser-madrid-sur/

Smart Cities Seminar 2023
https://cadenaser.com/cmadrid/2023/10/24/el-marco-legal-de-la-ia-o-su-aplicacion-en-satelites-de-comunicacion-en-la-novena-edicion- del-seminario-smart-cities-de-la-urjc-ser-madrid-sur/

OMEGA (Telecinco-TV)
http://www.telecinco.es/informativos/tecnologia/Cientificos-inalambricas-eficiencia-energeticaedificios_0_2129400594.html

The Importance of DISSEMINATION ACTIVITIES:
- SMART CITIES URJC-IBM SEMINARS
- SUMMER COURSES
- SCIENCE WEEK
- NIGHT OF THE RESEARCHERS
- INSTITUTE (High Secondary School) VISITS

EXHIBITIONS: URJC 25 YEARS.

UNIVERSITY OF SENIORS: SUBJECT: ENERGY AND INTELLIGENT TELECOMMUNICATIONS.

END OF DEGREE, MASTER'S END AND THESIS.

“ENERGY EFFICIENCY IN BUILDINGS WITH WIRELESS SENSOR NETWORKS

Co-funded by the European Union

Why with Wireless Sensor Networks?

Presently most standards related to energy quality and energy saving in heating and cooling of buildings is related to the design phase based on dynamic simplified simulations and theoretical design calculations…

However several studies showed that the real performance after realisation of the building may deviate significantly from this theoretically designed performance

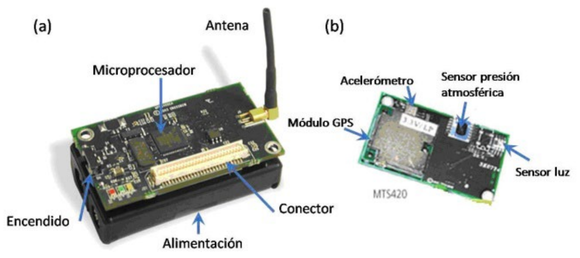
The expensive and highly intrusive implementation process, are the main problems of conventional monitoring systems regarding experimental performance assessment of full size building in occupancy conditions.

Consequently the availability of a reliable measurement system minimizing its wiring would be a remarkable step forwards.

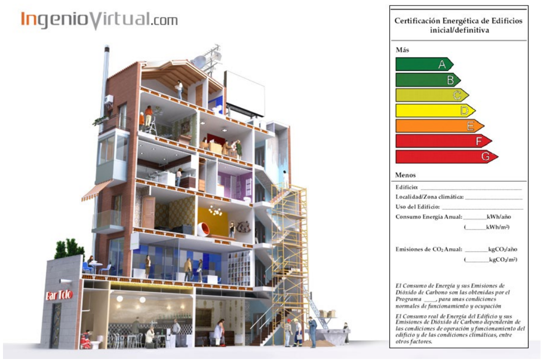
A monitoring system based on wireless sensor network (WSN) should be a solution

The overall objective of these research projects is the development of a non-intrusive high quality measurement system for energy efficiency monitoring of full size constructed buildings in occupancy conditions, allowing the integration of specific measurements related to intelligent elements, low energy consumption technologies

OBJECTIVE



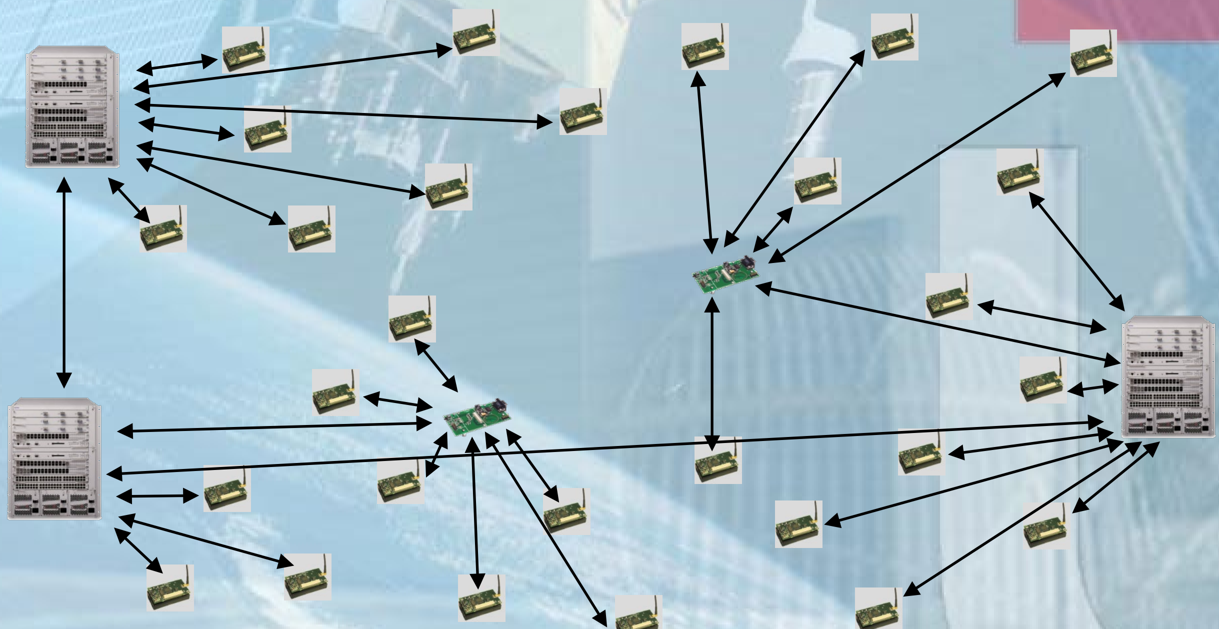
The overall objective of these research projects is the development of a non-intrusive high quality measurement system for energy efficiency monitoring of full size constructed buildings in occupancy conditions, allowing the integration of specific measurements related to intelligent elements, low energy consumption technologies



ABOUT WIRELESS SENSOR NETWORKS (WSN)

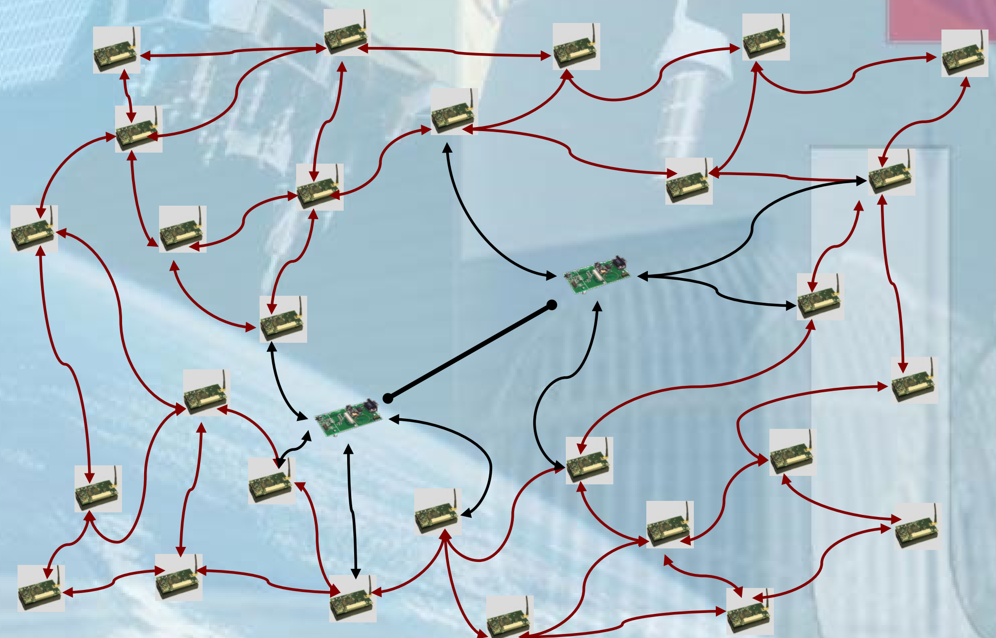
Ad Hoc Wireless Networks. Characteristics

