
50 Sensor Applications for a Smarter World
Get Inspired!
libelium

INTRODUCTION

Alicia Asín
Libelium's CEO

David Gascón
Libelium's CTO

Since 2008, there are more objects connected to the Internet than persons in the world and this figure will hit 50 billion by 2020!. Now we can interact not only with contents in websites but with real objects.

For the first time, we can live in Smart Cities full of sensors that help us to improve our lifestyle and machines which talk to other machines on their own. As a result, people and objects jump into the Internet adding new layers of data and complexity. The "virtual" Internet we knew is becoming more "physical" than ever: we have entered into the Internet of Things era.

Now we are able to collect data everywhere from our environment, infrastructures, businesses and even ourselves, and this huge amount of information is generating a new ecosystem of business opportunities around its storage, analysis and accesibility.

In Libelium we believe that the new Internet of Things requires an open platform capable of dealing with different technologies, communication protocols and sensor databases. For this reason we released 2 years ago the first Wireless Sensor Network Platform to be Open Source, horizontal, modular and accessible to help developers design and deploy sensor applications on top, easily and within the minimun time to market. This new platform reached the market under the name "Waspmote".

During the past 2 years, more than 2,000 developers worldwide have joined our sensor platform, creating a compact and incredibly reliable framework which forms the base of the Libelium Community. They have proved Waspmote's versatility by doing amazing applications and new bussiness models with it. In this document we show just 50 of the hundreds that were sent when we started asking our Community members about what they had been doing with Waspmote during this past two years.

We want this document to be an inspirational guide that helps you to create imaginative and profitable applications in the new Internet Of Things era. Our mission is supporting you along all this way.

Let's start now: Think, Develop, Go!

CONTENTS

A UNIVERSE OF APPLICATIONS FOR GETTING INSPIRED...

Welcome to Libelium World

In this catalogue you will find a list with some of the possible applications with our products. If you want more information about them, visit our Applications section: http://www.libelium.com/applications

There, you will access to whitepapers and success stories related to each application.

What are you looking for?

Tell us your need,

and we will help you to find a solution:
commercial@libelium.com

SMART CITIES

01 **Smart Parking**
Monitoring of parking spaces availability in the city.

02 **Structural health**
Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.

03 **Noise Urban Maps**
Sound monitoring in bar areas and centric zones in real time.

04 **Traffic Congestion**
Monitoring of vehicles and pedestrian levels to optimize driving and walking routes.

05 **Smart Lighting**
Intelligent and weather adaptive lighting in street lights.

06 **Waste management**
Detection of rubbish levels in containers to optimize the trash collection routes.

07 **Intelligent Transportation Systems**
Smart Roads and Intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.

> *Smart City technology investment will total $108 billion by 2020.*
>
> ***Pike Research***

SMART ENVIRONMENT

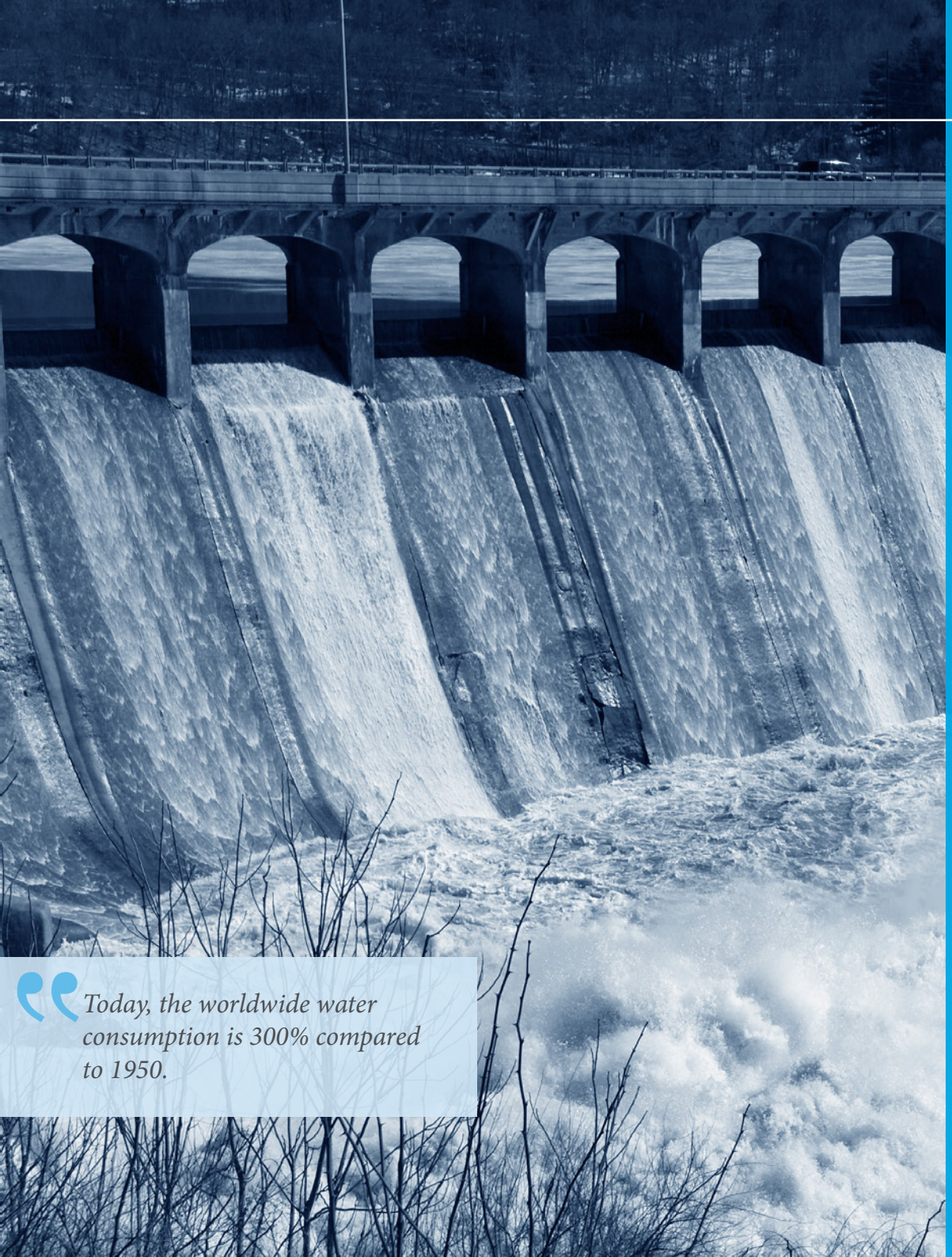
08 Forest Fire Detection
Monitoring of combustion gases and preemptive fire conditions to define alert zones.

