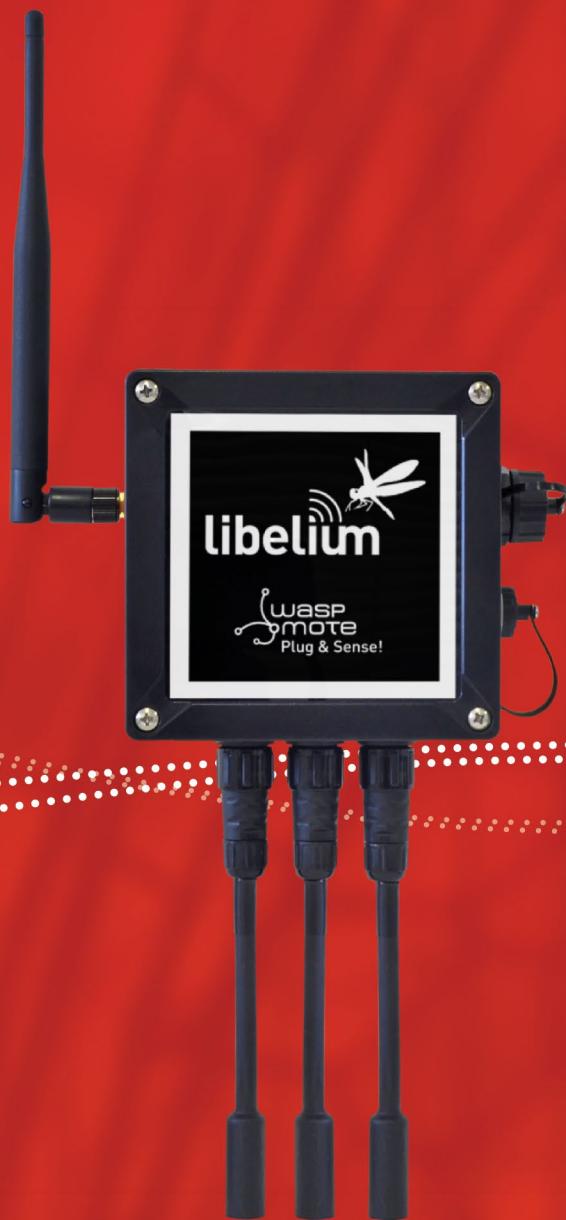


Waspmote Plug & Sense!

Technical Guide



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1. General and safety information

- Read carefully Limited Warranty and Terms and Conditions of Use before using "Wasp mote Plug & Sense!".
- Do not open casing and do not damage black warranty stickers. If you do so, you will lose warranty.
- Do not remove any of the connectors.
- Do not allow contact between metallic objects and electronic parts to avoid injury and burns.
- Never immerse equipment in any liquid.
- Keep equipment within temperature range indicated in recommendation section.
- Do not connect or power equipment using cables that have been damaged.
- Place equipment in an area to which only maintenance personnel can have access (in a restricted access zone)
- In any case keep children away from the equipment.
- If there is a power failure, immediately disconnect from the mains.
- If using a battery whether or not in combination with a solar panel as a power source follow the voltage and current specifications indicated in the section "External solar panel connector".
- If a software failure occurs, contact Libelium technical support before doing any action by yourself.
- Do not place equipment on trees or plants as they could be damaged by its weight.
- Be particularly careful if you are connected through a software interface for handling the machine; if settings of that interface are incorrectly altered, it could become inaccessible.
- If you need to clean the node, wipe it with a dry towel.
- If Wasp mote Plug & Sense! needs to be returned please send it completely dry and free from contaminants.
- Wasp mote Plug & Sense! is not designed to be placed in hard environmental conditions, under dangerous chemical elements, explosive atmospheres with flammable gases, high voltage installations or special installations. Please contact Libelium technical support to ensure your application is compatible with Wasp mote Plug & Sense!

2. Important: Read before use

The following list shows just some of the actions that produce the most common failures and warranty-voiding. Complete documentation about usage can be found at <http://www.libelium.com/development>. Failure to comply with the recommendations of use will entail the warranty cancellation.

Software:

- Upload code only using WaspMote IDE. If a different IDE is used, WaspMote can be damaged and can become unresponsive. This use is not covered under warranty.
- Do not unplug any connector while uploading code. WaspMote can become unresponsive. This use is not covered under warranty.
- Do not connect or disconnect any connector while WaspMote is ON. WaspMote can become unstable or unresponsive, and internal parts can be damaged. This fact is not covered under warranty.

Hardware:

- Do not handle black stickers seals on both sides of the enclosure (Warranty stickers). Their integrity is the proof that WaspMote Plug & Sense! has not been opened. If they have been handled, damaged or broken, the warranty is void.
- Do not open WaspMote Plug & Sense! in any case. This will automatically make the warranty void.
- Do not handle the four metallic screws of WaspMote Plug & Sense!. They ensures waterproof seal.
- Do not submerge WaspMote Plug & Sense! in liquids.
- Do not place nodes on places or equipment where it could be exposed to shocks and/or big vibrations.
- Do not expose WaspMote Plug & Sense! to temperatures below -10°C or above 50°C.
- Do not power WaspMote with other power sources than the original provided by Libelium. Voltage and current maximum ratings can be exceeded, stopping WaspMote working and voiding warranty.
- Do not try to extract, screw, break or move WaspMote Plug & Sense! connectors far from necessary usage, waterproof sealing can be damaged and warranty will be voided.
- For more information: <http://www.libelium.com>
- Do not connect any sensor on the solar panel connector and also do not connect the solar panel to any of sensor connectors. WaspMote can be damaged and warranty void.
- Do not connect any sensor not provided by Libelium.
- Do not place WaspMote Plug & Sense! where water can reach internal parts of sensors.
- Do not get the magnet close to a metal object. The magnet is really powerful and will get stuck.
- Do not place the magnet close to electronic devices, like PCs, batteries, etc, they could be damaged, or information could be deleted.

3. Waspmote vs Waspmote Plug & Sense!

Waspmote is the original line in which developers have a total control over the hardware device. You can physically access to the board and connect new sensors or even embed it in your own products as an electronic sensor device.

The Waspmote Plug & Sense! line allows developers to forget about electronics and focus on services and applications. You can deploy wireless sensor networks in an easy and scalable way ensuring minimum maintenance costs. The platform consists of a robust waterproof enclosure with specific external sockets to connect the sensors, the solar panel, the antenna and even the USB cable in order to reprogram the node. It has been specially designed to be scalable, easy to deploy and maintain.



Figure : Waspmote



Figure : Waspmote Plug & Sense!

4. General view

This section shows main parts of WaspMote Plug & Sense! and a brief description of each one. In later sections all parts will be described deeply.

4.1. Specifications

- **Material:** polycarbonate
- **Sealing:** polyurethane
- **Cover screws:** stainless steel
- **Ingress protection:** IP65
- **Impact resistance:** IK08
- **Rated insulation voltage AC:** 690 V
- **Rated insulation voltage DC:** 1000 V
- **Heavy metals-free:** Yes
- **Weatherproof:** true - nach UL 746 C
- **Ambient temperature (min.):** -10 °C
- **Ambient temperature (max.):** 50 °C
- **Approximated weight:** 800 g

In the pictures included below it is shown a general view of WaspMote Plug & Sense! main parts. Some elements are dedicated to node control, others are designated to sensor connection and other parts are just identification elements. All of them will be described along this guide.

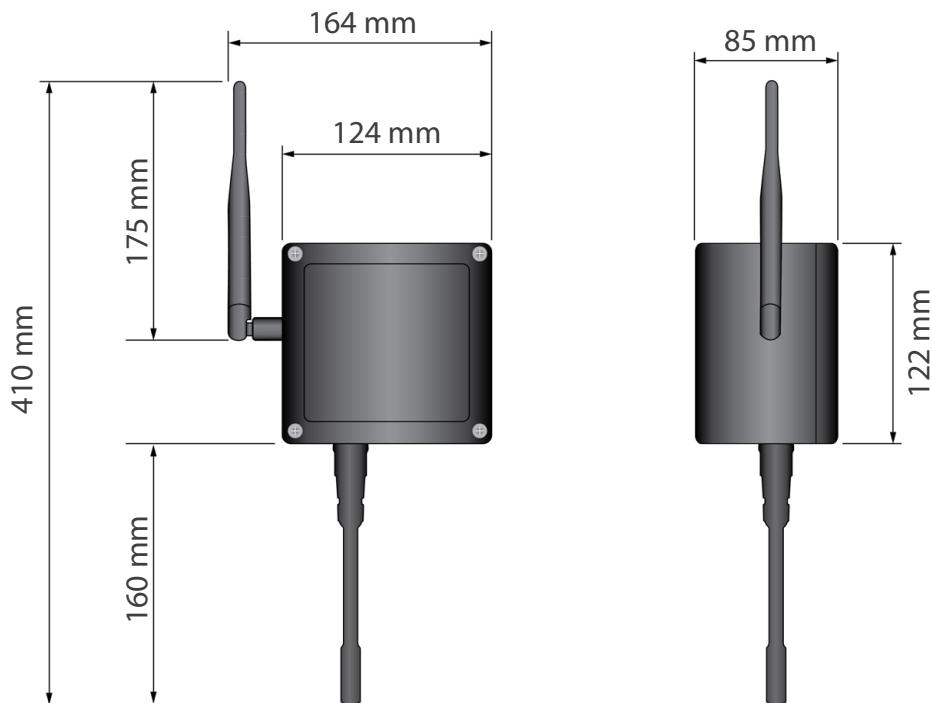


Figure : Main view of WaspMote Plug & Sense!

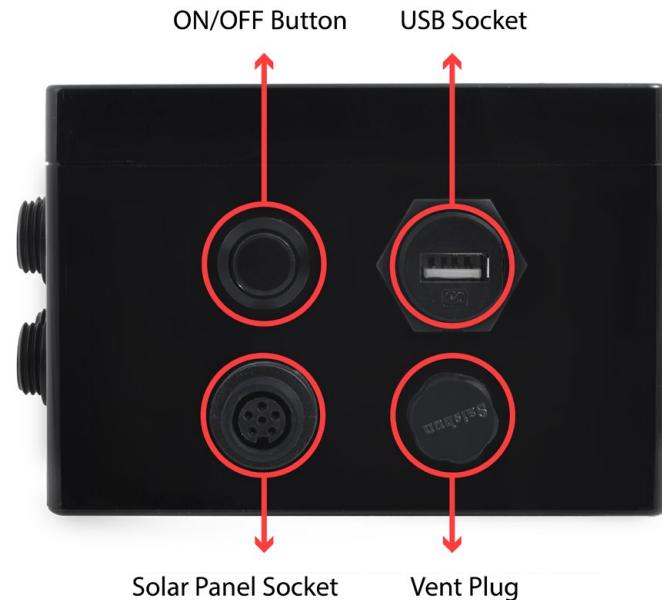


Figure : Control side of the enclosure

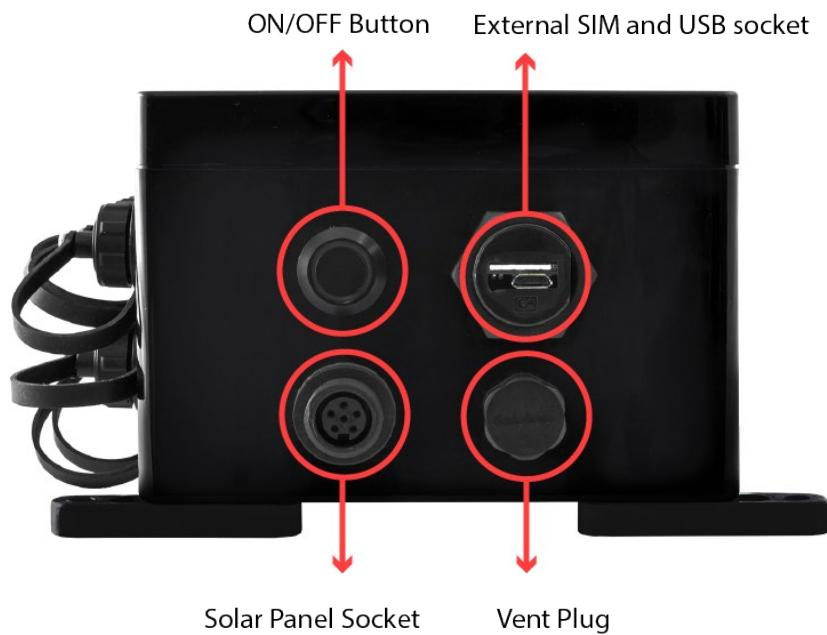


Figure : Control side of the enclosure for GPRS or 3G models



Figure : Sensor side of the enclosure



Figure : Antenna side of the enclosure



Figure : Front view of the enclosure



Figure : Back view of the enclosure



Figure : Warranty stickers of the enclosure

Important note: Do not handle black stickers seals of the enclosure (Warranty stickers). Their integrity is the proof that Wasp mote Plug & Sense! has not been opened. If they have been handled, damaged or broken, the warranty is automatically void.

4.2. Parts included

Next picture shows Wasp mote Plug & Sense! and all of its elements. Some of them are optional accessories that may not be included.



Figure : Wasp mote Plug & Sense! accessories: 1 enclosure, 2 sensor probes, 3 external solar panel, 4 USB cable, 5 antenna, 6 cable ties, 7 mounting feet (screwed to the enclosure), 8 extension cord, 9 solar panel cable, 10 wall plugs & screws

4.3. Identification

Each Waspmote model is identified by stickers. Next figure shows front sticker.

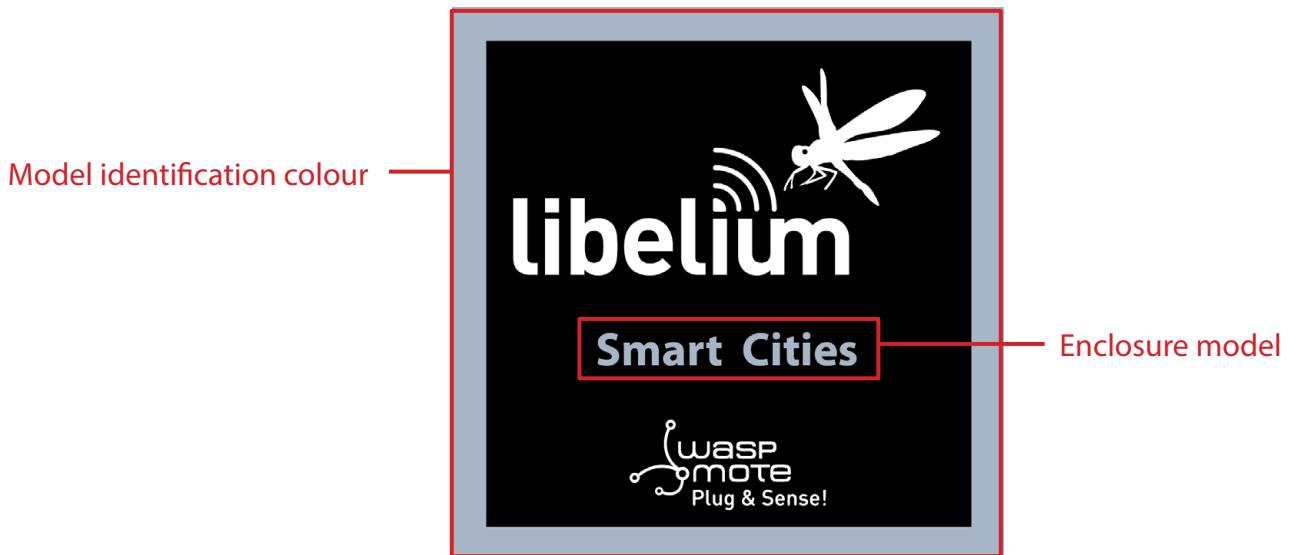


Figure : Front sticker of the enclosure

There are many configurations of Waspmote Plug & Sense! line, all of them identified by one unique sticker. Next image shows all possibilities.



Figure : Different front stickers

Moreover, WaspMote Plug & Sense! includes a back sticker where it is shown identification numbers, radio MAC addresses, etc. It is highly recommended to annotate this information and save it for future maintenance. Next figure shows it in detail.

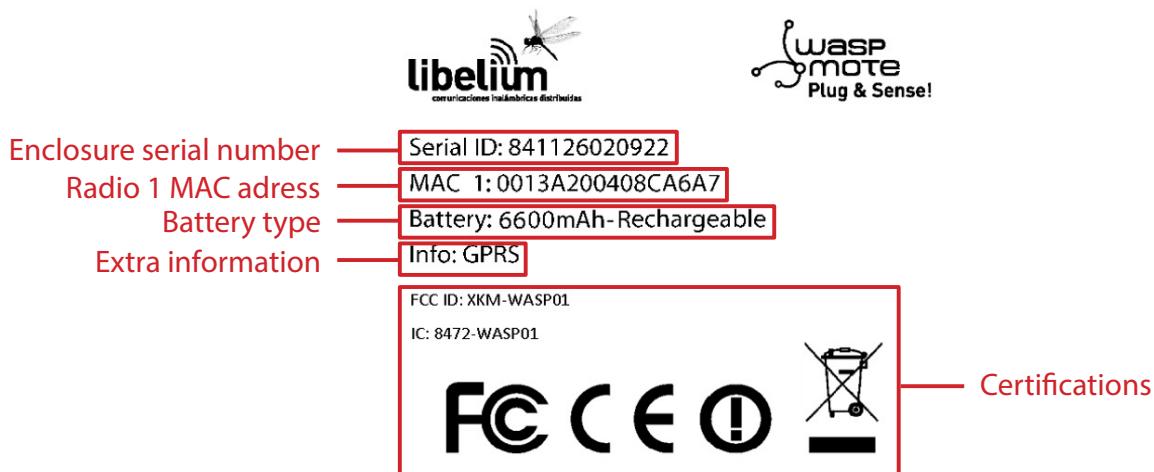


Figure : Back sticker

Sensor probes are identified too by a sticker showing the measured parameter and the sensor manufacturer reference.



Figure : Sensor probe identification sticker

5. Sensor probes

All sensing capabilities of WaspMote Plug & Sense! are provided by sensor probes. Each sensor probe contains one sensor, some necessary protections against outdoor environmental conditions and a waterproof male connector.

The standard length of a sensor probe is about 150mm, including waterproof connector, but it could vary due to some sensors need special dimensions. Weight of a standard probe rounds 20g (gases probes, temperature and humidity (Sensirion), etc), but there are some special cases which can rise this weight.

Sensor probes are designed to be used in vertical position (with sensor looking to the ground). In this position, the protection cap of each sensor probe is effective against bad weather conditions.

Each model has six dedicated sockets to connect sensor probes. They are located in the sensor side, as shown below. Each socket has a protecting cap. When one of the six sensor connector is not used, be sure the cap is screwed to protect the connector.



Figure : Enclosure sensor side with protection caps

Each sensor socket is identified by a letter from A to F (see picture below). The user should understand that each sensor probe should go in a dedicated socket, due to each sensor has different power requirements (current and voltage levels), dedicated circuitry, etc. So please see corresponding section about where to connect each probe.

Always be sure you connected probes in right socket, otherwise they can be damaged.

Never connect a sensor not provided by Libelium to any of the sensor connectors. Electronic inside can be damaged and warranty will be automatically void.

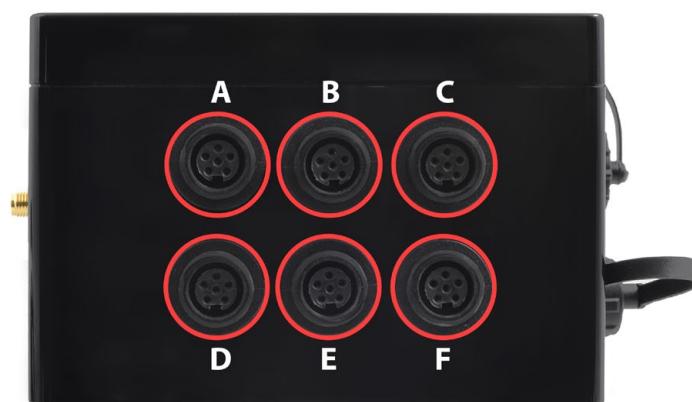


Figure : Enclosure sensor side without protection caps

It should be taken into account that sensor probe connector has only one matching position. The user should align sensor probe connector looking at the little notch of the connector (see image below). Notice that the sensor connector is male type and the enclosure sensor connector is female type.



Figure : Detail of sensor waterproof connector

Besides that, there is a locking nut which should be screwed till the connector is completely fixed to the enclosure.



Figure : Connecting a sensor probe to the enclosure

Please use sensors officially provided by Libelium. Any other sensor can damage WaspMote Plug & Sense! and void the warranty.

5.1. New Sensor probes

According to the feedback received from customers and as a part of Libelium Quality Service Policy, Libelium has designed new rigid sensor probes. They consist of a solid tube protecting the sensor to get them always straight and standardize as maximum as possible the size and shape of the probes. This avoids bending and deliver a more professional finish to each node. The result is more esthetic and probes are uniform.



Figure : New sensor probes

5.2. Sensor probes types

Libelium provides many different sensor probes depending on what is going to be measured. This section describes main features of each type. If further information is required, please refer for the corresponding sensor board guide available on [Libelium website](#).

Standard Type

This sensor probe is the most common. Sensor is placed inside a plastic cylinder acting as a protection against rain and water, but allowing sensor interact with environment to measure necessary parameters.

Sensor probes of this type are:

- Temperature
- Carbon monoxide - CO
- Methane - CH₄
- LPG
- Air pollutants 1: C₆H₅CH₃, H₂S, CH₃CH₂OH, NH₃, H₂
- Air pollutants 2: C₄H₁₀, CH₃CH₂OH, H₂, CO, CH₄
- Alcohol derivates: CH₃CH₂OH, H₂, C₄H₁₀, CO, CH₄
- Humidity
- Atmospheric pressure
- Carbon dioxide - CO₂
- Nitrogen dioxide - NO₂
- Ozone - O₃
- Hydrocarbons - VOC
- Oxygen - O₂
- Carbon monoxide – CO
- Noise sensor (dBA) - Microphone



Figure : Standard sensor probe

White protection probe

This probe is designed to avoid sunlight effects and prevent from water and rain, but allowing humidity measurement.

Only the Temperature + Humidity (Sensirion) sensor and the Temperature, Humidity and Pressure sensor include this special protection.



Figure : Humidity and temperature (Sensirion) probe

Luminosity - LDR probe

This probe is designed to allow sunlight go thought a transparent protection.



Figure : Luminosity probe

Liquid Presence probe (point)

This probe is designed to allow placing the sensor near its application.



Figure : Liquid Presence probe (point)

Liquid level probe

This probe is designed to measure liquid levels.



Figure : Liquid level probe

Liquid flow probe

This probe is designed to measure liquid flow through a pipe.



Figure : Liquid flow probe

Hall effect probe

This probe is designed to control the opening of doors, windows, etc.



Figure : Hall effect probe

Solar radiation probe

This probe is designed to measure solar radiation.



Figure : Solar radiation probe

Soil temperature probe

This probe is designed to be buried into the ground to measure its temperature.



Figure : Soil temperature probe

Soil moisture probe

This probe is designed to be buried into the ground to measure its moisture.



Figure : Soil moisture probe

Dendrometer probe

This probe is designed to measure trunk, stem and fruit diameter of vegetables.



Figure : Dendrometer probe

Leaf wetness probe

This probe is designed to measure wetness on vegetable leafs.



Figure : Leaf wetness probe

Weather Station WS-3000 probe

This probe is designed to measure wind direction, wind speed and rain.



Figure : Weather Station WS-3000 probe

Linear displacement probe

This probe is designed to measure small linear displacements.



Figure : Linear displacement probe

Current sensor probe

This probe is designed to measure the current which goes through a cable.



Figure : Current sensor probe

Liquid Presence probe (line)

This probe is designed to allow placing the sensor near its application.



Figure : Liquid Presence probe (line)

Directionable Type

This type of probe is only for some sensors. Sensor is placed inside a plastic modular hose that allows us to point them where we want to measure with it.



Figure : Configurations of directionable sensor probes

Sensor probes of this type are:

- **Presence - PIR directionable probe**

This probe is designed to allow infrared light through a lens, necessary for presence applications.



Figure : Presence (PIR) directionable probe

- **Ultrasound sensor directionable probe**

This probe is designed to measure distances using ultrasonic waves.



Figure : Ultrasound directionable probe

- **Luminosity (Luxes accuracy) directionable probe**

This probe is designed to measure luxes indoors and outdoors.



Figure : Luminosity (luxes accuracy) directionable probe

5.3. Extension cord

This element is used when one sensor needs to be placed far from the node. Two lengths are available: 1.5 and 3m. Next picture shows an extension cord.



Figure : Extension cord accessory

Extension cord has a female and a male connector. The first one (female) should be connected to sensor probe. Next picture shows it.



Figure : Connecting a probe with an extension cord

Moreover, the male connector should be connected to the enclosure as shown below.



Figure : Connecting an extension cord to the enclosure

6. Internal sensors

6.1. Temperature

WaspMote RTC has a built in internal temperature sensor which it uses to recalibrate itself. We can use it to obtain the temperature inside WaspMote Plug & Sense!.

The sensor is shown in a 10-bit two's complement format. It has a resolution of 0.25 °C and the measurable temperature range is between -40 °C and +85 °C. As previously specified, the sensor is prepared to measure board temperature by itself and it can thereby compensate for oscillations in quartz crystal used as a clock.

Complete information can be found in the document "RTC Programming Guide", available in the [Development section](#) of Libelium website.

6.2. Accelerometer

WaspMote has a built in acceleration sensor which informs the mote of acceleration variations experienced on each one of the 3 axes (X,Y,Z). The integration of this sensor allows the measurement of acceleration on the 3 axes (X,Y,Z), establishing 2 kind of events: Free Fall and Direction Detection Change.



Figure : Axis direction in WaspMote Plug & Sense!

Complete information can be found in the document called Accelerometer Programming Guide, available in the [Development section](#) of Libelium website.

7. Radios

Waspmote Plug & Sense! may integrate many radio modules for communication in the ISM (Industrial Scientific Medical) bands.

Model	Protocol	Frequency	txPower	Sensitivity	Range *
XBee-802.15.4-Pro	802.15.4	2.4GHz	100mW	-100dBm	7000m
XBee-ZB-Pro	ZigBee-Pro	2.4GHz	50mW	-102dBm	7000m
XBee-868	RF	868MHz	315mW	-112dBm	12km
XBee-900	RF	900MHz	50mW	-100dBm	10Km
LoRaWAN	LoRaWAN	868, 900 and 433 MHz bands	up to 18.5 dBm	-136dBm	- km - Typical base station range
LoRa	RF	868 and 900 MHz	14 dBm	-137dBm	21+Km
Sigfox	Sigfox	868MHz	14 dBm	-126dBm	- km - Typical base station range
WiFi	802.11b/g	2.4GHz	0dBm - 12dBm	-83dBm	50m-500m
GPRS Pro and GPRS+GPS	-	850MHz/900MHz/1800MHz/1900MHz	2W(Class4) 850MHz/900MHz, 1W(Class1) 1800MHz/1900MHz	-109dBm	- Km - Typical carrier range
3G/GPRS	-	Europe version: Dual-band UMTS, tri-band GSM/GPRS/EDGE America/Australia version: Dual-Band: UMTS, quad-Band GSM/GPRS/EDGE	UMTS 0.25 W, GSM 2 W, DCS/PCS 1 W	-106dBm	- Km - Typical carrier range
Bluetooth Low Energy	Bluetooth v.4.0 / Bluetooth Smart	2.4GHz	3dBm	-103dBm	100m

* Line of sight, Fresnel zone clearance and 5dBi dipole antenna.

These modules have been chosen for their high receiving sensitivity and transmission power, as well as for being 802.15.4 compliant (XBee-802.15.4 model) and ZigBee-Pro v2007 compliant (XBee-ZB model).

7.1. 802.15.4 PRO

Module	Frequency	TX power	Sensitivity	Channels	Distance
PRO	2,40 – 2,48GHz	63.1mW	-100dBm	13	7000m

The frequency used is the free band of 2.4GHz, using 16 channels with a bandwidth of 5MHz per channel.

2.4 GHz Band

5MHz

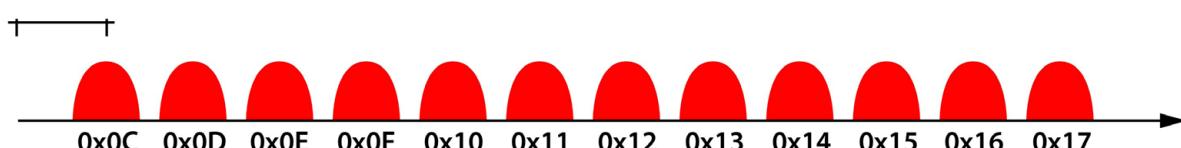


Figure : Frequency channels in the 2.4GHz band

Channel Number	Frequency
0x0C – Channel 12	2,405 – 2,410 GHz
0x0D – Channel 13	2,410 – 2,415 GHz
0x0E – Channel 14	2,415 – 2,420 GHz
0x0F – Channel 15	2,420 – 2,425 GHz
0x10 – Channel 16	2,425 – 2,430 GHz
0x11 – Channel 17	2,430 – 2,435 GHz
0x12 – Channel 18	2,435 – 2,440 GHz
0x13 – Channel 19	2,440 – 2,445 GHz
0x14 – Channel 20	2,445 – 2,450 GHz
0x15 – Channel 21	2,450 – 2,455 GHz
0x16 – Channel 22	2,455 – 2,460 GHz
0x17 – Channel 23	2,460 – 2,465 GHz

Figure : Channels used by the XBee modules in 2.4GHz

XBee 802.15.4 modules comply with IEEE 802.15.4 standard which defines physical and link level (MAC layer). The XBee modules add certain functionalities to those contributed by the standard, such as:

- **Node discovery:** certain information has been added to packet headers so that they can discover other nodes on the same network. It allows a node discovery message to be sent, so that the rest of the network nodes respond indicating their data (Node Identifier, @MAC, @16 bits, RSSI).
- **Duplicated packet detection:** This functionality is not set out in the standard and is added by the XBee modules.

Encryption is provided through the AES 128b algorithm. Specifically through the AES-CTR type. In this case the Frame Counter field has a unique ID and encrypts all the information contained in the Payload field which is the place in the 802.15.4 frame where data to be sent is stored.

Extra information about the encryption systems in 802.15.4 and ZigBee sensor networks can be accessed reading “Security in 802.15.4 and ZigBee networks” document located in [Development section](#) of Libelium website.

Common topology in 802.15.4 Networks is Star topology, where nodes send directly the sensor data to the Gateway.