- Lack of infrastructure



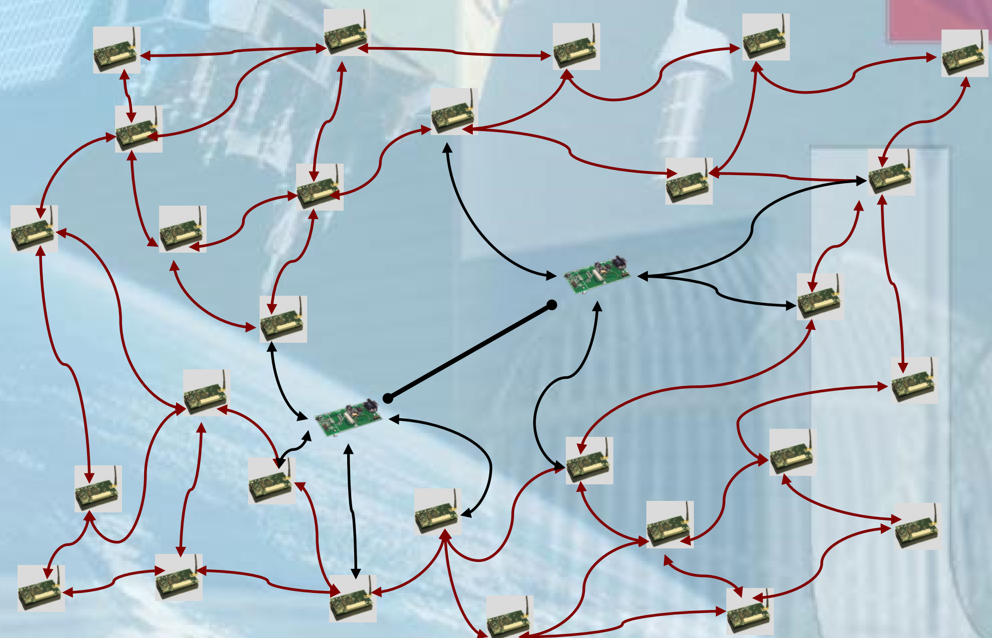
Ad Hoc Wireless Networks. Characteristics

- Radio Chanel



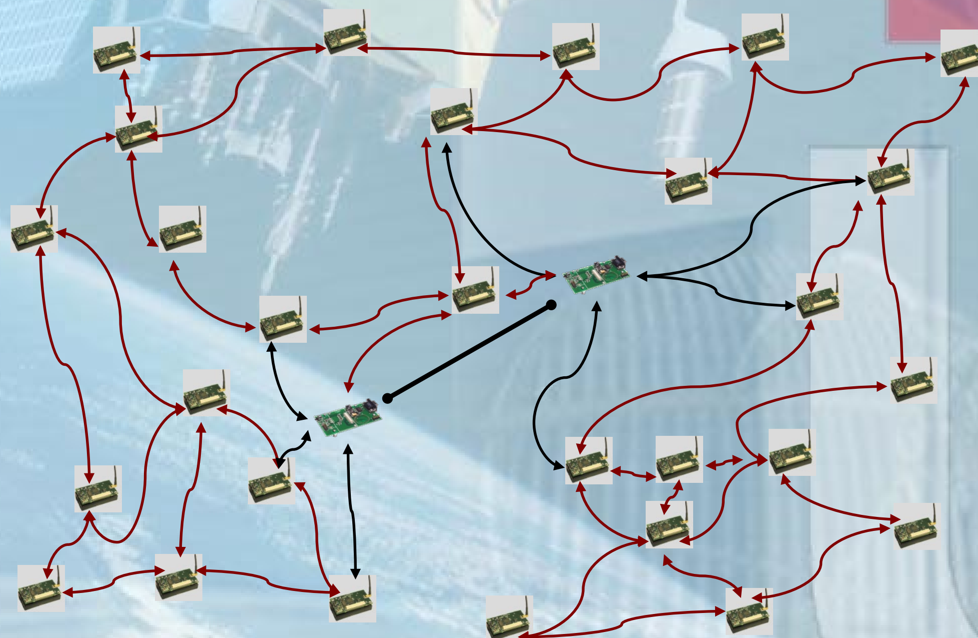
Ad Hoc Wireless Networks. Characteristics

- Mobile Nodes



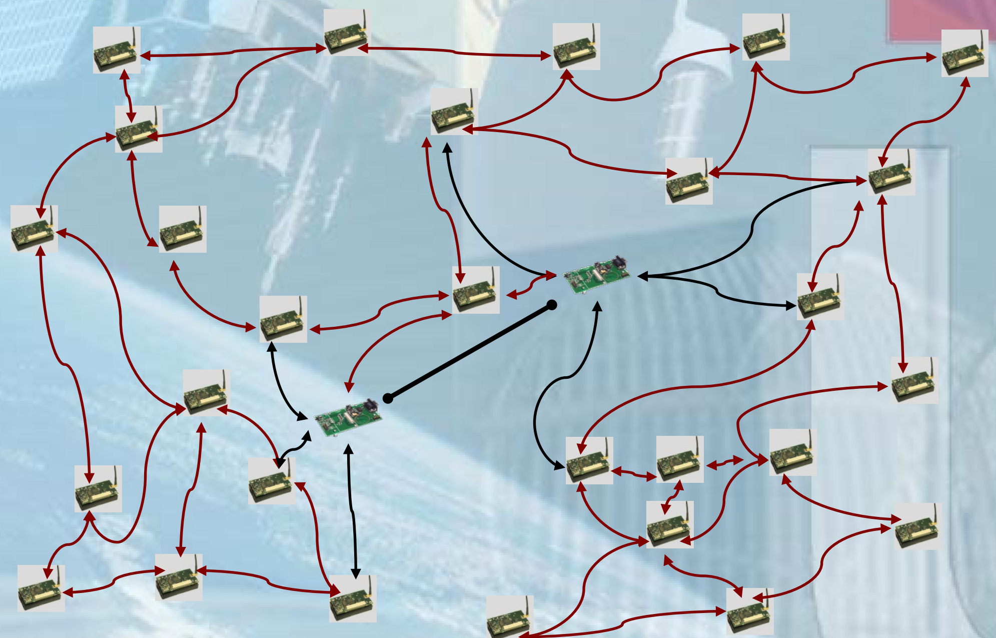
Ad Hoc Wireless Networks. Routing

- Dynamic topology maintenance



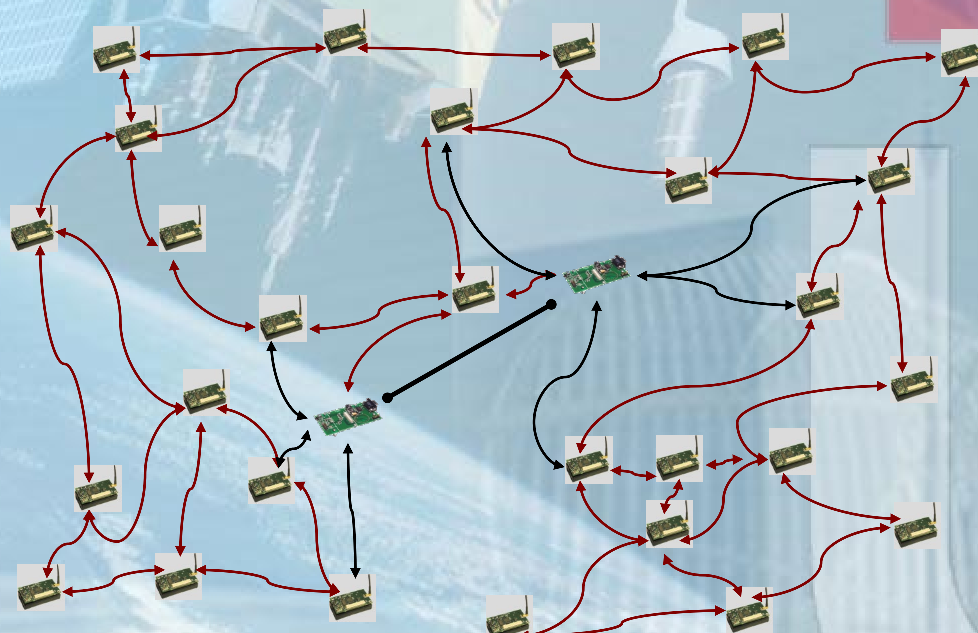
Ad Hoc Wireless Networks. Routing

- Multihop



Ad Hoc Wireless Networks. Routing

- Minimización de costes

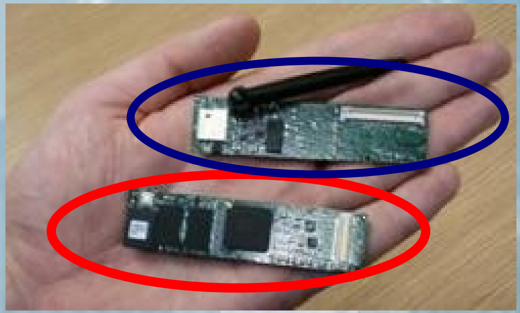


(Wireless Sensor Network)

En el caso de las WSN, los nodos son pequeñas unidades (del tamaño de una caja de cerillas) que tienen solamente

- Una placa de sensores
- unos pocos kilobytes de memoria,
- un procesador de unos cuantos MHz,
- una unidad de radiocomunicación de pocos metros de alcance,
- y una fuente de poder consistente en una o dos baterías tipo AA.