09 Air Pollution
Control of CO_2 emissions of factories, pollution emitted by cars and toxic gases generated in farms.

10 Landslide and Avalanche Prevention
Monitoring of soil moisture, vibrations and earth density to detect dangerous patterns in land conditions.

11 Earthquake Early Detection
Distributed control in specific places of tremors.

More than 100,000 wildfires clear 4 million to 5 million acres (1.6 - 2 million ha) of land only in the USA.



Today, the worldwide water consumption is 300% compared to 1950.

SMART WATER

12 Water Quality
Study of water suitability in rivers and the sea for fauna and eligibility for drinkable use.

13 Water Leakages
Detection of liquid presence outside tanks and pressure variations along pipes.

14 River Floods
Monitoring of water level variations in rivers, dams and reservoirs.

SMART METERING

15 **Smart Grid**
Energy consumption monitoring and management.

16 **Tank Level**
Monitoring of water, oil and gas levels in storage tanks and cisterns.

17 **Photovoltaic Installations**
Monitoring and optimization of performance in solar energy plants.

18 **Water Flow**
Measurement of water pressure in water transportation systems.

19 **Silos Stock Calculation**
Measurement of emptiness level and weight of the goods.

European Union mandates that 100% of European households have smart metering capabilities by 2022.

Nuclear energy covers 16% of the planet energy needs.

SECURITY & EMERGENCIES

20 Perimeter Access Control
Access control to restricted areas and detection of people in non-authorized areas.

21 Liquid Presence
Liquid detection in data centers, warehouses and sensitive building grounds to prevent break downs and corrosion.

22 Radiation Levels
Distributed measurement of radiation levels in nuclear power stations surroundings to generate leakage alerts.

23 Explosive and Hazardous Gases
Detection of gas levels and leakages in industrial environments, surroundings of chemical factories and inside mines.

Failure to restock supermarket shelves costs the FMCG industry 4 billion € each year.

ECR Europe

RETAIL

24 **Supply Chain Control**
Monitoring of storage conditions along the supply chain and product tracking for traceability purposes.

25 **NFC Payment**
Payment processing based in location or activity duration for public transport, gyms, theme parks, etc.

26 **Intelligent Shopping Application**
Getting advices in the point of sale according to customer habits, preferences, presence of allergic components for them or expiring dates.

27 **Smart Product Management**
Control of rotation of products in shelves and warehouses to automate restocking processes.

Each year, more than 100 million shipping containers travel around the globe.

LOGISTICS

28 Quality of Shipment Conditions
Monitoring of vibrations, strokes, container openings or cold chain maintenance for insurance purposes.

29 Item Location
Search of individual items in big surfaces like warehouses or harbours.

30 Storage Incompatibility Detection
Warning emission on containers storing inflammable goods closed to others containing explosive material.

31 Fleet Tracking
Control of routes followed for delicate goods like medical drugs, jewels or dangerous merchandises.

INDUSTRIAL CONTROL

32 **M2M Applications**
Machine auto-diagnosis and assets control.

33 **Indoor Air Quality**
Monitoring of toxic gas and oxygen levels inside chemical plants to ensure workers and goods safety.

34 **Temperature Monitoring**
Control of temperature inside industrial and medical fridges with sensitive merchandise.

35 **Ozone Presence**
Monitoring of ozone levels during the drying meat process in food factories.

36 **Indoor Location**
Asset indoor location by using active (ZigBee) and passive tags (RFID/NFC).

37 **Vehicle Auto-diagnosis**
Information collection from CanBus to send real time alarms to emergencies or provide advice to drivers.

The volume of cellular M2M subscriptions is expected to increase fourfold between 2010 and 2016.

Pyramid Research

The 60% of water is needed in irrigation, and 20-30% out of this figure is wasted due to evaporation and over-watering.

SMART AGRICULTURE

38 **Wine Quality Enhancing**
Monitoring soil moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.

39 **Green Houses**
Control micro-climate conditions to maximize the production of fruits and vegetables and its quality.

40 **Golf Courses**
Selective irrigation in dry zones to reduce the water resources required in the green.

41 **Meteorological Station Network**
Study of weather conditions in fields to forecast ice formation, rain, drought, snow or wind changes.

42 **Compost**
Control of humidity and temperature levels in alfalfa, hay, straw, etc. to prevent fungus and other microbial contaminants.

SMART ANIMAL FARMING

43 **Offspring Care**
Control of growing conditions of the offspring in animal farms to ensure its survival and health.

44 **Animal Tracking**
Location and identification of animals grazing in open pastures or location in big stables.

45 **Toxic Gas Levels**
Study of ventilation and air quality in farms and detection of harmful gases from excrements.

> *The CH_4 emissions from animal farming in the U.S. have increased a 17% during the past decade.*
>
> ***U. S. Environmental Protection Agency***

European Union homes should cut energy consuption by 20% by 2020 according to Kyoto Protocol.

DOMOTIC & HOME AUTOMATION

46 **Energy and Water Use**
Energy and water supply consumption monitoring to obtain advice on how to save cost and resources.

47 **Remote Control Appliances**
Switching on and off remotely appliances to avoid accidents and save energy.

48 **Intrusion Detection Systems**
Detection of windows and doors openings and violations to prevent intruders.

49 **Art and Goods Preservation**
Monitoring of conditions inside museums and art warehouses.