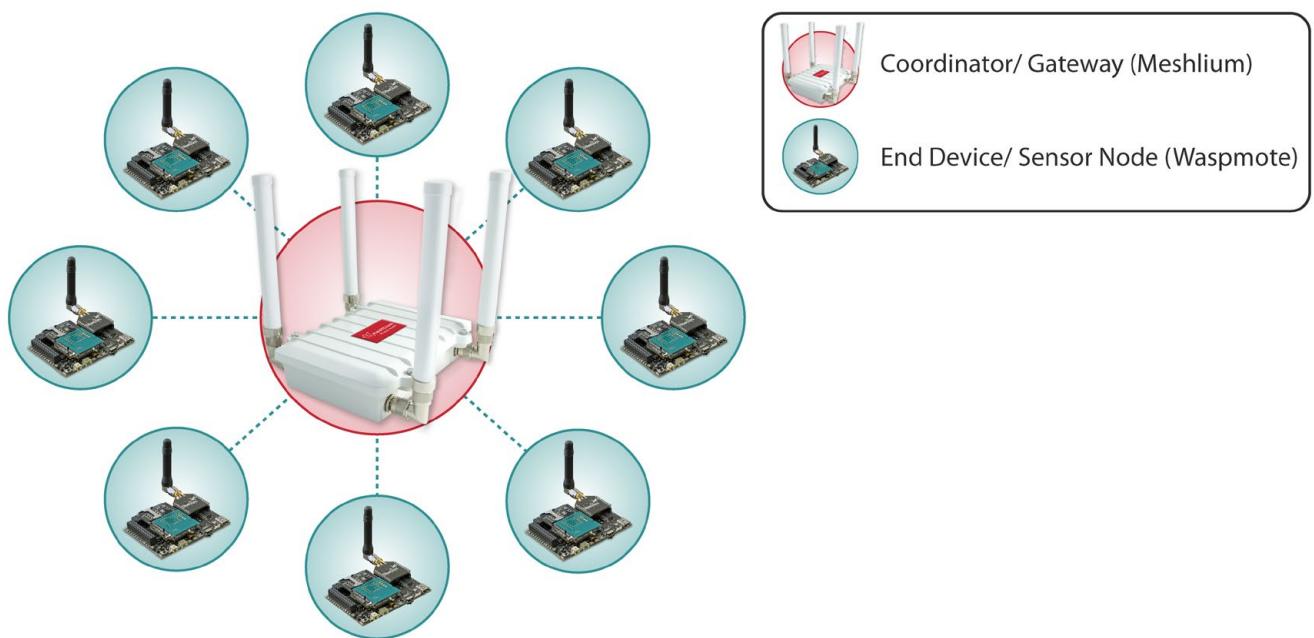


Figure : Star topology

Regarding energy, the transmission power can be adjusted to several values:

Parameter	Tx XBee-PRO
0	10dBm
1	12dBm
2	14dBm
3	16dBm
4	18dBm

Figure : Transmission power values

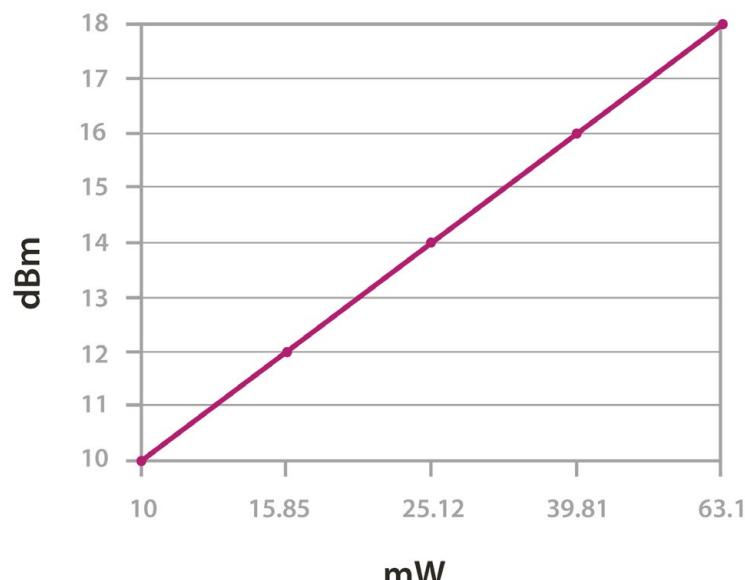


Figure : XBee-PRO TX Power

All information about their programming and operation can be found in the 802.15.4 Networking Guide available at [Development section](#) of Libelium website.

7.2. ZigBee PRO

Module	Frequency	Transmission Power	Sensitivity	Number of channels	Distance
XBee-ZB-PRO	2,40 – 2,48GHz	50mW	-102dBm	13	7000m

As ZigBee is supported in the IEEE 802.15.5 link layer, it uses the same channels as described in previous section, with the peculiarity that the XBee-ZB-PRO model limits the number of channels to 13.

XBee-ZB modules comply with the ZigBee-PRO v2007 standard. These modules add certain functionalities to those contributed by ZigBee, such as:

- **Node discovery:** some headings are added so that other nodes within the same network can be discovered. It allows a node discovery message to be sent, so that the rest of the network nodes respond indicating their specific information (Node Identifier, @MAC, @16 bits, RSSI).
- **Duplicated packet detection:** This functionality is not set out in the standard and is added by the XBee modules.

The topologies in which these modules can be used are star and tree.

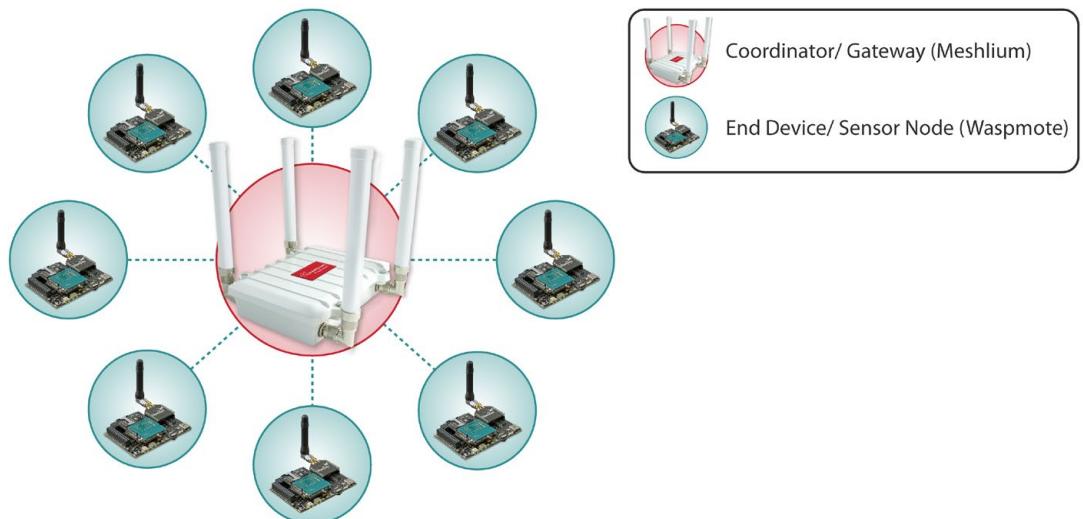


Figure : Star topology

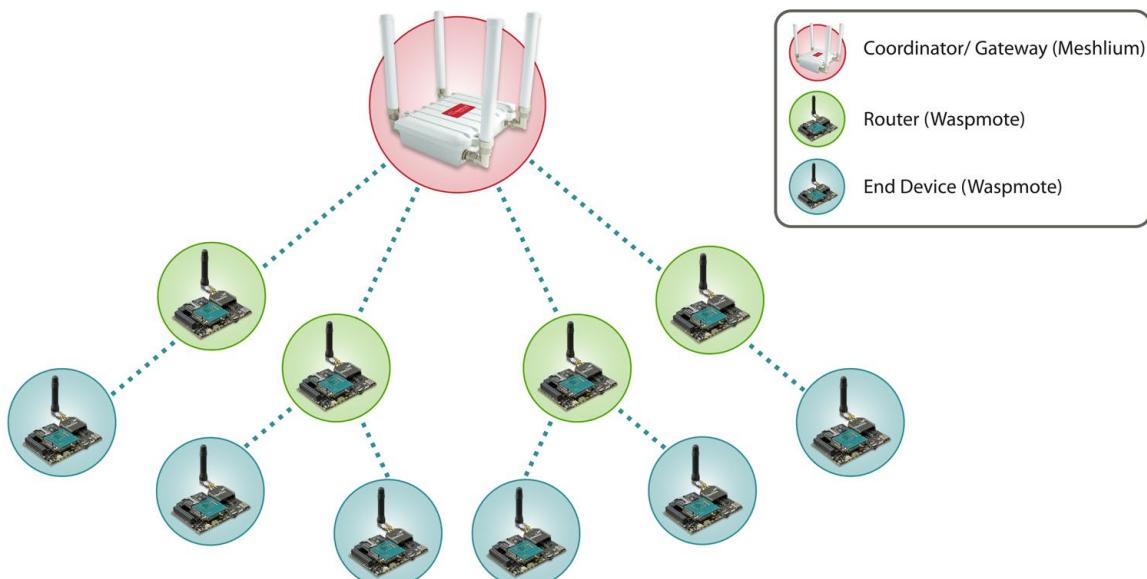


Figure : Tree topology

All information about their programming and operation can be found in the ZigBee Networking Guide available at [Development section](#) of Libelium website.

7.3. DigiMesh

XBee-802.15.4 and XBee-900 modules can use an optional firmware (DigiMesh) so that they are able to create mesh networks instead of the usual point to point topology. This firmware has been developed by Digi aimed for allowing modules to sleep, synchronize themselves and work on equal terms, avoiding the use of node routers or coordinators that have to be permanently powered on. Characteristics of the implemented protocol:

- Self Healing: any node can join or leave the network at any moment.
- All nodes are equal. There are no father-son relationships.
- Silent protocol: reduced routing heading due to using a reactive protocol similar to AODV (Ad hoc On-Demand Vector Routing).
- Route discovery: instead of keeping a route map, routes are discovered when they are needed.
- Selective ACKs: only the recipient responds to route messages.
- Reliability: the use of ACKs ensures data transmission reliability.
- Sleep Modes: low energy consumption modes with synchronization to wake at the same time.

The classic topology of this type of network is mesh, as the nodes can establish point to point connections with brother nodes through the use of parameters such as the MAC or network address or by making multi-jump connections.

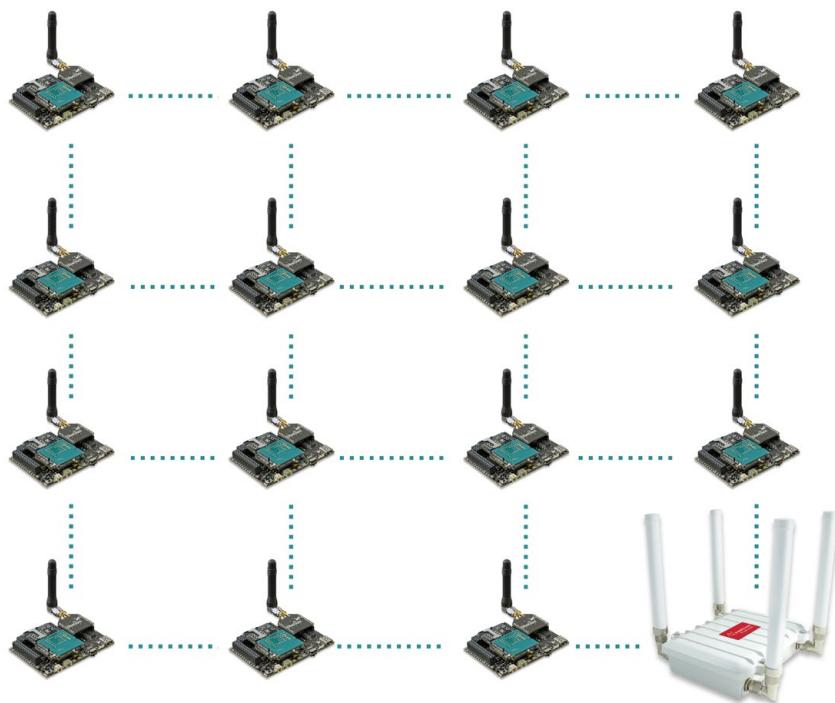


Figure : Mesh topology

Module	Frequency	Tx Power	Sensitivity	Channels	Distance
PRO	2,40 – 2,48GHz	100mW	-100dBm	7	7km

XBee DigiMesh modules share hardware features with XBee-802.15.4 modules, being able to switch from one to the other by changing the firmware.

XBee DigiMesh modules are based on the standard IEEE 802.15.4 that supports functionalities enabling mesh topology use.

All information about their programming and operation can be found in the DigiMesh Networking Guide available at [Development section of Libelium website](#).

7.4. 868MHz

Module	Frequency	Transmission Power	Sensitivity	Channels	Distance
XBee 868	869,4 – 869,65MHz	315mW	-112dBm	1	12km

The frequency used is the 869MHz band (Europe), using 1 single channel. The use of this module is only allowed in Europe. See certification section to obtain more information.

869.4 - 869.65MHz

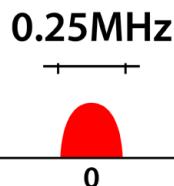


Figure : Channel frequency on 869MHz

Encryption is provided through the AES 128b algorithm. Specifically through the type AES-CTR. In this case the Frame Counter field has a unique ID and encrypts all information contained in Payload field which is the place in the link layer frame where the data to be sent is stored.

The way in which libraries have been developed for module programming means that encryption activation is as simple as running the initialization function and giving it a key to use in the encryption.

Common topology in 868 Networks is Star topology, where nodes send directly the sensor data to the Gateway.

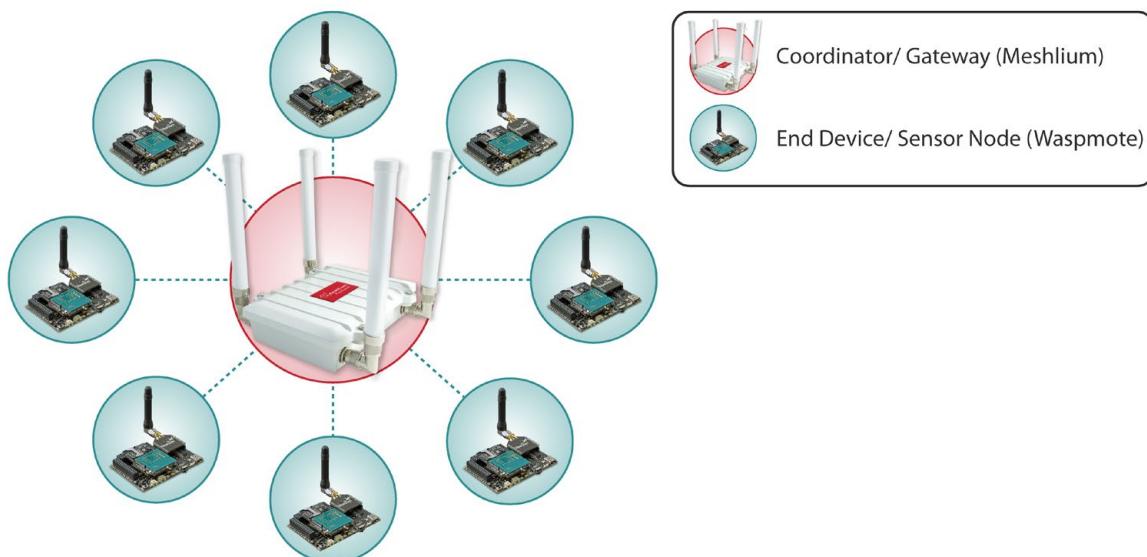


Figure : Star topology

Regarding the energy section, the transmission power can be adjusted to several values:

Parameter	Tx XBee - 868
0	0dBm
1	13.7dBm
2	20dBm
3	22dBm
4	25dBm

Figure : Transmission power values

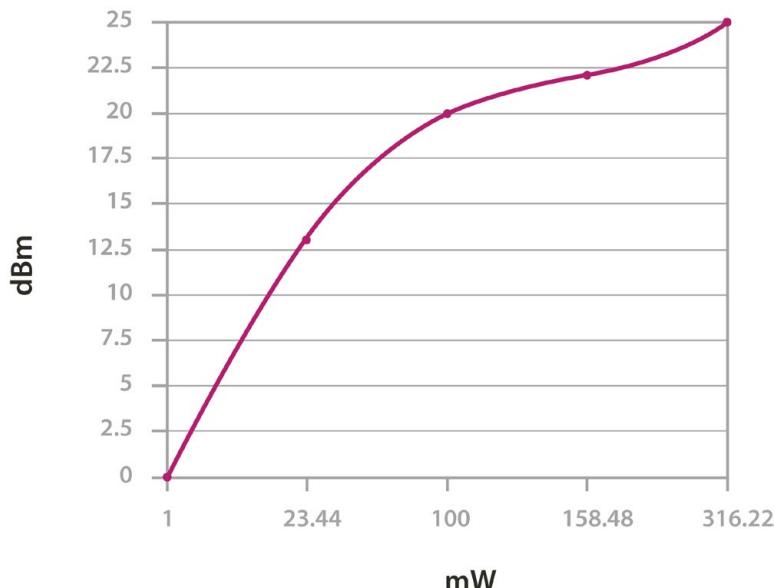


Figure : XBee TX Power

All information about their programming and operation can be found in the 868MHz Networking Guide available at [Development section](#) of Libelium website.

7.5. 900MHz

Module	Frequency	Tx Power	Sensitivity	Channels	Distance
XBee 900	902-928MHz	50mW	-100dBm	12	10km

The frequency used is the 900MHz band, using 12 channels with a bandwidth of 2.16MHz per channel and a transmission rate of 156.25kbps. The use of this module is only allowed in the United States and Canada. More information can be obtained about the Certifications in the corresponding section.

902-928 MHz Band

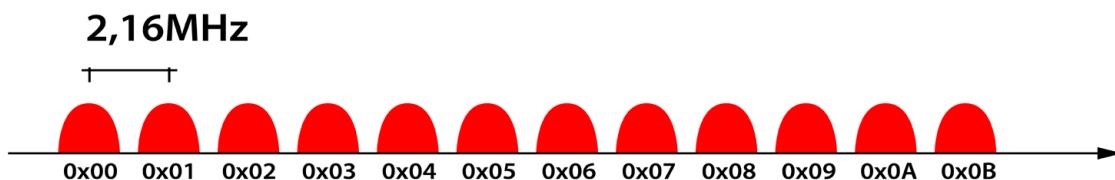


Figure : Channel frequencies in the 900MHz band

Encryption is provided through the AES 128b algorithm. Specifically through the type AES-CTR. In this case the Frame Counter field has a unique ID and encrypts all the information contained in the Payload field which is the place in the link layer frame where the data to be sent is stored.

The way in which the libraries have been developed for module programming means that encryption activation is as simple as running the initialization function and giving it a key to use in the encryption.

The classic topology for this type of network is a star topology, as the nodes can establish point to point connections with brother nodes through the use of parameters such as MAC address or that of the network.

All information about their programming and operation can be found in the 900MHz Networking Guide available at [Development section](#) of Libelium website.

7.6. LoRaWAN

LoRaWAN is a Low Power Wide Area Network (LPWAN) specification intended for wireless battery operated devices in regional, national or global network. LoRaWAN target key requirements of Internet of things such as secure bi-directional communication, mobility and localization services. This standard will provide seamless interoperability among smart Things without the need of complex local installations and gives back the freedom to the user, developer, businesses enabling the role out of Internet of Things.

LoRaWAN network architecture is typically laid out in a star-of-stars topology in which gateways is a transparent bridge relaying messages between end-devices and a central network server in the back-end. Gateways are connected to the network server via standard IP connections while end-devices use single-hop wireless communication to one or many gateways.



Figure : LoRaWAN network

Communication between end-devices and gateways is spread out on different frequency channels and data rates. The selection of the data rate is a trade-off between communication range and message duration. Due to the spread spectrum technology, communications with different data rates do not interfere with each other and create a set of "virtual" channels increasing the capacity of the gateway. To maximize both battery life of the end-devices and overall network capacity, the LoRaWAN network server is managing the data rate and RF output for each end-device individually by means of an adaptive data rate (ADR) scheme.

National wide networks targeting internet of things such as critical infrastructure, confidential personal data or critical functions for the society has a special need for secure communication. This has been solved by several layer of encryption.

Protocol: LoRaWAN 1.0, Class A

LoRaWAN-ready

Frequency:

- LoRaWAN 868/433 modules: 868 MHz and 433 MHz ISM bands
- LoRaWAN 900 module: 900-930 MHz ISM band

TX power:

- LoRaWAN 868/433 modules: up to +14 dBm
- LoRaWAN 900 module: up to +18.5 dBm

Sensitivity: down to -136 dBm

Range: >15 km at suburban and >5 km at urban area. Typically, each base station covers some km. Check the LoRaWAN Network in your area.

Chipset consumption:

- LoRaWAN 868/433 modules: 38.9 mA
- LoRaWAN 900 module: 124.4 mA

Radio data rate:

- LoRaWAN 868/433 modules: from 250 to 5470 bps
- LoRaWAN 900 module: from 250 to 12500 bps

Receiver: purchase your own base station or use networks from LoRaWAN operators

All the information about their programming and operation can be found in the LoRaWAN Networking Guide available at [Development section](#) of Libelium website.



Figure : LoRaWAN 868 module

7.7. Sigfox

Sigfox is a private company that aims to build a worldwide network especially designed for IoT devices. The network is cellular, with thousands of base stations deployed in each country. Sigfox technology offers very long ranges for low-power, battery-constrained nodes. Sigfox is great for very simple and autonomous devices which need to send small amounts of data to this ubiquitous network, taking advantage on the Sigfox infrastructure.

So Sigfox is similar to cellular (GSM-GPRS-3G-4G) but is more energy-efficient, and the annual fees are lower.

Sigfox uses a UNB (Ultra Narrow Band) based radio technology to connect devices to its global network. The use of UNB is key to providing a scalable, high-capacity network, with very low energy consumption, while maintaining a simple and easy to rollout star-based cell infrastructure.

- **Frequency:** ISM 868 MHz
- **TX Power:** 14 dBm
- **ETSI limitation:** 140 messages of 12 bytes, per module per day
- **Range:** Typically, each base station covers some km. Check the [Sigfox Network](#)
- **Chipset consumption:** TX: 49 mA @ +14 dBm
- **Radio Data Rate:** 100 bps
- **Receive sensitivity:** -126 dBm
- **Sigfox certificated:** Class 0u (the highest level)



Figure : Sigfox network

The network operates in the globally available ISM bands (license-free frequency bands) and co-exists in these frequencies with other radio technologies, but without any risk of collisions or capacity problems. Sigfox currently uses the most popular European ISM band on 868MHz (as defined by ETSI and CEPT).

Sigfox is being rolled out worldwide. It is the responsibility of the system integrator to consult the catalog of [SNOs](#) (Sigfox Network Operators) for checking coverage in the deployment area.

The Sigfox back-end provides a web application interface for device management and configuration of data integration, as well as standards based web APIs to automate the device management and implement the data integration.

All the information about their programming and operation can be found in the Sigfox Networking Guide available at [Development section](#) of Libelium website.

7.8. LoRa

- **Protocol:** Own, developed at Libelium. Not compatible with LoRaWAN.
- **Model:** Semtech SX1272
- **Frequencies available:** 860-1000 MHz, fits both 868 (Europe) and 915 MHz (USA) ISM bands
- **Max TX power:** 14 dBm
- **Sensitivity:** -137 dBm
- **Range:**
 - Line of Sight: 21+ km / 13.4+ miles (LoS and Fresnel zone clearance)
 - Non Line of Sight: 2+ km / 1.2+ miles (nLoS going through buildings, urban environment)
- **Antenna:**
 - 868 / 915 MHz: 0 / 4.5 dBi
 - Connector: RP-SMA
- **Encryption:** AES 128/192/256b (performed by WaspMote API)
- **Control Signal:** RSSI
- **Topology:** Star
- **Receiver/Central node:** Meshlium LoRa, special Gateway LoRa (SPI) or another WaspMote or Plug & Sense! unit

This is the radio with the best range performance, thanks to the excellent receiver sensitivity that the LoRa™ technology offers. Besides, Libelium developed a library which enables addressable, reliable and robust communications with ACK, re-tries or time-outs strategies.

The user can set any frequency in the 868 and 900MHz bands, with pre-defined channels. The use of this module is allowed in virtually any country.

863-870 MHz Band

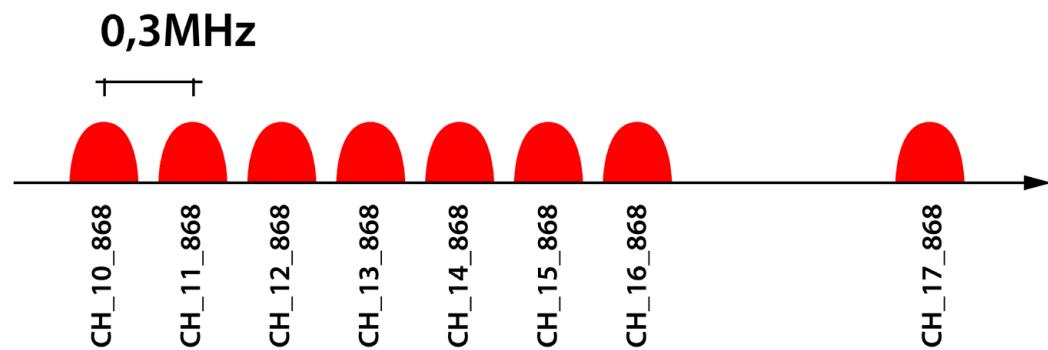


Figure : Channel frequencies in the 868MHz band

902-928 MHz Band

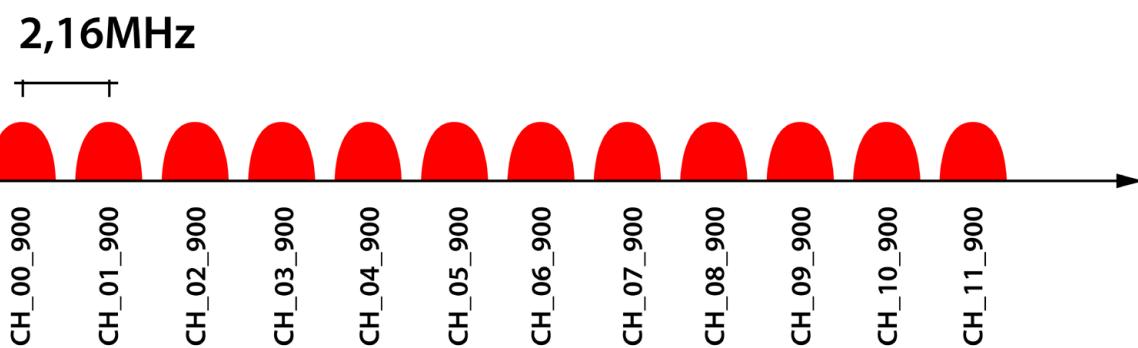


Figure : Channel frequencies in the 900MHz band

Encryption is implemented in the application level, thanks to the Wasp mote's AES library. The payload inside the wireless packet is encrypted so only nodes knowing the key can read the content. The encryption activation is as simple as running one of our LoRa with AES encryption examples.

The topology for this type of network is a star topology, as the nodes can establish point to point connections with brother nodes, normally with the central one.

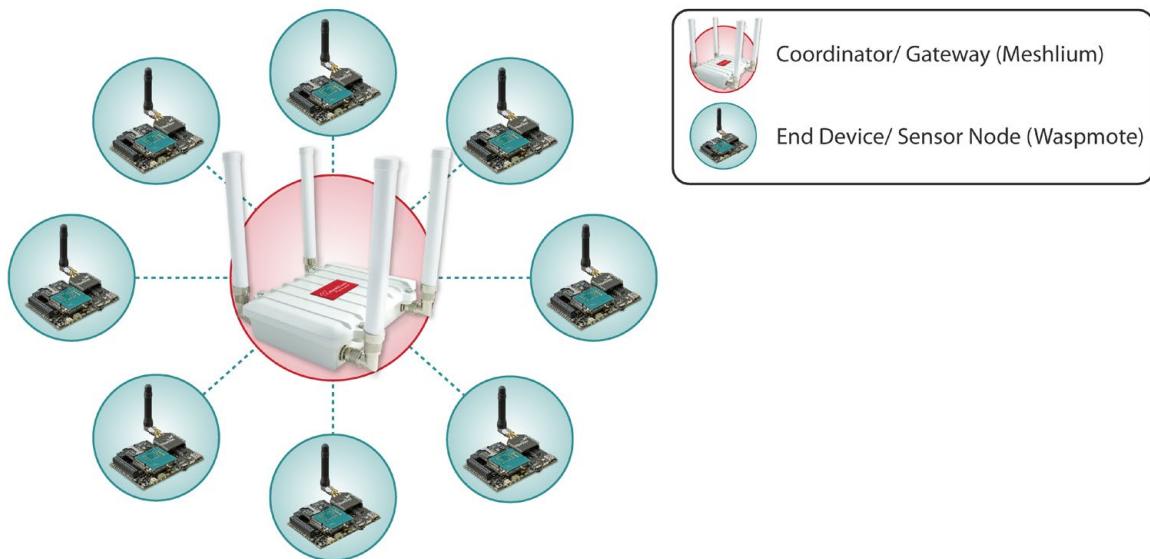


Figure : Star topology

All information about their programming and operation can be found in the SX1272 LoRa Networking Guide available at the [Development section](#) of the Libelium website.

7.9. WiFi

WiFi module for the WaspMote platform completes the current connectivity possibilities enabling the direct communication of the sensor nodes with any WiFi router in the market. As well as this, this radio allows WaspMote to send directly the information to any iPhone or Android Smartphones without the need of an intermediate router, what makes possible to create WiFi sensor networks anywhere using just WaspMote and a mobile device as all of them run with batteries.

With this radio, WaspMote can make HTTP connections retrieving and sending information to the web and FTP servers, as well as using TCP/IP and UDP/IP sockets in order to connect to any server located on the Internet.

Features:

- Protocols: 802.11b/g - 2.4GHz
- TX Power: 0dBm - 12dBm (variable by software)
- RX Sensitivity: -83dBm
- Antenna connector: RP-SMA
- Antenna: 5dBi
- Security: WEP, WPA, WPA2
- Topologies: AP
- 802.11 roaming capabilities

Actions:

- TCP/IP - UDP/IP socket connections
- HTTP web connections
- FTP file transfers
- Direct connections with iPhone and Android
- Connects with any standard WiFi router
- DHCP for automatic IP assignation
- DNS resolution enabled

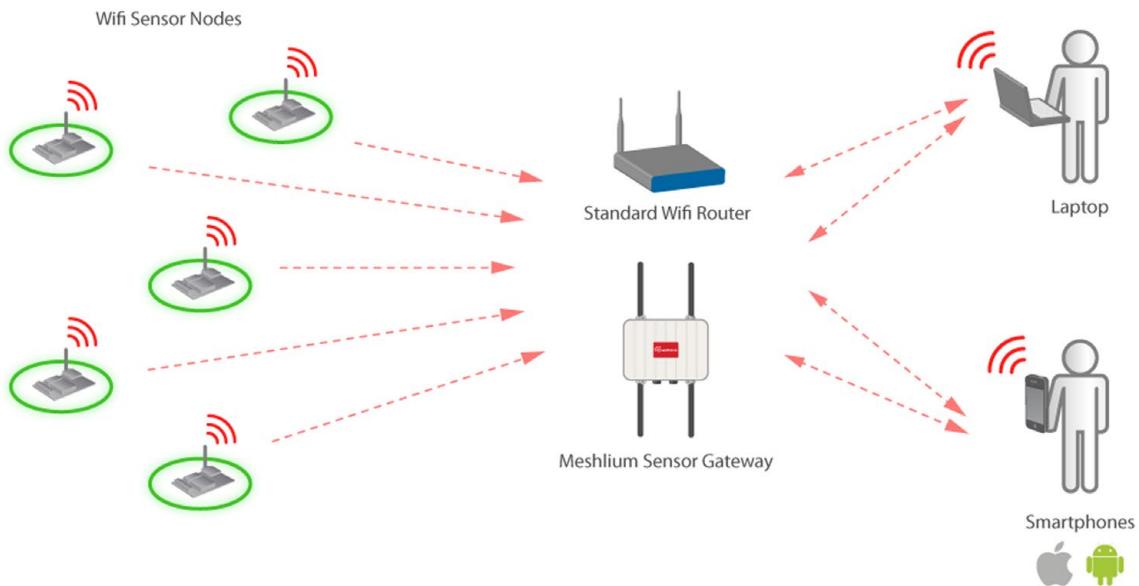
All information about their programming and operation can be found in the WiFi Networking Guide available at [Development section](#) of Libelium website.

7.9.1. WiFi Topologies

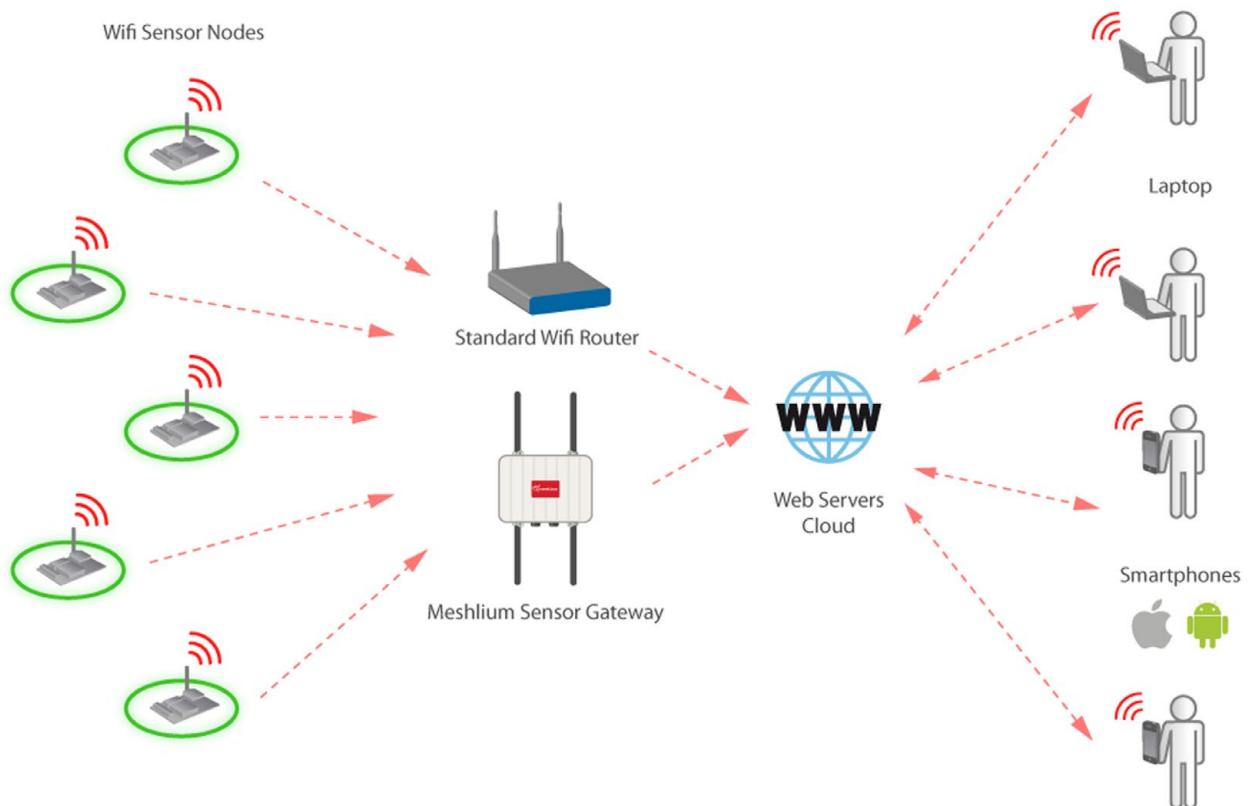
7.9.1.1. Access Point

Sensor nodes may connect to any standard WiFi router which is configured as Access Point (AP) and then send the data to other devices in the same network such as laptops and smartphones. This is the common case when implementing home sensor networks and when using the data inside an Intranet.

Once associated with the Access Point, the nodes may ask for an IP address by using the DHCP protocol or use a preconfigured static IP. The AP connection can be encrypted, in this case, you have to specify also the pass-phrase or key to the WiFi module. The WiFi module supports these security modes: WEP-128, WPA2-PSK, WPA1-PSK, and WPA-PSK mixed mode.



Nodes may also connect to a standard WiFi router with DSL or cable connectivity and send the data to a web server located on the Internet. Then users are able to get this data from the Cloud. This is the typical scenario for companies which want to give data accessibility services.



As pointed before the WiFi module can join any standard WiFi router, however the connection may also be performed using **Meshlum** instead of a standard WiFi router. Meshlum is the multiprotocol Gateway designed by Libelium which is specially recommended for outdoor applications as it is designed to resist the hardest conditions in real field deployments.

When it is recommended to use Meshlium instead a standard WiFi access point?

As pointed before the WiFi module for WaspMote can connect to any standard WiFi router ("home oriented") in the market. However when deploying sensor networks outdoors you need a robust machine capable of resist the hardest conditions of rain, wind, dust, etc. Meshlium is specially designed for real deployments of wireless sensor networks as it is waterproof (IP-65) and counts with a robust metallic enclosure ready to resist the hardest atmospheric conditions.

Meshlium is also ready to deal with hundreds of nodes at the same time, receiving sensor data from all of them and storing it in its internal database or sending it to an Internet server. As well as this, Meshlium may work as a WiFi to 3G/GPRS gateway, giving access to the internet to all the nodes in the network using the mobile phones infrastructure.

It is also important to mention that the transmission power of the WiFi interface integrated in Meshlium is many times higher than the ones available in "home oriented" WiFi routers so the distance we can get increases dramatically from a few meters to dozens or even hundreds depending on the location of the nodes.

Using Meshlium as WiFi Access Point allows to control and to store the messages received from the WiFi module, or allows to combine WiFi technology with other protocols such as ZigBee. Meshlium may work as:

- an XBee/LoRa to Ethernet router for WaspMote nodes
- an XBee/LoRa to 3G/GPRS router for WaspMote nodes
- a WiFi Access Point
- a WiFi Mesh node (dual band 2.4GHz-5GHz)
- a WiFi to 3G/GPRS router
- a Bluetooth scanner and analyzer
- a SmartPhone scanner (detects iPhone and Android devices)

For more information about Meshlium go to: <http://www.libelium.com/meshlium>



7.10. GPRS

WaspMote can integrate a GSM (Global System for Mobile communications) / GPRS (General Packet Radio Service) module to enable communication using the mobile telephone network.

- **Model:** SIM900 (SIMCom)
- **Quadband:** 850MHz/900MHz/1800MHz/1900MHz
- **TX Power:** 2W(Class 4) 850MHz/900MHz, 1W(Class 1) 1800MHz/1900MHz
- **Sensitivity:** -109dBm

This module can carry out the following tasks:

- Making/Receiving calls
- Making 'x' tone missed calls
- Sending/Receiving SMS
- Single connection and multiple connections TCP/IP and UDP/IP clients
- TCP/IP server.
- HTTP Service
- FTP Service (downloading and uploading files)

Note: The SIM card can be installed by the user thanks to the External SIM socket.

All information about their programming and operation can be found in the **GSM/GPRS Networking Guide** available at [Development section](#) of Libelium website.

7.11. GPRS+GPS

WaspMote can integrate a GSM (Global System for Mobile communications) / GPRS (General Packet Radio Service) module to enable communication using the mobile telephone network. Also, this module integrates a GPS receiver.

Model: SIM908 (SIMCom)

GPRS features:

- Quadband: 850MHz/900MHz/1800MHz/1900MHz
- TX Power: 2W(Class 4) 850MHz/900MHz, 1W(Class 1) 1800MHz/1900MHz
- Sensitivity: -109dBm

GPS features:

- Time-To-First-Fix: 30 s (typ.)
- Sensitivity (tracking): -160 dBm
- Sensitivity (adquisition): -143 dBm
- Accuracy horizontal position : <2.5m CEP

This module can carry out the following tasks:

- Making/Receiving calls
- Making 'x' tone missed calls
- Sending/Receiving SMS
- Single connection and multiple connections TCP/IP and UDP/IP clients
- TCP/IP server.
- HTTP Service
- FTP Service (downloading and uploading files)
- GPS receiver

Note: The SIM card can be installed by the user thanks to the External SIM socket.

All information about their programming and operation can be found in the GPRS+GPS Networking Guide available at the [Development section](#) of Libelium website.

7.12. 3G/GPRS

WaspMote can integrate a 3G/GPRS module, to enable communication using the mobile telephone network.

- Model: SIM5215 (SIMCom)
- Versions: Europe and America/Australia
- Europe version:
 - Dual-Band: 900/2100 MHz
 - Tri-Band: 850/900/1800 MHz
- America/Australia version:
 - Dual-Band: 850/1900 MHz
 - Quad-Band: 850/900/1800/1900 MHz
- WCDMA (downlink): up to 384 kbps
- WCDMA (uplink): up to 384 kbps
- TX power:
 - UMTS 850/900/1900/2100: 0.25 W
 - GSM 850/900: 2 W
 - DCS 1800 / PCS 1900: 1 W
- Sensitivity: -106dBm

This module can carry out the following tasks:

- Support microSD card up to 32GB
- 64MB of internal storage space
- Making/Receiving calls
- Making 'x' tone missed calls
- Sending/Receiving SMS
- Single connection and multiple connections TCP/IP and UDP/IP clients
- TCP/IP server.
- HTTP and HTTPS service
- FTP Service (downloading and uploading files)
- Sending/receiving email (SMTP and POP3)

Note: The SIM card can be installed by the user thanks to the External SIM socket.

All information about their programming and operation can be found in the 3G/GPRS Networking Guide available at the Development section of Libelium website.

7.13. Bluetooth Low Energy

The WaspMote Bluetooth Low Energy module is also available for the WaspMote Plug & Sense! platform. BLE modules use the 2.4GHz band (2402MHz – 2480 MHz). It has 37 data channels and 3 advertisement channels, with a 2MHz spacing and GFSK modulation.

Features:

- Protocol: Bluetooth v.4.0 / Bluetooth Smart
- Chipset: BLE112
- RX Sensitivity: -103dBm
- TX Power: [-23dBm, +3dBm]
- Antenna: 2dBi/5dBi antenna options
- Security: AES-128
- Range: 100 meters (at maximum TX power)
- Consumption: sleep (0.4uA) / RX (8mA) / TX (36mA)

Actions:

- Send broadcast advertisements (iBeacons)
- Connect to other BLE devices as Master / Slave
- Connect with Smartphones and Tablets
- Set automatic cycles sleep / transmission
- Calculate distance using RSSI values
- Perfect for indoor location networks (RTLS)
- Scan devices with maximum inquiry time
- Scan devices with maximum number of nodes
- Scan devices looking for a certain user by MAC address

8. Internal storage

Wasp mote Plug & Sense! has an internal SD (Secure Digital) card. FAT16 file system is used and cards up to 2GB are supported.

To get an idea of the capacity of information that can be stored in a 2GB card, simply divide its size by the average for what a sensor frame in Wasp mote usually occupies (approx. 100 Bytes):

2GB/100B = 20 million measurements

The limit in files and directories creation per level is 256 files per directory and up to 256 sub-directories in each directory. There is no limit in the number of nested levels.

The SD card is also used to store the firmware image when performing Over the Air Programming (OTAP).

All information about their programming and operation can be found in the SD Card Programming Guide available at the [Development section](#) of Libelium website.

Note: *Wasp mote must not be switched off or reset while there are ongoing read or write operations in the SD card. Otherwise, the SD card could be damaged and data could be lost.*

9. ON / OFF Button

This button is used to turn ON or OFF WaspMote. It is a latch type button with two static positions as shown below. In ON position, the button remains a bit lower than the LED ring.



Figure : On / Off button at off position



Figure : Turning On Waspmote

Note: The ON / OFF button can be in ON or OFF position to charge the battery. Obviously, non-rechargeable batteries cannot be recharged with any method.

Note: Also, RTC time is now kept correctly even if the button is turned to OFF position.

9.1. External led

The ON / OFF button includes a red ring LED, which can be managed by software using dedicated functions described below. This LED can be used for instance to know that WaspMote is ON, or for debugging purposes at developing phase. By default, WaspMote Plug & Sense! comes with a code that blinks briefly (3 times in less than one second) this LED when it is turned ON. The LED can be managed specifying ON time or just setting this state with specific API functions. The user should take into account that the usage of this LED will increase power consumption due to external LED consumes 4.4 mA.



Figure : Waspmote turned On

External LED ring can be managed with next code lines:

```
Utils.setExternalLED(LED_ON); // Turns external led ON
Utils.setExternalLED(LED_OFF); // Turns external led OFF
```

There is also another useful function which blinks external LED during specified time.

```
Utils.externalLEDBlink(uint_16 time) // Time must be in seconds
```

Finally, there is an extra function to know the external LED state:

```
Utils.getExternalLED(); // Read external led state
```

10. Resetting Waspmote plug & sense! with an external magnet

Waspmote Plug & Sense! can be reset with an external magnet, with no contact. If one node stops working or if a defective behavior is detected, it would be costly to uninstall the node to bring it back to laboratory. This feature allows the network manager to reset the node in a quick and easy way.

The hardware consists of a reed switch connected to the Waspmote reset line. When the user gets the magnet close to the reed-switch, the reset is activated. When the user moves the magnet away, the reset line is released (the external led will blink) and Waspmote executes the bootloader first and then, the setup function. After the setup, it will continue with the loop function. Next pictures shows the right way to reset the node using an external magnet, first moving it closer, and then moving it away.



Figure : Moving the magnet closer to the node



Figure : Moving the magnet away from the node

The magnet is made of neodymium. It is a special, high-power magnet. We only advise to use the magnet Libelium provides. The user must be careful because the magnet is so powerful that it can get stuck to metal objects. Besides, the magnet must be kept away from electronic devices like PCs, batteries, etc, since they could be damaged or information could be deleted.

It is not mandatory, but highly recommended to consider this feature when designing the project. Every Plug & Sense! node comes with the hardware to allow the contactless reset, but the magnet is optional, an accessory. It is highly recommended to purchase one magnet (one unit is enough for many nodes). The user should design the software in a way the node can be reset if things go wrong. Remember that laboratory tests are always needed to validate the feature before your final deployment.

When the node is already deployed in the field, and for instance it is installed in a traffic light, this feature can be used to reset the node easily, as it is shown in the diagram below, where a technician uses a pole with the magnet attached in one side.

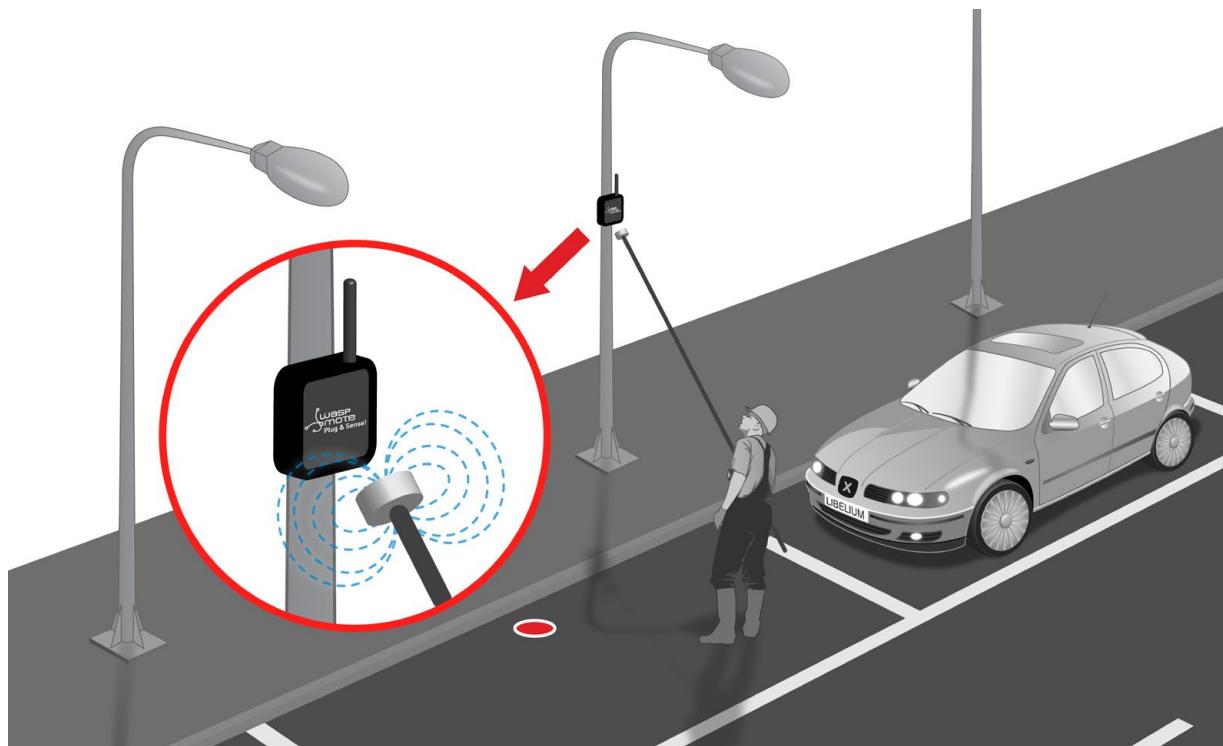


Figure : Resetting a Plug & Sense! node with a pole and magnet

11. USB

This connector is used to upload code into WaspMote with a male to male USB cable provided by Libelium. Just connect one side of the cable to this connector, removing protection cap and connect the other side to a PC to upload a code or to charge the battery in case your model has a rechargeable battery. Next picture shows an example.



Figure : USB connector and protective cap



Figure : Connecting the USB cable to Waspmote

When uploading processes are finished, do not forget to screw firmly the protection cap to avoid connector damage. Never connect a USB which exceed maximum ratings of USB standard.



Figure : Connecting USB charger

For indoor deployments the nodes can be recharged using the USB charger.

Important: Use the USB charger just with the models which includes rechargeable battery and the regular USB cable.



Figure : Charging the mote by USB

11.1. Outdoors USB Cable

The Outdoors USB Cable is made for outdoors applications with high power consumption requirements, where nodes need to be permanently powered. It consists of a 3 meter cable with the solar socket connector on one end, and a USB male A type on the other end.

The solar socket end is meant to be connected on the solar socket of Plug & Sense!, it is not valid for the sensor sockets. This special end is waterproof and suitable for outdoors connections.

On the other hand, the USB end of the cable is thought to be connected to the USB charger (AC/DC, 5 V output). Bear in mind that this end is not waterproof so it cannot be used outdoors. Please protect it accordingly.



Figure : Outdoors USB Cable

One application of the cable is to power a node placed on the facade of a building; the USB cable goes indoors through a nearby window, and the USB end remains indoors, connected to a wall adapter.

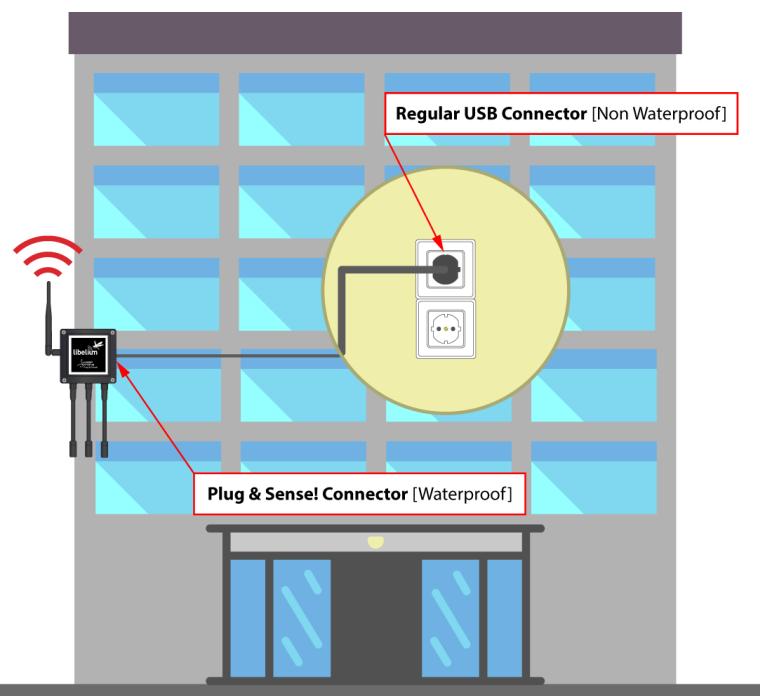


Figure : Application of the Outdoors USB Cable

11.2. External SIM socket

The External SIM socket replaces the USB socket in two types of devices:

- WaspMote Plug & Sense! devices **with GPRS or GPRS+GPS module or 3G module**
- Meshlium devices with 3G module

The External SIM socket is composed of 2 connectors:

- micro-SIM card
- micro-USB (type B)



Figure : External SIM socket in a Plug & Sense! with GPRS or 3G modules

The operation with the micro-USB socket is just the same than with the normal USB socket. Just remember to use a micro-USB cable.



Figure : Connecting the micro-USB cable to Plug & Sense!

The micro-SIM card connector allows the user to connect the SIM card he likes from the outside. It is not necessary to send a SIM card to Libelium for proper installation. You can ask your telecommunication provider for a micro-SIM card. Alternatively you can take a normal SIM card and transform it into a micro-SIM card with a SIM card cutter.

Besides, the micro-SIM card connector has a push-pull mechanism, so it is really easy to remove the card with the aid of one nail.



Figure : Push-pull mechanism in the External SIM socket

Please mind the correct orientation of the micro-SIM card: the side of the chip must look towards the micro-USB connector, and the 45°-angled corner must face the device.

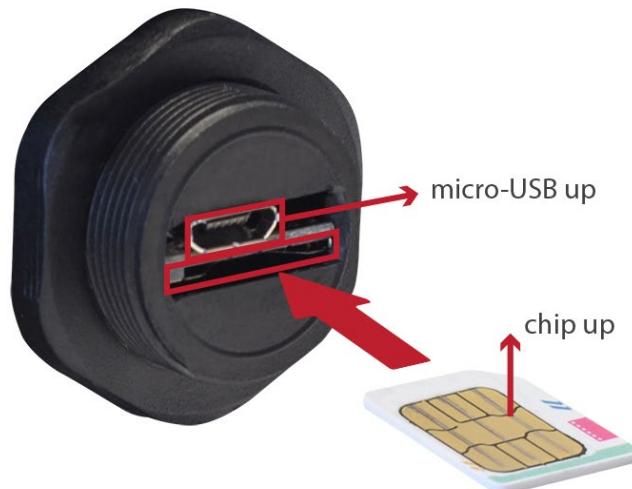


Figure : Correct orientation of the micro-SIM card

It is highly important to turn off the Plug & Sense! device in a secure way before inserting a micro-SIM card, or removing an existing SIM-card. The user can damage the device if this operation is done "on-the-fly".

Make sure you closed the External SIM socket with its protection cap before outdoors deployment.

Take into account that the External SIM socket has a limited resistance so please be gentle and do not push too hard with the USB or SIM card.



Figure : Inserting a SIM card with care in the External SIM socket

12. Internal solar panel

Libelium provides two choices for the solar panel, internal and external.

The internal solar panel is embedded in the front of the enclosure, occupying almost all WaspMote front surface.

Internal solar panel features

- **Max power:** 1.3 W
- **Max power voltage:** 6,5 V
- **Max power current:** 205 mA
- **Dimensions:** 111 x 91 x 3 mm



Figure : WaspMote Plug & Sense! with internal solar panel

It is highly recommended to ensure the best conditions for the solar panel:

- 45 degrees of inclination
- Solar panel side faced to the south

Libelium provides special brackets in order to install it correctly.



Figure : Typical application with internal solar panel

13. External solar panel

This panel should be connected to the external solar panel connector. As shown in picture below, it has identical shape as sensor connectors, but is placed on the control side of the enclosure, below the ON/OFF button.

External solar panel features

- **Max power:** 3W
- **Max power voltage:** 5,8 V
- **Max power current:** 520 mA
- **Dimensions:** 234 x 160 x 17 mm
- **Weight:** 0.54 Kgs



Figure : External solar panel connector

Do not connect any sensor on this connector and also do not connect the solar panel to a sensor connector. WaspMote can be damaged and warranty will be void.



Figure : Connecting the solar panel to WaspMote Plug & Sense!

In the next picture a typical installation with external solar panel is shown. Notice that the enclosure is placed just under the solar panel, using it as a protection against sun and rain.

Libelium provides special brackets in order to install it correctly.



Figure : Typical installation of the external solar panel

14. Vent plug / Pressure Compensator

The purpose of the Vent Plug is to avoid condensation by compensating external / internal pressure. Do not try to connect anything to this element and also do not modify its position or any of its parts.



Figure : Vent plug of Waspmote Plug & Sense!

15. Antenna

By default WaspMote Plug & Sense! has one external antenna of 5dBm with a standard reverse polarized SMA connector. This connector allows to connect the RF antenna.



Figure : Antenna connector of the enclosure

To ensure good RF coverage, be sure antenna points to the sky and also be sure antenna is screwed completely to the connector. To connect the antenna, just align it with the connector and screw it carefully. Antenna must be connected in order to ensure RF communication.



Figure : Connecting antenna to the enclosure

Note: Once WaspMote Plug & Sense! is installed, it is recommended to fix it using a tape like the one shown in the picture below.



Figure : Recommended tape



Figure : Ensure antenna remains in the right position

Do not try to connect other kind of antennas which do not match with SMA RP standard connector and also other antennas not provided by Libelium.

16. Sensor protection

16.1. Special probes

There are some sensor probes which include special protection against sunlight and bad environmental conditions. For instance, the Temperature + Humidity (Sensirion) probe has a special filter which allows humidity measurement but offers protection against water.

However, a lot of sensor probes include just a standard protection. If the final application involves bad environmental conditions and a lot of sunlight hours, Libelium suggests the usage of a solar radiation shield.

In addition, refer to corresponding section for more information about sensor probes.

17. Batteries

Libelium provides two different battery option for WaspMote Plug & Sense!:

- Rechargeable 6600mAh
- Non rechargeable 26Ah

WaspMote has a control and safety circuit which makes sure the battery charge current is always adequate. The following images show battery discharging for a typical load and for a specific case.



Figure : Typical discharging curve for battery

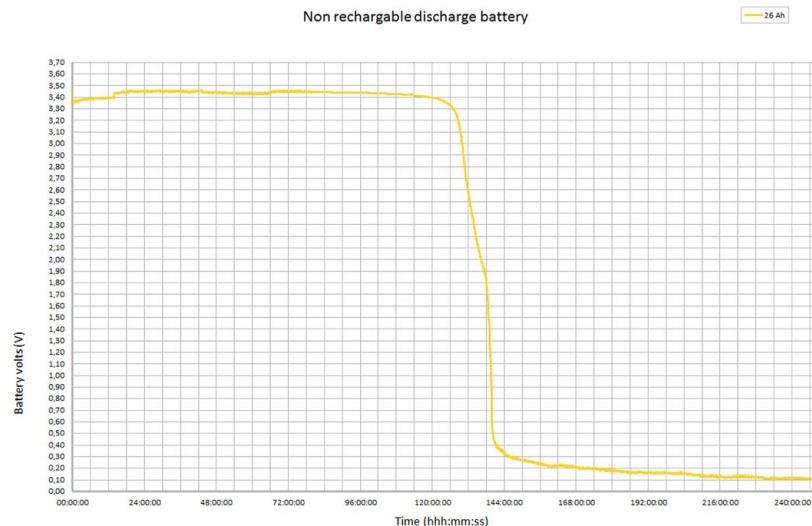


Figure : Typical discharging curve for 26Ah battery with a 20 Ohm load

Note: As shown above, the discharging curve for 26Ah battery is always plain, due to its technology. This means there is no way to know what is the percentage of remaining charge in a non-rechargeable battery.

Note: The ON / OFF button can be in ON or OFF position to charge the battery. Obviously, non-rechargeable batteries cannot be recharged with any method.

18. Models

There are some defined configurations of Wasp mote Plug & Sense! depending on which sensors are going to be used. Wasp mote Plug & Sense! configurations allows connecting up to six sensor probes at the same time.

Each model takes a different conditioning circuit to enable the sensor integration. For this reason each model allows to connect just its specific sensors.

This section describes each model configuration in detail, showing the sensors which can be used in each case and how to connect them to Wasp mote. In many cases, the sensor sockets accept the connection of more than one sensor probe. See the compatibility table for each model configuration to choose the best probe combination for the application.

It is very important to remark that each socket is designed only for one specific sensor, so **they are not interchangeable**. Always be sure you connected probes in the right socket, otherwise they can be damaged.

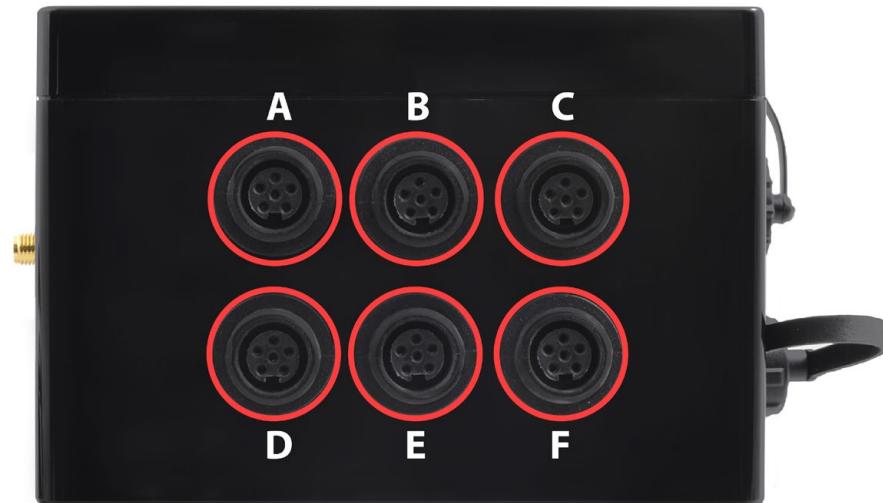


Figure : Identification of sensor sockets

18.1. Smart Environment

Smart Environment model is designed to monitor environmental parameters such as temperature, humidity, atmospheric pressure and some types of gases. The main applications for this Wasp mote Plug & Sense! configuration are city pollution measurement, emissions from farms and hatcheries, control of chemical and industrial processes, forest fires, etc. Go to the application section in the [Libelium website](#) for a complete list of services.



Figure : Smart Environment Wasp mote Plug & Sense! model

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A	Temperature	9203
	Carbon monoxide - CO	9229
	Methane - CH ₄	9232
	Ammonia – NH ₃	9233
	Liquefied Petroleum Gases: H ₂ , CH ₄ , ethanol, isobutene	9234
	Air pollutants 1: C ₄ H ₁₀ , CH ₃ CH ₂ OH, H ₂ , CO, CH ₄	9235
	Air pollutants 2: C ₆ H ₅ CH ₃ , H ₂ S, CH ₃ CH ₂ OH, NH ₃ , H ₂	9236
	Alcohol derivates: CH ₃ CH ₂ OH, H ₂ , C ₄ H ₁₀ , CO, CH ₄	9237
B	Humidity	9204
	Atmospheric pressure	9250
C	Carbon dioxide - CO ₂	9230
D	Nitrogen dioxide - NO ₂	9238 , 9238 -B
E	Ozone - O ₃	9258 , 9258 -B
	Hydrocarbons - VOC	9201 , 9201-B
	Oxygen - O ₂	9231
F	Carbon monoxide - CO	9229
	Methane - CH ₄	9232
	Ammonia – NH ₃	9233
	Liquefied Petroleum Gases: H ₂ , CH ₄ , ethanol, isobutene	9234
	Air pollutants 1: C ₄ H ₁₀ , CH ₃ CH ₂ OH, H ₂ , CO, CH ₄	9235
	Air pollutants 2: C ₆ H ₅ CH ₃ , H ₂ S, CH ₃ CH ₂ OH, NH ₃ , H ₂	9236
	Alcohol derivates: CH ₃ CH ₂ OH, H ₂ , C ₄ H ₁₀ , CO, CH ₄	9237

Figure : Sensor sockets configuration for Smart Environment model

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.2. Smart Environment PRO

The Smart Environment PRO model has been created as an evolution of Smart Environment. It enables the user to implement pollution, air quality, industrial, environmental or farming projects with high requirements in terms of high accuracy, reliability and measurement range as the sensors come calibrated from factory.



Figure : Smart Environment PRO Waspmote Plug & Sense! model

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A, B, C and F	Carbon Monoxide (CO) [Calibrated]	9371-P
	Carbon Dioxide (CO ₂) [Calibrated]	9372-P
	Oxygen (O ₂) [Calibrated]	9373-P
	Ozone (O ₃) [Calibrated]	9374-P
	Nitric Oxide (NO) [Calibrated]	9375-P
	Nitric Dioxide (NO ₂) [Calibrated]	9376-P
	Sulfur Dioxide (SO ₂) [Calibrated]	9377-P
	Ammonia (NH ₃) [Calibrated]	9378-P
	Methane (CH ₄) and Combustible Gas [Calibrated]	9379-P
	Hydrogen (H ₂) [Calibrated]	9380-P
	Hydrogen Sulfide (H ₂ S) [Calibrated]	9381-P
	Hydrogen Chloride (HCl) [Calibrated]	9382-P
	Phosphine (PH ₃) [Calibrated]	9384-P
	Ethylene (ETO) [Calibrated]	9385-P
	Chlorine (Cl ₂) [Calibrated]	9386-P
D	Particle Matter (PM1 / PM2.5 / PM10) - Dust	9387-P
E	Temperature, Humidity and Pressure	9370-P

Figure : Sensor sockets configuration for Smart Environment PRO model

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.3. Smart Security

The main applications for this WaspMote Plug & Sense! configuration are perimeter access control, liquid presence detection and doors and windows openings.



Figure : Smart Security WaspMote Plug & Sense! model

Note: The probes attached in this photo could not match the final location. See next table for the correct configuration.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A	Temperature + Humidity (Sensirion)	9247
B	Liquid flow	9296, 9297, 9298
C	Presence - PIR	9212
D	Luminosity (LDR)	9205
	Liquid level	9239, 9240, 9242
	Liquid presence	9243, 9295
	Hall effect	9207
E	Luminosity (LDR)	9205
	Liquid level	9239, 9240, 9242
	Liquid presence	9243
	Hall effect	9207
F	Luminosity (LDR)	9205
	Liquid level	9239, 9240, 9242
	Liquid presence	9243
	Hall effect	9207

Figure : Sensor sockets configuration for Smart Security model

As we see in the figure below, thanks to the directionable probe, the presence sensor probe (PIR) may be placed in different positions. The sensor can be focused directly to the point we want.



Figure : Configurations of the Presence sensor probe (PIR)

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.4. Smart Water

The Smart Water model has been conceived to facilitate the remote monitoring of the most relevant parameters related to water quality. With this platform you can measure more than 6 parameters, including the most relevant for water control such as dissolved oxygen, oxidation-reduction potential, pH, conductivity and temperature. An extremely accurate turbidity sensor has been integrated as well.

The Smart Water Ions line is complementary for these kinds of projects, enabling the control of concentration of ions like Ammonium (NH_4^+), Bromide (Br⁻), Calcium (Ca²⁺), Chloride (Cl⁻), Cupric (Cu²⁺), Fluoride (F⁻), Iodide (I⁻), Lithium (Li⁺), Magnesium (Mg²⁺), Nitrate (NO₃⁻), Nitrite (NO₂⁻), Perchlorate (ClO₄⁻), Potassium (K⁺), Silver (Ag⁺), Sodium (Na⁺) and pH. Take a look to the Smart Water Ions line in the next section.

Refer to [Libelium website](#) for more information.



Figure : Smart Water Plug&Sense! model

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
B	pH	9328
	Oxidation-Reduction Potential (ORP)	9329
C	pH	9328
	Oxidation-Reduction Potential (ORP)	9329
D	Soil/Water Temperature	9255 (included by default)
E	Dissolved Oxygen (DO)	9327
F	Conductivity	9326
	Turbidity	9353

Figure : Sensor sockets configuration for Smart Water model

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.5. Smart Water Ions

The Smart Water Ions models specialize in the measurement of ions concentration for drinking water quality control, agriculture water monitoring, swimming pools or waste water treatment.

The Smart Water line is complementary for these kinds of projects, enabling the control of parameters like turbidity, conductivity, oxidation-reduction potential and dissolved oxygen. Take a look to the Smart Water line in the previous section. Refer to Libelium website for more information.

There are 3 variants for Smart Water Ions: Single, Double and PRO. This is related to the type of ion sensor that each variant can integrate. Next section describes each configuration in detail.



Figure : Smart Water Ions Waspmote Plug & Sense! model

18.5.1. Single

This variant includes a Single Junction Reference Probe, so it can read all the single type ion sensors.

Sensor sockets are configured as shown in the table below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A, B, C and D	Calcium Ion (Ca^{2+})	9352
	Fluoride Ion (F^-)	9353
	Fluoroborate Ion (BF_4^-)	9354
	Nitrate Ion (NO_3^-)	9355
	pH (for Smart Water Ions)	9363
E	Single Junction Reference	9350 (included by default)
F	Soil/Water Temperature	9255 (included by default)

Figure : Sensor sockets configuration for Smart Water Ions model, single variant

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.5.2. Double

This variant includes a Double Junction Reference Probe, so it can read all the double type ion sensors. Sensor sockets are configured as shown in the table below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A, B, C and D	Bromide Ion (Br ⁻)	9356
	Chloride Ion (Cl ⁻)	9357
	Cupric Ion (Cu ²⁺)	9358
	Iodide Ion (I ⁻)	9360
	Silver Ion (Ag ⁺)	9362
	pH (for Smart Water Ions)	9363
E	Double Junction Reference	9351 (included by default)
F	Soil/Water Temperature	9255 (included by default)

Figure : Sensor sockets configuration for Smart Water Ions model, double variant

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.5.3. Pro

This special variant integrates extreme quality sensors, with better performance than the Single or Double lines. In this case, there is only one type of reference probe and up to 16 different ion parameters can be analyzed in 4 sockets.

Sensor sockets are configured as shown in the table below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A, B, C or D	Ammonium Ion (NH_4^+) [PRO]	9412
	Bromide Ion (Br^-) [PRO]	9413
	Calcium Ion (Ca^{2+}) [PRO]	9414
	Chloride Ion (Cl^-) [PRO]	9415
	Cupric Ion (Cu^{2+}) [PRO]	9416
	Fluoride Ion (F^-) [PRO]	9417
	Iodide Ion (I^-) [PRO]	9418
	Lithium Ion (Li^+) [PRO]	9419
	Magnesium Ion (Mg^{2+}) [PRO]	9420
	Nitrate Ion (NO_3^-) [PRO]	9421
	Nitrite Ion (NO_2^-) [PRO]	9422
	Perchlorate Ion (ClO_4^-) [PRO]	9423
	Potassium Ion (K^+) [PRO]	9424
E	Silver Ion (Ag^+) [PRO]	9425
	Sodium Ion (Na^+) [PRO]	9426
F	pH [PRO]	9411
	Reference Sensor Probe [PRO]	9410 (included by default)
F	Soil/Water Temperature	9255 (included by default)

Figure : Sensor sockets configuration for Smart Water Ions model, PRO variant

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.6. Smart Cities

The main applications for this WaspMote Plug & Sense! model are noise maps (monitor in real time the acoustic levels in the streets of a city), air quality, waste management, structural health, smart lighting, etc. Refer to [Libelium website](#) for more information.



Figure : Smart Cities WaspMote Plug & Sense! model

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A	Temperature	9203
	Soil temperature	86949*
	Ultrasound (distance measurement)	9246
B	Humidity	9204
	Ultrasound (distance measurement)	9246
C	Luminosity (LDR)	9205
D	Noise sensor (dBA)	9259
F	Linear displacement	9319

* Ask Libelium [Sales Department](#) for more information.

Figure : Sensor sockets configuration for Smart Cities model

As we see in the figure below, thanks to the directionable probe, the ultrasound sensor probe may be placed in different positions. The sensor can be focused directly to the point we want to measure.



Figure : Configurations of the ultrasound sensor probe

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.7. Smart Parking

The Plug & Sense! Smart Parking node allows to detect available parking spots by placing the node on the pavement. It works with a magnetic sensor which detects when a vehicle is present or not.

The node benefits from Sigfox and LoRaWAN technologies (868 and 900 MHz bands), getting ubiquitous coverage with few base stations. The device is very optimized in terms of power consumption, resulting in a long battery life. Its small size and the robust and surface-mount enclosure enables a fast installation, without the need of digging a hole in the ground. Finally, the developer does not need to program the node, but just configure some key parameters. Remote management and bidirectional communication allow to change parameters from the Cloud.



Figure: Plug & Sense! Smart Parking node

There are specific documents for parking applications at [Libelium website](#). Refer to Smart Parking Technical Guide to see typical applications for this model and how to make a good installation.

18.8. Smart Agriculture

The Smart Agriculture models allow to monitor multiple environmental parameters involving a wide range of applications. It has been provided with sensors for air and soil temperature and humidity (Sensirion), solar visible radiation, wind speed and direction, rainfall, atmospheric pressure, etc.

The main applications for this WaspMote Plug & Sense! model are precision agriculture, irrigation systems, greenhouses, weather stations, etc. Refer to [Libelium website](#) for more information.

Two variants are possible for this model, normal and PRO. Next section describes each configuration in detail.



Figure : Smart Agriculture WaspMote Plug & Sense! model

18.8.1. Normal

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A	Humidity + Temperature (Sensirion)	9247
B	Atmospheric pressure	9250
C	Soil temperature	86949*
	Soil moisture	9248
D	Weather Station WS-3000 (anemometer + wind vane + pluviometer)	9256
E	Soil moisture	9248
F	Leaf wetness	9249
	Soil moisture	9248

* Ask Libelium [Sales Department](#) for more information.

Figure : Sensor sockets configuration for Smart Agriculture model

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.8.2. PRO

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A	Humidity + Temperature (Sensirion)	9247
B	Soil temperature	9255
C	Solar radiation	9251, 9257
D	Soil temperature	86949*
	Soil moisture	9248
E	Dendrometers	9252, 9253, 9254
	Soil moisture	9248
F	Leaf wetness	9249
	Soil moisture	9248

* Ask Libelium [Sales Department](#) for more information.

Figure : Sensor sockets configuration for Smart Agriculture PRO model

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.9. Ambient Control

This model is designed to monitor main environment parameters in an easy way. Only three sensor probes are allowed for this model, as shown in next table.



Figure : Ambient Control WaspMote Plug & Sense! model

Sensor sockets are configured as it is shown in figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Parameter	Reference
A	Humidity + Temperature (Sensirion)	9247
B	Luminosity (LDR)	9205
C	Luminosity (Luxes accuracy)	9325
D	Not used	-
E	Not used	-
F	Not used	-

Figure : Sensor sockets configuration for Ambient Control model

As we see in the figure below, thanks to the directionable probe, the luminosity sensor probe may be placed in different positions. The sensor can be focused directly to the light source we want to measure.



Figure : Configurations of the Luminosity sensor probe (luxes accuracy)

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

18.10. Radiation Control

The main application for this Waspmote Plug & Sense! configuration is to measure radiation levels using a Geiger sensor. For this model, the Geiger tube is already included inside Waspmote, so the user does not have to connect any sensor probe to the enclosure. The rest of the other sensor sockets are not used.



Figure : Radiation Control Waspmote Plug & Sense! model

Sensor sockets are not used for this model.

Note: For more technical information about each sensor probe go to the [Development section](#) in Libelium website.

19. First steps

Waspmote Plug & Sense! comes from factory with a program which lets you check the right operation of the node. Refer to chapter Programming → Compilaton where all details are explained in detail.

20. Programming

WaspMote Plug & Sense! can be programmed by using Libelium's Integrated Development Environment (IDE).

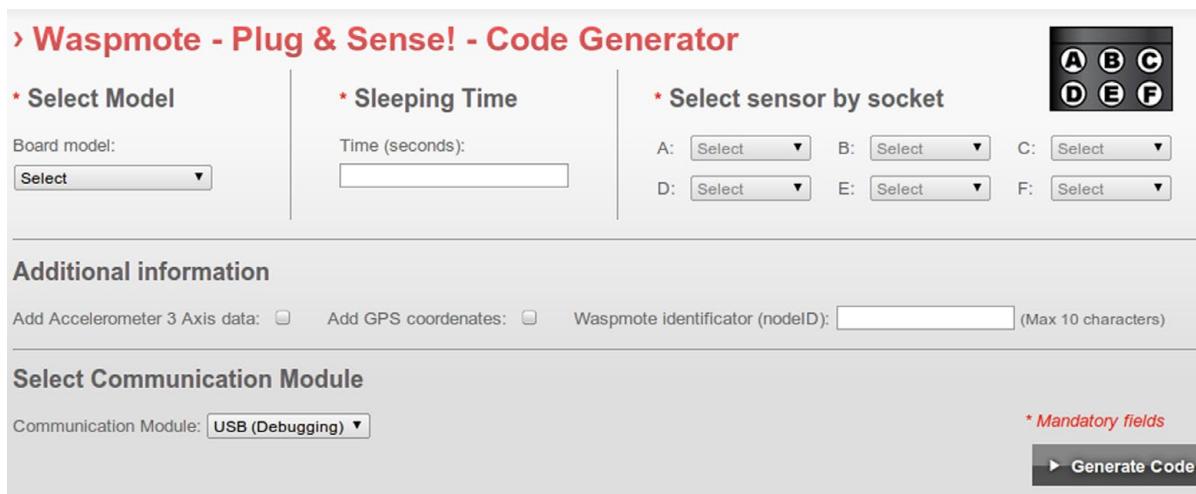
For further details on how to install the WaspMote IDE and how to compile and upload your first programs, we advise to read the "WaspMote IDE: User Guide". This guide contains step-by-step indications to get started; it can be found on the Plug & Sense! Development section:

www.libelium.com/development/plug-sense/sdk_applications/

20.1. Code generator

To make it easier to start with WaspMote Plug & Sense!, Libelium provides a code generator to help in the first steps of development. This code generator is available at the [Development section](#) on Libelium website.

Using this tool, the user can obtain fully functional codes for all WaspMote Plug & Sense! models including all sensor probes possibilities. Main parts of this online tool and the process to obtain a fully functional code are described below.



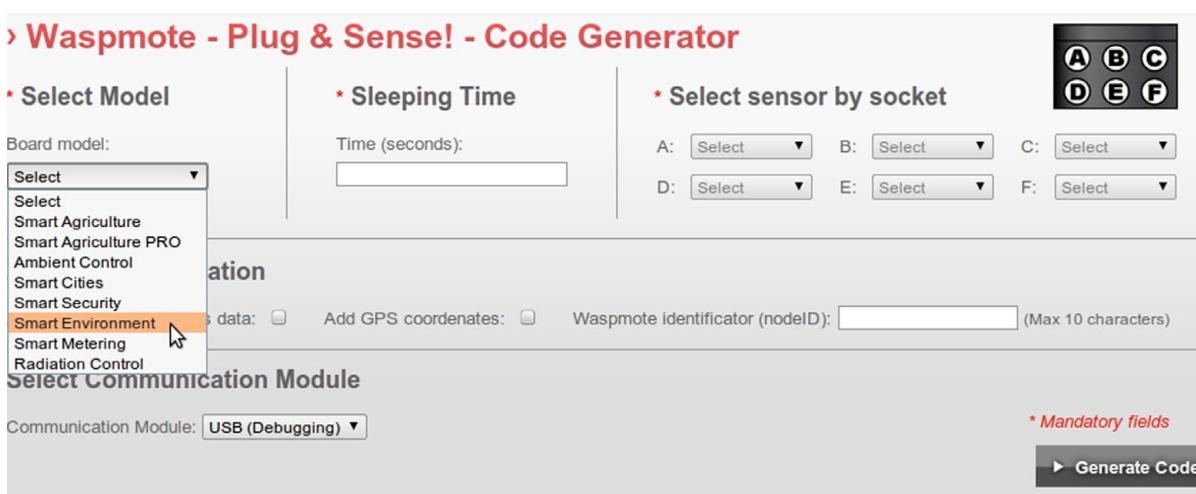
The screenshot shows the main interface of the WaspMote - Plug & Sense! - Code Generator. It is divided into several sections:

- Select Model:** A dropdown menu labeled "Board model" with options like "Select", "Smart Agriculture", "Smart Agriculture PRO", etc.
- Sleeping Time:** A section with a label "Time (seconds):" and a text input field.
- Select sensor by socket:** A section with six dropdown menus labeled A through F, each with "Select" as the default value. To the right is a legend with circles labeled A, B, C, D, E, and F.
- Additional information:** Fields for "Add Accelerometer 3 Axis data:" (checkbox), "Add GPS coordinates:" (checkbox), and "Waspmote identificator (nodeID):" (text input field with a character limit of 10).
- Select Communication Module:** A dropdown menu labeled "Communication Module" with "USB (Debugging)" selected. A note indicates "* Mandatory fields".
- Generate Code:** A button labeled "Generate Code" with a right-pointing arrow icon.

Figure : Main window of WaspMote Plug & Sense! code generator

Step 1: Select the corresponding model

Always be sure you select the right model. Otherwise some internal parts could be damaged if you try to upload a code for a different model.



This screenshot shows the "Select Model" dropdown menu open, displaying various WaspMote models. The "Smart Environment" option is highlighted with a mouse cursor. Other visible options include "Select", "Smart Agriculture", "Smart Agriculture PRO", "Ambient Control", "Smart Cities", "Smart Security", "Smart Metering", and "Radiation Control". The rest of the interface is identical to the previous screenshot, showing the sleeping time, sensor selection, additional information, communication module selection, and generate code button.

Figure : Selection WaspMote Plug & Sense! model

Step 2: Select the sensors connected to each socket

Be sure you have selected the sensors in each socket in the same way as you physically connect the sensor probes to Wasp mote Plug & Sense!.

Wasp mote - Plug & Sense! - Code Generator

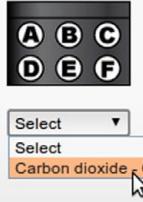
* Select Model Board model: <input type="button" value="Smart Environment"/>	* Sleeping Time Time (seconds): <input type="text" value=""/>	* Select sensor by socket A: NH3 B: Humidity C: Select D: Select E: Select F: Carbon dioxide, CO 
Additional information Add Accelerometer 3 Axis data: <input type="checkbox"/> Add GPS coordinates: <input type="checkbox"/> Wasp mote identifier (nodeID): <input type="text"/> (Max 10 characters)		
Select Communication Module Communication Module: <input type="button" value="USB (Debugging)"/>		
<i>* Mandatory fields</i> <input type="button" value="Generate Code"/>		

Figure : Selecting the used sensor probes

Step 3: Select the sleeping time

Wasp mote will sleep the specified time each loop. Time must be specified in seconds.

Wasp mote - Plug & Sense! - Code Generator

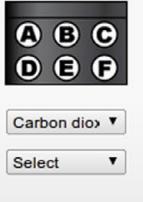
* Select Model Board model: <input type="button" value="Smart Environment"/>	* Sleeping Time Time (seconds): <input type="text" value="300"/>	* Select sensor by socket A: NH3 B: Humidity C: Carbon dio D: Select E: Select F: Select 
Additional information Add Accelerometer 3 Axis data: <input type="checkbox"/> Add GPS coordinates: <input type="checkbox"/> Wasp mote identifier (nodeID): <input type="text"/> (Max 10 characters)		
Select Communication Module Communication Module: <input type="button" value="USB (Debugging)"/>		
<i>* Mandatory fields</i> <input type="button" value="Generate Code"/>		

Figure : Selecting the sleeping time

Step 4: Select communication module

Select the corresponding radio module for your model and include the necessary networking parameters, as MAC address, etc.

› WaspMote - Plug & Sense! - Code Generator

* Select Model	* Sleeping Time	* Select sensor by socket
Board model: <input type="button" value="Smart Environment"/>	Time (seconds): <input type="text" value="300"/>	A: NH3 B: Humidity C: Carbon dio D: Select E: Select F: Select
Additional information		
Add Accelerometer 3 Axis data: <input type="checkbox"/> Add GPS coordinates: <input type="checkbox"/> WaspMote identificator (nodeID): <input type="text"/> (Max 10 characters)		
Select Communication Module Communication Module: <input type="button" value="802.15.4 2.4GHz"/> <small>* Mandatory fields</small> MAC: <input type="text" value="0013A2004052414"/> <input type="button" value="Generate Code"/>		

Figure : Selecting communication module

Step 5: Additional information

If you are using the accelerometer, select the corresponding check box to collect this data. Also a mote identifier can be set here

› WaspMote - Plug & Sense! - Code Generator

* Select Model	* Sleeping Time	* Select sensor by socket
Board model: <input type="button" value="Smart Environment"/>	Time (seconds): <input type="text" value="300"/>	A: NH3 B: Humidity C: Carbon dio D: Select E: Select F: Select
Additional information		
Add Accelerometer 3 Axis data: <input checked="" type="checkbox"/> Add GPS coordinates: <input checked="" type="checkbox"/> WaspMote identificator (nodeID): <input type="text" value="Waspmote01"/> (Max 10 characters)		
Select Communication Module Communication Module: <input type="button" value="802.15.4 2.4GHz"/> <small>* Mandatory fields</small> MAC: <input type="text" value="0013A2004052414B"/> <input type="button" value="Generate Code"/>		

Figure : Selecting additional information

Step 6: Press "generate code" button

The code is generated and it is also displayed. Always check the generated code to understand how it works. Now you can download the code and upload it to your WaspMote Plug & Sense!.

› WaspMote - Plug & Sense! - Code Generator

*** Select Model**

Board model:

*** Sleeping Time**

Time (seconds):

*** Select sensor by socket**

A:	NH3	B:	Humidity	C:	Carbon dio
D:	Select	E:	Select	F:	Select

Additional information

Add Accelerometer 3 Axis data: Add GPS coordinates: WaspMote identifier (nodeID): (Max 10 characters)

Select Communication Module

Communication Module:

MAC:

** Mandatory fields*

► Generate Code

► Download Code

› Generated Code

```
// Step 1
#include <WaspSensorGas.h>
#include <WaspXBee802.h>

// Step 2

char CONNECTOR_A[3] = "CA";
char CONNECTOR_B[3] = "CB";
char CONNECTOR_C[3] = "CC";
char CONNECTOR_D[3] = "CD";
char CONNECTOR_E[3] = "CE";
char CONNECTOR_F[3] = "CF";
```

Figure : Generating the code

For further information and questions about codes for WaspMote Plug & Sense!, please refer to [Libelium website](#) and ask in the dedicated forum.

Note: The Gateway is just a UART-USB bridge. This means that the Gateway cannot be programmed and code cannot be uploaded.

20.2. Real time Clock - RTC

WaspMote Plug & Sense! has a built in Real Time Clock – RTC, which keeps it informed of the time. This allows to program and perform time-related actions such as:

"Sleep for 1h 20 min and 15sec, then wake up and perform the following action"

Or even programs to perform actions at absolute intervals, e.g.:

"Wake on the 5th of each month at 00:20 and perform the following action"

All RTC programming and control is done through the I2C bus.

Alarms:

Alarms can be programmed in the RTC specifying day/hour/minute/second. That allows total control about when the mote wakes up to capture sensor values and perform actions programmed on it. This allows WaspMote Plug & Sense! to be in the saving energy mode (Deep Sleep) and makes it wake up just at the required moment.

As well as relative alarms, periodic alarms can be programmed by giving a time measurement, so that the node reprograms its alarm automatically each time one is triggered.

WaspMote Plug & Sense! can keep the RTC time correctly even if the ON / OFF button is switched to OFF position.

RTC module has an internal compensation mechanism for the oscillation variations produced in the quartz crystal by changes in temperature (Temperature Compensated Crystal Oscillator – TCXO).

Most RTCs on the market have a variation of $\pm 20\text{ppm}$ which is equivalent to a 1.7s loss of accuracy per day (10.34min/year), however, the model used in WaspMote Plug & Sense! has a loss of just $\pm 2\text{ppm}$, which matches to a variation of 0.16s per day (1min/year).

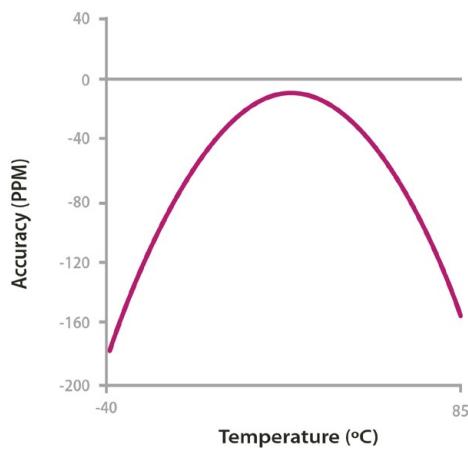


Figure : Uncompensated variation curve

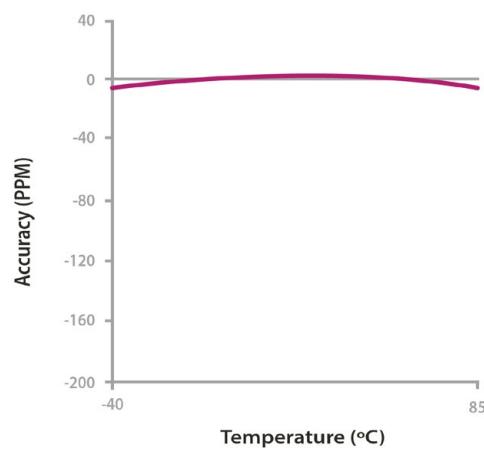


Figure : Compensated variation curve

As shown, variations in accuracy are near to zero at room temperature and minimal when moved to the ends of the temperature scale.

Source: Maxim-ic.com

(For more information about clock calibrating methods in real time, consult web page:
http://www.maxim-ic.com/appnotes.cfm/an_pk/3566)

The recalibration process of the oscillation crystal is carried out thanks to the data received by the RTC's internal temperature sensor .

Note: the RTC's internal temperature sensor is only meant for the time derive compensation, but not for common air temperature sensing (we advise our Sensor Boards for that).

The RTC is responsible for waking the node up from energy saving mode called Deep Sleep. In addition, it controls when it has to wake up the node and perform a particular action.

All information about their programming and operation can be found in the RTC programming Guide available at the [Development section](#) of Libelium website.

20.3. Interruptions

At the request of the microcontroller, it receives all types of interruption as hardware interruptions.

There are only five sensors that can cause an interruption:

- Pluviometer
- Presence (PIR)
- Hall effect
- Liquid presence
- Liquid level

The sensors are mainly connected to WaspMote through the microprocessor's analog and digital inputs. Libelium developed several sensor integration boards which facilitate their connection with the processing unit. Each one of these sensor boards has several pins used to manage the generation and capture of interruptions.

When an interruption is generated by a sensor, the main loop of the program stops, and the corresponding subroutine for the sensor is executed. After that, main loop continues with normal operation.

If more information about WaspMote interruptions is required, please refer to the interruptions programming guide available at the [Development section](#) of Libelium website.

21. Uploading code

Using the USB connector, a new code can be uploaded to WaspMote without opening WaspMote Plug & Sense!. Just connect one side of the USB cable to this connector, removing protection cap if necessary and connect the other side to a PC. Remember that WaspMote must be ON to allow uploading a new code. Next steps describe this process in detail.

Step 1: Open the USB connector

Remove the protection cap of the USB connector.



Figure : Removing the USB cap

* In the case you have a Plug & Sense! with GPRS or 3G modules, insert your micro-SIM card in the External SIM socket with care.



Figure : Inserting a SIM card with care in the External SIM socket

Step 2: Connect the USB cable to Wasp mote Plug & Sense!

Connect one side of the provided male-to-male USB cable to the USB connector. For models with GPRS or 3G modules, a micro-USB is supplied.



Figure : Connecting the USB cable to Wasp mote Plug & Sense!

Step 3: Connect the USB cable to PC

Connect the other side of the USB cable to your PC.



Figure : Connecting the node to a PC

Step 4: Turn On Wasp mote Plug & Sense!

Be sure you have turned ON the node by pressing ON/OFF button.



Figure : Turning ON Wasp mote

Step 5: Open Wasp mote IDE

Now open Wasp mote IDE. If you do not have Wasp mote IDE already installed in your PC, then go to the [Development section](#) of Libelium website to download the latest version ; there is a dedicated guide to help in the process: "Wasp mote IDE: User Guide".

If it is the first time you plug a Wasp mote Plug & Sense! on your PC and you are unable to see the proper USB port, maybe you should install the latest FTDI drivers: <http://www.ftdichip.com/Drivers/D2XX.htm>

Moreover, if you have troubles installing FTDI drivers and your computer is unable to recognize Wasp mote, please follow the installation guide for your operating system on your next link: <http://www.ftdichip.com/Support/Documents/InstallGuides.htm>

Step 6: Select the corresponding code

Build your own code for your model using the online code generator provided by Libelium at the [Development section](#) of Libelium website (see corresponding section for details about how to use the code generator). Download and open it in Waspmote IDE.

Save the sketch (Waspmote IDE has a button for that), for example with the name “Waspmote_Plug_Sense_test_code”, and check the IDE message “Done Saving”.

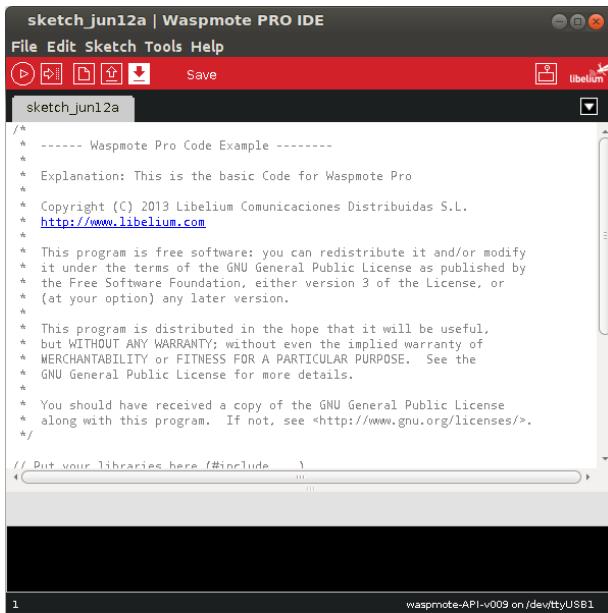


Figure : Preparing code for Waspmote Plug & Sense!

Step 7: Select the corresponding API

Select the latest API version going to tools/board. There can be only one API in each installed IDE. Please read the “IDE: User Manual” for more details.

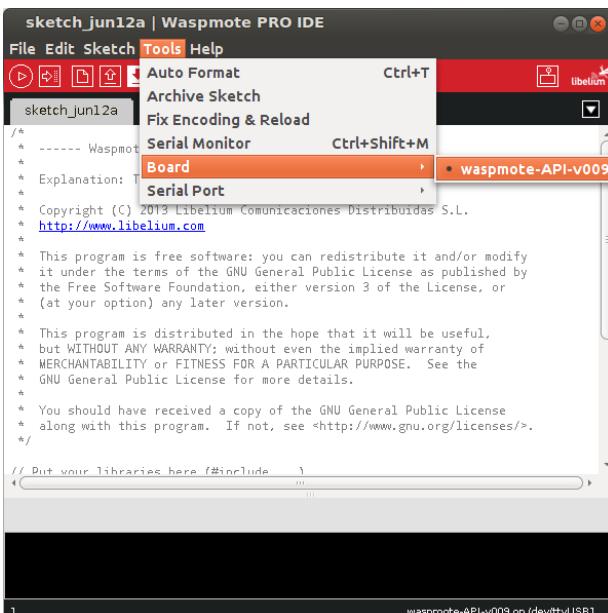


Figure : Selecting API

Please notice that Waspmote “OEM” and Plug & Sense! share the same API and IDE. The same software system is valid for both platforms.

Step 8: Select the USB port

Select the corresponding serial port by going to tools/serial port. If you are unable to see the proper USB port maybe you should install the latest FTDI drivers.

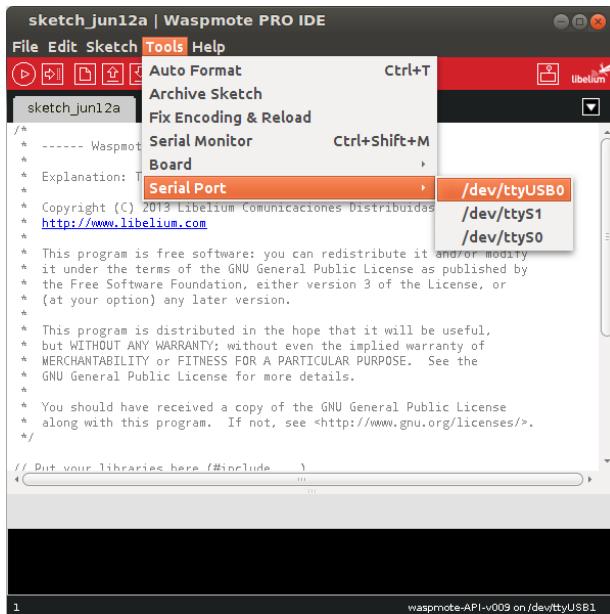


Figure : Selecting the USB port for Waspmote Plug & Sense!

Note: the name of the USB ports depends on the OS and the particular PC you have. The best way to find the USB where Waspmote is connected is trial & error.

Step 9: Compile the code

Compile the code (the IDE has a button for that), and check there are no errors or warnings. The IDE should say "Done Compiling".

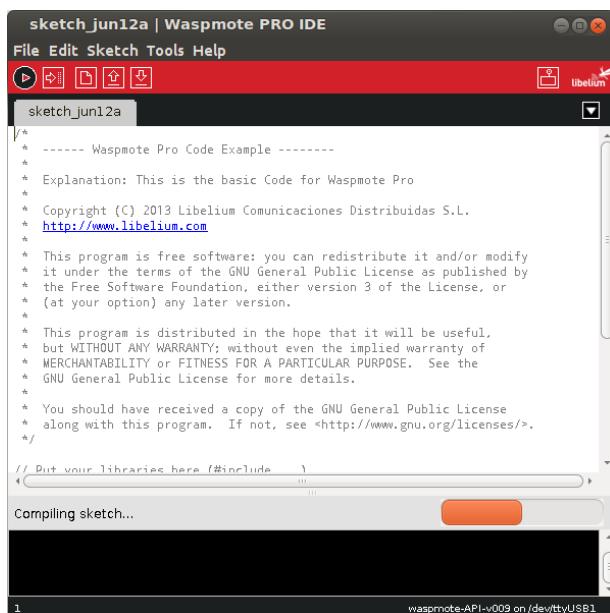


Figure : Compiling a code for Waspmote Plug & Sense!

Step 10: Upload the code

Now, press the upload button and see messages coming out from IDE. During a while you will see message "uploading to I/O board".



Figure : Uploading a code for Waspmote Plug & Sense!

Wait a few seconds until the process ends and check there are no error messages, just "Done uploading" message.

Step 11: Open the Serial Monitor

If uploading processes are successfully completed, open Serial Monitor to see the output of the uploaded code.

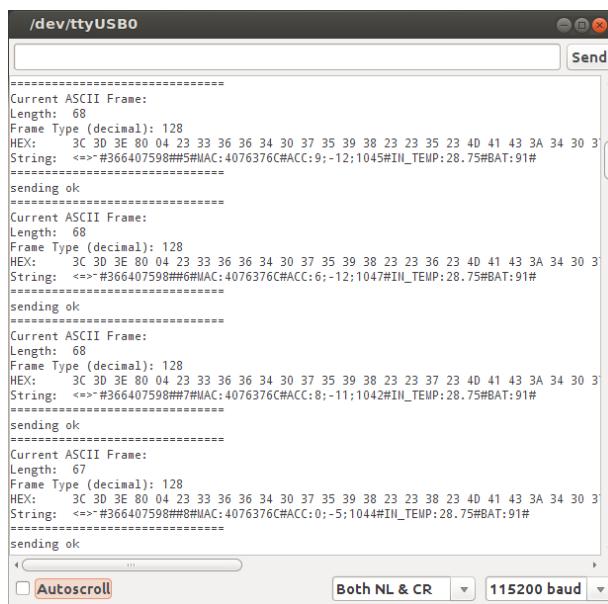


Figure : Opening Waspmote IDE serial monitor

When uploading processes are finished successfully, do not forget to screw the protection cap of USB connector to avoid its damage.

Never connect a USB which exceed maximum rating of the USB standard. Waspmote can be damaged and warranty voided.

22. Over the air programming – OTA

22.1. Overview

The concept of Wireless Programming or commonly known as Programming Over the Air (OTA) has been used in the past years overall for the reprogramming of mobile devices such as cell phones. However, with the new concepts of Wireless Sensor Networks and the Internet of Things where the networks consist of hundreds or thousands of nodes OTA is taken to a new direction, and for the first time it is applied using unlicensed frequency bands (2.4GHz, 868MHz, 900MHz) and with low consumption and low data rate transmission using protocols such as 802.15.4 and ZigBee.

Besides, Libelium provides an OTA method based on FTP transmissions to be used with GPRS, GPRS+GPS, 3G and WiFi modules.

Note that the concept of OTA may have some other names such as:

- Over the air → OTA
- Over the air Programming → OTAP
- Firmware over the air → FOTA
- Programming Over the air → POTA
- Over the air service provisioning → OTASP
- Over the air provisioning → OTAP
- Over the air parameter administration → OTAPA
- Over the air upgrade → OTAU
- Over the air update → OTAUR
- Over the air Download → OAD
- Over the air flashing → OTAF
- Over the air parameter administration → OTAPA
- Multihop Over the air programming (MOTAP)

22.2. Benefits

Libelium OTA Benefits:

OTA with 802.15.4/ZigBee:

- Enables the upgrade or change of firmware versions without physical access.
- Discover nodes in the area just sending a broadcast discovery query.
- Upload new firmware in few minutes.
- No interferences: OTA is performed using a change of channel between the programmer and the desired node so no interferences are generated to the rest of the nodes.

OTA with 3G/GPRS/WiFi:

- Enables the upgrade or change of firmware versions without physical access.
- Upgrades the new firmware by querying a FTP server which helps to keep battery life.
- Upload new firmware in few minutes.

22.3. Concepts

There are two different OTA methodologies:

- OTA with 802.15.4/ZigBee modules
- OTA with 3G/GPRS/WiFi modules via FTP

OTA with 802.15.4/ZigBee modules

The idea is simple. When the programmer (normally the Gateway) sends a new program it is stored in the SD card. A second command “start_new_program” is needed in order to make them start. Then, the nodes copy the program from the SD card to the Flash memory and start the new program.

Steps:

- Locate the node to upgrade
- Check current software version
- Send the new program
- Reboot and start with the new program
- Restore the previous program if the process fails

OTA modes:

- Unicast: Reprogram a specific node
- Multicast: Reprogram several nodes at the same time sending the program just once
- Broadcast: Reprogram the entire network sending the program just once

Topologies:

- Direct access: when the nodes are accessed in just one hop (no forwarding of the packets is needed)
- Multihop: when the nodes are accessed in two or more hops. In this mode some nodes have to forward the packets sent by the Gateway in order to reach the destination

Protocols supported:

- 802.15.4 - 2.4GHz (Worldwide)
- ZigBee - 2.4GHz (Worldwide)
- DigiMesh - 2.4GHz (Worldwide)
- RF - 868MHz (Europe)
- RF - 900MHz (US, Canada, Australia)

Storage System:

Once we have sent the program to WaspMote it will store it in the internal memory, a 2GB SD card.

If we have into account that the maximum size for a program is 128KB, this means we can store thousands different firmware versions inside each node.

Encryption and Authentication:

All the data which is sent in the OTA process can be secured by activating the encryption algorithm AES 128b which works in the link layer. As well as this, a second pass key is needed to be known by the OTA programmer (the Gateway) in order to be authenticated and validated by each node before starting with the OTA action requested.

OTA-Shell:

The OTA-Shell application can be used in Windows, Linux and MacOS. It allows to control in a quick and powerful way all the options available in OTA. If you are using Meshlium as the Gateway of the network, the OTA-Shell environment comes already preinstalled and ready to use. This is the recommended way when deploying a real scenario.

OTA with 3G/GPRS/WiFi modules via FTP

The reprogramming process in this type of OTA is initiated by Wasp mote and it is supported by an FTP server.

Steps:

- Wasp mote queries the FTP server for a new program version
- Check if program name, path and version are correct
- Download the new program
- Reboot and start with the new program

Topologies:

- Protocols which support FTP transmissions are directly connected to the Network Access Point

Protocols supported:

- 3G - Dual-Band WCDMA/UMTS 900/2100 MHz
- GPRS - Tri-Band GSM/GPRS/EDGE 850/900/1800 MHz
- WiFi - 2.4GHz (Worldwide)

Storage System:

Once the program is downloaded to Wasp mote it is stored in the 2GB SD card.

Meshlium OTA-FTP plug-in

Meshlium provides a FTP server and Manager System plug-in which permits to configure the server automatically by attaching the program binary file to be used.

22.4. OTA with 802.15.4/ZigBee modules

22.4.1. OTA Step by Step

- **Locate the node or nodes to upgrade**

Using the ‘scan_nodes’ function we can search for a specific node or send a global query looking for any node which is ready to be reprogrammed with the OTA process.

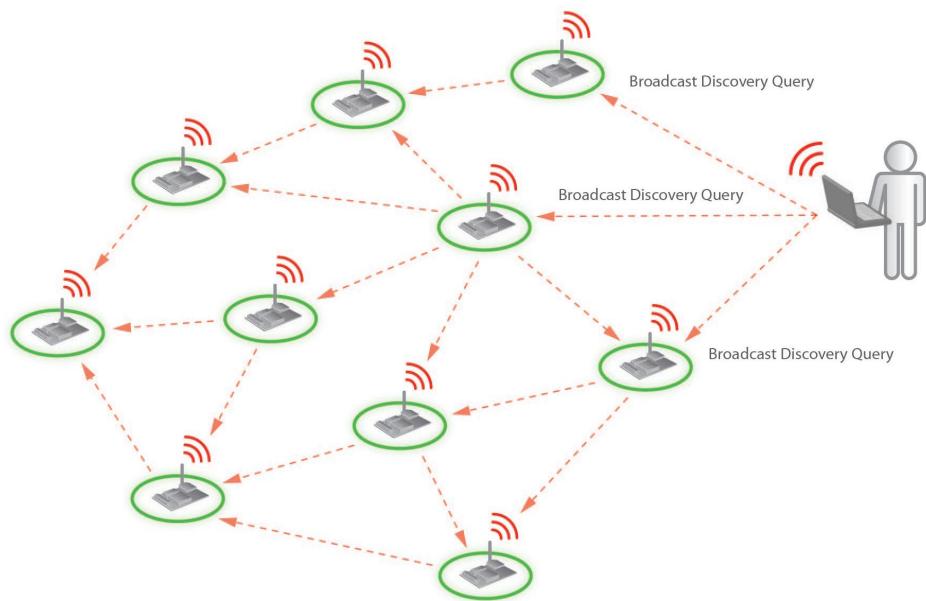


Figure : Sending Broadcast discovery queries

The nodes which are ready at this moment will answer with a “Ready to OTA” frame.

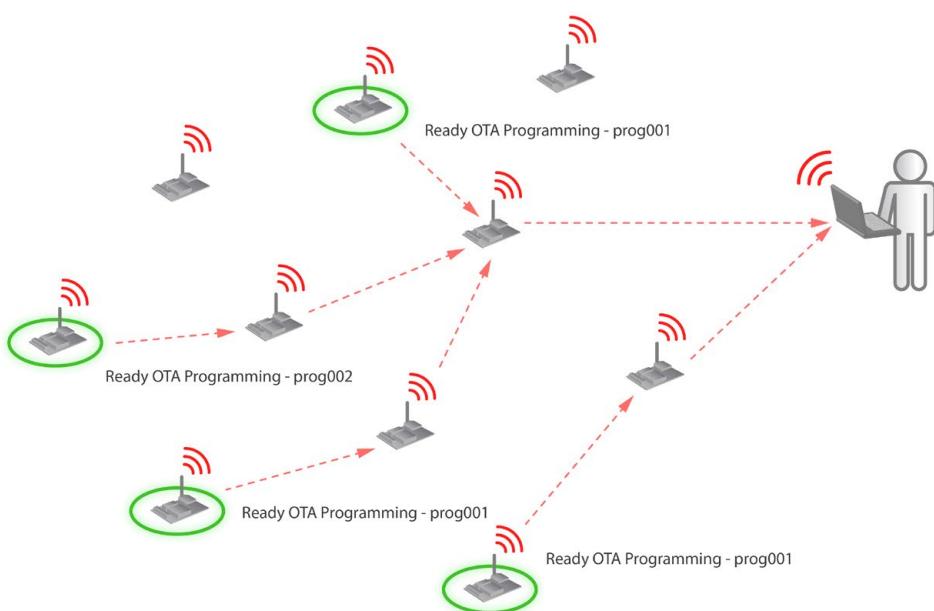


Figure : Waspotes reply to discovery queries

- Send the new program

We can use the 'send' command with the unicast, multicast or broadcast option depending on how many nodes we want to reprogram at the same time.

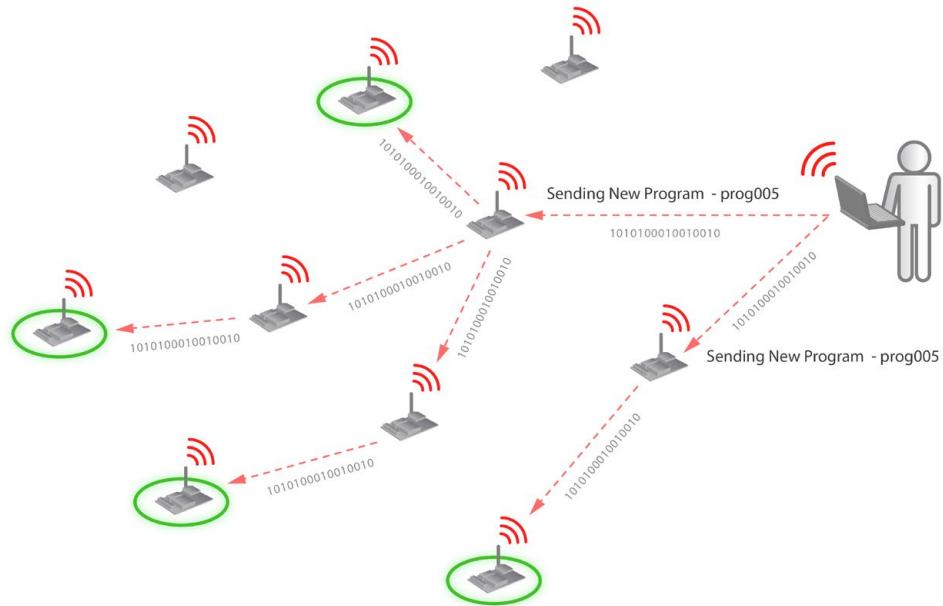


Figure : Sending new program via OTA

Each node which receives the program sends a message to the Gateway to inform of the success of the process.

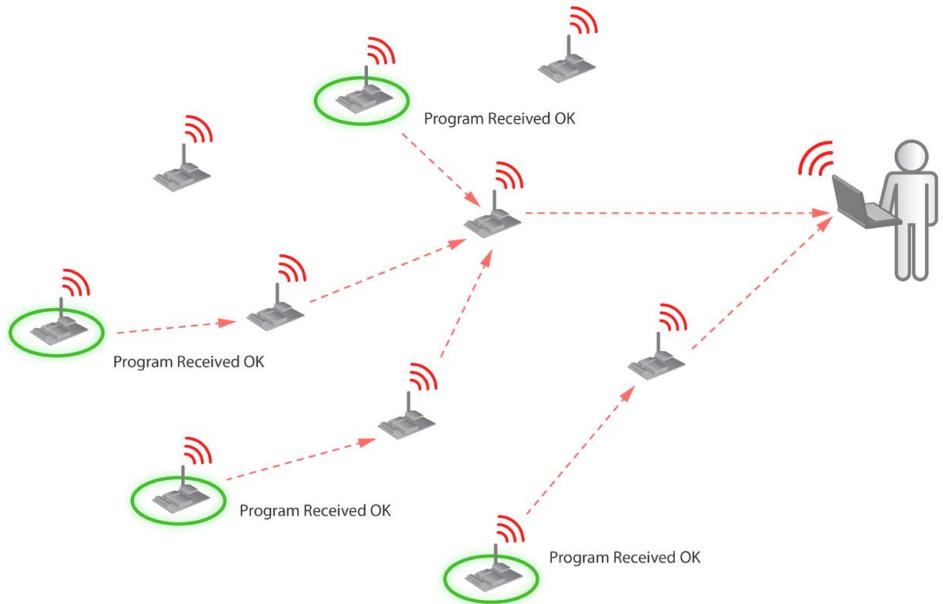


Figure : Wasp motes reply OTA process was alright

- Reboot and start with the new program**

In order to make the nodes start executing the new program, the Gateway needs to send the 'start_new_program' command.

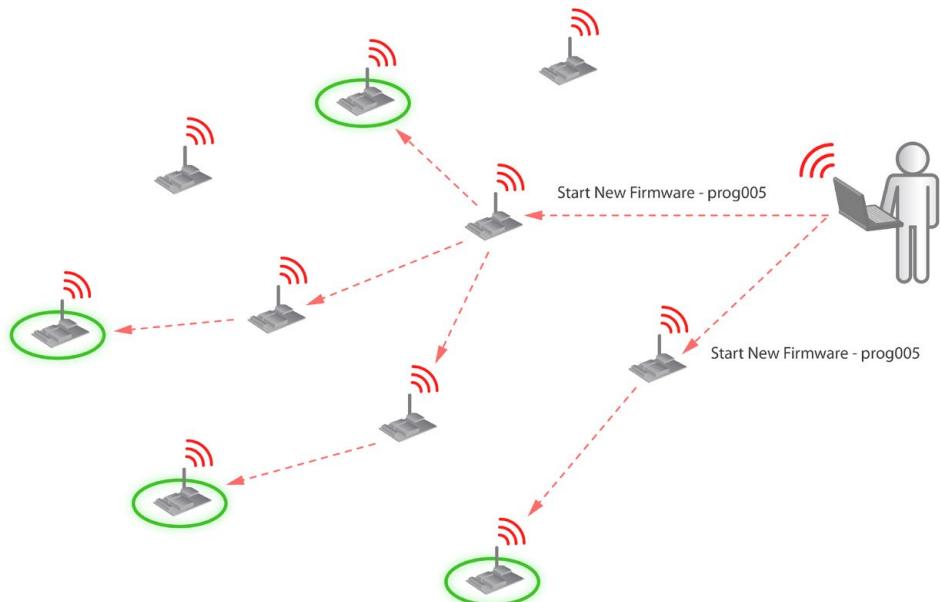


Figure : OTA Gateway commands some Wasp motes to start a new program

Each node which receives this packet will copy the program from the SD to the Flash memory and will start running the new binary.



Figure : Wasp motes confirm the new program was started

22.4.2. OTA Shell

A powerful command line application called 'OTA Shell' has been developed in order to manage all the features of OTA.

The environment needed to execute OTA Shell comes already preinstalled in Meshlium (the Linux router developed by Libelium which acts as the ZigBee Gateway of the sensor network). Although it can also be executed in a Linux, Windows and Mac OS system.

All information about their programming and operation can be found in the Over the Air Programming Guide available at the Development section of Libelium website.

In order to know more about OTA including how to download and use the OTA Shell application please go to the Development section:

http://www.libelium.com/development/plug_&_sense

22.5. OTA with 3G/GPRS/WiFi modules via FTP

It is possible to update the WaspMote's program using Over The Air Programming and the following modules: 3G, GPRS or WiFi module.

22.5.1. Procedure

The WaspMote reprogramming is done using an FTP server and an FTP client which is WaspMote itself. The FTP server can be configured by Meshlium. Otherwise, the user will have to setup an FTP server.

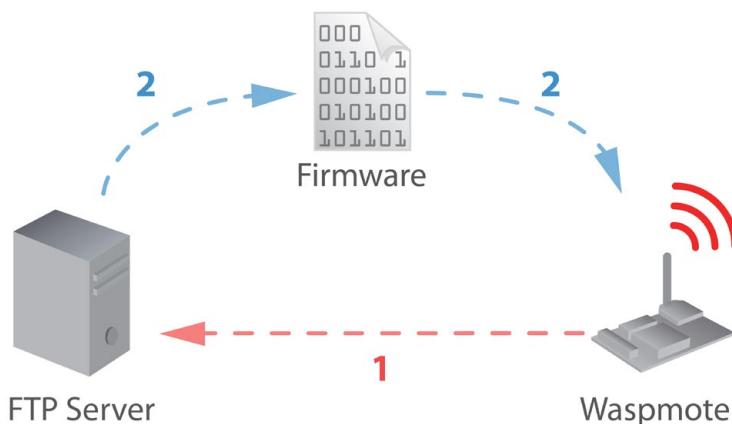


Figure : OTA via FTP protocol

There are two basic steps involved in OTA procedure:

- **Step 1:** WaspMote requests a special text file which gives information about the program to update: program name, version, size, etc.
- **Step 2:** If the information given is correct, WaspMote queries the FTP server for a new program binary file and it updates its flash memory in order to run the new program.

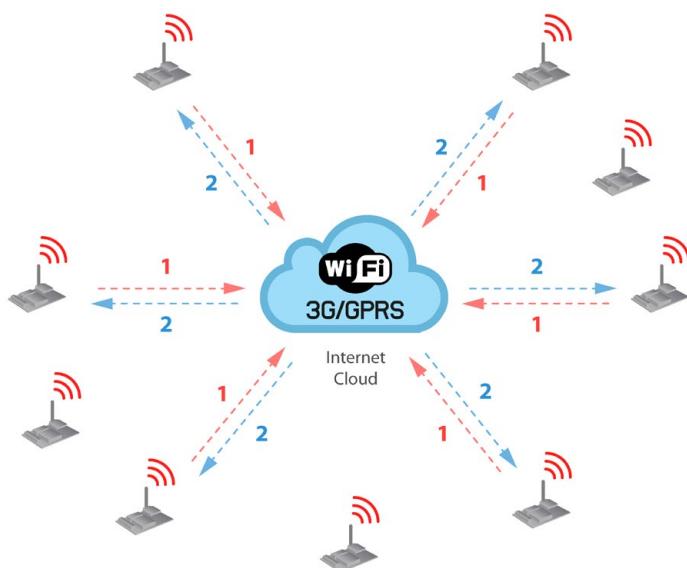


Figure : OTA steps via FTP protocol

22.5.2. Setting the FTP server configuration

The FTP server that WaspMote connects to needs a specific configuration so as to OTA work properly. There are two ways to set up the FTP server:

Extern user's FTP server: The user sets up an FTP server following the specific settings which are described within OTA Guide.

Meshlium FTP server: There is a specific plugin which allows the user to setup the FTP server automatically indicating the new binary to be downloaded.

23. Encryption Libraries

The new Encryption Libraries are designed to add to the WaspMote sensor platform the capabilities necessary to protect the information gathered by the sensors. To do so **two cryptography layers** are defined:

- **Link Layer:** In the first one all the nodes of the network share a common **preshared key** which is used to encrypt the information using **AES 128**. This process is carried out by specific hardware integrated in the same 802.15.4/ZigBee radio, allowing the maximum efficiency of the sensor nodes energy consumption. This first security layer ensures no third party devices will be able to even connect to the network (access control).
- **Secure Web Server Connection:** The second security technique is carried out in Meshlium -the Gateway- where **HTTPS** and **SSH** connections are used to send the information to the Cloud server located on the Internet.

A third optional encryption layer allows each node to encrypt the information using the Public key of the Cloud server. Thus, the information will be kept confidentially all the way from the sensor device to the web or data base server on the Internet.

23.1. Transmission of sensor data

Information is encrypted in the application layer via software with **AES 256** using the key shared exclusively between the origin and the destination. Then the packet is encrypted again in the link layer via hardware with **AES 128** so that only trusted packets be forwarded, ensuring access control and improving the usage of resources of the network.

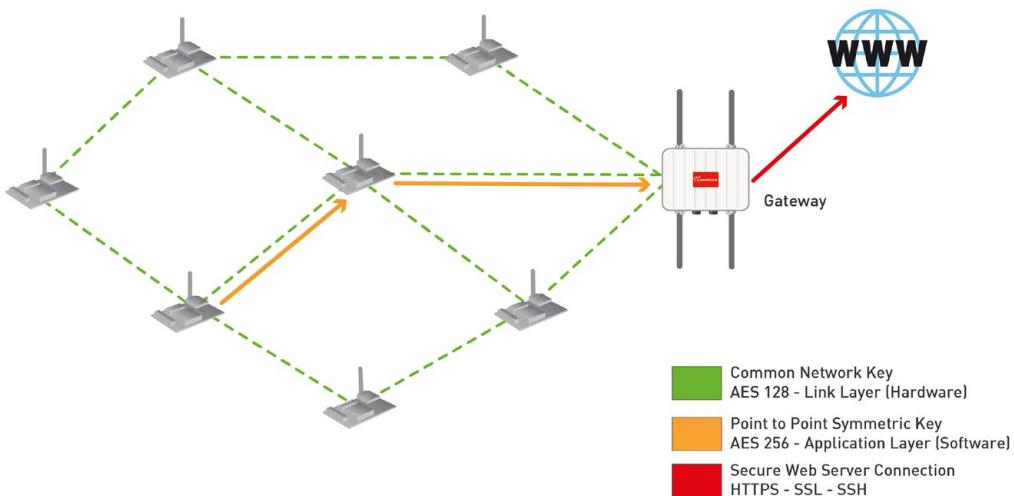


Figure : Communication diagram

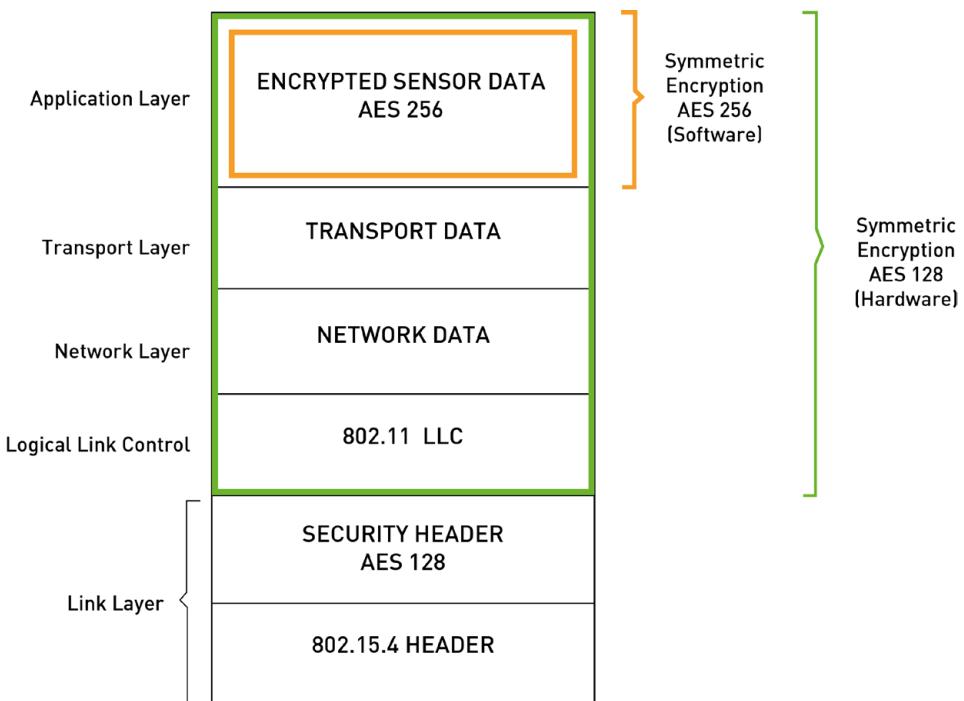


Figure : Wasp mote frame on OSI stack for communication

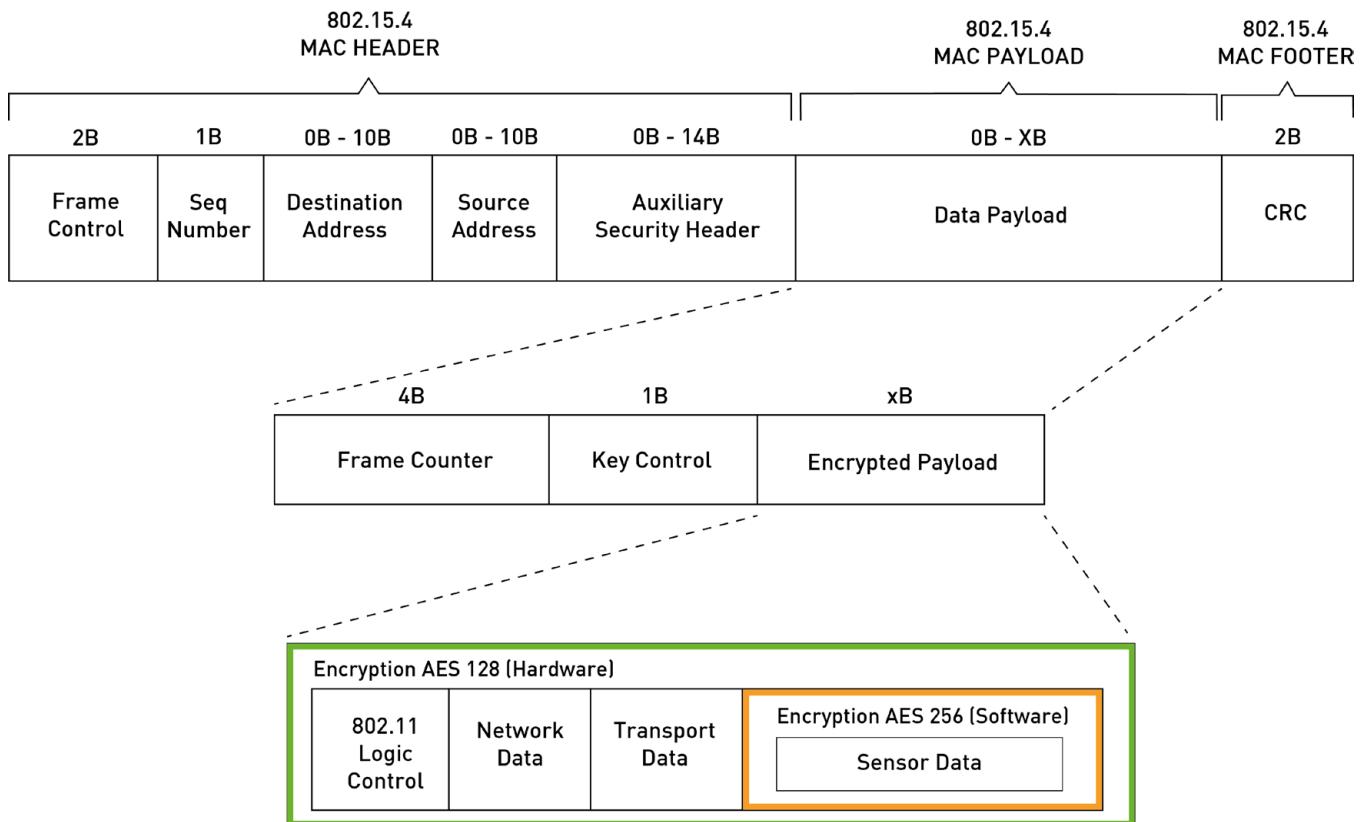


Figure : Wasp mote frame structure for communication

Note: For more information read the “Encryption Programming Guide” in the Wasp mote [Development section](#)

24. Interacting with Wasp mote Plug & Sense!

24.1. Receiving XBee frames with Wasp mote Gateway

24.1.1. Wasp mote Gateway

This device allows the collection of data which flows through the sensor network into a **PC** or device with a standard USB port. Wasp mote Gateway will act as a "**data bridge or access point**" between the sensor network and the receiving equipment. This receiving equipment will be responsible for storing and using the data received depending on the specific needs of the application.



Figure : Wasp mote Gateway

The receiving equipment can be a PC with Linux, Windows or Mac-OS, or any device compatible with standard USB connectivity. The Gateway offers a "plug" **USB A** connector, so the receiving device has to have a "receptacle" USB A connector.

Once the Gateway is correctly installed, a new communication serial port connecting directly to the XBee module's UART appears in the receiving equipment, which allows the XBee to communicate directly with the device, being able to both receive data packets from the sensor network as well as modify and/or consult the XBee's configuration parameters.

Another important function worth pointing out is the possibility of **updating or changing the XBee module's firmware**.

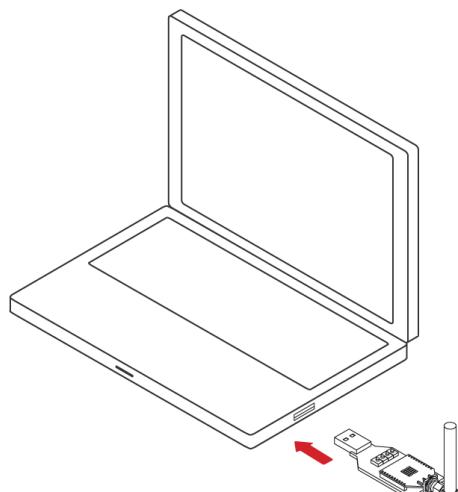


Figure : Wasp mote Gateway connected in a PC

LEDs

Four indicator LEDs are included in the Gateway:

- USB power LED: indicates that the board is powered through the USB port
- X LED: indicates that the board is receiving data from the USB port.
- TX LED: Indicates that the board is sending data to the USB port
- I/O 5 configurable LED: associate

The configurable LED connected to the XBee's I/O 5 pin can be configured either as the XBee's digital output or as the XBee's indicator of association to the sensor network.

Buttons

- Reset: allows the XBee module to be reset.
- I/O - 0: button connected to the XBee's I/O pin 0.
- I/O - 1: button connected to the XBee's I/O pin 1.
- RTS - I/O – 6: button connected to the XBee's I/O pin 6.

All the buttons connect each one of its corresponding data lines with GND when pressed. None of these have pull-up resistance so it may be necessary to activate any of the XBee's internal pull-up resistances depending on the required use.

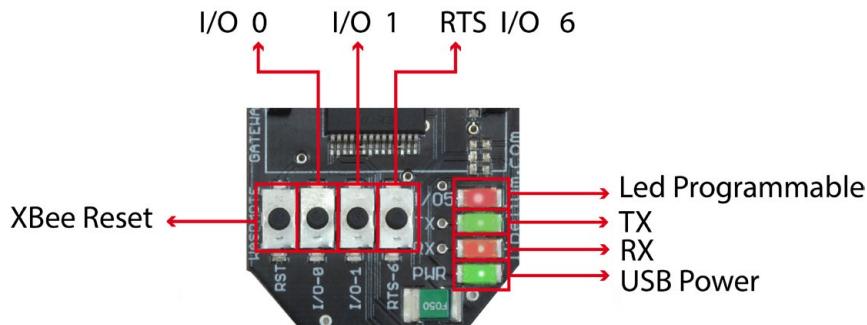


Figure : LEDs in WaspMote Gateway

24.1.2. Linux receiver

When using Linux it is possible to use various applications to capture the input from the serial port. Libelium recommends to use the 'CuteCom' application.

Once the application is launched the speed and the USB where WaspMote has been connected must be configured.

The speed that must be selected is 115200 which is the standard speed set up for WaspMote.

The USB where WaspMote has been connected must be added the first time this application is run, adding USB0, USB1, etc (up to the USB number of each computer) according to where WaspMote has been connected. For this, the 'Device' window must be modified so that if WaspMote is connected to USB0, this window contains '/dev/ttyUSB0'.

Once these parameters are configured, capture is started by pressing the 'Open Device' button.

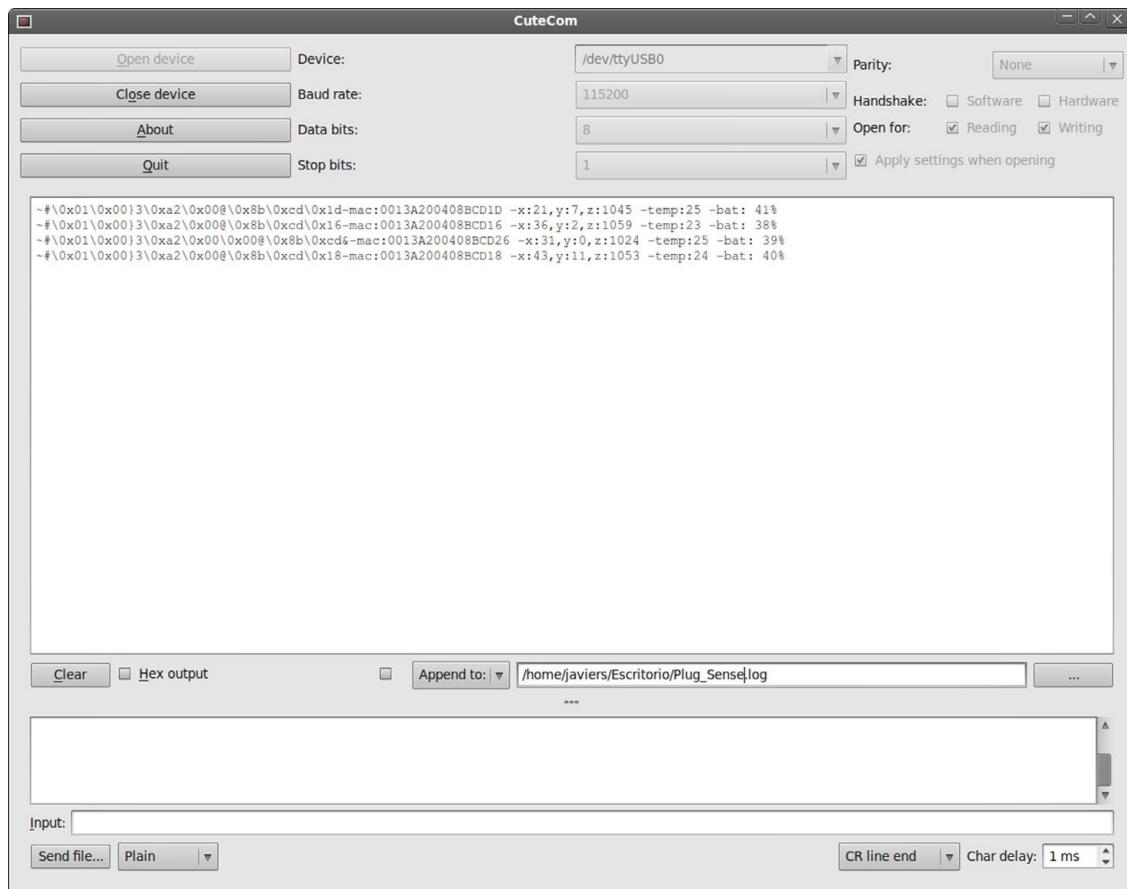


Figure : Cutecom application capturing Waspmote's output

24.1.3. Windows receiver

If Windows is used, the application 'Hyperterminal' can be used to capture the output of the serial port.

This application can be found installed by default in 'Start/Programs/Accessories/Communication', but if it is not available it can be downloaded from: <http://hyperterminal-private-edition-hpe.en.softonic.com/>

Once this application is launched the connection must be configured. The first step is to give it a name



Figure : Step 1 of establishing connection

The next step is to specify the port on which WaspMote has been connected, in this case the system recognizes it as 'COM9' (this will vary on each computer):



Figure : Step 2 of establishing connection

The next step is to specify the speed and configuration parameters:

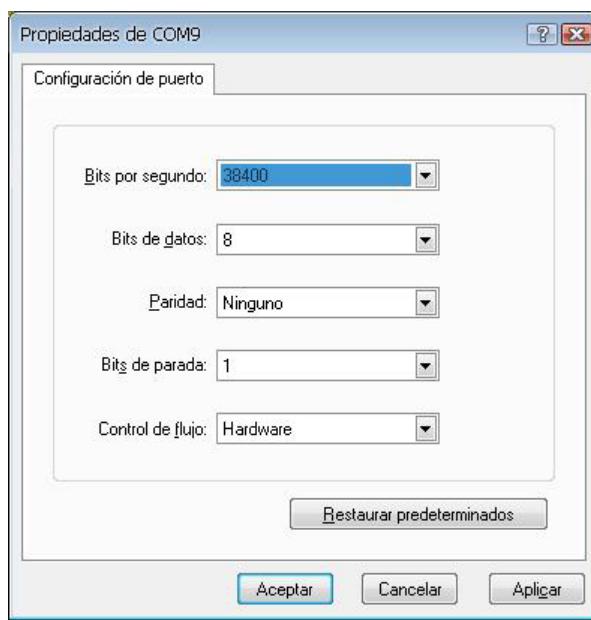


Figure : Step 3 of establishing connection

Once these steps have been performed connection with WaspMote has been established, and listening to the serial port begins.

The following image shows this application capturing WaspMote's output, while the example code 'WaspMote Accelerator Basic Example' is run.

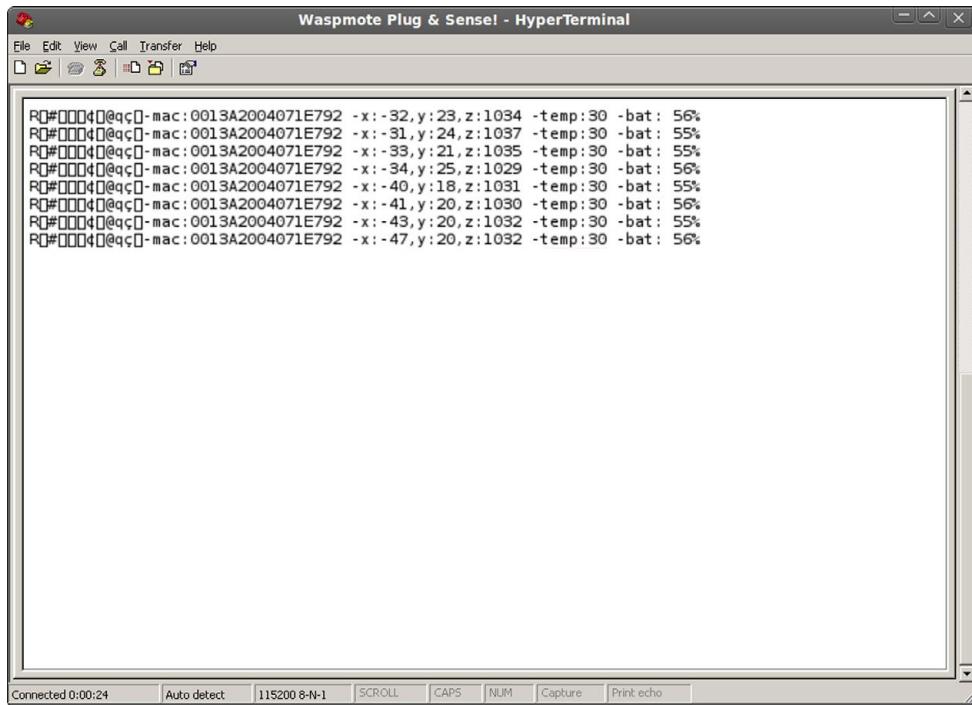


Figure : HyperTerminal application capturing Waspmote's output.

24.1.4. Mac-OS receiver

If MAC OS X is used (version later than 10.3.9) the application 'ZTERM' can be used to capture the serial port output. This application can be downloaded from: <http://www.dalverson.com/zterm/>

This application is configured automatically, establishing the USB on which Waspmote has been connected and the speed.

The following image shows this application capturing Waspmote's output, while the example code 'Waspmote Accelerator Basic Example' is run.

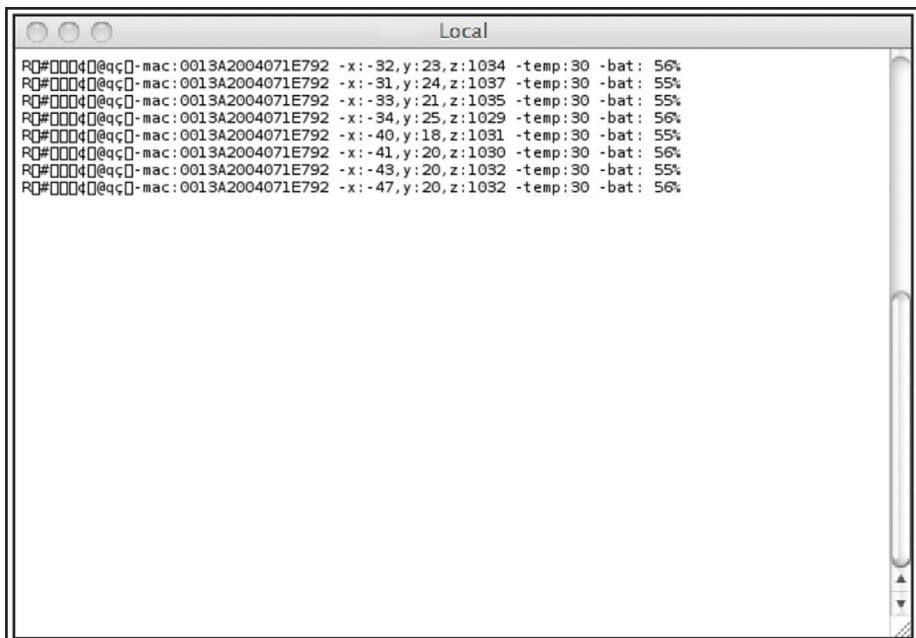


Figure : Waspmote's output capture

24.2. Meshlium



Figure : Meshlium Gateway

Meshlium is a Linux router which works as the Gateway of the Waspmote sensor network. It can contain different radio interfaces: WiFi 2.4GHz, WiFi 5GHz, **3G/GPRS**, Bluetooth and **XBee/LoRa**. As well as this, Meshlium can be solar and battery powered. These features along with an **aluminium IP-65 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, XBee, LoRa, Bluetooth and 3G/GPRS configurations a long with the storage options of the sensor data received.

Meshlium Xtreme allows you to even detect iPhone and Android devices and in general any device which works with WiFi or Bluetooth interfaces. The idea is to be able to measure the amount of people and cars which are present in a certain point at a specific time, allowing the study of the evolution of the traffic congestion of pedestrians and vehicles.

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

24.2.1. What can I do with Meshlium?

- Connect your wireless network to Internet through Ethernet, WiFi and 3G/GPRS
- Store the sensor data in a local or external data base in just one click!
- Create a WiFi Mesh Network in just two steps!
- Set a WiFi Access point in 1 minute
- Discover Bluetooth users and store their routes

24.2.2. How do they work together?

Meshlium receives the sensor data sent by Wasp mote using its wireless radios.

Then 4 possible actions can be performed:

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

24.2.2.1. Meshlium Storage Options

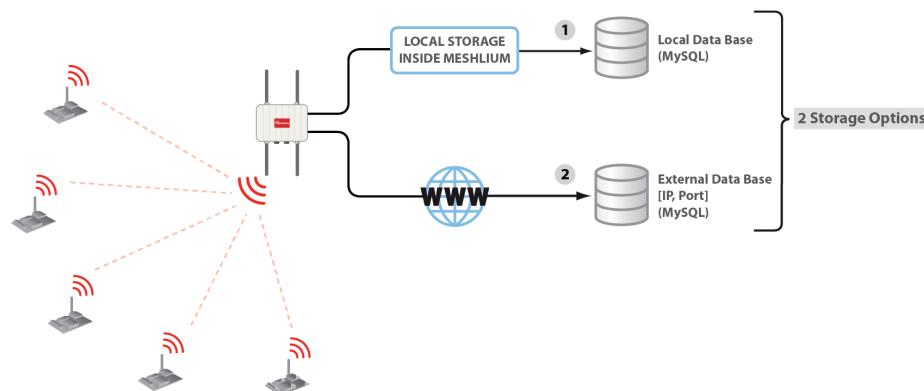


Figure : Meshlium Storage Options

- Local Data Base
- External Data Base

24.2.2.2. Meshlium Connection Options

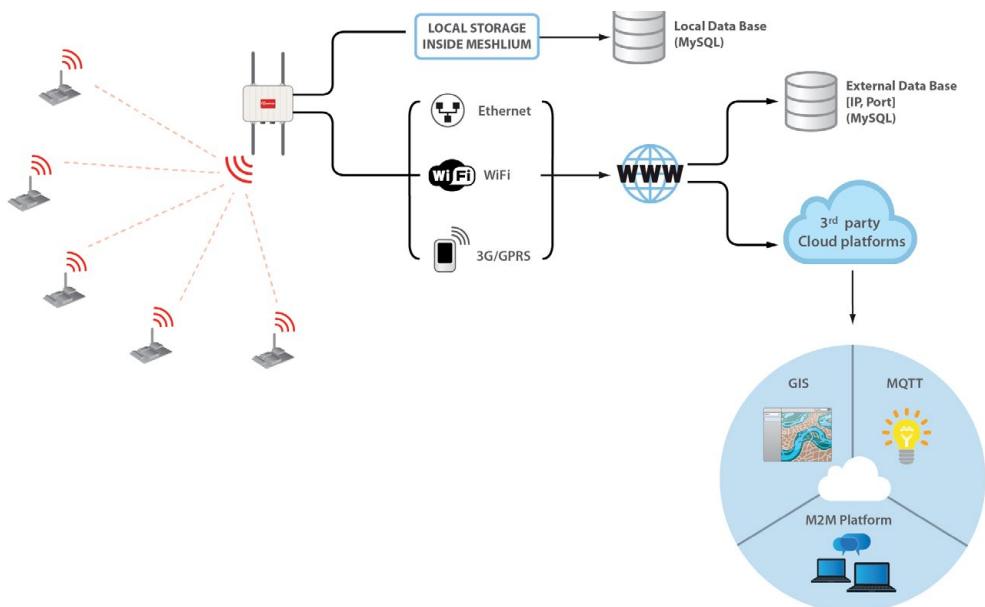


Figure : Meshlium Connection Options

- XBee / LoRa / GPRS / 3G / WiFi → Ethernet
- XBee / LoRa / GPRS / 3G / WiFi → WiFi
- XBee / LoRa / GPRS / 3G / WiFi → 3G/GPRS

24.2.3. Capturing and storing sensor data in Meshlium from a Waspmote sensor network

When you buy a kit containing Waspmotes, Gateway and Meshlium, the Waspmotes come already configured to send frames to the Gateway. Later, once the user has developed the code for transmitting to Gateway, he can switch to Meshlium.

Meshlium will receive the sensor data sent by Waspmote using the wireless radio and it will store the frames in the Local Data Base. That can be done in an automatic way thanks to the **Sensor Parser**.

The **Sensor Parser** is a software system which is able to do the following tasks in an easy and transparent way:

- receive frames from XBee and LoRa (with the Data Frame format)
- receive frames from 3G/GPRS, WiFi and Ethernet via HTTP protocol (Manager System version 3.1.4 and above)
- parse these frames
- store the data in a local Database
- synchronize the local Database with an external Database

Besides, the user can add his own sensors.

The initial frames sent by Waspmote contain the next sequence (XBee API frame characters are removed here):

```
-\0x00I\0x90\0x00}3\0xa2\0x00@z\0xcb\0x92\0xd8\0xd3\0x02<=>\0x80\0x03#35689722##7#ACC:80;10
;987#IN_TEMP:22.50#BAT:93#\0xb4
```

Initially there are some hexadecimal characters, which belong to the API frame, followed by the message. In the above example the message is:

```
<=>\0x80\0x03#35689722##7#ACC:80;10;987#IN_TEMP:22.50#BAT:93#
```

They are formed by the accelerometer values, RTC internal temperature value, and battery level. The MAC address is added and other helpful information.

Meshlium comes with all the radios ready to be used. Just “plug & mesh!”. All the Meshlium nodes come with the WiFi AP ready so that users can connect using their WiFi devices. Connect the Ethernet cable to your network hub, restart Meshlium and it will automatically get an IP from your network using DHCP *.

(*) For the Meshlium Mesh AP and for the Meshlium XBee Mesh AP the Internet connection depends on the GW of the network.

Then access Meshlium through the WiFi connection. First of all search the available access points and connect to “Meshlium”.

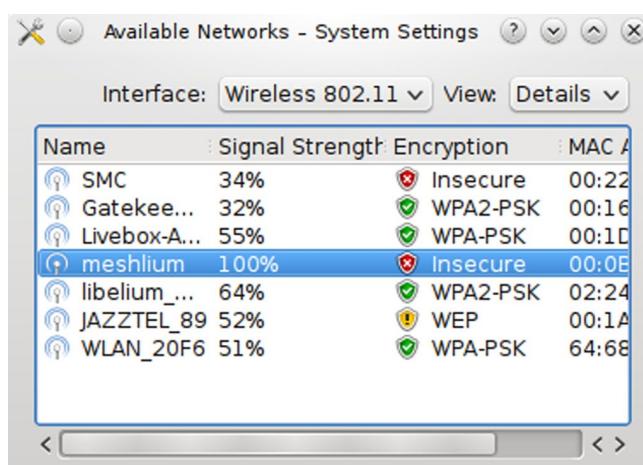


Figure : Available Networks screenshot

No password is needed as the network is public (you can change it later in the WiFi AP Interface options). When you select it, Meshlium will give an IP from the range 10.10.10.10 - 10.10.10.250.

Now you can open your browser and access to the Meshlium Manager System:

- **URL:** http://10.10.10.1/ManagerSystem
- **user:** root
- **password:** libelium



Figure : Meshlium Manager System Login screen

Now we go to the “Sensor Networks” tab.

ID	Date	Sync	ID Wasp	ID Secret	Frame Type	Frame Number	Sensor
791	2014-05-19 08:05:37	128	wasp5	1111	132	22224	BAT
790	2014-05-19 08:05:37	128	wasp5	1111	132	22224	HUMA
789	2014-05-19 08:05:37	128	wasp5	356895649	128	0	BAT
788	2014-05-19 08:05:37	128	wasp5	356895649	128	0	TIME
787	2014-05-16 12:44:45	128	wasp5	1111	132	22224	BAT
786	2014-05-16 12:44:45	128	wasp5	1111	132	22224	HUMA
785	2014-05-16 11:57:27	128	wasp5	356895649	128	0	BAT
784	2014-05-16 11:57:27	128	wasp5	356895649	128	0	TIME
783	2014-05-16 11:41:28	128	wasp5	382544983	128	18	GPS
782	2014-05-16 11:41:28	128	wasp5	382544983	128	18	ACC
781	2014-05-16 11:41:28	128	wasp5	382544983	128	18	IN_TEMP
780	2014-05-16 11:41:28	128	wasp5	382544983	128	18	TIME
779	2014-05-16 11:40:53	128	wasp5	382544983	128	17	GPS

Figure : Sensor Networks tab

There are 6 different XBee models can be configured:



Figure : XBee / LoRa radio models

Depending the kind of XBee model the parameters to be configured may vary.

Complete list:

- **Network ID:** Also known as PAN ID (Personal Area Network ID)
- **Channel:** frequency channel used
- **Network Address:** 16b address (hex field) - MY
- **Node ID:** maximum 20 characters (by default "Meshlium")
- **Power level:** [0..4] (by default 4)
- **Encrypted mode:** true/false (by default false)
- **Encryption Key:** 16 characters maximum
- **MAC:** 64b hardware address. It is a read only value divided in two parts:
 - MAC-high: 32b (hex field)
 - MAC-low: 32b (hex field)

These parameters must be also configured in the WaspMote sensor nodes. Access to all the information related to WaspMote at: <http://www.libelium.com/waspMote>

DigiMesh

Network ID:	3332
Channel:	0x0E ▾
Node ID:	Meshlum
Power Level:	2 ▾
Encrypted mode:	Off ▾
Encryption key:	<input type="text"/>
MAC high:	13a200
MAC low:	407791fc
<input type="button" value="Load MAC"/> <input type="button" value="Check status"/> <input style="background-color: black; color: white; border: none; padding: 2px 10px; margin-left: 10px;" type="button" value="Save"/>	

Figure : XBee parameters configuration

To discover the MAC address of the XBee module just press the “Load MAC” button.

The “Check status” option allows to see if the radio is working properly and if the configuration stored on it matches the values set in the Manager System.

Both process ("Load MAC" and "Check status") require the ZigBee capturer daemon to be stopped. This means no frames will be received while executing this actions. Be patient this can take up to 1 minute to finish.

DigiMesh

Network ID:	3332	Connecting to serial port ... Connected.
Channel:	0x0E	Network ID: OK
Node ID:	meshlium	Node ID: OK
Power Level:	2	Power Level: OK
Encrypted mode:	Off	Encrypted Mode: OK
Encryption key:		
MAC high:	13a200	
MAC low:	407791fc	
<input type="button" value="Load MAC"/> <input type="button" value="Check status"/>		<input type="button" value="Save"/>

Figure : XBee parameters configuration

Note: When you buy a WaspMote Developer kit with Meshlium and with the XBee ZB as ZigBee radio both the WaspMote GW and Meshlium come configured as Coordinator of the network. Take into account that only one of them can be working at the same time.

Note: If the encryption check fails but the rest of parameters are OK, it means the radio has an old version of the firmware but it is working perfectly.

- Capturing and storing sensor data

As said before, in a kit containing Wasp motes, Gateway and Meshlium, the Wasp motes come already configured to send frames to the Gateway. Later, once the user has developed the code for transmitting to Gateway, he can switch to Meshlium.

Meshlium will receive the sensor data sent by Wasp mote using the radio and it will store the frames in the Local Data Base. That can be done in an automatic way thanks to the **Sensor Parser**.

The **Sensor Parser** is a software system which is able to do the following tasks in an easy and transparent way:

- receive frames from XBee and LoRa (with the Data Frame format)
- receive frames from 3G/GPRS, WiFi and Ethernet via HTTP protocol (Manager System version 3.1.4 and above)
- parse these frames
- store the data in local Database
- synchronize the local Database with an external Database

Besides, the user can add his own sensors.

The initial frames sent by Wasp mote contain the next sequence (XBee API frame characters are removed here):

```
~\0x00I\0x90\0x00}3\0xa2\0x00@z\0xcb\0x92\0xd8\0xd3\0x02<=>\0x80\0x03#35689722##7#ACC:80;10
;987#IN_TEMP:22.50#BAT:93#\0xb4
```

Initially there are some hexadecimal characters, which belong to the XBee API frame, followed by the message. In the above example the message is:

```
<=>\0x80\0x03#35689722##7#ACC:80;10;987#IN_TEMP:22.50#BAT:93#
```

They are formed by the accelerometer values, RTC internal temperature value, and battery level. The MAC address is added and other helpful information.

In order to add your own sensor frames properly go to the section "Sensors". All frames captured will be able to stored on Local Database, however the frame has not been defined is stored in the database. See the picture below in order to see different frames types and how they are saved in the database.

ID	Date	Sync	ID Wasp	ID Secret	Frame Type	Frame Number	Se
87493	2013-01-31 08:33:38	0	N1	35690399	253	57	IN
87492	2013-01-31 08:33:38	0	N1	35690399	253	57	BA
87491	2013-01-31 08:33:38	0	N1	35690399	253	57	ST
87489	2013-01-31 08:33:27	0	<=>#35690399#N1#56#STR:Xbee frame#BAT:90#IN_TE				
87488	2013-01-31 08:33:17	1	N1	35690399	253	55	IN
87487	2013-01-31 08:33:17	1	N1	35690399	253	55	BA
87486	2013-01-31 08:33:17	1	N1	35690399	253	55	ST
87485	2013-01-31 08:33:06	1	N1	35690399	253	54	IN
87484	2013-01-31 08:33:06	1	N1	35690399	253	54	BA
87483	2013-01-31 08:33:06	1	N1	35690399	253	54	ST
87482	2013-01-31 08:32:56	1	N1	35690399	253	53	IN
87481	2013-01-31 08:32:56	1	N1	35690399	253	53	BA
87480	2013-01-31 08:32:56	1	N1	35690399	253	53	ST

Figure : Different frames types

If you change any of the parameters in Wasp mote or Meshlium you will have to do it in both platforms so that they still can communicate.

We can perform three different storage options with the frames captured:

- Local Data Base
- External Data Base

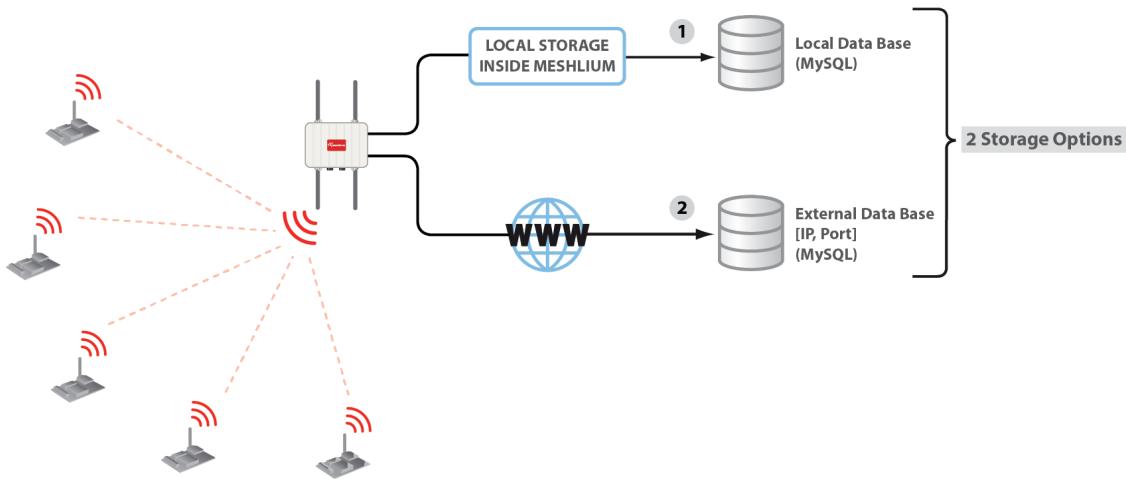


Figure : Meshlium Storage options

You can also send the information received to the Internet using the Ethernet, WiFi and 3G/GPRS interfaces.

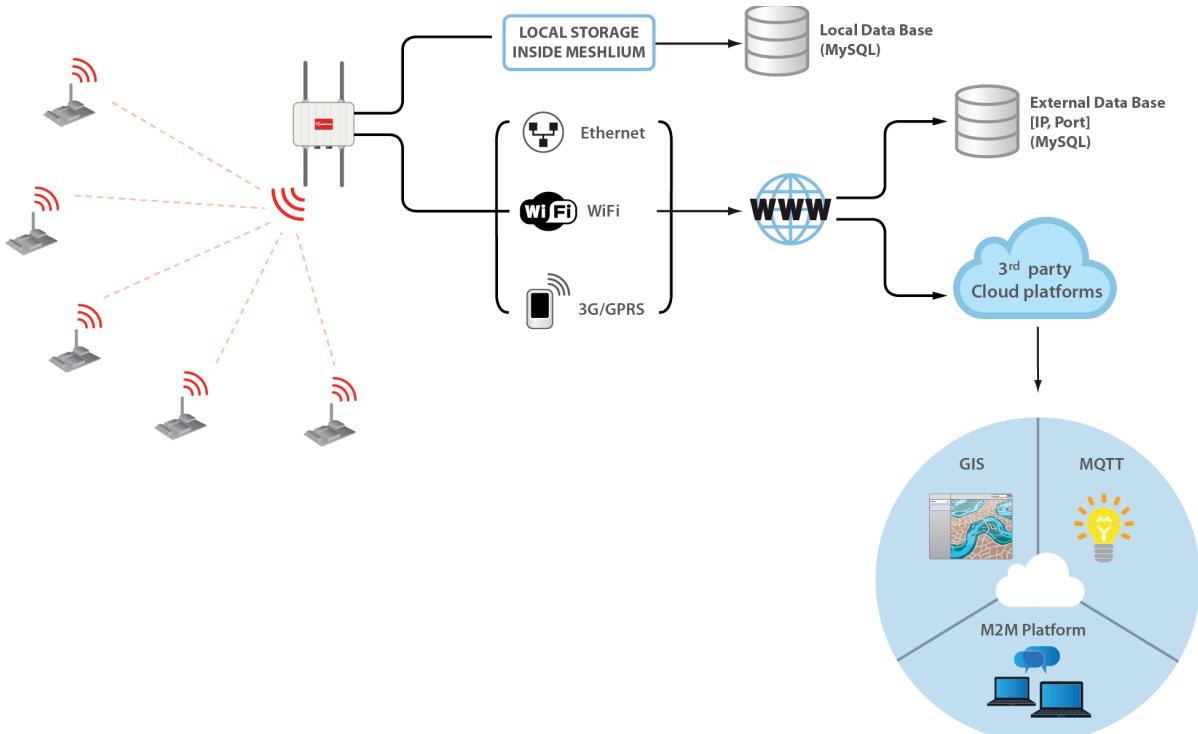


Figure : Meshlium Connection options

Local Data Base

Meshlium has a MySQL data base up and running which is used to store locally the information captured. In the "Local Data Base" tab you can see the connection parameters.

- **Database:** MeshliumDB
- **Table:** sensorParser
- **IP:** localhost / 10.10.10.1 *
- **Port:** 3306
- **User:** root
- **Password:** libelium2007

You can change the password, see the Users Manager section.

(*) Depending on the parameters set in the Interfaces section.

Captured Data

Local DataBase | External Database | Show me NOW | Advanced

Connection data

 Store frames in the local data base
Save

Show data | Last 100 insertions.

ID	Date	Sync	ID Wasp	ID Secret	Frame Type	Frame Number	Se
73650	2013-01-30 18:57:18	0	N1	35690399	253	29	IN
73649	2013-01-30 18:57:18	0	N1	35690399	253	29	BA
73648	2013-01-30 18:57:18	0	N1	35690399	253	29	ST
73647	2013-01-30 18:57:07	0	N1	35690399	253	28	IN
73646	2013-01-30 18:57:07	0	N1	35690399	253	28	BA
73645	2013-01-30 18:57:07	0	N1	35690399	253	28	ST
73644	2013-01-30 18:56:57	0	N1	35690399	253	27	IN
73643	2013-01-30 18:56:57	0	N1	35690399	253	27	BA
73642	2013-01-30 18:56:57	0	N1	35690399	253	27	ST
73641	2013-01-30 18:56:46	0	N1	35690399	253	26	IN
73640	2013-01-30 18:56:46	0	N1	35690399	253	26	BA
73639	2013-01-30 18:56:46	0	N1	35690399	253	26	ST
73638	2013-01-30 18:56:36	0	N1	35690399	253	25	IN

Figure : Local Data Base tab

Steps:

1. Set the check box "Store frames in the local data base" and press the "Save" button.

From this time Meshlium will automatically perform Scans and will store the results in the Local Data Base. This process will also continue after restarting Meshlium.

At any time you can see the last "x" records stored. Just set how many insertions you want to see and press the "Show data" button.

External Data Base

Meshlium can also store the information captured in an External Data Base.

Steps:

1. Pressing the "Show sql script" you will get the code needed to create the data base along with the table and the right privileges.

Captured Data

Local DataBase	External Database	Show me NOW	Advanced
Connection data <div style="display: flex; justify-content: space-between;"> <div style="flex: 1;"> <p>Database: ParserExternal</p> <p>Table: zigbeeParser</p> <p>IP: 192.168.1.6</p> <p>Port: 3306</p> <p>User: root</p> <p>Password: root</p> </div> <div style="flex: 1;"> <input checked="" type="checkbox"/> Store frames in the external data base Synchronize each <input type="text" value="30"/> seconds <input type="button" value="Save"/> </div> </div> <p>Show data Last <input type="text" value="100"/> insertions. Show sql script (to create database and table)</p> <p><input type="button" value="Save"/> <input type="button" value="Check Connection"/> <input type="button" value="Synchronize Now"/></p>			
Just copy paste: <pre>CREATE database MeshliumDB;</pre> Just copy paste: <pre>CREATE TABLE IF NOT EXISTS `sensorParser` (`id` int(11) NOT NULL auto_increment, `id_wasp` text character set utf8 collate utf8_unicode_ci, `id_secret` text character set utf8 collate utf8_unicode_ci, `frame_type` int(11) default NULL, `frame_number` int(11) default NULL, `sensor` text character set utf8 collate utf8_unicode_ci, `value` text character set utf8 collate utf8_unicode_ci, `timestamp` timestamp NOT NULL default CURRENT_TIMESTAMP, `raw` text character set utf8 collate utf8_unicode_ci, PRIMARY KEY (`id`)) ENGINE=MyISAM DEFAULT CHARSET=latin1 AUTO_INCREMENT=1 ;</pre>			

Figure : External Database tab - showing SQL Script

2. Insert this code in your MySQL management application.

3. Fill the Connection Data fields with the information about where the data base is located (IP, Port) and with the authentication options (Database, Table, User, Password).

This data are stored in `/mnt/lib/cfg/sensorExternalDB` file.

4. Now press the "Check Connection" button to see if the configuration is correct.

Captured Data

Local DataBase	External Database	Show me NOW	Advanced
Connection data <div style="border: 1px solid #ccc; padding: 5px; margin-top: 10px;"> [] <input checked="" type="checkbox"/> Store frames in the external data base Synchronize each <input type="text" value="30"/> seconds Save Show data Last <input type="text" value="100"/> insertions. Show sql script (to create database and table) Save Check Connection Synchronize Now </div>			
Connecting to the database server ... Selecting database ... OK			

Figure : External Database tab - checking connection

5. Set the check box "Store frames in external database", you can defined the interval how often to synchronize the local database with external database and press the "Save" button.

From this time Meshlium will automatically perform Scans and will store the results in the External Data Base each . This process will also continue after restarting Meshlium.

You can also choose to sync when you want. Just press the "Synchronize Now" button.

Captured Data

Local DataBase External Database Show me NOW Advanced **Synchronizing...**

Connection data

Database: Parse External
 Table: zigbeeParser
 IP: 192.168.1.6
 Port: 3306
 User: root
 Password: root

Store frames in the external data base
 Synchronize each 30 seconds **Save**

Show data Last 100 insertions Show SQL script (to create database and table)

Save **Check Connection** **Synchronize Now**

ID	Date	ID Wasp	ID Secret	Frame Type	Frame Number	Sen
73848	2013-01-30 19:03:06	N1	35690399	253	62	IN_
73847	2013-01-30 19:03:06	N1	35690399	253	62	BAT
73846	2013-01-30 19:03:06	N1	35690399	253	62	STR
73845	2013-01-30 19:02:56	N1	35690399	253	61	IN_
73844	2013-01-30 19:02:56	N1	35690399	253	61	BAT
73843	2013-01-30 19:02:56	N1	35690399	253	61	STR
73842	2013-01-30 19:02:45	N1	35690399	253	60	IN_
73841	2013-01-30 19:02:45	N1	35690399	253	60	BAT
73840	2013-01-30 19:02:45	N1	35690399	253	60	STR
73839	2013-01-30 19:02:35	N1	35690399	253	59	IN_
73838	2013-01-30 19:02:35	N1	35690399	253	59	BAT
73837	2013-01-30 19:02:35	N1	35690399	253	59	STR
73836	2013-01-30 19:02:24	N1	35690399	253	58	IN_

Figure : External Database tab - last "x" records stored

At any time you can see the last "x" records stored. Just set how many insertions you want to see and press the "Show data" button.

Captured Data

Local DataBase		External Database		Show me NOW	Advanced																																																																																																		
Connection data <hr/> <div style="display: flex; justify-content: space-between;"> <div style="flex: 1;"> Database: ParserExternal Table: zigbeeParser IP: 192.168.1.6 Port: 3306 User: root Password: root </div> <div style="flex: 1;"> <input checked="" type="checkbox"/> Store frames in the external data base Synchronize each <input type="text" value="30"/> seconds Save </div> </div> <hr/> <div style="display: flex; justify-content: space-between;"> Show data Last <input type="text" value="100"/> insertions. Show sql script (to create database and table) </div> <hr/> <div style="display: flex; justify-content: space-between;"> Save Check Connection Synchronize Now </div>																																																																																																							
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>ID</th> <th>Date</th> <th>ID Wasp</th> <th>ID Secret</th> <th>Frame Type</th> <th>Frame Number</th> <th>Service</th> </tr> </thead> <tbody> <tr><td>73593</td><td>2013-01-30 18:48:08</td><td>N1</td><td>35690399</td><td>253</td><td>233</td><td>IN_</td></tr> <tr><td>73592</td><td>2013-01-30 18:48:08</td><td>N1</td><td>35690399</td><td>253</td><td>233</td><td>BAT</td></tr> <tr><td>73591</td><td>2013-01-30 18:48:08</td><td>N1</td><td>35690399</td><td>253</td><td>233</td><td>STR</td></tr> <tr><td>73590</td><td>2013-01-30 18:47:57</td><td>N1</td><td>35690399</td><td>253</td><td>232</td><td>IN_</td></tr> <tr><td>73589</td><td>2013-01-30 18:47:57</td><td>N1</td><td>35690399</td><td>253</td><td>232</td><td>BAT</td></tr> <tr><td>73588</td><td>2013-01-30 18:47:57</td><td>N1</td><td>35690399</td><td>253</td><td>232</td><td>STR</td></tr> <tr><td>73587</td><td>2013-01-30 18:47:47</td><td>N1</td><td>35690399</td><td>253</td><td>231</td><td>IN_</td></tr> <tr><td>73586</td><td>2013-01-30 18:47:47</td><td>N1</td><td>35690399</td><td>253</td><td>231</td><td>BAT</td></tr> <tr><td>73585</td><td>2013-01-30 18:47:47</td><td>N1</td><td>35690399</td><td>253</td><td>231</td><td>STR</td></tr> <tr><td>73584</td><td>2013-01-30 18:47:36</td><td>N1</td><td>35690399</td><td>253</td><td>230</td><td>IN_</td></tr> <tr><td>73583</td><td>2013-01-30 18:47:36</td><td>N1</td><td>35690399</td><td>253</td><td>230</td><td>BAT</td></tr> <tr><td>73582</td><td>2013-01-30 18:47:36</td><td>N1</td><td>35690399</td><td>253</td><td>230</td><td>STR</td></tr> <tr><td>73581</td><td>2013-01-30 18:47:26</td><td>N1</td><td>35690399</td><td>253</td><td>229</td><td>IN_</td></tr> </tbody> </table>						ID	Date	ID Wasp	ID Secret	Frame Type	Frame Number	Service	73593	2013-01-30 18:48:08	N1	35690399	253	233	IN_	73592	2013-01-30 18:48:08	N1	35690399	253	233	BAT	73591	2013-01-30 18:48:08	N1	35690399	253	233	STR	73590	2013-01-30 18:47:57	N1	35690399	253	232	IN_	73589	2013-01-30 18:47:57	N1	35690399	253	232	BAT	73588	2013-01-30 18:47:57	N1	35690399	253	232	STR	73587	2013-01-30 18:47:47	N1	35690399	253	231	IN_	73586	2013-01-30 18:47:47	N1	35690399	253	231	BAT	73585	2013-01-30 18:47:47	N1	35690399	253	231	STR	73584	2013-01-30 18:47:36	N1	35690399	253	230	IN_	73583	2013-01-30 18:47:36	N1	35690399	253	230	BAT	73582	2013-01-30 18:47:36	N1	35690399	253	230	STR	73581	2013-01-30 18:47:26	N1	35690399	253	229	IN_
ID	Date	ID Wasp	ID Secret	Frame Type	Frame Number	Service																																																																																																	
73593	2013-01-30 18:48:08	N1	35690399	253	233	IN_																																																																																																	
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73590	2013-01-30 18:47:57	N1	35690399	253	232	IN_																																																																																																	
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73585	2013-01-30 18:47:47	N1	35690399	253	231	STR																																																																																																	
73584	2013-01-30 18:47:36	N1	35690399	253	230	IN_																																																																																																	
73583	2013-01-30 18:47:36	N1	35690399	253	230	BAT																																																																																																	
73582	2013-01-30 18:47:36	N1	35690399	253	230	STR																																																																																																	
73581	2013-01-30 18:47:26	N1	35690399	253	229	IN_																																																																																																	

Figure : Show me now! tab

Show me now!

In the "Show me now!" tab you can see in real time the Scans captured.

You can specify if you want the information to be updated periodically with the defined interval just checking the "Use the Defined Interval" button.

Captured Data

Local DataBase	External Database	Show me NOW	Advanced Database
----------------	-------------------	--------------------	-------------------

Start Scan	<input checked="" type="checkbox"/> Use the defined Scan interval	<input type="text" value="10"/> Seconds	
------------	---	---	--

```

ASCII frame
Internal ID:35690399 Wasp mote ID:N1 Frame Type:253 Frame Number:64
STR:Xbee frame
BAT:93
IN_TEMP:29.75

ASCII frame
Internal ID:35690399 Wasp mote ID:N1 Frame Type:253 Frame Number:62
STR:Xbee frame
BAT:93
IN_TEMP:29.75

ASCII frame
Internal ID:35690399 Wasp mote ID:N1 Frame Type:253 Frame Number:60
STR:Xbee frame
BAT:93
IN_TEMP:29.75

ASCII frame
Internal ID:35690399 Wasp mote ID:N1 Frame Type:253 Frame Number:58
STR:Xbee frame
BAT:93
IN_TEMP:29.75

```

Figure : Show me now! tab

Advanced Database

In the "Advanced" tab you can see information about the state in which they are databases.

It displays information about the Local and External database, showing the following information:

- Local and External Database names
- Local and External Database sizes
- Local and External Tables
- Total Local and External Entries
- Synchronized Local Frames
- Unsynchronized Local Frames

Captured Data

Local DataBase	External Database	Show me NOW	Advanced												
Local Database <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <tr> <td style="width: 30%;">Database:</td> <td style="width: 70%;">MeshlumDB</td> </tr> <tr> <td>Database Size:</td> <td>12.35 Mb</td> </tr> <tr> <td>Table:</td> <td>sensorParser</td> </tr> <tr> <td>Entries:</td> <td>900</td> </tr> <tr> <td>Synchronized Frames:</td> <td>0</td> </tr> <tr> <td>Unsyncronized Frames:</td> <td>900</td> </tr> </table> <div style="display: flex; justify-content: space-around; width: 100%; margin-top: 10px;"> Remove synchronized Data Remove ALL Content </div>				Database:	MeshlumDB	Database Size:	12.35 Mb	Table:	sensorParser	Entries:	900	Synchronized Frames:	0	Unsyncronized Frames:	900
Database:	MeshlumDB														
Database Size:	12.35 Mb														
Table:	sensorParser														
Entries:	900														
Synchronized Frames:	0														
Unsyncronized Frames:	900														
External Database <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <tr> <td style="width: 30%;">Database:</td> <td style="width: 70%;">ParserExternal</td> </tr> <tr> <td>Database Size:</td> <td>5.05 Mb</td> </tr> <tr> <td>Table:</td> <td>zigbeeParser</td> </tr> <tr> <td>Entries:</td> <td>72852</td> </tr> </table> Logs Sync <pre style="margin-top: 10px; font-family: monospace; font-size: 0.8em;"> 2013-01-30 17:48:50.257 - Synchronization OK 2013-01-30 17:49:20.157 - Synchronization OK 2013-01-30 17:49:50.218 - Synchronization OK 2013-01-30 17:50:20.077 - Synchronization OK 2013-01-30 17:50:50.327 - Synchronization OK 2013-01-30 17:51:20.088 - Synchronization OK 2013-01-30 17:51:50.187 - Synchronization OK 2013-01-30 17:52:24.039 - Synchronization OK 2013-01-30 17:52:53.808 - Synchronization OK </pre>				Database:	ParserExternal	Database Size:	5.05 Mb	Table:	zigbeeParser	Entries:	72852				
Database:	ParserExternal														
Database Size:	5.05 Mb														
Table:	zigbeeParser														
Entries:	72852														

From this tab, **you can delete all the information contained in the Local database or Remove synchronized data**. Before performing these actions, a confirmation message will be displayed.

Note: Before running these options, it is recommended to have a backup or having synchronized your local database with external database.

Captured Data

Local DataBase External Database Show me NOW Advanced

Local Database

Database:	MeshlumDB
Database Size:	13.50 Mb
Table:	sensorParser
Entries:	15301
Synchronized Frames:	15295
Unsyncronized Frames:	6

Remove synchronized Data **Remove ALL Content**

External Database

Mensaje de la página 192.168.1.103:

? Synchronized data of sensorParser table will be deleted.
Do you want to continue?

Cancelar **Aceptar**

2013-01-31 08:33:49.315 - Synchronization OK
2013-01-31 08:34:19.401 - Synchronization OK
2013-01-31 08:34:49.138 - Synchronization OK

Figure : Advanced Tab – Remove data

In addition can display a log of the date of the last synchronization between the local database and external database was successful.

Logs Sync

```
2013-01-30 17:48:50.257 - Synchronization OK
2013-01-30 17:49:20.157 - Synchronization OK
2013-01-30 17:49:50.218 - Synchronization OK
2013-01-30 17:50:20.077 - Synchronization OK
2013-01-30 17:50:50.327 - Synchronization OK
```

Figure : Advanced Tab – Synchronization log

24.2.4. Capturer logs

Inside "Sensor Networks" exist the section **Logs**, in this section you can see the last frames received on Meshlium.

Sensor Log

```
ASCII-35690399-N1-253-43-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-44-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-45-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-46-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-47-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-48-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-49-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-50-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-51-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-52-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-53-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-54-,STR:Xbee frame,BAT:93,IN TEMP:25.50
ASCII-35690399-N1-253-55-,STR:Xbee frame,BAT:93,IN TEMP:25.75
ASCII-35690399-N1-253-56-,STR:Xbee frame,BAT:93,IN TEMP:25.75
ASCII-35690399-N1-253-57-,STR:Xbee frame,BAT:93,IN TEMP:25.75
ASCII-35690399-N1-253-58-,STR:Xbee frame,BAT:93,IN TEMP:25.75
ASCII-35690399-N1-253-59-,STR:Xbee frame,BAT:93,IN TEMP:25.75
```

Frame Log

```
<=>?#35690399#N1#17#STR:Xbee frame#BAT:93#IN TEMP:23.50#
<=>?#35690399#N1#18#STR:Xbee frame#BAT:93#IN TEMP:23.50#
<=>?#35690399#N1#19#STR:Xbee frame#BAT:93#IN TEMP:23.50#
<=>?#35690399#N1#20#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#21#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#22#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#23#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#24#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#25#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#26#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#27#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#28#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#29#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#30#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#31#STR:Xbee frame#BAT:93#IN TEMP:24.25#
<=>?#35690399#N1#32#STR:Xbee frame#BAT:93#IN TEMP:25.00#
<=>?#35690399#N1#33#STR:Xbee frame#BAT:93#IN TEMP:25.00#
```

Figure : Sensor log

First show the "sensor log", in this logs shows the frames are stored after being processed.

ASCII-35690399-N1-253-198-,STR:Xbee frame,BAT:93,IN_TEMP:31.50

secondly shown "Frame Log", in this logs shows the frames stored as the arrive to Meshlium.

<=>?#35690399#N1#198#STR:Xbee frame#BAT:93#IN_TEMP:31.50#

24.2.5. Sensors

In section “Sensor List”, the user can **add new sensors or delete sensors**.

By default Meshlum recognize all Libelium official sensors frames. All sensors frames that Meshlum can capture and store must be specified in an XML file.

The file with official sensors of Libelium is located in `/mnt/lib/cfg/parser/sensors.xml`

The button “update sensors” update the Libelium official sensor. User sensors remaining unchanged.

Users can add and remove sensors in an easy and simple from ManagerSystem.

To add a new sensor the user must complete the fields:

- ASCII ID: sensor id for ASCII frame.
- Fields: This field specifies the number of sensor fields sent in the frame. This helps to calculate the frame length.
- Type: type of fields
 - uint8_t
 - int
 - float
 - string
 - ulong
 - array(ulong)

Once all fields are filled in, click on the button “Add sensor”

Available Sensors

ID	ASCII ID	Fields	Type
0	CO	1	float
1	CO2	1	float
2	O2	1	float
3	CH4	1	float
4	LPG	1	float
5	NH3	1	float
6	AP1	1	float
7	AP2	1	float
8	SV	1	float
9	NO2	1	float
10	O3	1	float
11	VOC	1	float
12	TCA	1	float
13	TFA	1	float
14	HUMA	1	float
15	PA	1	float
16	PW	1	float
17	BEND	1	float
18	VBR	1	uint_8
19	HALL	1	uint_8
20	LP	1	uint_8
21	LL	1	uint_8
22	LUM	1	float
23	PIR	1	uint_8
24	ST	1	float
25	MCP	1	uint_8
26	CDG	1	uint_8

Sensors Updated

ID	ASCII ID	Fields	Type
200	AGM	9	uint_8

Figure : Sensor List – Addition

The new user sensors will be added to the new XML file, the file with user sensors is located in /mnt/lib/cfg/parser/user_sensors.xml

Note: In "Waspmote data frame guide" document is located more extensive information about how to build the frame.

To delete sensor the user must press the garbage can that appears to the left of the description of the sensor. To complete the action should accept a confirmation message.

User sensors

	ID	ASCII ID	Fields	Type
	200	AGM	9	uint_8

Figure : Sensor List – Remove

24.2.6. Sending frames from Meshlium to Waspmote

Meshlium can also send frames to the Waspmote nodes. In order to use this feature you have to stop the "capturing and storing" daemon which is running in the system.

To do so access by SSH to Meshlium and stop the default ZigBee daemon::

```
$ /etc/init.d/ZigbeeScanD.sh stop
```

Now you can execute the ZigBeeSend command. There are several ways to send information to a node:

- Using its 802.15.4 MAC address (64b)
- Using its Network address (MY) (16b)
- Performing a broadcast transmission

Sending to Waspmote using its MAC address (64b):

```
$ ./ZigBeeSend -mac 0013a2004069165d "Hello Waspmote!"
```

Sending to Waspmote using its Net address (MY - 16b):

```
$ ./ZigBeeSend -net 1234 "hello Waspmote!"
```

Send to all the Waspmote devices at the same time - Broadcast mode:

```
$ ./ZigBeeSend -b "hello everybody!"
```

The source code "ZigbeeSend.c" and the reception program to be installed in Waspmote can be downloaded from the Meshlium Development section: <http://www.libelium.com/development/meshlium>

You can download these files and change them in order to get new features and sending options.

Compilation:

The compilation can be done in the same Meshlium. Just copy these files in a folder accessing by SSH and execute:

```
$ gcc -o ZigBeeSend ZigBeeSend.c -lpthread
```

Important: If you want to create a "ZigBee sending" daemon that is executed each time Meshlium starts you have to deactivate the "ZigBee Capturer" daemon (/etc/init.d/ZigbeeScanD.sh) as the ZigBee radio has to be used by one process at a time.

You will find support in the Libelium Forum at: <http://www.libelium.com/forum>

24.2.7. Interacting with 3rd party Cloud platforms

Libelium has partnered with the best Cloud software solution providers to offer you all the necessary components to deploy Internet of Things (IoT), machine-to-machine (M2M) or Smart Cities projects with minimum time-to-market. Meshlium is ready to send sensor data to many Cloud software platforms. Just select the most suitable for you, get an account from the provider and configure your Meshlium. To get a list of the available Cloud platforms, see the section “Cloud Connector” of the Meshlium Technical Guide.

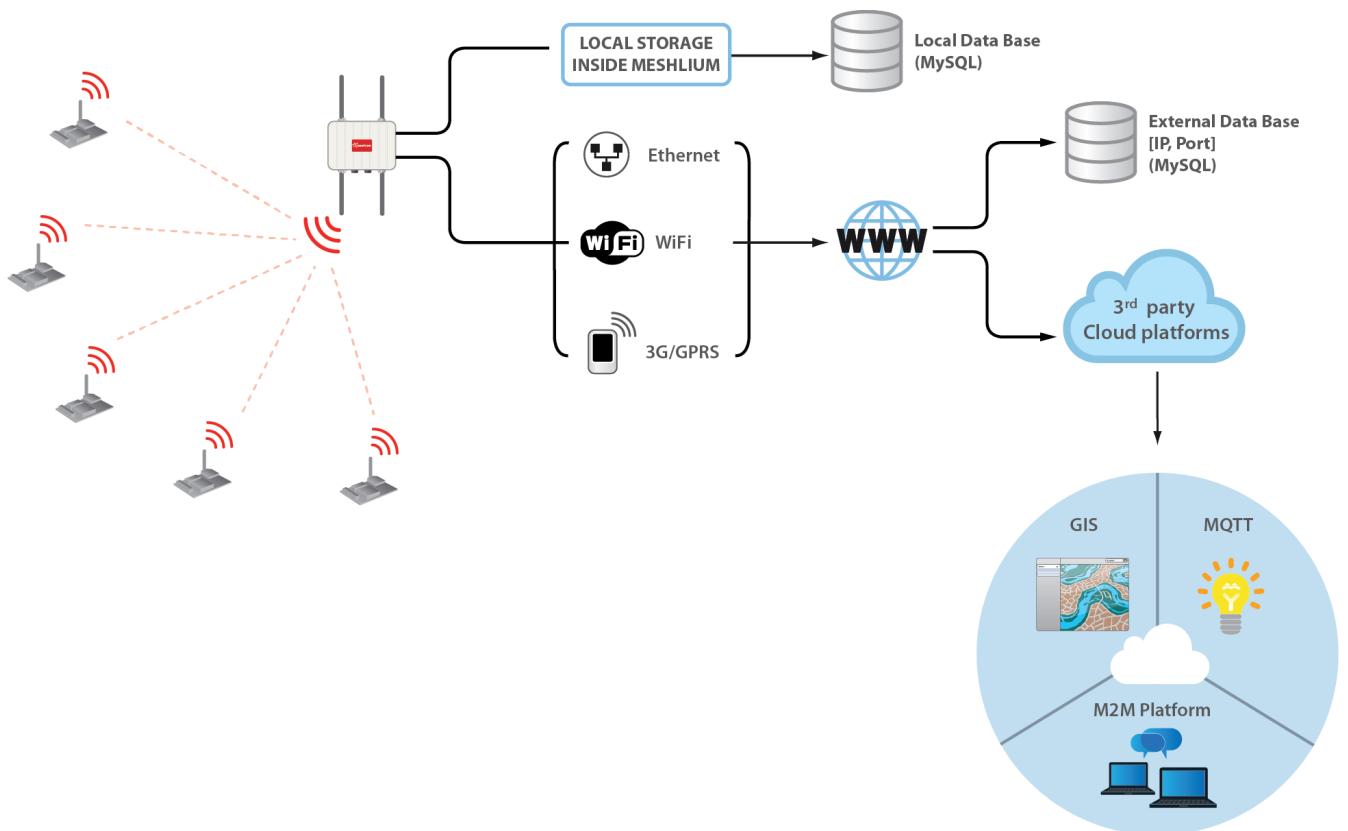


Figure : Cloud connector diagram

25. Installation

The right behavior of WaspMote Plug & Sense! depends on a reliable installation. Libelium provides the necessary accessories to make it easier, like cable ties, mounting feet and other accessories.

Wherever WaspMote Plug & Sense! is placed, please be sure you tight it firmly and the enclosure is not affected by wind, vibrations and other environmental conditions. Libelium does not take responsibility of damages to third parts caused by a bad installation. Moreover, it is recommended to power off WaspMote Plug & Sense! during its installation.

25.1. Parts

Mounting feet

Libelium provides four mounting feet accessories to allow easy fixing WaspMote Plug & Sense! to walls, etc. Mounting feet come already fixed to the enclosure using a screw, as shown in figures below.



Figure : Mounting feet accessory

The mounting feet come assembled in vertical position.



Figure : Mounting foot in vertical position

Moreover, Libelium provides some extra screws and wall plugs to fix the node to a wall. See next sections for more details.

Be sure you fix firmly all of the four mounting feet, otherwise the node can fall down due to wind effects, vibrations or other causes.

Cable ties

Another provided accessories are PVC coated stainless steel cable ties. Dimensions of these ties are 1 meter length and 5 millimeters width.



Figure : Metal cable ties



Figure : Using metal cable ties

Solar panel bracket

The solar panel brackets are used to achieve 45 degrees of inclination when a solar panel is used.

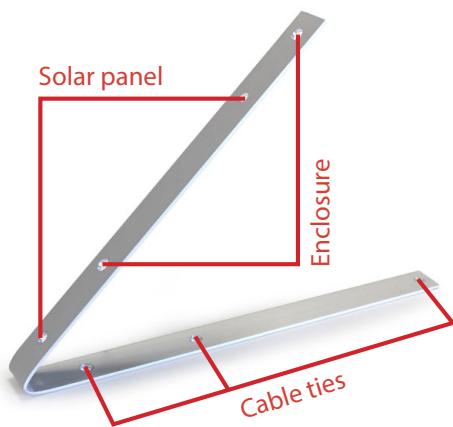


Figure : Solar panel bracket

Wasp mote Plug & Sense! accessories can vary depending on which configuration is acquired. See text and figure below to know which accessories are provided with each of the three options.



Figure : Wasp mote Plug & Sense! accessories

1- Basic

This configuration includes 4 mounting feet (A), 4 screws type 1 (B), 4 screws type 2 (C), 4 wall plugs (E) and 2 cable ties (I). No solar panel is included.

2- With internal solar panel

This configuration includes 4 mounting feet (A), 4 screws type 1 (B), 4 screws type 2 (C), 4 wall plugs (E), 4 screws type 3 (D), 4 nuts (F), 8 washers (G), 2 solar panel brackets (H) and 2 cable ties (I). The solar panel is embedded in the enclosure.

3- With external solar panel

This configuration includes 4 mounting feet (A), 4 screws type 1 (B), 8 screws type 2 (C), 8 wall plugs (E), 4 screws type 3 (D), 4 nuts (F), 8 washers (G), 2 solar panel brackets (H), 4 cable ties (I) and 1 external solar panel (J).

25.2. Street Light installation

The node can be fixed to a street light using the PVC coated stainless steel cable ties provided by Libelium. Always be sure that the enclosure is firmly tied and environmental elements (like wind) do not modify its position. Next pictures show examples of typical installation processes using external or internal solar panel in combination with the provided accessories.

25.2.1. External solar panel

Step 1: Secure the mounting feet to WaspMote Plug & Sense!

Use provided screws to secure firmly the mounting feet to the node.



Figure : Securing the mounting feet to WaspMote Plug & Sense!

Step 2: Prepare the cable ties

Introduce cable ties through external holes of the mounting feet.



Figure : Preparing metal cable ties

Step 3: Secure the solar panel bracket to the external solar panel

Use provided screws to secure the solar panel bracket to the external solar panel. Be sure you place screws in the right bracket holes, as shown in the figure below.



Figure : Preparing the external solar panel

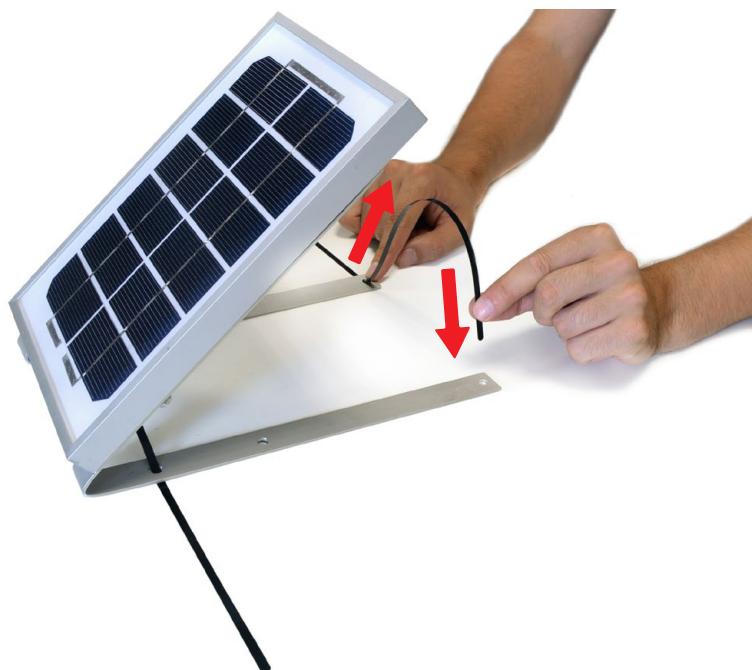


Figure : Adding cable ties to the external solar panel

Step 4: Secure Wasp mote Plug & Sense! to the street light

Place Wasp mote Plug & Sense! on street light tightening firmly the metal cable ties. Be sure that the node remains completely tied to street light to avoid it could fall down.



Figure : Placing Wasp mote Plug & Sense! on a street light

Step 5: Secure the external solar panel to the street light

It is recommended to place the external solar panel above Wasp mote Wasp mote Plug & Sense!, using it as a roof. This will increase protection against rain and sunlight. Use cable ties and the dedicated holes of the solar panel bracket to complete Wasp mote Plug & Sense! installation.



Figure : Placing external solar panel above Wasp mote

25.2.2. Internal solar panel

If the node has an internal solar panel, it should be placed in 45° angle to optimize the solar panel efficiency, using the solar panel bracket.

Step 1: Secure the mounting feet to Waspmote Plug & Sense!

Use provided screws to firmly mount the feet to the node as shown in step 1 of previous section.

Step 2: Secure the solar panel bracket to Waspmote Plug & Sense!

Use dedicated holes of solar panel bracket to secure Waspmote. Remember that the sensor side must face to the ground.



Figure : Securing the solar panel bracket to Waspmote

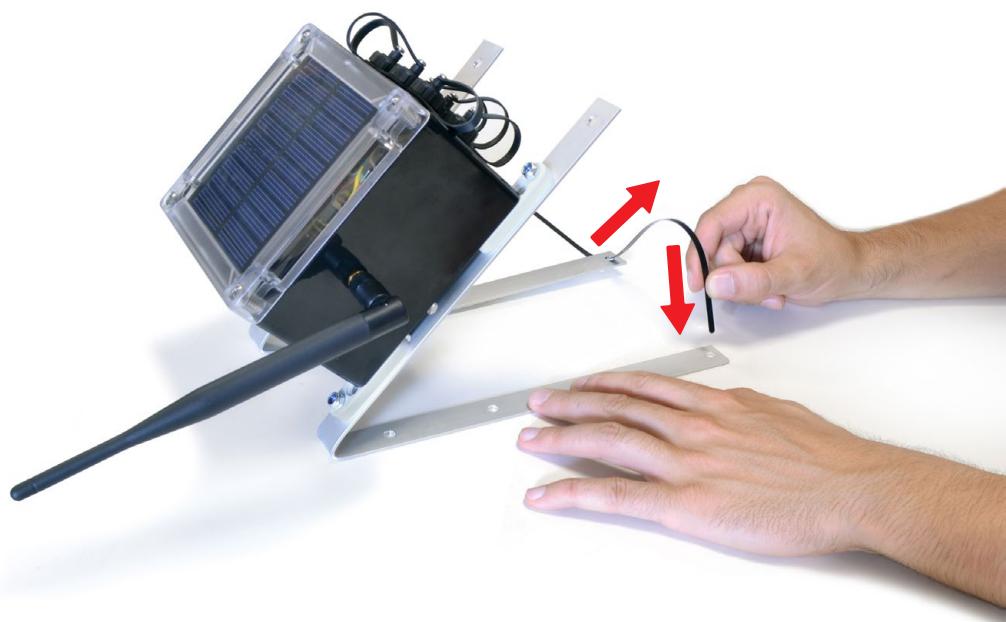


Figure : Adding cable ties to the internal solar panel

Step 3: Securing WaspMote to the street light

Place WaspMote Plug & Sense! with the solar panel bracket on street light tightening it firmly using the provided metal cable ties. Be sure that the node remains completely tied to the street light to avoid it could fall down.

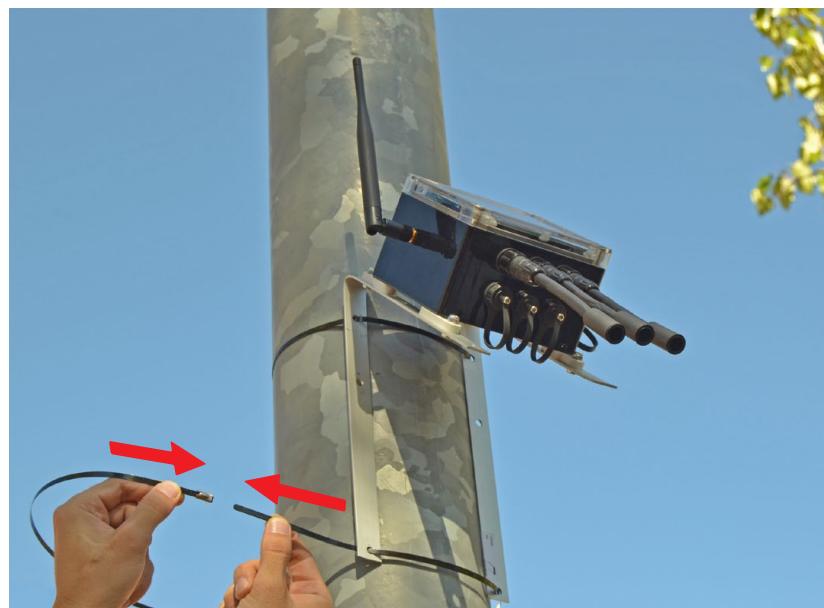


Figure : Securing WaspMote to the street light

25.3. Wall

Another typical installation of WaspMote Plug & Sense! is on the walls. Using the mounting feet accessory, the node can be tied using provided screws and wall plugs. Next pictures show examples of typical installation processes using the external or internal solar panel in combination with provided accessories.

25.3.1. External solar panel

Step 1: Secure the mounting feet to WaspMote Plug & Sense!

Use provided screws to secure firmly mounting feet to the node as shown in step 1 of the previous section.

Step 2: Secure the solar panel bracket to the external solar panel

Use provided screws to secure the solar panel bracket to the external solar panel. Be sure you place screws in the right bracket holes, as shown in previous section.

Step 3: Secure WaspMote Plug & Sense! to the wall.

Use provided screws and wall plugs to secure firmly the node to the wall. Check if the node remains completely fixed to avoid it could fall down.



Figure : WaspMote Plug & Sense! placed on a wall

Step 4: Secure the external solar panel to a wall

It is recommended to place the external solar panel above the node, using it as a roof. This will increase protection against rain and sun. Use screws and the dedicated holes of the solar panel bracket to complete the installation.



Figure : Placing the external solar panel above Waspmote

25.3.2. Internal solar panel

Moreover, if the node has an internal solar panel, it should be placed in 45° angle to optimize the solar panel **efficiency, using the solar panel bracket.**

Step 1: Secure the mounting feet to Waspmote Plug & Sense!

Use the provided screws to secure firmly the mounting feet to node **as shown in step 1 of the previous section.**

Step 2: Secure solar panel bracket to Waspmote Plug & Sense!

Use the dedicated holes of the solar panel bracket to secure the node as shown in the previous section. Remember **that the sensor side must face to the ground.**

Step 3: Securing Waspmote Plug & Sense! to a wall

Place Waspmote Plug & Sense! with the solar panel bracket on a wall tightening it firmly using the screws. Be sure the node remains completely tied to street light to avoid it could fall down.



Figure : Securing Waspmote to a wall.

26. Energy Consumption

26.1. Consumption tables

WaspMote

ON	15 mA
Sleep	55 uA
Deep sleep	55 uA

WaspMote modules

	ON	SLEEP	OFF	Sending	Receiving
XBee 802.15.4 PRO	56,68 mA	0,12 mA	0 µA	187,58 mA	57,08 mA
Bee ZigBee PRO	45,56 mA	0,71 mA	0 µA	105 mA	50,46 mA
XBee 868	60,82 mA	--	0 µA	160 mA	73 mA
XBee 900	64,93 mA	0,93 mA	0 µA	77 mA	66 mA
WIFI	33 mA	4 uA	0 uA	38 mA	38 mA
GPRS / GPRS+GPS	100 mA	1 mA	0 uA	100 mA	100 mA
3G/GPRS	150mA	1 mA	0 uA	300mA	300mA
Bluetooth Low Energy	8 mA	0.4 uA	0 mA	36 mA	36 mA

Note: The sleep mode for XBee is not a very useful feature, since the advised action is to switch XBee off after transmission. If the user puts XBee in sleep mode and also switches WaspMote to sleep or deepsleep, and if the SD card is plugged, there will be an excessive power consumption: 220 µA or more (instead of the expected 110 µA). This is due to parasite power. To solve that, the user should not use the XBee sleep mode. Another solution is to call `sleep()` or `deepsleep()` with `ALL_OFF` or `UART0_OFF` parameters.

26.2. Energy system

26.2.1. Concepts

WaspMote Plug & Sense! has 3 operational modes.

- **ON:** Normal operation mode. Consumption in this state is 15mA.
- **Sleep:** The main program is paused, the microcontroller passes to a latent state, from which it can be woken up by all asynchronous interruptions and by the synchronous interruption generated by the Watchdog. The duration interval of this state is from 32ms to 8s. Consumption in this state is 55µA.
- **Deep Sleep:** The main program pauses, the microcontroller passes to a latent state from which it can be woken up by all asynchronous interruptions and by the synchronous interruption triggered by the RTC. The interval of this cycle can be from 8 seconds to minutes, hours, days. Consumption in this state is 55µA.

	Consumption	Micro	Cycle	Accepted Interruptions
ON	9mA	ON	-	Synchronous and Asynchronous
Sleep	62µA	ON	32ms - 8s	Synchronous (Watchdog) and Asynchronous
Deep Sleep	62µA	ON	8s – min/hours/days	Synchronous (RTC) and Asynchronous

On the other hand, each module has up to 3 operation modes.

- ON: Normal operation mode.
- Sleep: In this mode some module functions are stopped and passed to asynchronous use, normally guided by events. It functions differently in each module and is specific to each one (programmed by the manufacturer).
- OFF: By using digital switches controlled by the microcontroller the module is switched off completely. This mode has been implemented by Libelium as an independent layer of energy control, so that it can reduce consumption to a minimum ($\sim 0\mu\text{A}$) without relegating to techniques implemented by the manufacturer.

All information about their programming and operation can be found in the Energy and Power Programming Guide available at the [Development section](#) of Libelium website.

All the documentation is located in the [Development section](#) in the Libelium website.

26.2.2. Sleep mode

Main program is paused and the microcontroller passes to a latent state, from which it can be woken by all asynchronous interruptions and by the synchronous interruption generated by the Watchdog. The duration interval of this state is from 32ms to 8s. Consumption in this state is $55\mu\text{A}$.

In this mode, the microcontroller stops executing the main program. The program stack where all the variables and log values are stored keep their value, so when the node returns to ON mode, the next instruction is executed and the variable values are maintained.

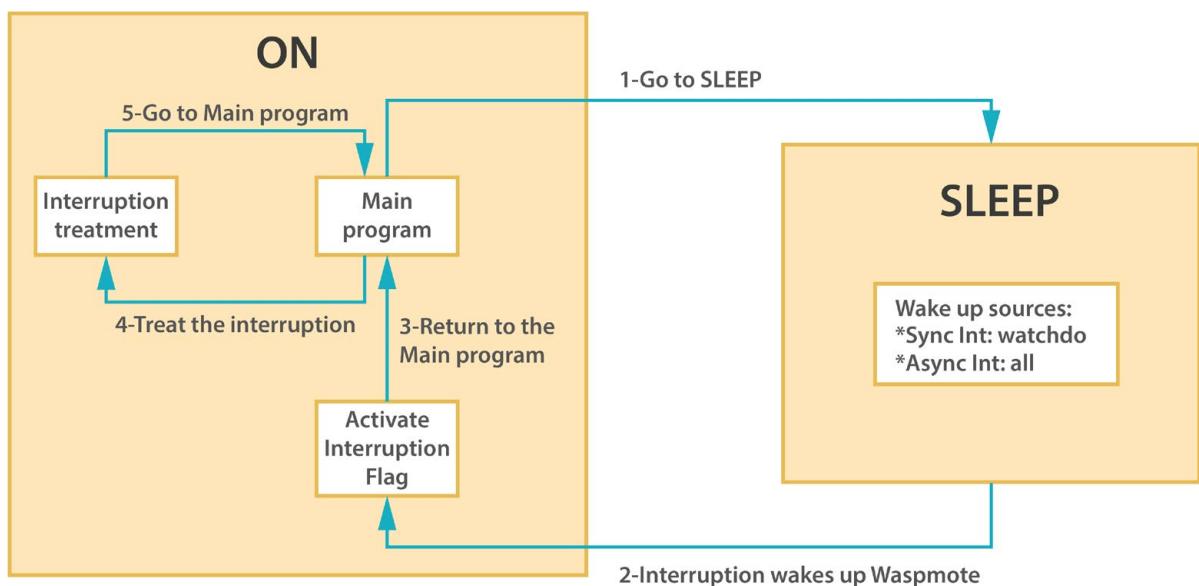


Figure : From ON to Sleep

26.2.3. Deep sleep mode

The main program is paused, the microcontroller passes to a latent state from which it can be woken by all the asynchronous interruptions and by the synchronous interruption launched by the RTC. The interval of this cycle can be from 8 seconds to minutes, hours, days. Consumption in this state is $55\mu\text{A}$.

In this mode, the micro stops executing the main program. The program stack where all the variables and log values are stored keep their value, so when the node returns to ON mode, next instruction is executed and the variable values are maintained.

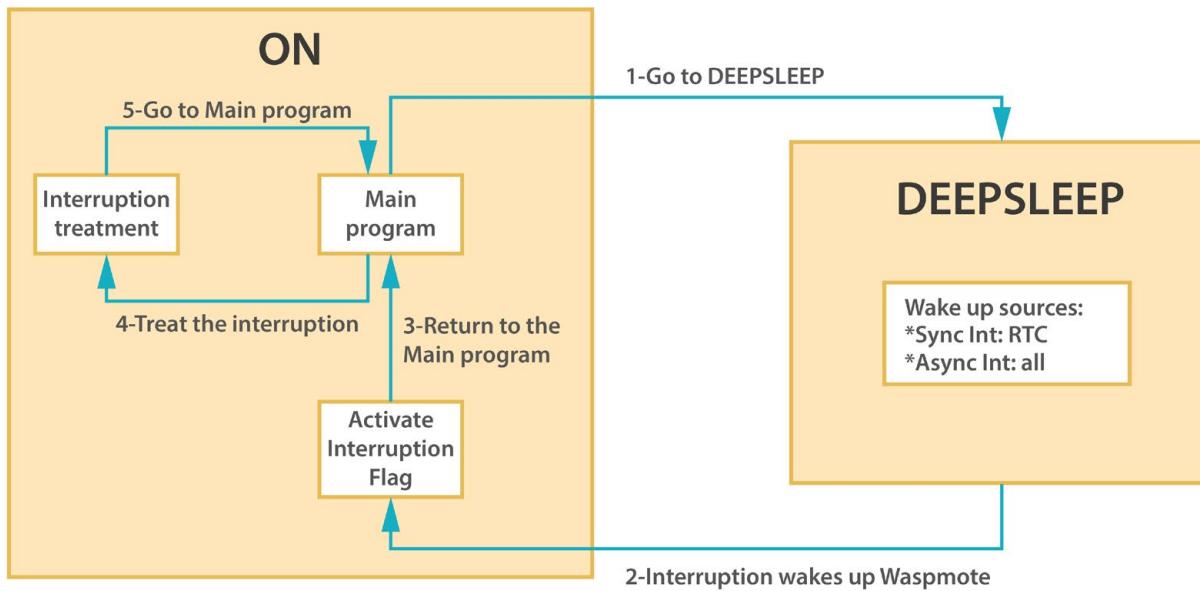


Figure : From ON to Deep Sleep

26.3. Lifetime of the sensors

Libelium sensor probes are designed to increase lifetime of sensors when they are used outdoors. However, each sensor has a different lifetime depending on environmental conditions, usage and many other factors that Libelium cannot control.

It is suggested to use a solar shield with sensor probes which are going to be installed in places where sunlight is present. Besides, always use sensor probes following all recommendations given in this guide, to ensure the best lifetime.

The next table shows an appropriated lifetime of sensors which for physical limitations may expire.

Sensor probe type	Lifetime
Gas sensors	3 months – 2 years
Humidity and Temperature (Sensirion)	6 months – 2 years
Solar radiation	1 year – 2 years
Soil moisture	1 year – 2 years

Note: Gas sensors may require replacement for optimal accuracy.

Note: Current sensor probe is not designed to be used outdoors.

Note: Some of sensor probes like Particle Matter, presence (PIR), ultrasound or solar radiation require a periodic maintenance due to dust and dirt and environment particles may affect to right measurements.

27. Recommendations

Libelium gives some recommendations to improve performance and efficiency of Wasp mote Plug & Sense!, enlarging useful life of all of its elements.

- Try placing Wasp mote Plug & Sense! and its sensors out of the sun. It is known that sun rays accelerates plastic elements deterioration.
- Wasp mote Plug & Sense! is waterproof (rated at IP65). Avoid rain or water can reach the node directly when possible.
- If your model includes external solar panel, it is a good idea to place the node under the solar panel, to keep the node out of the rain, but ensuring solar panel is faced to south (north if you are on the south hemisphere) and titled 45°.
- Always place the node under RF coverage of other Wasp motes or Meshliums. It is a good idea to check RF communication before fixing the node to its final position.
- It is recommended to write down Wasp mote Plug & Sense! identification data of external sticker before placing it in its final place.
- Wasp mote Plug & Sense! is rated to IK07 against impacts. However, avoid any external object or machinery can impact with the node.
- Keep the node and its sensors out of range of people who can damage installation, wet sensors, etc.
- Temperature operating range is from -10°C to 50°C. Always ensure that the environment temperature is between these limits.
- Libelium takes no responsibility of any damage to third parties caused by a bad installation.

28. Documentation Changelog

From 6.0 to 6.1:

- Notes added for the new Americas version of the 3G radio

From 5.9 to 6.0:

- The new Smart Water Ions PRO line was added
- References to the 900 MHz version of LoRaWAN
- The new Plug & Sense! Smart Parking line was introduced
- The 3G chipset was changed
- The Outdoors USB Cable was added
- Solar Shields were discontinued
- The GPS module was discontinued

From v5.8 to v5.9:

- New section for the new sensor probes format

From v5.7 to v5.8:

- It is noted that the 4 black mounting feet come already screwed and in vertical position

From v5.6 to v5.7:

- References to the new LoRaWAN module
- Smart Metering models were discontinued

From v5.5 to v5.6:

- References to the new Sigfox module
- Socket A was deleted from the Smart Water Plug & Sense! because it is no longer needed

From v5.4 to v5.5:

- References to the new Smart Water Ions line
- Dissolved ions sensors were moved from Smart Water to Smart Water Ions

From v5.3 to v5.4:

- References to the new Smart Environment PRO line
- The Dust sensor is discontinued in the Plug & Sense! ecosystem; now, the recommended option is the Particle Matter sensor

From v5.2 to v5.3:

- References to the new LoRa module
- Updated specs for WiFi, Encryption and Meshlium

From v5.1 to v5.2:

- Added references to the new GPRS+GPS module

From v5.0 to v5.1:

- Added references to the new Turbidity sensor for Smart Water
- Noted that Plug & Sense! can keep RTC time and be recharged in OFF position
- Deleted explanation about Plug & Sense! being powered by WaspMote v12 and not v11 (transition cycle completed)
- Replaced references to old WaspMote Plug & Sense! IDE

From v4.9 to v5.0:

- Added references to the new Bluetooth Low Energy module

From v4.8 to v4.9:

- Added references to the new Smart Water line

From v4.7 to v4.8:

- Added references to the new Calibrated Gas Sensor line
- Errata correction

From v4.6 to v4.7:

- Changed Weather Meters name to Weather Station WS-3000

From v4.5 to v4.6:

- Added section for Meshlium Cloud Connector
- Added references to the External SIM socket
- Added new Liquid Presence sensor

From v4.4 to v4.5:

- Changed specifications due to the new GPS module (GPS v2)
- New IDE explanations

From v4.3 to v4.4:

- Deleted references to OTA reset

From v4.2 to v4.3:

- Magnet reset references
- OTA via 3G / GPRS / WiFi explained
- Errata correction

From v4.1 to v4.2:

- Added subsection 3G/GPRS in chapter Radios
- Added references in sections Consumption tables and limitations of use

29. Certifications

29.1. CE



In accordance with the 1999/05/CE directive, Libelium Comunicaciones Distribuidas S.L. declares that the WaspMote device conforms to the following regulations:

EN 55022:1998

EN 55022:1998/A1:2000

EN 55022:1998/A2:2003

EN 61000-4-3:2002

EN 61000-4-3/A1:2002

EN 61000-4-3:2006

UNE-EN 60950-1:2007

Compliant with ETSI EN 301 489-1 V1.6.1, EN 300 328, Date: March 26, 2009

If desired, the Declaration of Conformity document can be requested using the contact section at:

<http://www.libelium.com/contact>

WaspMote is a piece of equipment defined as a wireless sensor capture, geolocation and communication device which allows:

- Short and long distance data, voice and image communication
- Capture of analog and digital sensor data directly connected or through probes
- Wireless access enablement to electronic communication networks as well as local networks allowing cable free connection between computers and/or terminals or peripheral devices
- Geospatial position information
- Interconnection of wired networks with wireless networks of different frequencies
- Interconnection of wireless networks of different frequencies between each other
- Output of information obtained in wireless sensor networks
- Use as a data storage station
- Capture of environmental information through interface interconnection, peripherals and sensors
- Interaction with the environment through the activation and deactivation of electronic mechanisms (both analog and digital)

29.2. FCC



WaspMote models:

Model 1- FCC (XBee PRO series 1 OEM)

FCC ID: XKM-WASP01 comprising

- FCC ID: OUR-XBEEPRO

Model 2- FCC (XBee PRO ZB series 2)

FCC ID: XKM-WASP02 comprising

- FCC ID: MCQ-XBEEPRO2*

Model 3 - FCC (XBee 900MHz)

FCC ID: XKM-WASP03 comprising

- FCC ID: MCQ-XBEE09P

Installation and operation of any WaspMote model must assure a separation distance of 20 cm from all persons, to comply with RF exposure restrictions.

Module Grant Restrictions

FCC ID OUR-XBEEPRO

The antenna(s) used for this transmitter must be installed to provide the separation distances, as described in this filing, and must not be co-located or operating in conjunction with any other antenna or transmitter. Grantee must coordinate with OEM integrators to ensure the end-users of products operating with this module are provided with operating instructions and installation requirements to satisfy RF exposure compliance. Separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations. Power listed is continuously variable from the value listed in this entry to 0.0095W

FCC ID MCQ-XBEEPRO2

OEM integrators and End-Users must be provided with transmitter operation conditions for satisfying RF exposure compliance. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility. This grant is valid only when the device is sold to OEM integrators and the OEM integrators are instructed to ensure that the end user has no manual instructions to remove or install the device.

29.3. IC

WaspMote models:

Model 1- IC (XBee PRO series 1 OEM)

IC: 8472A-WASP01 comprising

- IC: 4214A-XBEEPRO

Model 2- IC (XBee PRO ZB series 2)

IC: 8472A-WASP02 comprising

- IC: 1846A-XBEEPRO2

Model 3- IC (XBee 900MHz)

IC: 8472A-WASP03 comprising

- IC: 1846A-XBEE09P

The term "IC:" before the equipment certification number only signifies that the Industry Canada technical specifications were met.

Installation and operation of any WaspMote model must assure a separation distance of 20 cm from all persons, to comply with RF exposure restrictions.

29.4. Use of equipment characteristics

- Equipment to be located in an area of restricted access, where only expert appointed personnel can access and handle it.
- The integration and configuration of extra modules, antennas and other accessories must also be carried out by expert personnel.

29.5. Limitations of use

The ZigBee/IEEE 802.15.4 module has a maximum transmission power of 20dBm.

It is regulated according to EN 301 489-1 v 1.4.1 (202-04) and EN 301 489-17 V1.2.1 (2002-08). The configuration software must be used to limit to a maximum power of 12'11dBm (PL=0).

The 868MHz XBee module has a maximum transmission power of 27dBm. This module is regulated only for use in Europe.

The 900MHz XBee module has a maximum power of 20dBm. This module is regulated only for use in the United States.

The GSM - 3G/GPRS module has a power of 2W (Class 4) for the 850MHz/900MHz band and 1W (Class 1) for the 1800MHz and 1900MHz frequency band.

The 3G/GPRS module has a power of 0.25W for the UMTS 900MHz/2100MHz band, 2W for the GSM 850MHz/900MHz band and 1W DCS1800MHz frequency band.

Important: In Spain the use of the 850MHz band is not permitted. For more information contact the official organisation responsible for the regulation of power and frequencies in your country.

The cable (pigtail) used to connect the radio module with the antenna connector shows a loss of approximately 0.25dBi for GSM - 3G/GPRS.

The broadcast power at which the WiFi, XBee 2.4GHz, XBee 868MHz, XBee 900MHz operate can be limited through the configuration software. It is the responsibility of the installer to choose the correct power in each case, considering the following limitations:

The broadcast power of any of the modules added to that of the antenna used minus the loss shown by the pigtail and the cable that joins the connector with the antenna (in the event of using an extra connection cable) must not exceed 20dBm (100mW) in the 2.4GHz frequency band and 27dBm for the 868MHz band, according to the ETSI/EU regulation.

It is the responsibility of the installer to configure the different parameters of the equipment correctly, whether hardware or software, to comply with the pertinent regulation of each country in which it is going to be used.

Specific limitations for the 2.4GHz band.

- In Belgium, outdoor use is only on channels 11(2462MHz), 12(2467MHz) and 13(2472MHz) only. It can be used without a licence if it is for private use and at a distance less than 300m. Over longer distances or for public use, an IIBPT licence is required.
- In France the use of channels 10(2457MHz), 11(2462MHz), 12(2467MHz) and 13(2472MHz) is restricted. A licence is required for any use both indoors and outdoors. Contact ARCEP (<http://www.arcep.fr>) for further information.
- In Germany a licence is required for outdoor use.
- In Italy a licence is required for indoor use. Outdoor use is not permitted.
- In Holland a licence is required to outdoor use.
- In Norway, use near Ny-Alesund in Svalbard is prohibited. For further information enter Norway Posts and Telecommunications (<http://www.npt.no>).

Specific limitations for the 868MHz band.

- In Italy the maximum broadcast power is 14dBm.
- In the Slovakian Republic the maximum broadcast power is 10dBm.

Important: It is the responsibility of the installer to find out about restrictions of use for frequency bands in each country and act in accordance with the given regulations. Libelium Comunicaciones Distribuidas S.L does not list the entire set of standards that must be met for each country. For further information go to:

CEPT ERC 70-03E - Technical Requirements, European restrictions and general requirements: <http://www.erodocdb.dk/>

R&TTE Directive - Equipment requirements, placement on market: <http://www.erodocdb.dk/>

30. Maintenance

- Although WaspMote is a highly resistant product, please handle with care in order to enjoy a longer useful life.
- Handle WaspMote Plug & Sense! with care, do not allow it to drop or move roughly.
- Avoid placing the devices in areas reaching high temperatures that could damage the electronic components.
- The antennas screw on gently to the connector, do not force upon installing or you could damage the connectors.
- Do not use any type of paint on the device, it could affect the operation of connections and closing mechanisms.
- Do not store WaspMote Plug & Sense! in places exposed to dirt and dust in order to avoid damage to electronic components.
- Never open the casing, warranty will not cover products that have been opened.
- For cleaning, use a damp cloth, no aggressive chemical products.

31. Disposal and recycling

- When Wasp mote Plug & Sense! reaches the end of its useful life it must be taken to a recycling point for electronic equipment.
- The equipment should be disposed of separately from solid urban waste, please dispose of correctly.
- Your distributor will advise you on the most appropriate and environmentally-friendly way of disposing of the product and its packing.



32. Resources

You can find complete information and support in the next sections in the Libelium Website:

- Development: http://www.libelium.com/development/plug_&_sense
- Forum: <http://www.libelium.com/forum/>