COMUNICACIONES INALAMBRICAS



SENSOR

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Escuela Técnica Superior de Ingeniería de Telecomunicación

¿WSN, qué las hace diferentes?

Y lo más interesante es que, con tan limitados recursos, se espera que estas redes sean capaces de:

- Monitorizar el entorno
- realizar enrutamiento
- hacer agregación de datos
- correr aplicaciones,
- autoconfigurarse
- y operar en forma desatendida

por varios meses o incluso años…

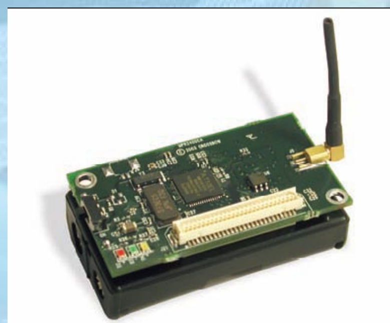
MONITORIZAR (Sensor)

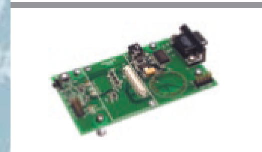
COMUNICAR

(Wireless Network)

El desarrollo de algoritmos, protocolos y sistemas para este tipo de redes presenta retos muy interesantes. (Actuales líneas de investigación)

Crossbow Motes



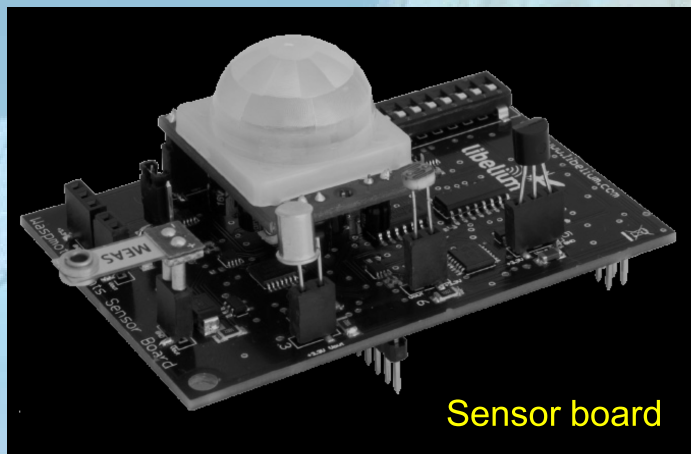
MIB510

Serial Port Programmer
IRIS, MICAz, MICA2 MICA-sensor Boards
Serial (RS-232)
Serial (RS-232)

MPR2400

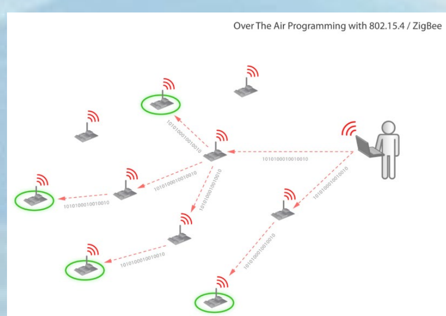
2.4GHz ISM Band
Atmel ATMega 128L
TI CC2420
Atmel AT45DB41B (512 kB)
4K bytes

MTS310	
	
•	Accelerometer (2 Axis)
	Actuator Relays
	Ambient Light
	Barometric Pressure & Temp.
•	Buzzer
	External Analog Sensor Inputs
	GPS
	GPIO
•	Magnetic Field
•	Microphone
	Photo-sensitive Light
•	Photoresistor
	Rel Humidity & Temperature
•	Thermistor

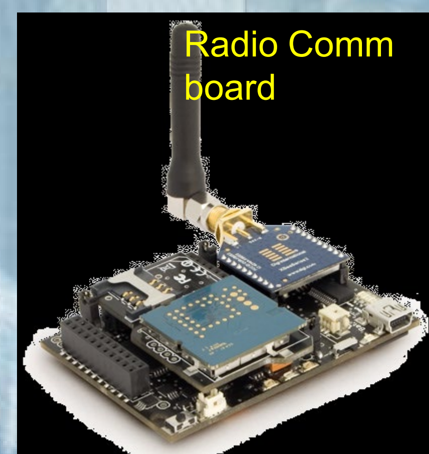
Wasp Motes Libelium



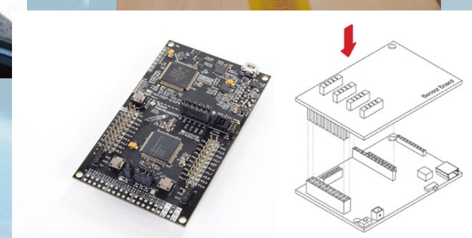
- Presión / Peso
- Doblez / Curvatura
- Vibración
- Impacto
- Efecto Hall
- Inclinación
- Temperatura (+/-)
- Presencia de líquido
- Nivel de líquido
- Luminosidad
- Presencia (PIR)
- Estiramiento

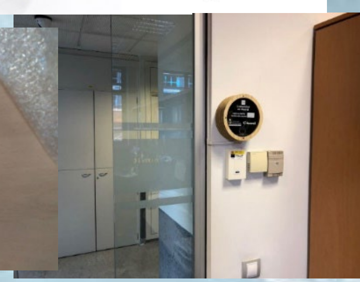


Microcontrolador: ATmega1281
Frecuencia: 8MHz
SRAM: 8KB
EEPROM: 4KB
FLASH: 128KB
SD Card: 2GB
Peso: 20gr
Dimensiones: 73.5 x 51 x 13 mm
Rango de Temperatura: [-20ºC, +65ºC]
Reloj: RTC (32KHz)
Consumo:
ON: 9mA
Sleep: 62µA
Deep Sleep: 62µA
Hibernate: 0.7µA
Funcionamiento sin recarga: 1año *

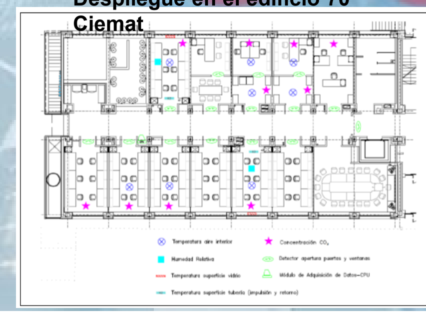


URJC-WSN





Despliegue en el edificio 70 Ciemat



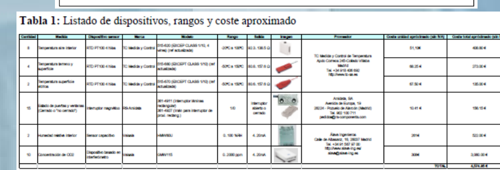
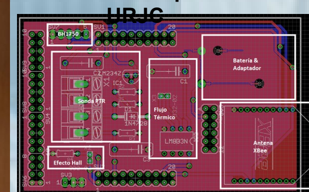