65+ people will go from 7% to 12% by 2030.

eHEALTH

50 Fall Detection
Assistance for elderly or disabled people living independent.

51 Medical Fridges
Control of conditions inside freezers storing vaccines, medicines and organic elements.

52 Sportsmen Care
Vital signs monitoring in high performance centers and fields.

53 Patients Surveillance
Monitoring of conditions of patients inside hospitals and in old people's home.

54 Ultraviolet Radiation
Measurement of UV sun rays to warn people not to be exposed in certain hours.

APPLICATIONS / SENSOR BOARD / SENSORS INTEGRATED

		Application	Sensor Board	Sensors integrated
SMART CITIES	01	Smart Parking	Smart Parking	Magnetic field
	02	Structural Health	Smart Cities	Crack detection, crack propagation, accelerometer, linear displacement
	03	Noise Urban Maps	Smart Cities	Microphone (dBSPLA)
	04	Traffic Congestion	Smart Parking	Magnetic field
	05	Smart Lighting	Events /Actuation	Light sensor (LDR), actuator relay
	06	Waste Management	Smart Cities	Ultrasound sensor (measure capacity)
	07	Intelligent Transportation Systems	Smart Parking / Events	Magnetic field, crack sensor, water and ice detection sensors
SMART ENVIRONMENT	08	Forest Fire Detection	Gases	CO, CO_2, temperature, humidity
	09	Air Pollution	Gases	NO_2, SH_2, CO, CO_2, Hydrocarbons, Methane (CH_4)
	10	Landslide and Avalanche Prevention	Smart Cities / Agriculture	Crack detection, crack propagation, accelerometer, linear displacement, soil moisture
	11	Earthquake Early Detection	Any	Accelerometer

APPLICATIONS / SENSOR BOARD / SENSORS INTEGRATED

		Application	Sensor Board	Sensors integrated
SMART WATER	12	Water Quality	Smart Water	PH, dissolved oxygen, turbidity
	13	Water Leakages	Smart Metering	Liquid flow sensor
	14	River Floods	Events	Level sensor (switch), ultrasound sensor
SMART METERING	15	Smart Grid	Smart Metering	Current and voltage sensors
	16	Tank Level	Smart Metering / Events	Level sensor (switch), ultrasound sensor (capacity measurement)
	17	Photovoltaic Installations	Smart Metering	Current and voltage sensors
	18	Water Flow	Smart Metering	Liquid flow sensor
	19	Silos Stock Calculation	Smart Metering	Ultrasound sensor (capacity measurement), load cells

APPLICATIONS / SENSOR BOARD / SENSORS INTEGRATED

	Application		Sensor Board	Sensors integrated
SECURITY AND EMERGENCIES	20	Perimeter Access Control	Events	PIR (infrared), hall effect (windows, doors), RFID and NFC tags
	21	Liquid Presence	Events	Water detection sensor
	22	Radiation Levels	Radiation / Agriculture	Geiger Muller tube (Beta and Gamma) [β, γ], ultraviolet sensor (UVA, UVB)
	23	Explosive and Hazardous Gases	Gases	O_2, H_2, CH_4, Isobutane, Ethanol
RETAIL	24	Supply Chain Control	Any	RFID and NFC tags
	25	NFC Payment	Any	RFID and NFC tags
	26	Intelligent Shopping Application	Any	RFID and NFC tags
	27	Smart Product Management	Smart Metering	Weight sensor (load cell), RFID and NFC tags

APPLICATIONS / SENSOR BOARD / SENSORS INTEGRATED

		Application	Sensor Board	Sensors integrated
LOGISTICS	28	Quality of Shipment Conditions	Events	Light, temperature, humidity, impact, vibrations, accelerometer
	29	Item Location	Any	RFID and NFC tags
	30	Storage Incompatibility Detection	Gases / Events	O_2, H_2, CH_4, Isobutane, Ethanol, RFID and NFC tags
	31	Fleet Tracking	Any	GPS
INDUSTRIAL CONTROL	32	M2M Applications	Events	Voltaje, vibration, accelerometer, current
	33	Indoor Air Quality	Gases	CO, CO_2, NH_3, NO_2, SH_2, CO, CO_2, O_3
	34	Temperature Monitoring	Events	Temperature, humidity, pressure
	35	Ozone Presence	Gases	Ozone (O_3)
	36	Indoor Location	Any	Passive tags (RFID+NFC) + Active tags (ZigBee, Wifi, Bluetooth)
	37	Vehicle Auto-diagnosis	Events	Voltaje, vibration, accelerometer, current

APPLICATIONS / SENSOR BOARD / SENSORS INTEGRATED

		Application	Sensor Board	Sensors integrated
SMART AGRICULTURE	38	Wine Quality Enhancing	Agriculture	Soil temperature / moisture, leaf wetness, atmospheric pressure, solar radiation (PAR), trunk diameter
	39	Green Houses	Agriculture	Soil temperature / moisture, leaf wetness, atmospheric pressure, solar radiation (PAR), trunk diameter
	40	Golf Courses	Agriculture	Soil moisture
	41	Meteorological Station Network	Agriculture	Anemometer, wind vane, pluviometer
	42	Compost	Agriculture	Humidity, soil moisture, soil temperature
SMART ANIMAL FARMING	43	Offspring Care	Gases	CH_4, SH_2, NH_3, temperature, humidity
	44	Animal Tracking	Any	Passive tags (RFID+NFC) + Active tags (ZigBee, Wifi, Bluetooth)
	45	Toxic Gas Levels	Gases	CH_4, SH_2, NH_3, temperature, humidity

APPLICATIONS / SENSOR BOARD / SENSORS INTEGRATED

		Application	Sensor Board	Sensors integrated
DOMOTIC AND HOME AUTOMATION	46	Energy and Water Use	Smart Metering	Current and voltage sensors, liquid flow sensor
	47	Remote Control Appliances	Events / Actuation	Actuator relay
	48	Intrusion Detection Systems	Events	PIR (infrared), hall effect (windows, doors)
	49	Art and Goods Preservation	Gases	Temperature, humidity, pressure, O_2
eHEALTH	50	Fall Detection	Any	Accelerometer
	51	Medical Fridges	Events	Light, temperature, humidity, impact, vibrations, accelerometer
	52	Sportsmen Care	eHealth	ECG, pulse, accelerometer, respiration
	53	Patients Surveillance	eHealth	ECG, pulse, accelerometer, respiration
	54	Ultraviolet Radiation	Agriculture	Ultraviolet sensor (UVA, UVB)

THE LIBELIUM EXPERIENCE: THINK, DEVELOP, GO!