Tabla 1: Listado de dispositivos, rangos y coste aproximado

Cantidad	Medida	Dispositivo sensor	Marca	Modelo	Rango	Salida	Imagen	Proveedor	Coste unidad aproximado (sin IVA)	Coste total aproximado (sin IVA)
8	Temperatura aire interior	RTD PT100 4 hilos	TC Medida y Control	515-620 (EXCEP CLASS 1/10, 4 wires) (ref actualizada)	-20ºC a 100ºC	92.3..138.5 Ω		TC Medida y Control de Temperatura Apdo Correos 345-Collado Villalba Madrid Tel. +34 918 406 692 http://www.tc-sa.es	51,10€	408,80 €
4	Temperatura terreno y superficie	RTD PT100 4 hilos	TC Medida y Control	515-680 (EXCEPT CLASS 1/10) (ref actualizada)	-50ºC a 150ºC	80.6..157.6 Ω			68,25 €	273,00 €
2	Temperatura superficie vidrios	RTD PT100 4 hilos	TC Medida y Control	515-670 (EXCEPT CLASS 1/10) (ref actualizada)	-50ºC a 150ºC	80.6..157.6 Ω			67,50 €	135,00 €
15	Estado de puertas y ventanas (Cerrado o "no cerrado")	Interruptor magnético	RS-Amidata	361-4911 (Interruptor láminas rectangular) 361-4927 (Imán para interruptor de proxi. rectang.)	1/0	Interruptor abierto o cerrado		Amidata, SA Avenida de Europa, 19 28224 - Pozuelo de Alarcón (Madrid) Tel. 902 100 711 pedidos@rs-components.com	10,41 €	156,15 €
2	Humedad relativa interior	Sensor capacitivo	Vaisala	HMW90U	0..100 %RH	4..20mA		Álava Ingenieros Calle de Albasanz, 16, 28037 Madrid Tel. +34 91 567 97 00 http://www.alava-ing.es/ alava@alava-ing.es	261€	522,00 €
10	Concentración de CO2	Dispositivo basado en interferómetro	Vaisala	GMW115	0..2000 ppm	4..20mA			308€	3.080,00 €
									TOTAL	4.574,95 €

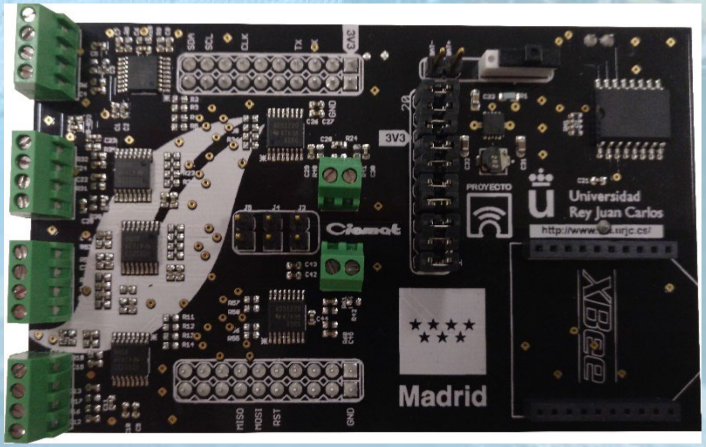
Prototipo Mota inalámbrica URJC



Los módulos que componen el prototipo:

- Batería & Adaptador
- Antena XBee
- Sonda PTR
- Sensor Hall
- Flujo Térmico
- BH1750 (luz)

Sensor Node



Compuesto por:

- Controlador: MSP432
- Adquisición de datos: Placa 'Hormigas'
- Com. Inalámbrica: Módulo XBee
- Energía: Batería de 19A y 3,6V

Adquisidores de Datos:

- 4x Sensores de voltaje/resistencia
- 2x Sensores de bucle de corriente 4-20mA
- 3x Sensores de cambio de estado [0, 1]V

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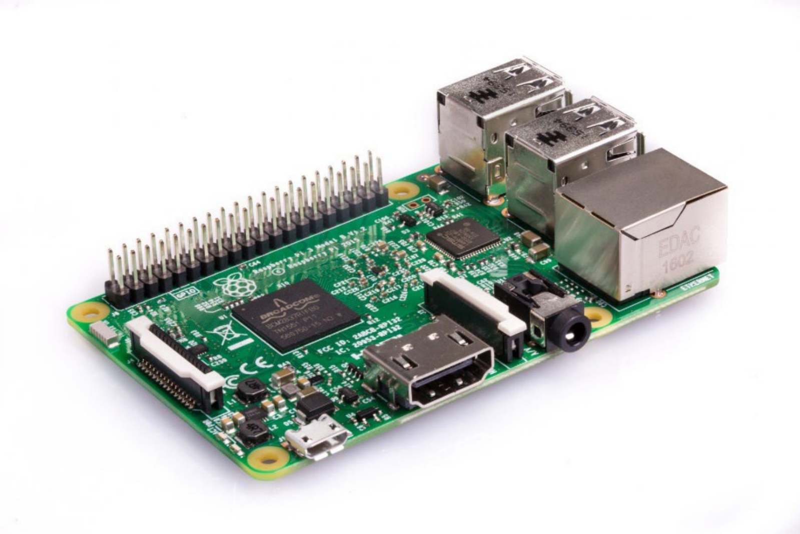
Gateway

- Desarrollado mediante *Raspberry Pi* (modelo 3B)
- Recibe, gestiona y retransmite (a un servidor) los mensajes de los despliegues
- Contiene una base de datos local para manejar datos del despliegue.



Server

Centraliza los datos generados en todos los despliegues.

Sus funciones son:

- Postprocesado:
  http://chorlito.tsc.urjc.es/nextcloud/
  - Reconstrucción
  - Filtrado
- Representación de datos
  - Dashboard: http://chorlito.tsc.urjc.es:8088
  - GIS: http://chorlito.tsc.urjc.es/mapas/

Deployment Madrid I

Location: Building-70, Ciudad Universitaria, Madrid

Deployed elements:

2x Gateways

17x Sensor Node

15x Door status sensors

8x Air temperature sensors

2x Surface temperature sensors

10x CO2 Sensors

2x Relative humidity sensorsUbicación: *Edificio-70*, Ciudad Universitaria, Madrid

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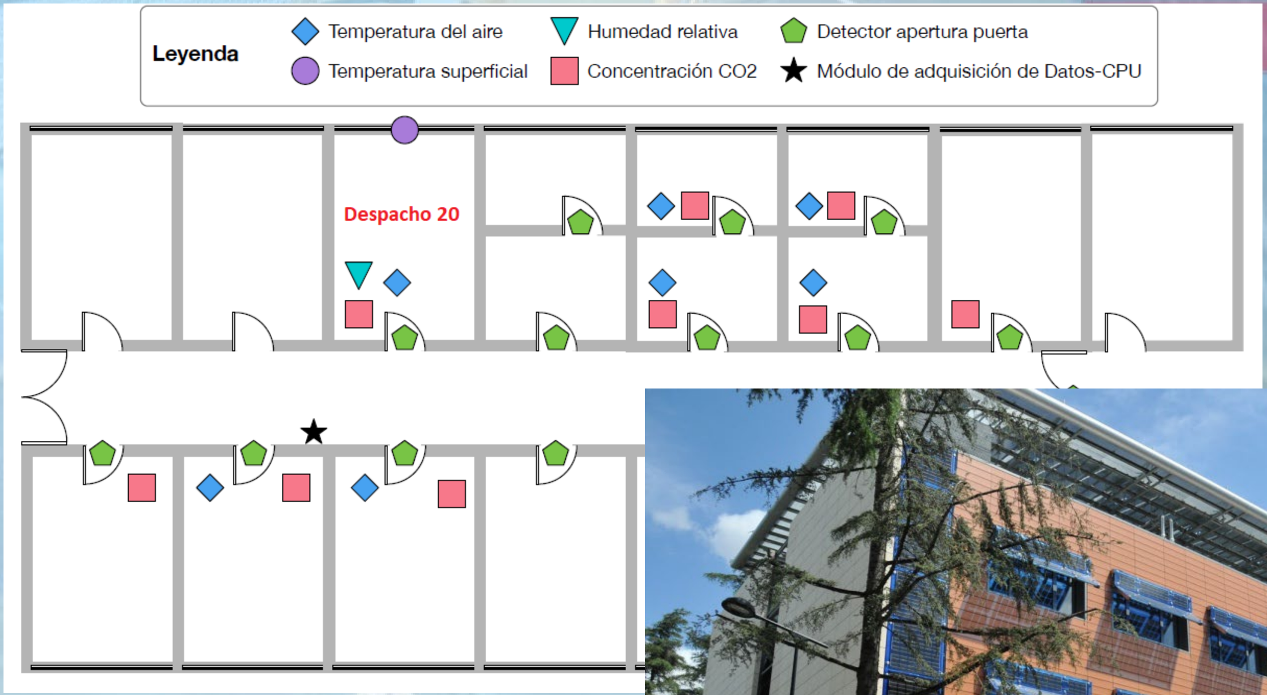
Deployment Madrid I



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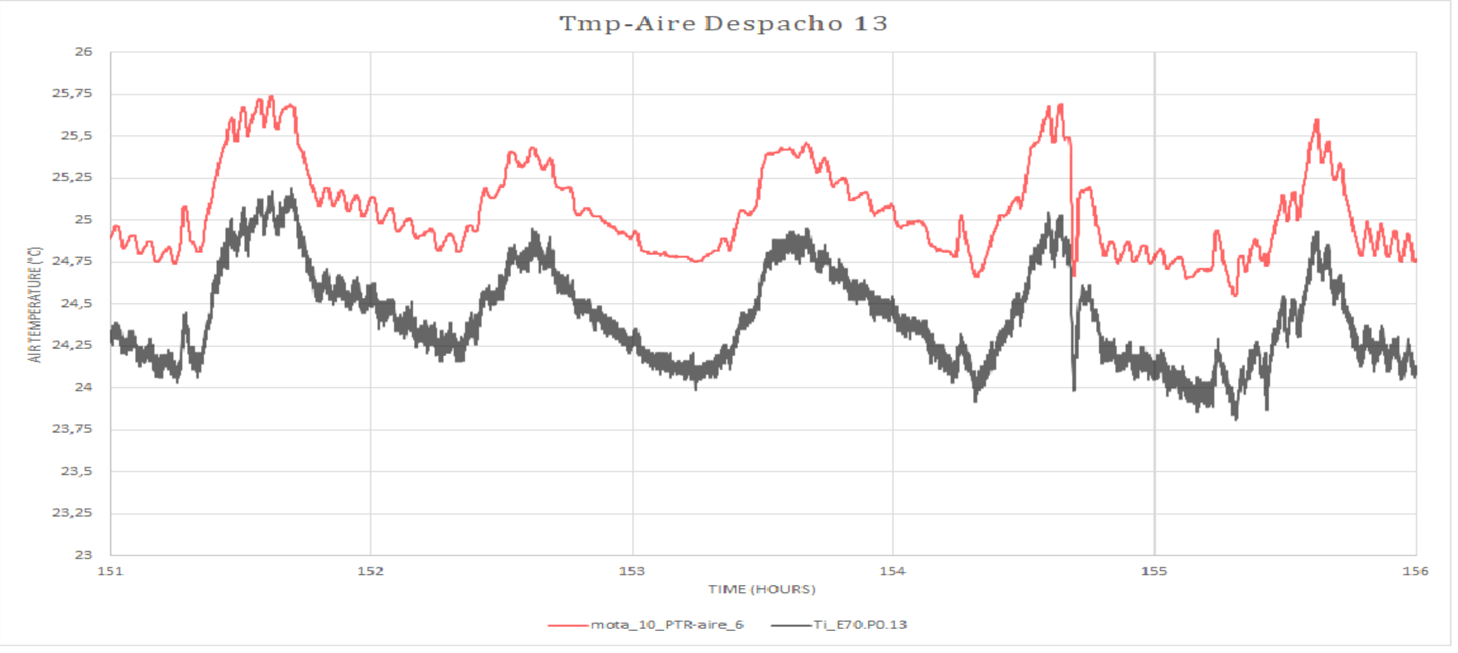
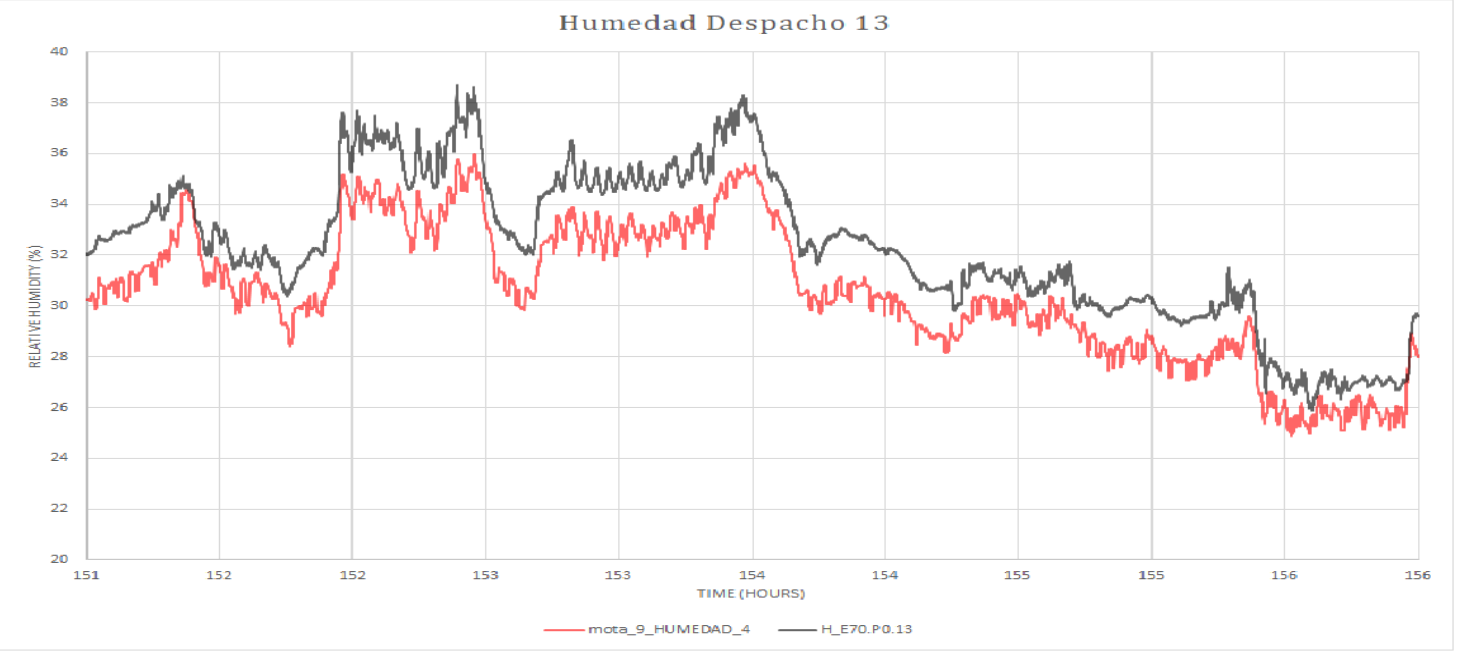
Comparative I: Air Temperature