About Our Technology

For system integrators delivering Smart Cities solutions, Libelium is the wireless sensor (MOTE) provider that delivers easy to program, modular, open source and low-power consuming devices.

Only Libelium is supported by a community of developers in the world's largest companies with deployments in 45 countries.

Easy Deployment

> *The Waspmote platform, together with its understandable Software and broad extension capabilities, is a great tool to ease the entry into the complex world of Wireless Sensor Networks.*

Sebastian Bader
Mid Sweden University (Sweden)

THE LIBELIUM EXPERIENCE: THINK, DEVELOP, GO!

Think

Before starting

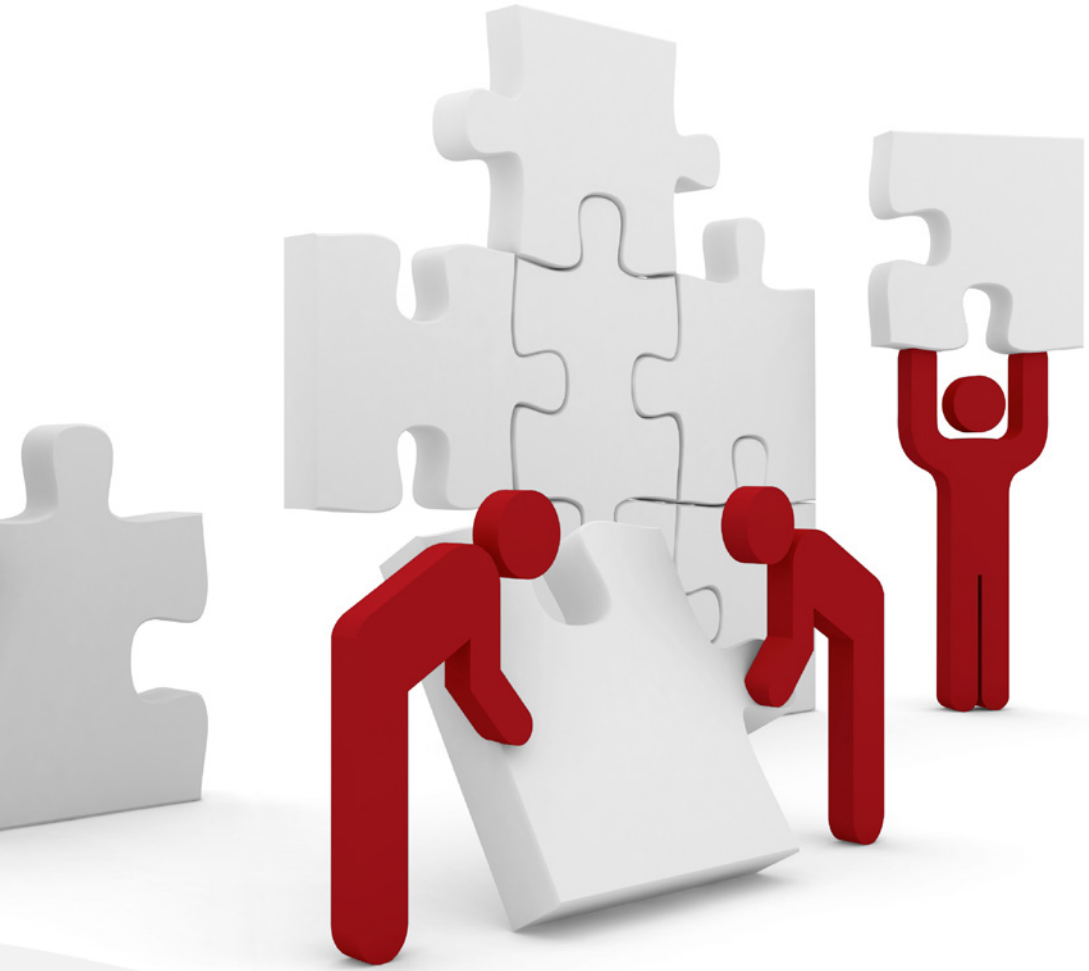
- Our catalog will guide you step by step through all the different options available in Waspmote: radios, sensors, power complements, etc. giving both technical and pricing information. You can ask for our products catalogue here: http://www.libelium.com/products/buy
- You will have a sales engineer assigned to you to ensure you choose the right and optimal configuration to your needs.
- Once ready, we will arrange the shipping and delivery directly to you without distributors.

Horizontal Platform

As Global System Integrator, we highly value the fact that the Waspmote platform allows us to be in any vertical within the minimun time to market, the comprehensive API gives us a lot of flexibility to program with a fast-learning curve.

D.A. - Consultant (Singapur)

THE LIBELIUM EXPERIENCE: THINK, DEVELOP, GO!



Develop

During the design

- You will access to all the information in the development and support sections. If you have any doubt, you can ask in our Community forum where our R&D team and a more than 2,000 developers worldwide will help you.
- The programming environment is Open Source and platform independent, you do not need to incur in software licenses costs.
- Our fast-learning API will make you able to develop the solution in the minimun time to market. If you want to speed up the deployment of your solution, we also offer in-company training and consultancy services.

Support

> *We had access to a wide range of information about the product, including its characteristics and possible applications through all the steps involving the purchase. Starting from before purchasing the product to the very end.*
>
> ***Cima Nuevas Tecnologías S.L (Spain)***

THE LIBELIUM EXPERIENCE: THINK, DEVELOP, GO!

Go!

Reach the market!

- If you have designed a product and plan to sell it in big amounts, we can help you with the hardware optimization for making a more cost-effective and efficient solution for you.
- Waspmote is so modular that you can just change the sensors on top, make very few changes in your program and have a new application market ready for expanding your business and maximizing your initial investment.
- We have advantages in prices, training and demo units for our partners. For more information, visit: http://www.libelium.com/partners
- You can use our website for promoting your success story and we can even make a press release together.

Training

The training was excellent, and I got enough coding practice to give me some confidence that I can review the C++ guide as well as the function parameter in order to develop some test products.

M.J. - Training Course Attendee
Mobile Operator Company (USA)

TECHNOLOGY: WASPMOTE & MESHLIUM

About our Technology

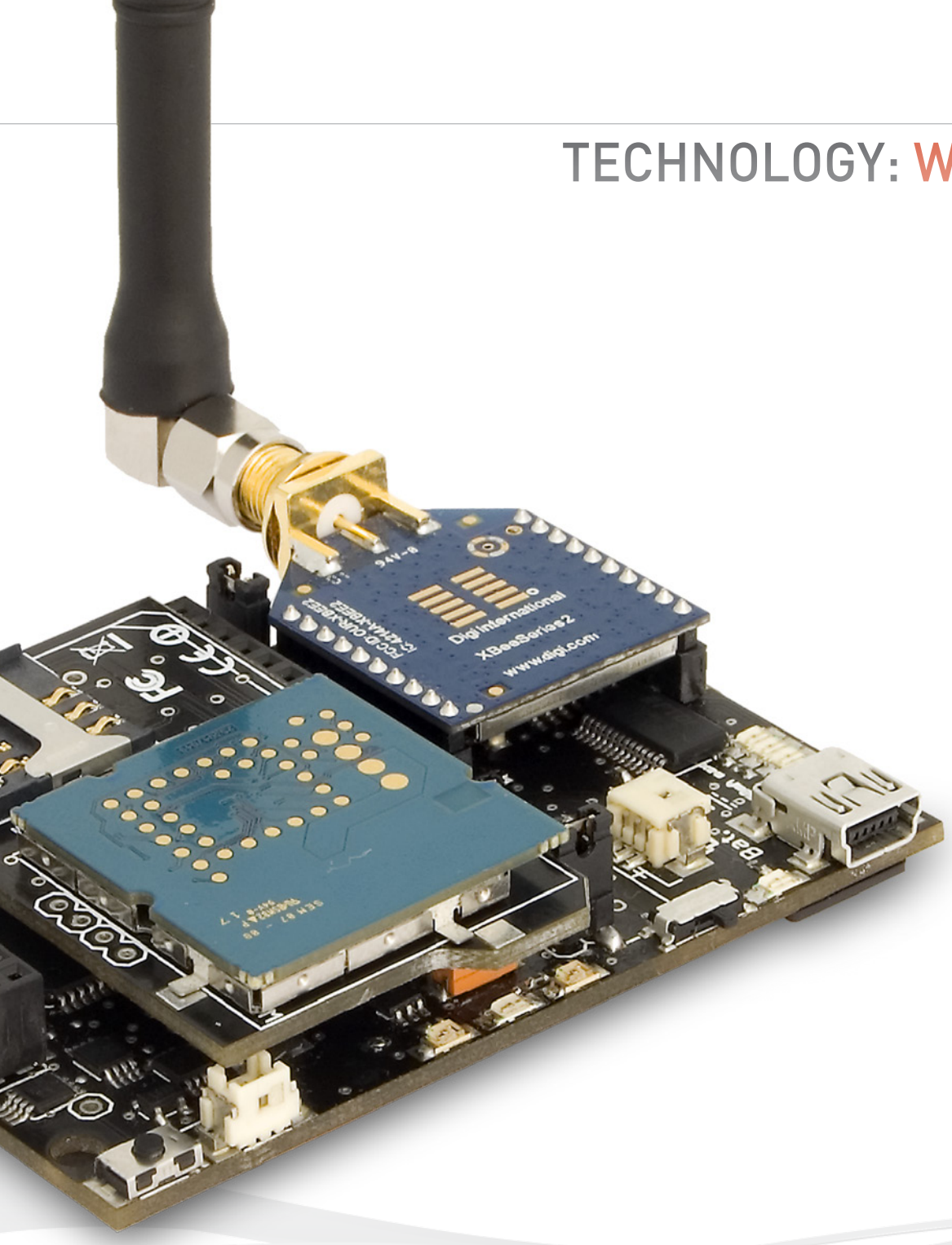
Waspmote and Meshlium are awarded products present in more than 45 countries.

All our products are modular, horizontal and easy to integrate into 3rd party systems.

Excellent Technology

> *Libelium took home a award in the Data Acquisition Products category for its Waspmote modular WSN platform. Waspmote offers not only impressive specifications but couples them with open source software as well as specialized sensor boards for particular applications. The judges loved the modular nature of the platform, its use of open source software, and its ruggedness, so important for monitoring applications of all kinds.*
>
> ***Melanie Martella***
> ***2010 Best of Sensors Expo Awards (Chicago, USA)***

TECHNOLOGY: WASPMOTE & MESHLIUM



Waspmote

Is a sensor device specially oriented to developers. It works with different protocols (ZigBee, Bluetooth, 3G/GPRS) and frequencies (2.4GHz, 868MHz, 900MHz) being capable of getting links up to 12km.

It counts with an hibernate mode of 0.7uA which allows to save battery when it is not transmitting. More than 50 sensors already available and a complete open source IDE (API libraries + compiler) made really easy to start working with the platform.

More info:
http://www.libelium.com/waspmote

Cutting-edge Technology

Libelium took a new award in the Data Acquisition category for its Radiation Sensor board that couples a Geiger counter with its Waspmote wireless sensor networking platform to create an emergency radiation sensor network. The judges loved how timely this product is; it illustrates all the qualities that make wireless sensor networks such a vital, exciting and, above all, useful technology — it is rapidly and flexibly deployed and it gives you information you need, in a useful form, and fast.

Melanie Martella
2011 Best of Sensors Expo Awards (Chicago, USA)

TECHNOLOGY: WASPMOTE & MESHLIUM

Meshlium

Is a Linux router which can contain 5 different radio interfaces: Wifi 2.4GHz, Wifi 5GHz, 3G/GPRS, Bluetooth and ZigBee. As well as this Meshlium can also integrate a GPS module for mobile and vehicular applications and be solar and battery powered. These features along with an aluminium IP67 enclosure allows Meshlium to be placed anywhere outdoor.

Meshlium comes with the Manager System, a web application which allows to control quickly and easily the Wifi, ZigBee, Bluetooth and 3G/GPRS configurations a long with the storage options of the sensor data received.

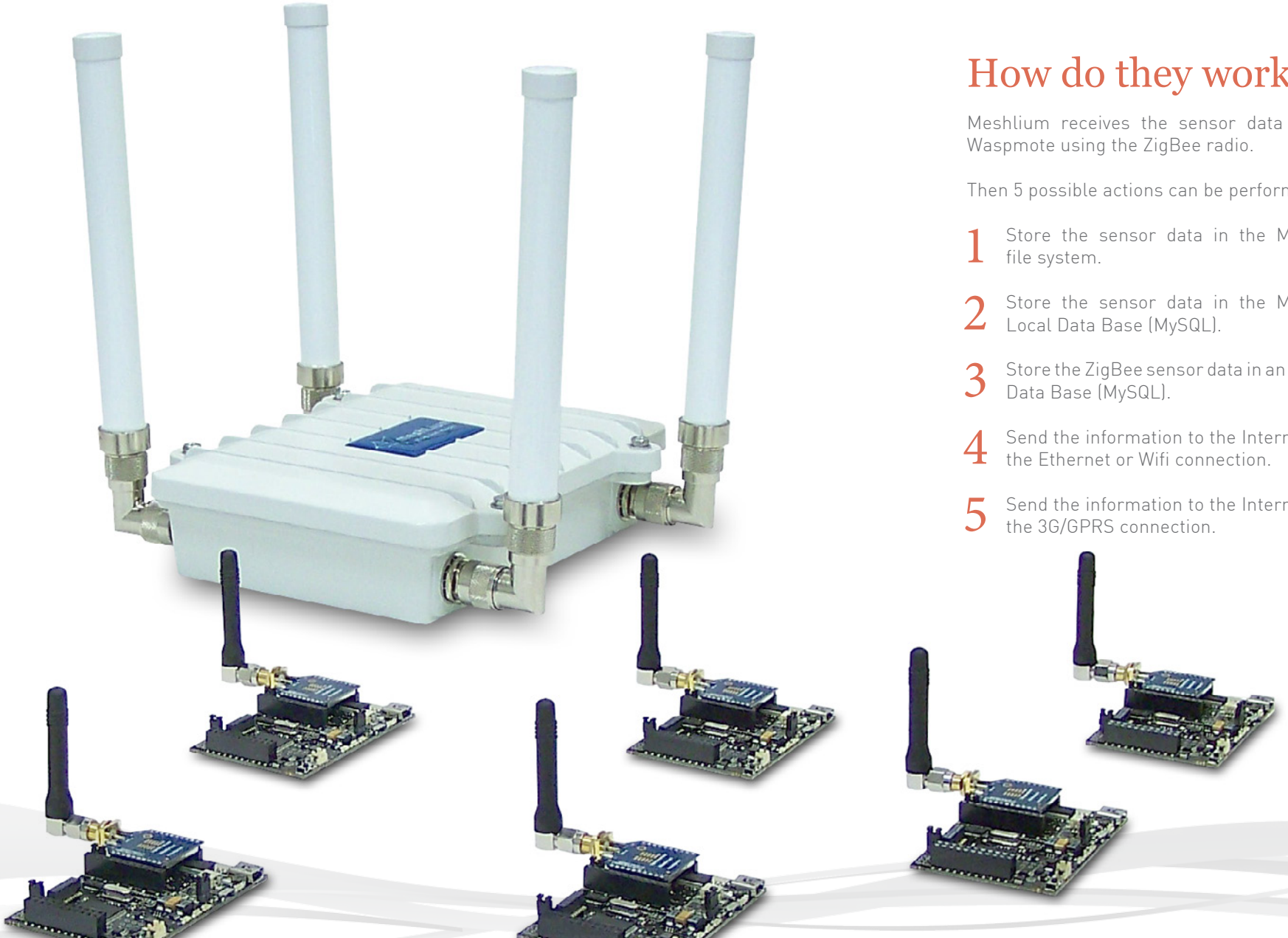
More info:
http://www.libelium.com/meshlium

Range VS Consumption

The quality of the demonstrators was high as reflected by the close result. The 'Best Demo Award' winner was Libelium for their Waspmote platform which can communicate over long distances while maintaining low power consumption.

Costis Kompis (Sweden)
Wireless Sensing Demonstrator Showcase 2010

TECHNOLOGY: WASPMOTE & MESHLIUM



How do they work together?

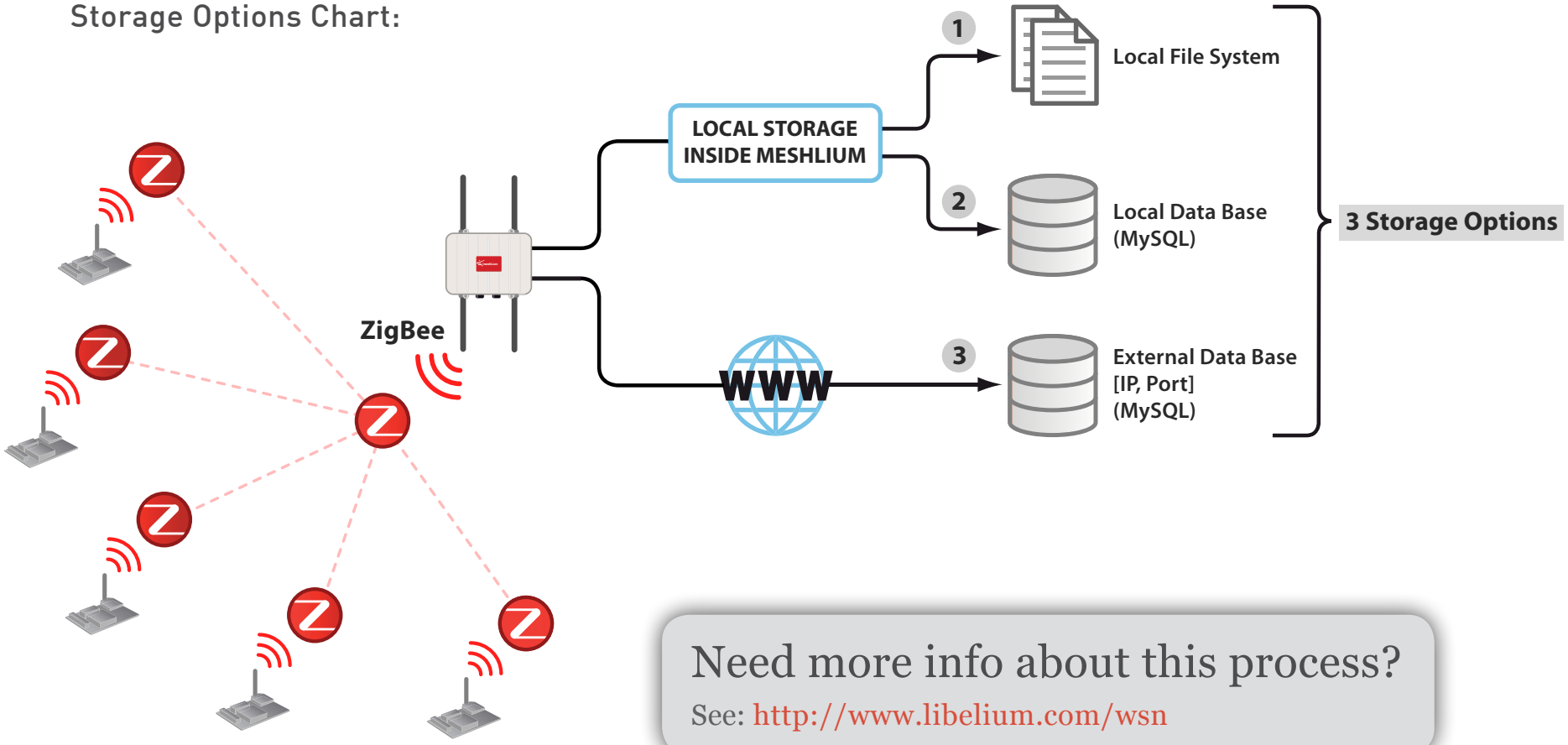
Meshlium receives the sensor data sent by Waspmote using the ZigBee radio.

Then 5 possible actions can be performed:

1. Store the sensor data in the Meshlium file system.
2. Store the sensor data in the Meshlium Local Data Base (MySQL).
3. Store the ZigBee sensor data in an External Data Base (MySQL).
4. Send the information to the Internet using the Ethernet or Wifi connection.
5. Send the information to the Internet using the 3G/GPRS connection.

TECHNOLOGY: WASPMOTE & MESHLIUM

Storage Options Chart:

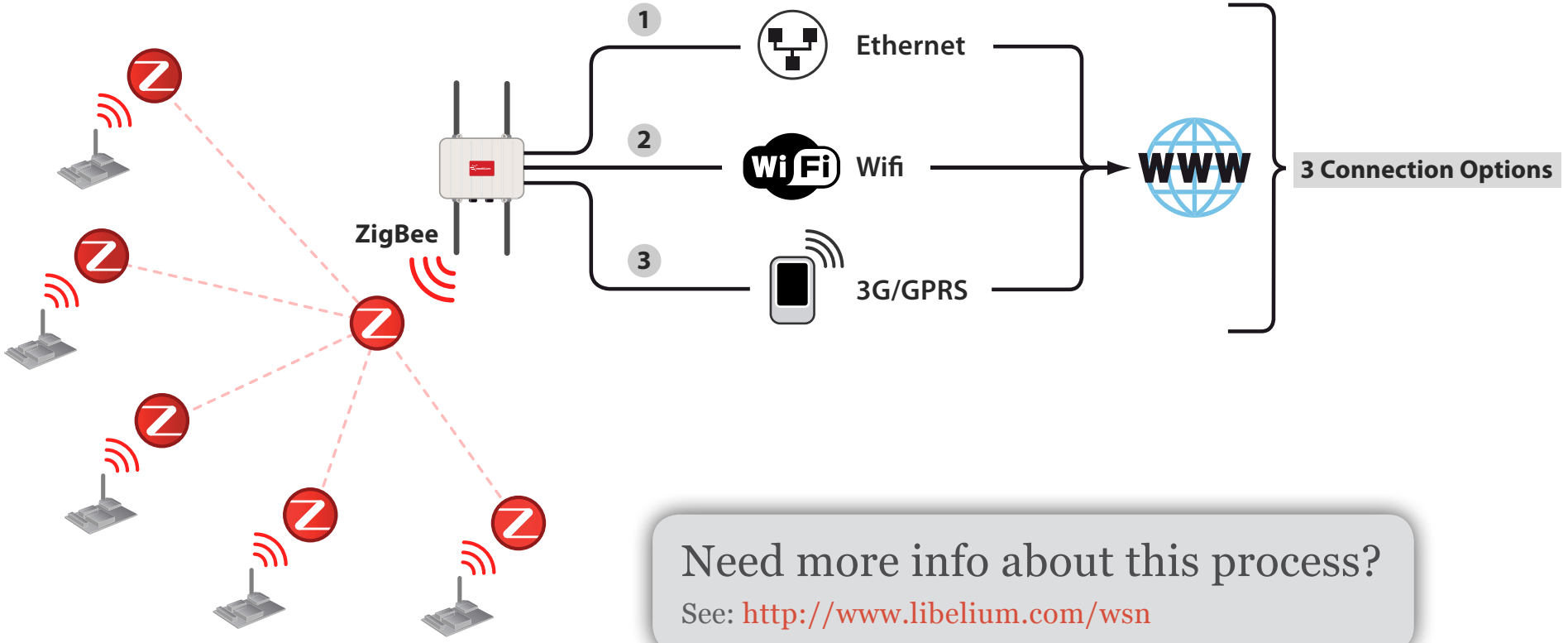


Need more info about this process?

See: http://www.libelium.com/wsn

TECHNOLOGY: WASPMOTE & MESHLIUM

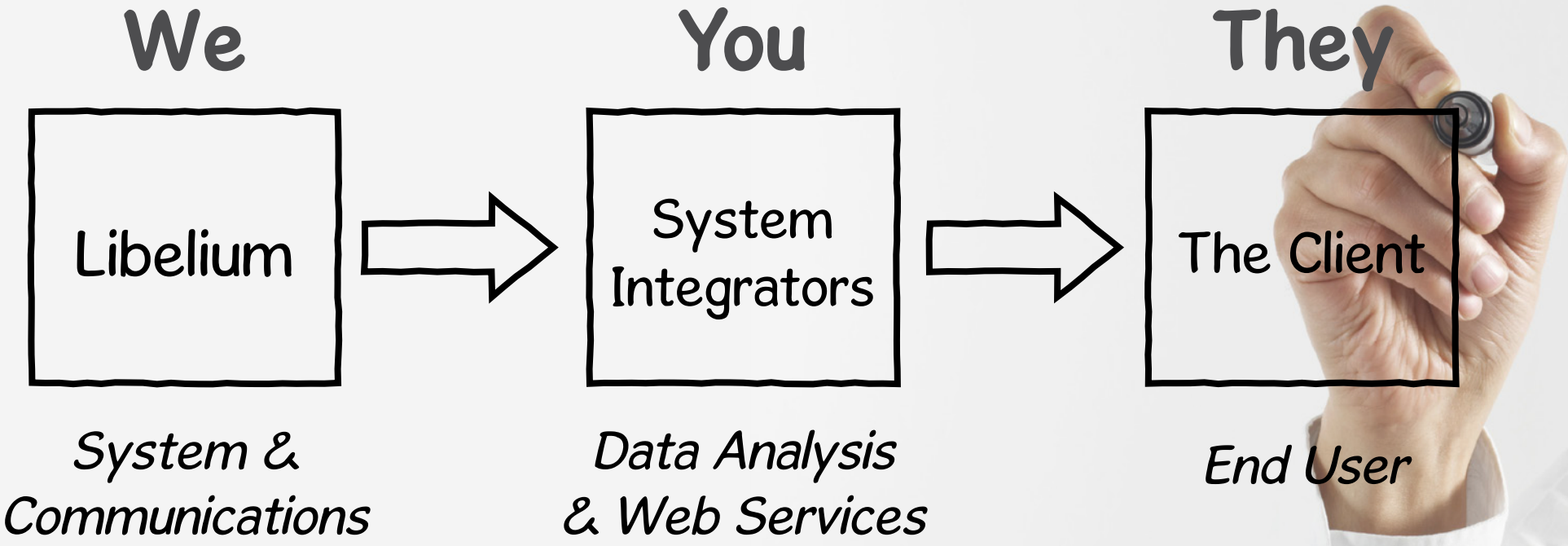
Connection Options Chart:



Need more info about this process?

See: http://www.libelium.com/wsn

->Enablers of the Internet of Things:



LIBELIUM'S CASE STUDIES

Smart Parking and environmental monitoring in one of the world's largest WSN

Challenge: *use the mesh capabilities of ZigBee and other adhoc protocols in a massive deployment of more than 1000 nodes located under the ground in order to enable the car detection in the streets of the city.*

SmartSantander is an ambitious project leaded by Telefonica that proposes a unique in the world city-scale experimental research facility sufficiently large, open, flexible and horizontal to stimulate the development of new applications by researchers, companies and citizens. At the same time, the network must provide services to Santander inhabitants such as helping them to find free parking spots and monitoring pollution levels. In this case, Waspmote modularity and flexibility has allowed to incorporate a second communication radio enabling experimentation while ensuring high availability services. Read more.

Detecting Forest Fires using Wireless Sensor Networks

Challenge: *deployment of sensor networks in harsh outdoors environments.*

SISVIA "Vigilancia y Seguimiento Ambiental" deployed a Wireless Sensor Network in Asturias (Spain) in order to detect forest fires by monitoring CO, CO_2, humidity and temperature in 210 hectares. In a hard environment like this long range communication links along with low power consumption and solar panels as energy source were Waspmote's most valuable features. Read more.

Wireless Sensor Networks to control Radiation Levels

Challenge: *fast design of a radiation detection sensor board for Waspmote in response to the accident in Fukushima.*

The creation of the Radiation Sensor Board was motivated by the nuclear disaster in Fukushima after the unfortunate earthquake and tsunami that struck Japan in March 2011. We wanted to help authorities to measure the levels of radiation of the affected zones without compromising the life of the security and rescue teams. For this reason we designed in just 3 weeks a Geiger Counter sensor board for Waspmote, which could read the radiation levels automatically and send the information in real time using wireless technologies like ZigBee and 3G/GPRS to the control point without human intervention. Read more.

LIBELIUM'S CASE STUDIES

Smart City project in Salamanca to monitor Air Quality and Urban Traffic

Challenge: *use one single sensor network infrastructure to monitor 7 environmental parameters and provide multiple services.*

This project has been developed by several companies and leaded by "Fundación CARTIF". Its main goal was to achieve sustainable management of the traffic in the city of Salamanca by using two key-elements: a pervasive air-quality sensor network along with prediction models. The project required the measurement of 7 parameters: CO, NO_2, O_3, temperature, humidity, dust particles (PM-10) and noise. The flexibility of Waspmote allowed to integrate all of them in the same sensor node, making the most of each point of the the network deployed. Read more.

Smart City project in Serbia for environmental monitoring by Public Transportation

Challenge: *deploy a mobile wireless sensor network with the sensor nodes located in vehicles.*

The EkoBus system was developed in collaboration with Ericsson and deployed in the cities of Belgrade and Pancevo. Several Waspmotes were installed on public transportation vehicles to monitor a set of environmental parameters over a large area as well as to provide additional information for the end-user like the location of the buses and estimated arrival times to bus stops. The GPS and 3G/GPRS modules allowed the Waspmotes to work as autonomous sensor collectors. Read more.

Smart Water project in Valencia to monitor Water Cycle Management

Challenge: *create a hybrid sensor network between mobile and fixed nodes and integration of water quality specific sensors.*

This project was developed by the Institute of Computer Technology in collaboration with the Polytechnic University of Valencia and Telefonica Cathedra in Valencia (Spain). The Smart Water System consist of a mobile wireless sensor network that can be fast deployed in a particular area to monitor water quality by measuring parameters such as PH, conductivity, oxydation reduction potential (redox), disolved oxygen (DO) and turbidity. In this case, modularity and horizontal architecture of Waspmote allowed the customers to easily integrate these new sensors. Read more.

Next Step?

Tell us about your project.
We want to make it real.

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- Phone: +34 976 547 492

www.libelium.com

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