Comparative II: Humidity



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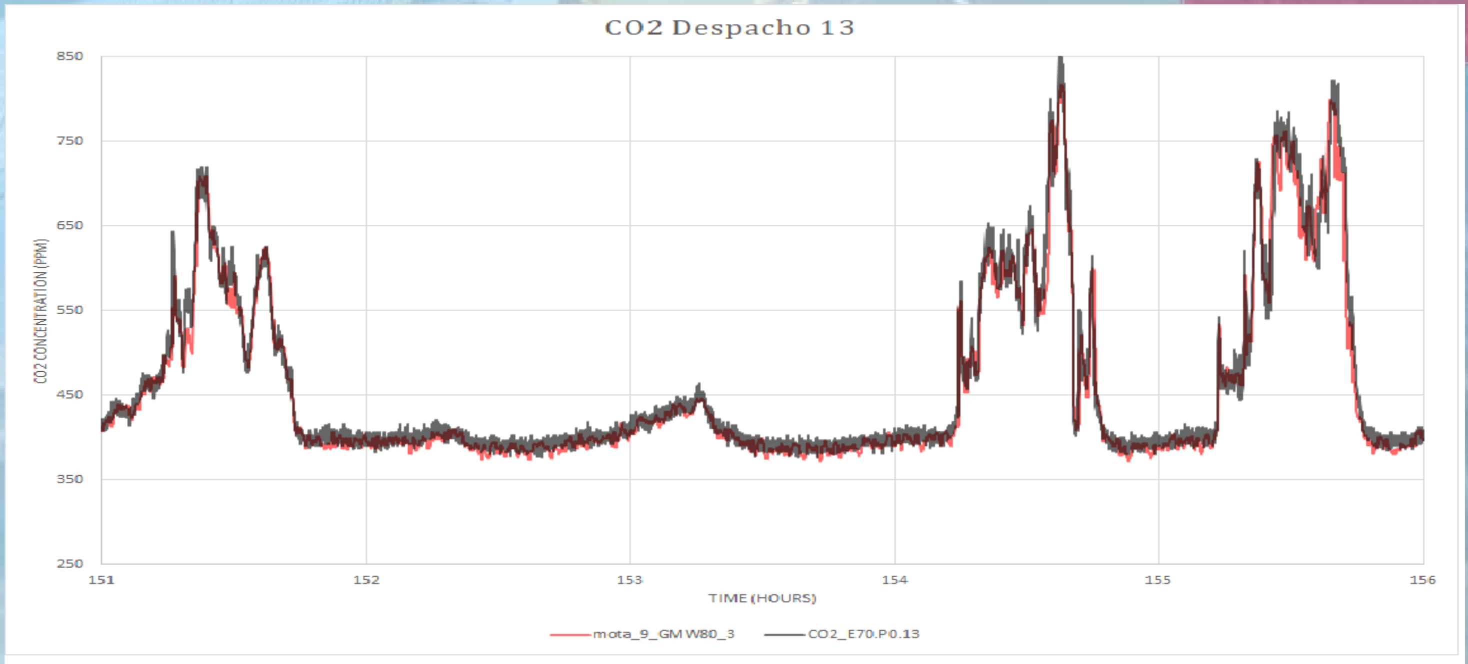
Comparative III: CO_2



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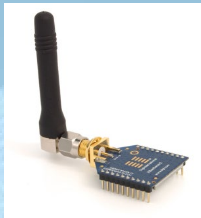
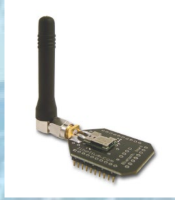
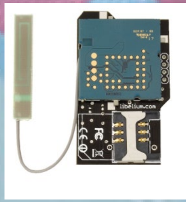


Zigbee



Bluetooth

WiFi



GSM-GPRS-3G

	Zigbee	**Bluetooth**	**WiFi**	**GSM-3G**
PROTOCOLO	802.15.4	802.15.1	802.11	
FRECUENCIA	2.4 GHz	2.4 GHz	2.4 GHz	850MHz/900MHz/1800MHz/1900MHz
TX power	1 mW	1.8 mW	16 mW	1 W
Distance* (LOS)	100m	250m		….

Wireless sensor networks (WSN) are a special type of networks that allow their deployment without any prior infrastructure use, at any time and place, achieving a non-intrusive monitoring network that characterizes the behavior of a system in a given environment with a great diversity of applications [1][2][3][4][5].

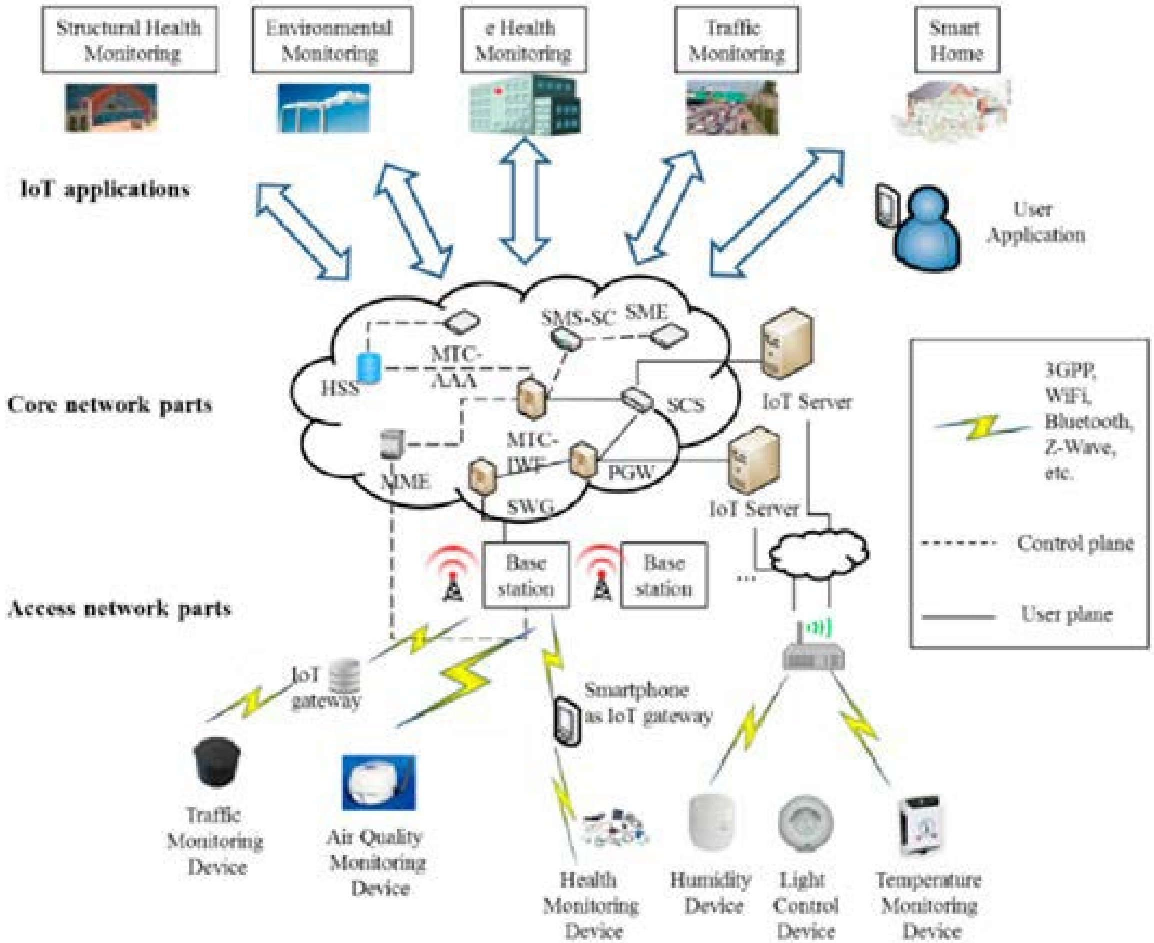
The objective of WSNs focuses on the monitoring of certain measurable physical parameters, imposed by the application in question. The number of devices or nodes, with a size of a few cm2, that make up the network can vary between a few units and tens of thousands.

The devices that make up this WSN are composed of two very different structures: one for sensing or monitoring and another for radio communications.

Likewise, they have a non-negligible computational structure, capable of being programmed, thus being transformed into intelligent sensor nodes, the so-called “smart motes”.

Currently there are sensors capable of establishing wireless communications. Their limitation, however, comes from their inability to carry out on-board processing and operate on a network. The communications protocols used in these nodes have extensions (experimental and non-commercial) that would allow them to operate in a network, but never beyond a few dozen sensors.

Energy and multiple channel access restrictions sometimes do not allow transmission of all measured data to a CFD. Likewise, the low computational capacity and memory in the nodes can prevent complex processing of the measured data. Therefore, to have a broad life cycle of the network, it may sometimes be necessary to perform simple processing [6] of the data and subsequently send it to the CFD with the minimum information necessary for the reconstruction.



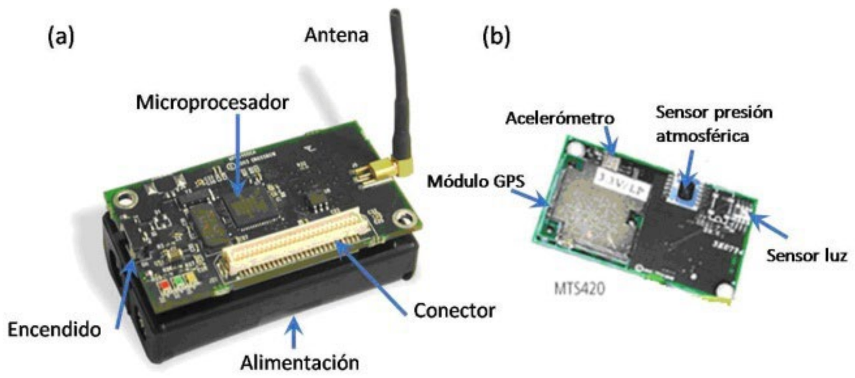
Generic IoT (Internet of Things) network architecture [7].

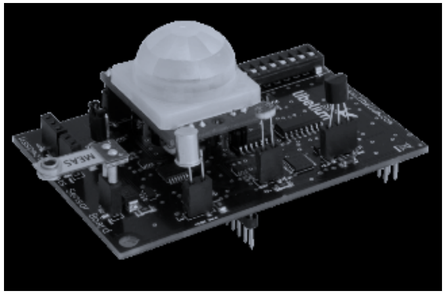
WIRELESS NODES (motes)

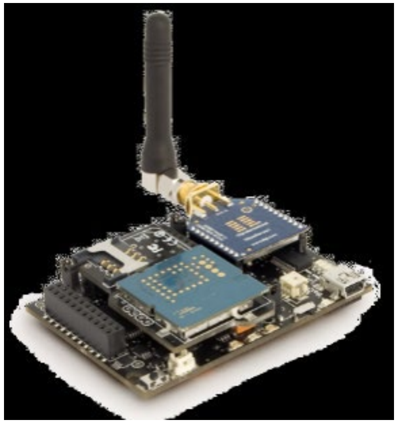
The components of the wireless network are the so-called wireless nodes, although their name "motes" or "motes" is very common.

A wireless mote basically consists of two parts: the sensor board and the communications board.

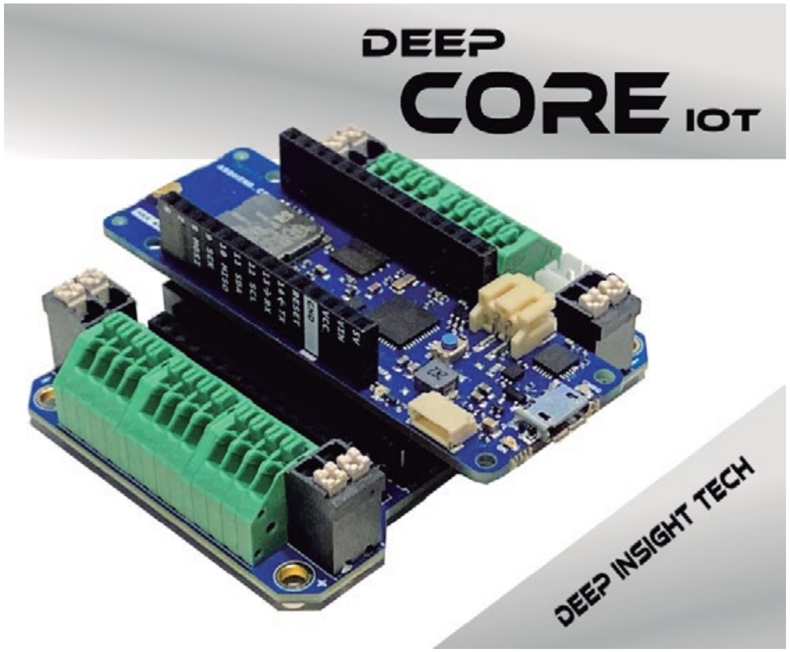
Over more than two decades of design and use, both the power supply, monitoring, electronics and communications protocols have been updated to new technologies.
An example is shown in the following figures.

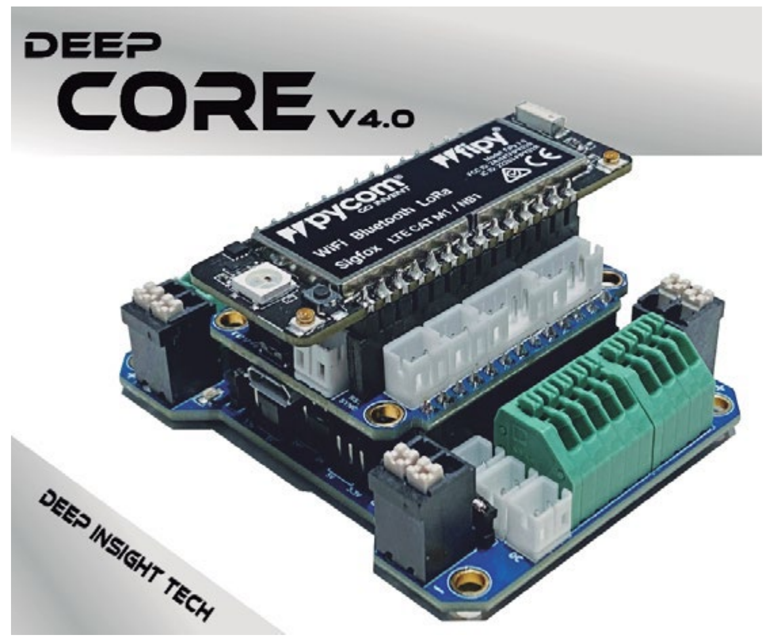

(a)
Antena
Microprocesador
Encendido
Alimentación
Conector
(b)
Acelerómetro
Sensor presión atmosférica
Módulo GPS
Sensor luz
MTS420






Comunidad de Madrid
UNION EUROPEA
Fondos estructurales
Ciemat


DEEP
CORE IOT
DEEP INSIGHT TECH


DEEP
CORE V4.0
pycom
WiFi Bluetooth LoRa
Sigfox LTE CAT M1 / NB1
DEEP INSIGHT TECH

There are short-range wireless technologies: “Low Data Rate Wireless Personal Networks (LR-WPN)”, (Zigbee, Z-Wave or Bluetooth Low Energy) that also have an 802.15 WG working group in the IEEE standardization body.
Other local area standards such as Wi-Fi allow the connection of IoT elements directly to the Internet, and with the appearance of Wi-Fi 6 (the new IEEE 802.11ax standard) energy consumption is reduced.[8][9][10]
Although it does not seem to be the case study of this project due to the coverage range, existing mid-range solutions based on mobile telephone communications (4G and 5G) allow the coverage radius to be expanded, at the cost of high energy consumption. However, with the emergence of technologies such as NB-IoT or LTE-M, evolutions of LTE/4G adapted to IoT, more limited consumption can be achieved.[10]

Finally, the current requirements of IoT applications have driven the emergence of new wireless communication technologies: "Low Power Wide Area Network (LP-WAN)".

These technologies provide low-power, low-rate, long-range communications, reaching 10 to 40 km in rural areas and 1 to 5 km in urban areas.

LoRa and Sigfox technologies appear, as LP-WAN standards, as native communication technologies for IoT. [11][12]

The power consumption used by individual nodes becomes a critical variable in the wireless world. Recent research trends in energy-efficient hardware and low-power protocols are working to improve network coverage, decrease latency, minimize energy used, and improve data reliability.

Low-power network protocols in indoor IoT applications such as LoRa, Sigfox, BLE, Zigbee, ANT, and numerous backscatter approaches are based on different network architectures and energy-saving strategies. LoRa nodes therefore save energy by communicating their data to long-distance gateways in a single hop, while Zigbee is designed to operate an efficient mesh network that supports several different topologies. BLE has been designed as a version of Bluetooth Low Energy suitable for peer-to-peer communication with high data rates and is even compatible with smartphones. In contrast, Sigfox uses a cellular-like system in an ultra-narrow band that requires little power, and backscatter technologies avoid the use of active radios by modulating and reflecting the incoming radio frequency (RF) signal.

REFERENCIAS

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RECENT PROJECTS and Diffusion:

- **SMART CAMPUS (URJC)**
- **NATIONAL RESEARCH PLAN PROJECT**
- **IX SMART CITIES URJC-IBM SEMINAR**

SMART CAMPUS

SMART CAMPUS

Objective

The objective of the project is to take the first step towards that Smart Campus by implementing a network of LoRa IoT nodes/sensors connected to an open and accessible LoRaWAN Wireless Network Infrastructure.

Variables that affect environmental comfort in classrooms and offices
CO_2 (ppm)
Temp (ºC)
Hum (% Hr)
TVOC (ppb)

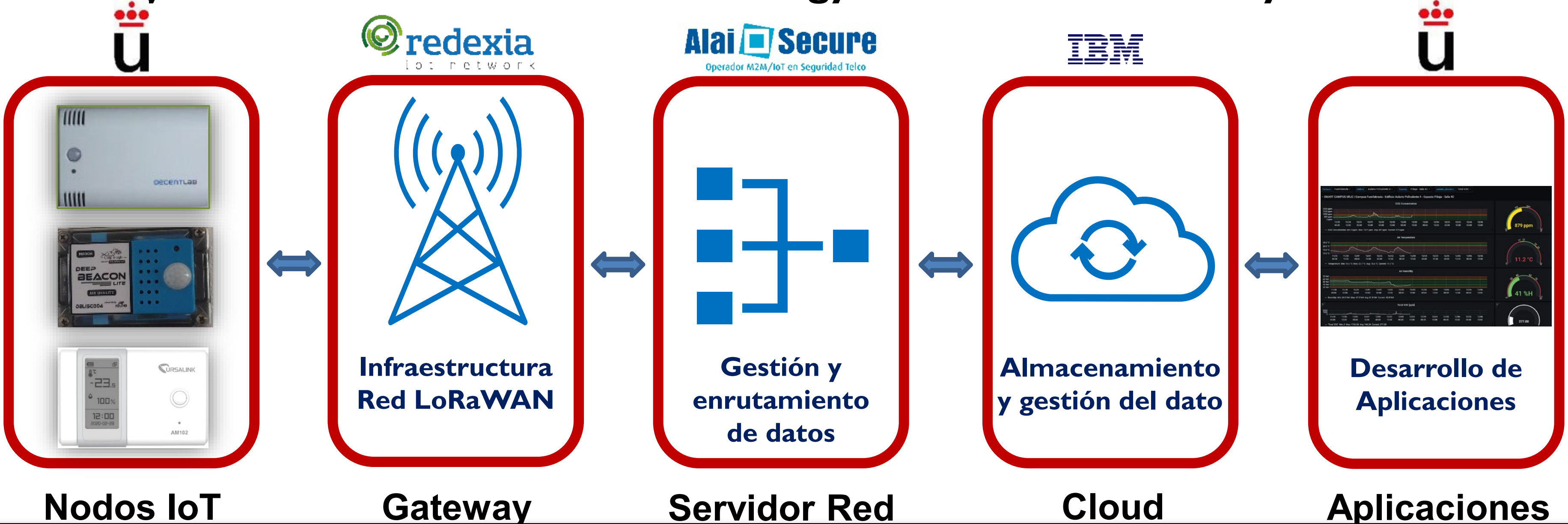
SMART CAMPUS

SMART CAMPUS

How to do it?

Through a collaboration agreement with three companies specialized in this type of technology: REDEXIA, ALAI SECURE (INGENIUM GROUP) and IBM.

Led by the Vice-Rector for Innovation and Transfer of the URJC, supported by a multidisciplinary team formed by UNEFE, the Signal and Communications Theory Area and the Electronic Technology Area of the University

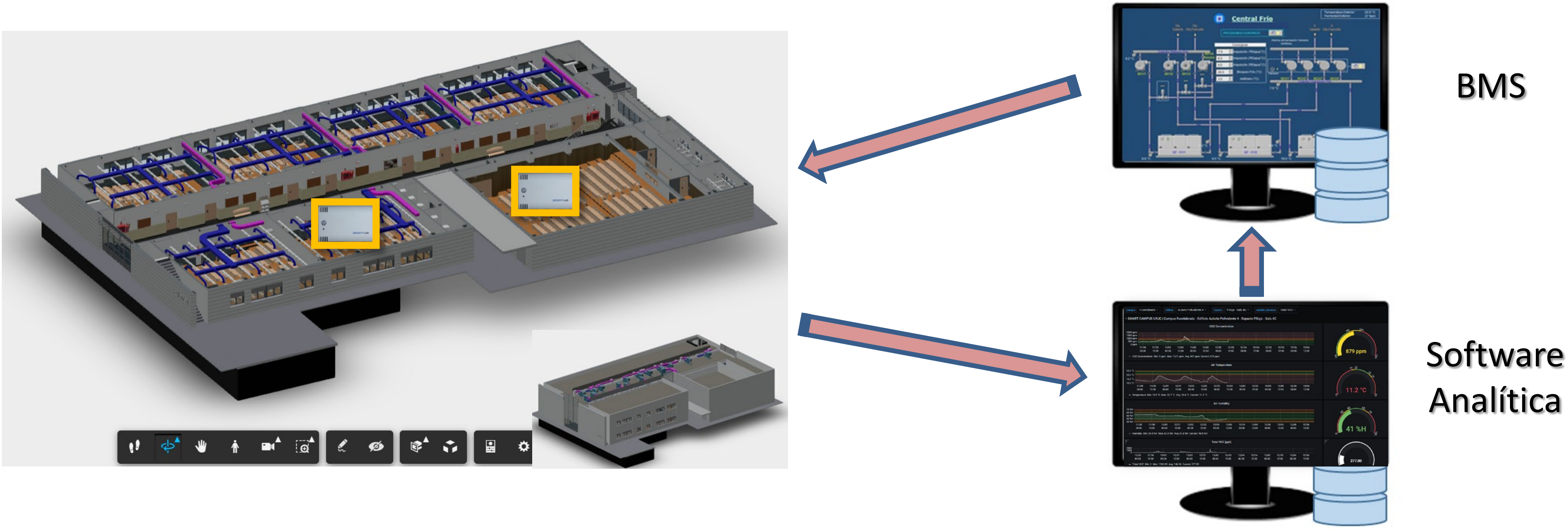


SMART CAMPUS

SMART CAMPUS

What will we use the transmitted data for?

The data transmitted by the IoT nodes are stored in a database to be processed by analytics software that uses programmed rules with the aim of optimizing the operation of the existing control systems (BMS) in buildings.



SMART CAMPUS

Control Panel developed by the URJC

https://chorlito.tsc.urjc.es/smartcampus

- NATIONAL RESEARCH PLAN PROJECT

MINISTERIO DE CIENCIA E INNOVACIÓN

Cofinanciado por la Unión Europea

AGENCIA ESTATAL DE INVESTIGACIÓN

Development of an analysis system for energy efficiency and environmental health in a residential urban environment for the transition of Fuenlabrada into a Smart City ***(De-Fuen-Smart)***

GENERAL OBJECTIVE

Development of an analysis system through the acquisition and analysis of data through autonomous wireless sensor networks for decision-making in urban and housing matters in the urban environment of Fuenlabrada as a "smart city" to allow an improvement in the energy efficiency and the generation of an environmental health knowledge map. Allowing the generation of a business innovation cluster.

- NATIONAL RESEARCH PLAN PROJECT

it is essential the presence all together of the Architecture teams of the **UPM (ETSAM)** and the URJC, as well as the **Telecommunication Engineering (ETSIT-URJC) team**, the **CIEMAT Renewable Energies** team and the essential presence of the **Institute Municipal Housing Authority of Fuenlabrada (IMVF)**, which will facilitate the study and the real scenario of a city for the development of the project.

- IX SMART CITIES URJC-IBM SEMINAR

PRESENTATIONS

“IBM Quantum Computing”

“Electromagnetic Compatibility in a wireless environment in Smart Cities”

AI integrated into the latest communications satellites.

Challenges and opportunities of the new “5G” in AI.

The urban development of a Smart City “Fuenlabrada”

Smart Cities hubs for entrepreneurship?

The importance of Sustainability, an investment for the future.

“The legal problems of the new artificial intelligence.”

Measurements and Simulation of Energy Efficiency in buildings in a Smart City. Success stories at the URJC in IOT, Campus and city of Fuenlabrada.

Round table with the speakers.

Patrocinado por: