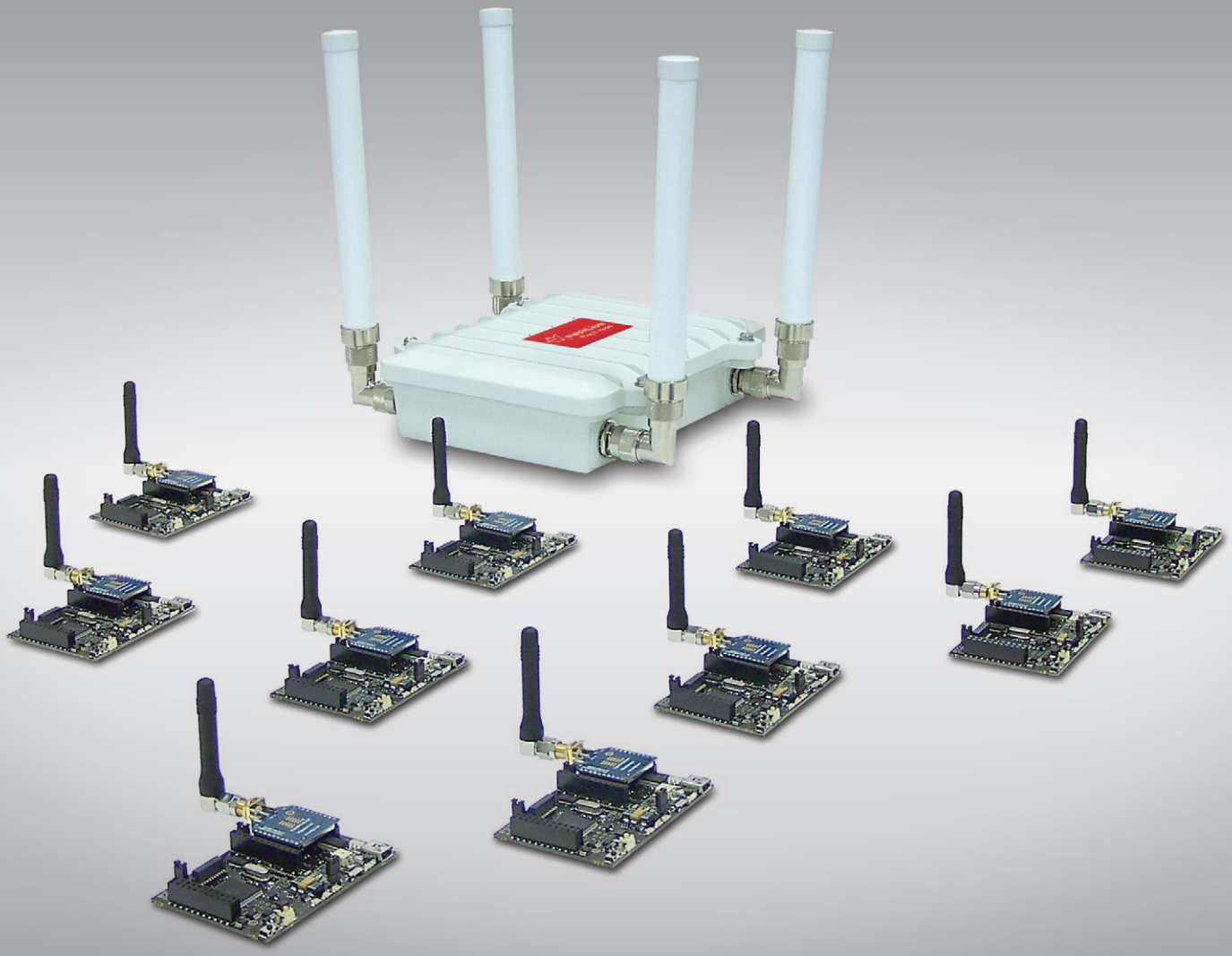
Wireless Sensor Networks

with Waspmote and Meshlium

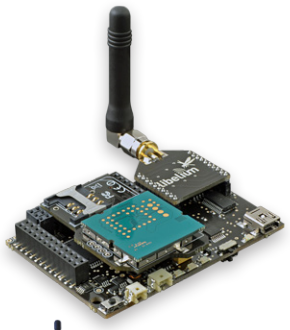


libelium

waspmote

Wireless Sensor Networks with Waspmote and Meshlium

- ## Three Libelium technologies:



Waspmote is a sensor device specially oriented to developers. It works with different protocols (ZigBee, LoRa, Bluetooth, GPRS) and frequencies (2.4GHz, 868MHz, 900MHz) being capable of getting links up to 22km. It counts with an hibernate mode of 0.06uA which allows to save battery when it is not transmitting. More than 50 sensors already available and a complete open source IDE (API libraries + compiler) made really easy to start working with the platform.

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

The new Waspmote Plug & Sense! line allows developers to forget about electronics and focus on services and applications. Now you can deploy wireless sensor networks in a easy and scalable way ensuring minimum maintenance costs. The new 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.

More info: **http://www.libelium.com/plug_&_sense**

Meshlium is a Linux router which works as the Gateway of the Waspmote Sensor Networks. It can contain 5 different radio interfaces: WiFi 2.4GHz, WiFi 5GHz, 3G/GPRS, Bluetooth and **XBee/LoRa**. As well as this, Meshlium can also integrate a GPS module for mobile and vehicular applications and be solar and battery powered. These features a long 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.

The new Meshlium Xtreme allows to 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**

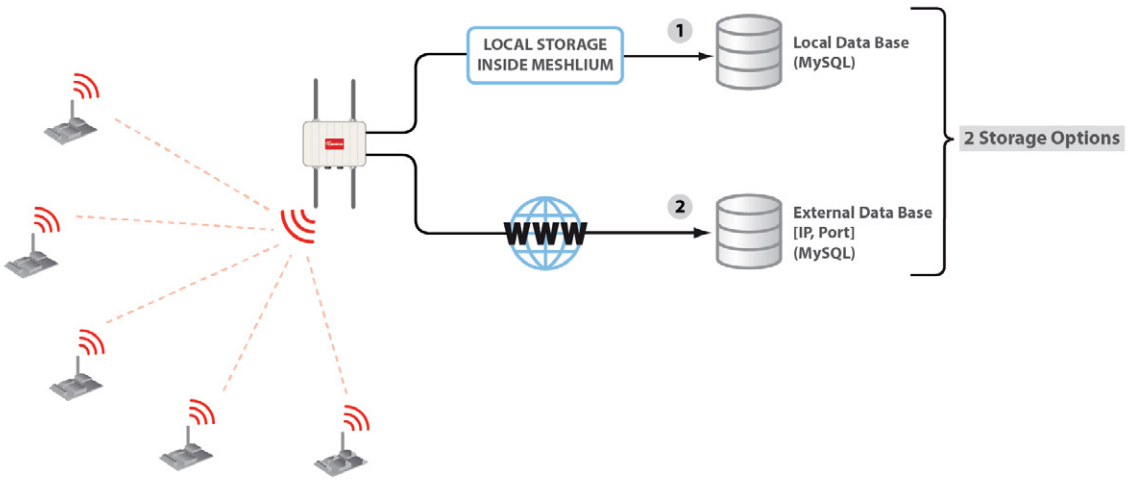
How do they work together?

Meshlium receives the sensor data sent by Waspmote using the XBee, LoRa, GPRS, 3G or WiFi radios.

Then 4 possible actions can be performed:

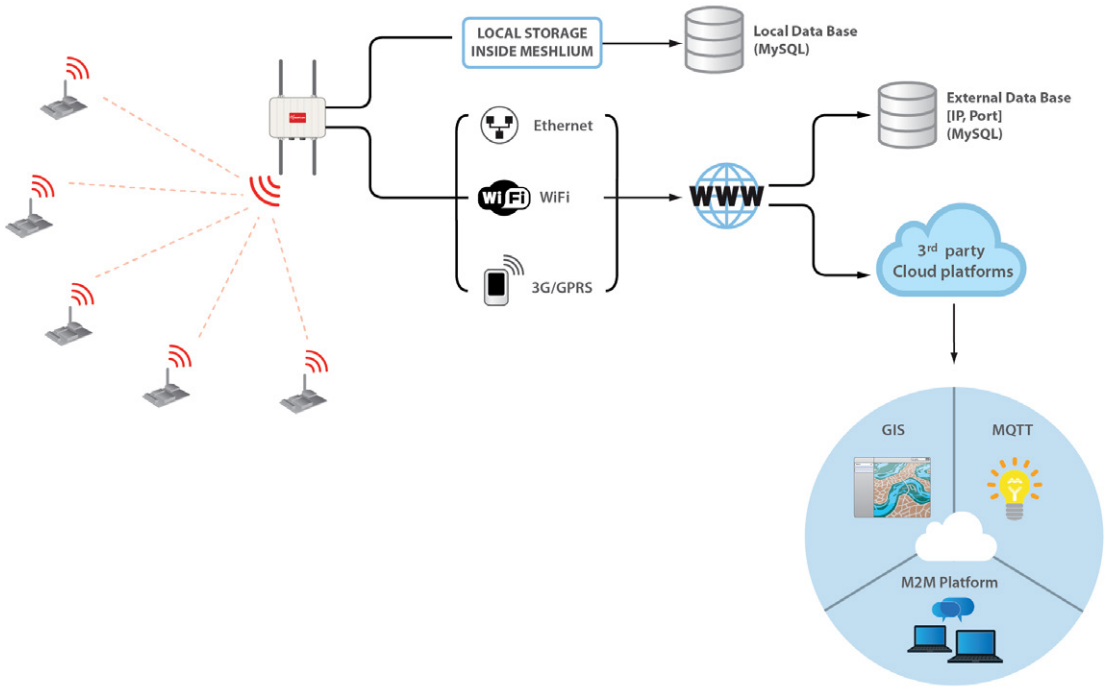
1. Store the sensor data in the Meshlium Local Data Base (MySQL)
2. Store the sensor data in an External Data Base (MySQL)
3. Send the information to the Internet using the Ethernet or WiFi connection
4. Send the information to the Internet using the 3G/GPRS connection

- **Meshlium Storage Options**



- Local Data Base
- External Data Base

- **Meshlium Connection Options**



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

- **Capturing and storing sensor data in Meshlium from a Waspmote sensor network**

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

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

The **Sensor Parser** is a new feature for Meshlium (version 3.0.5 or older). It is a new software system which is able to do the following tasks in an easy and transparent way:

- receive frames from XBee, LoRa, GPRS, 3G or WiFi (with the Data Frame format)
- 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:

```
~\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 header API frame, followed by the message. In the above example the message is:

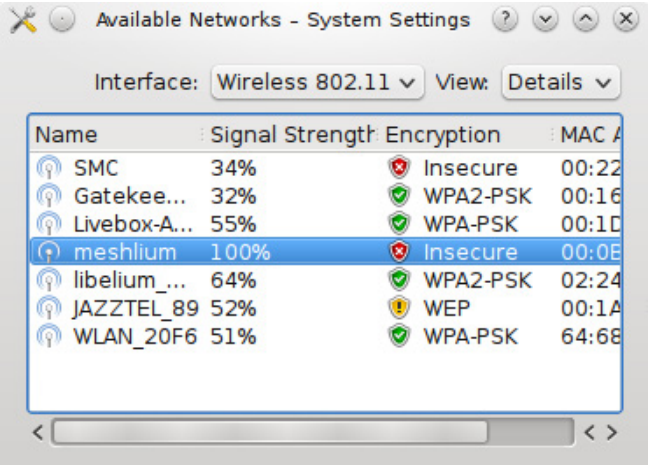
```
<=>\0x80\0x03#35689722##7#ACC:80;10;987#IN_TEMP:22.50#BAT:93#
```

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/LoRa 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".

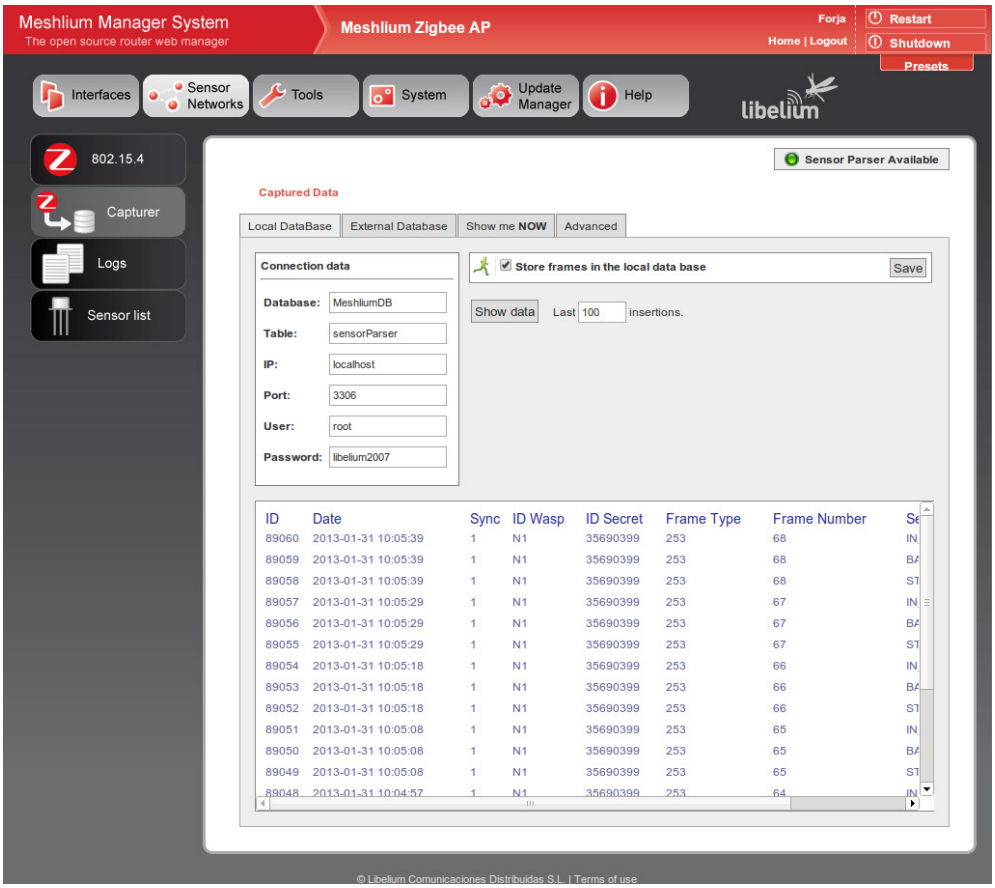


No password is needed as the network is public (you can change it later in the WiFi AP Interface options). When you select it, Meshlium will give an IP from the range 10.10.10.10 - 10.10.10.250.

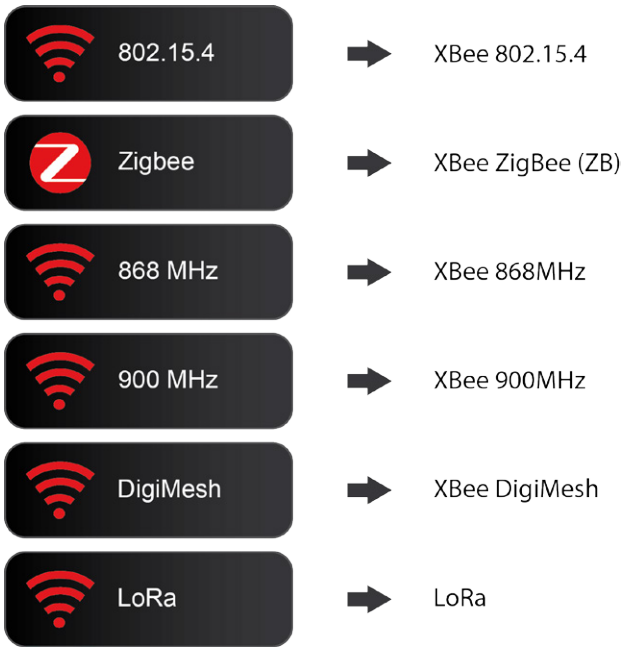
Now you can open your browser and access to the Meshlium Manager System:

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

Now we go to the "Sensor Networks" tab.



There are different RF/XBee models wich can be configured:

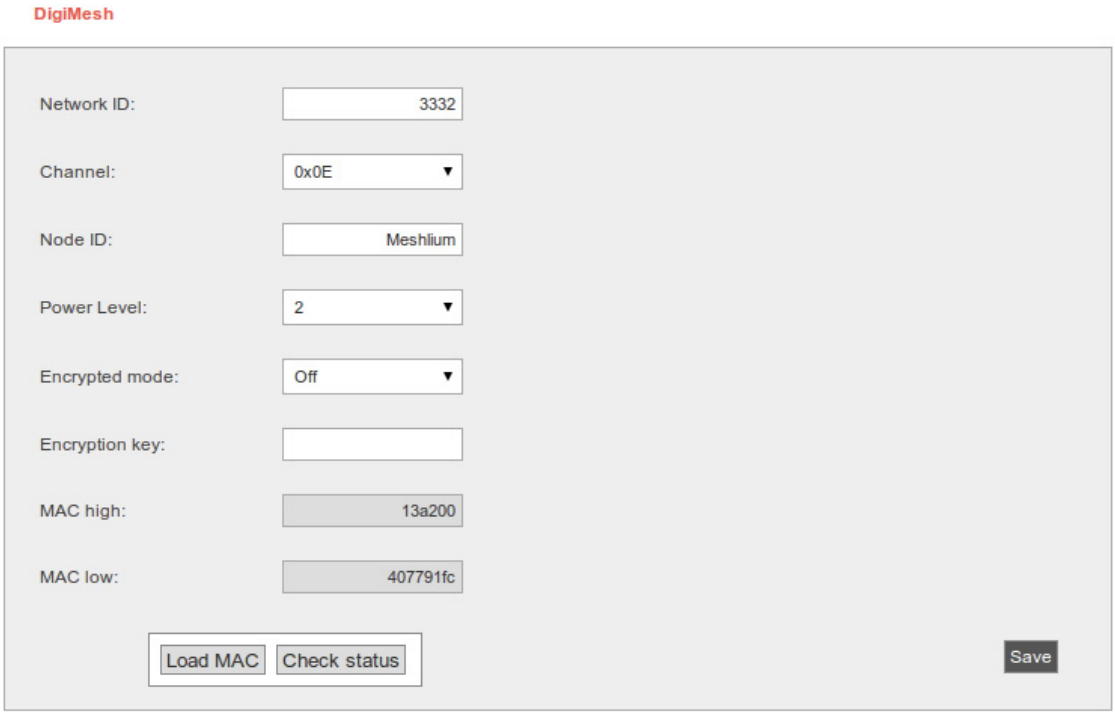


Depending the kind of XBee model the parameters to be configured may vary.

Complete list:

- **Network ID:** Also known as PAN ID (Personal Arena 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)

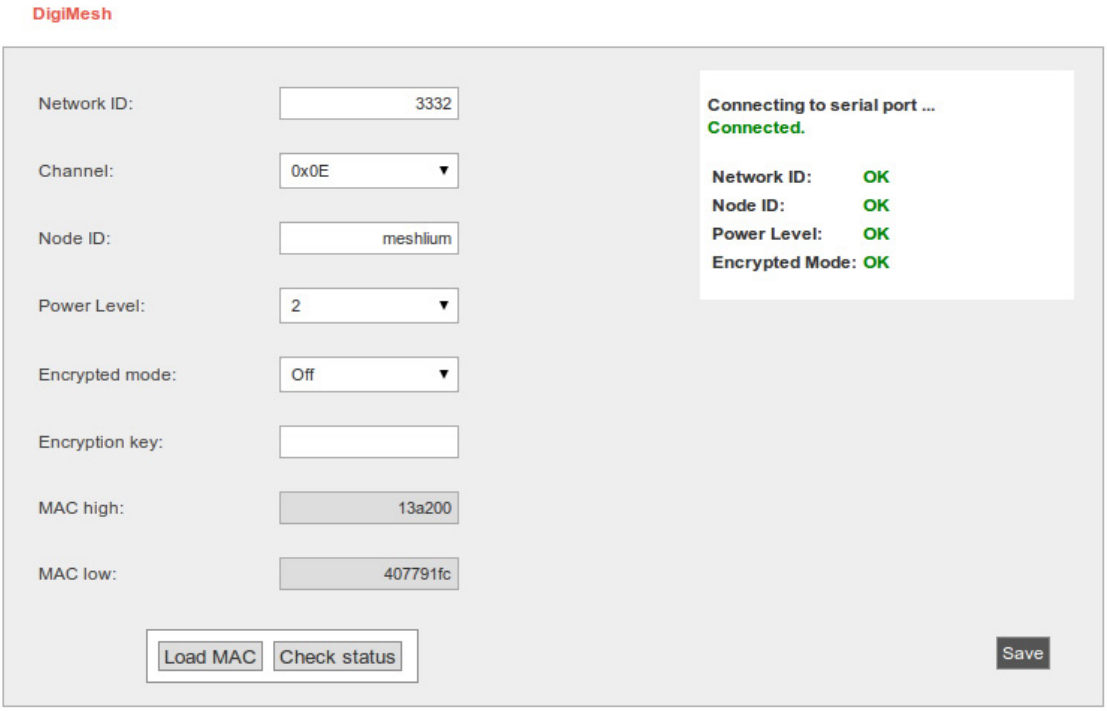
These parameters must be also configured in the Waspmote sensor nodes. Access to all the information related to Waspmote at: **http://www.libelium.com/waspmote**



To discover the MAC address of the radio 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 processes ("Load MAC" and "Check status") require the ZigBee capturer daemon to be stopped. This means no frames will be received while executing these actions. Be patient, this can take up to 1 minute to finish.



Note: *When you buy a 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 XBee radio has an old version of the firmware but it is working perfectly.*

- ## Capturing and storing sensor data

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

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

```
<=>\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.

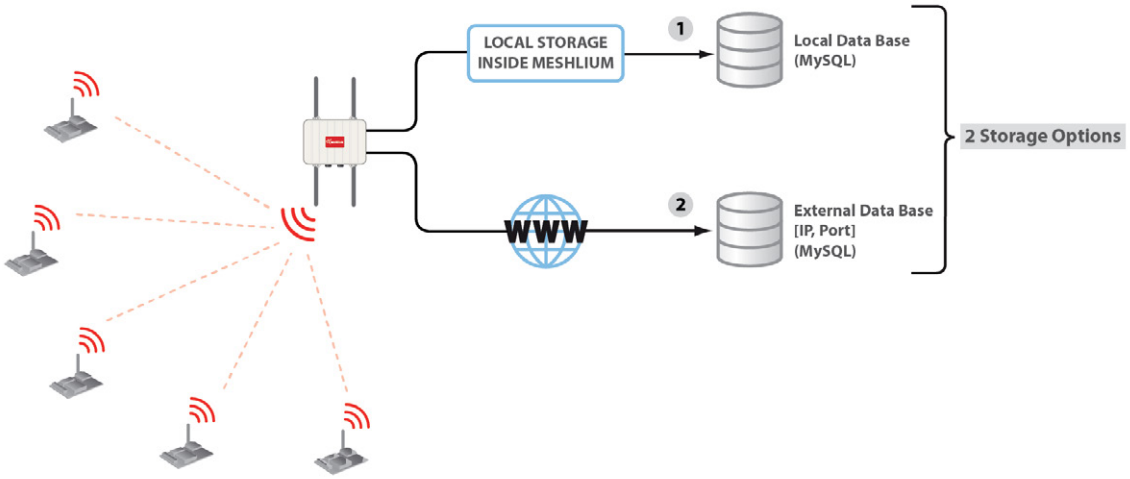
In order to add your own sensor frames properly go to the section "Sensors". However if you do not use the official Data Frame by Libelium, your data frames will be saved as a generic "Frame" in the database. See the picture below in order to see different frames types and how they are saved in the database.

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	<=>[illegible]#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

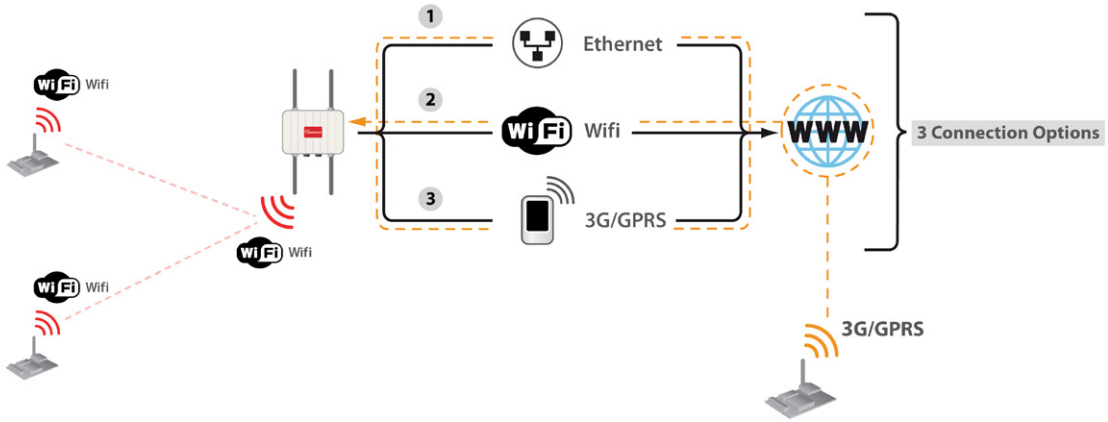
If you change any of the parameters in Waspmote or Meshlium you will have to do it in both platforms so that they still can communicate.

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

- Local Data Base
- External Data Base



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



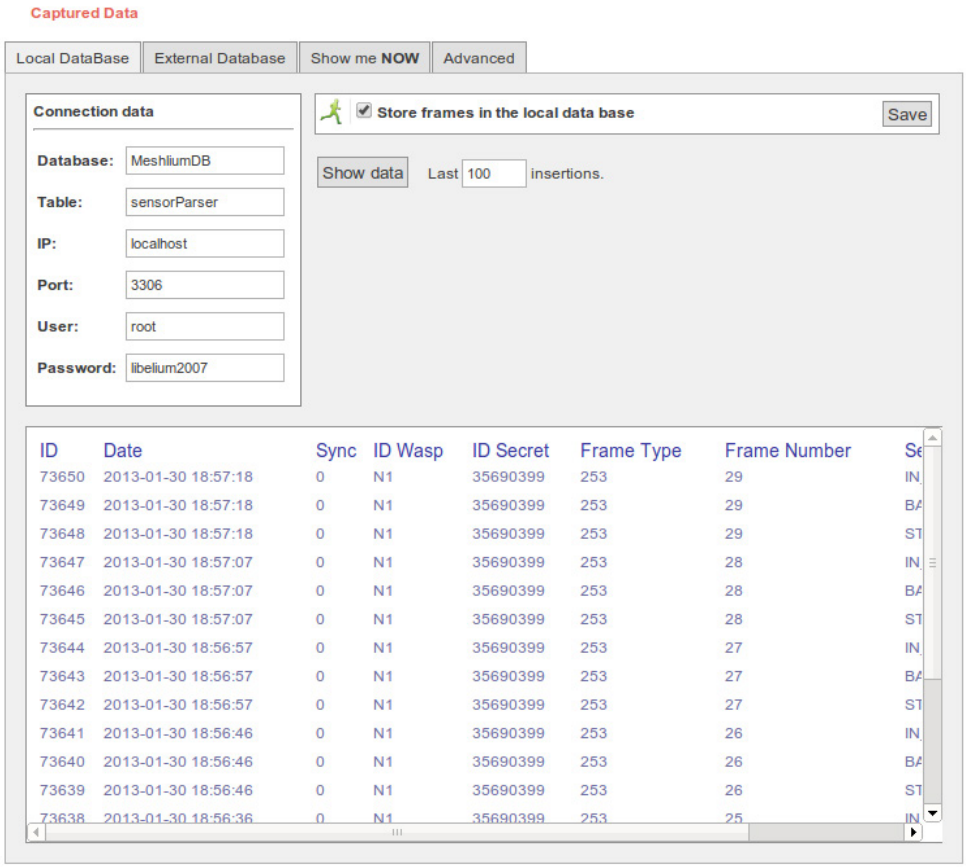
- ## Local Data Base

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.



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.

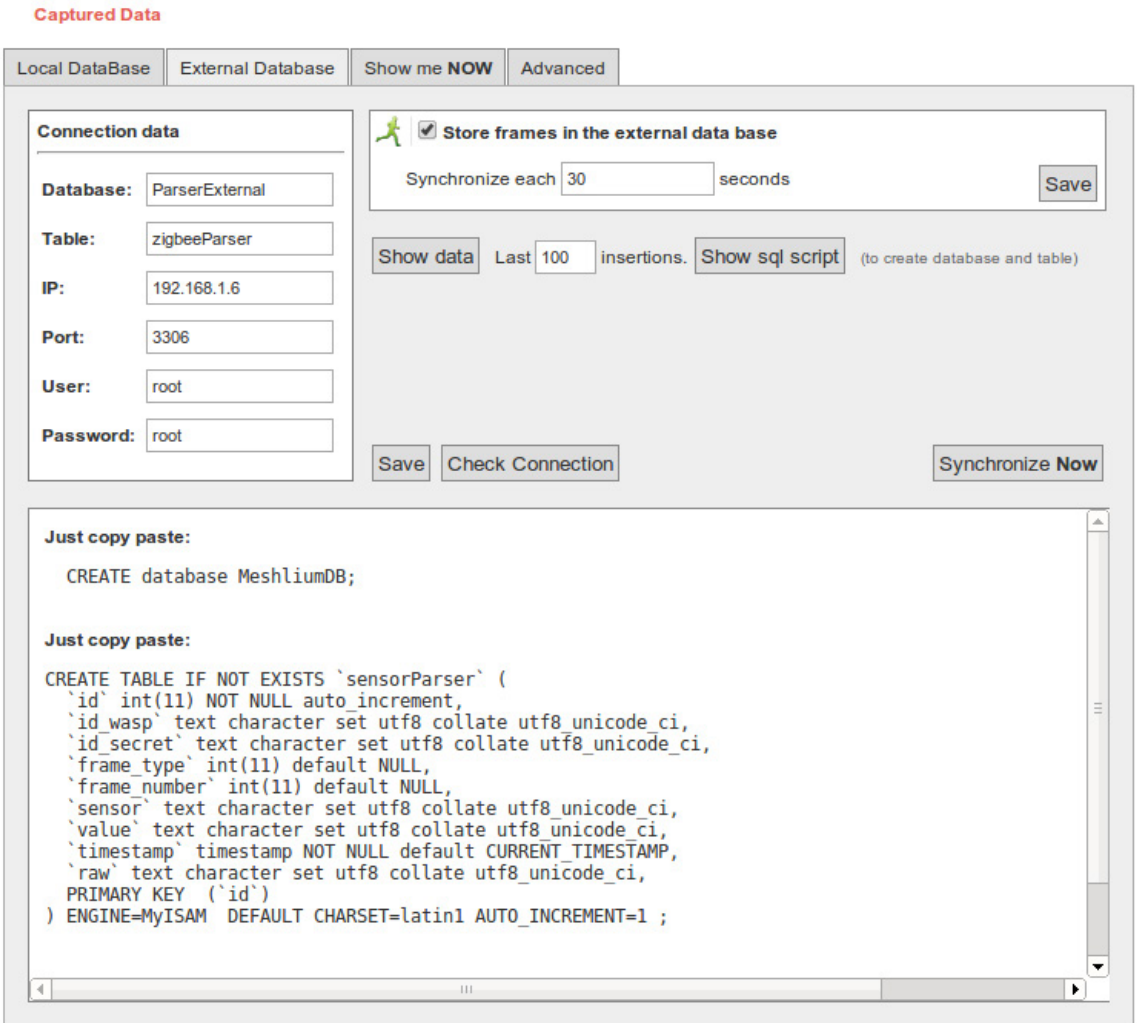
At any time you can see the last "x" records stored. Just set how many insertions you want to see and press the "Show data" button.

- ## External Data Base

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

Steps:

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

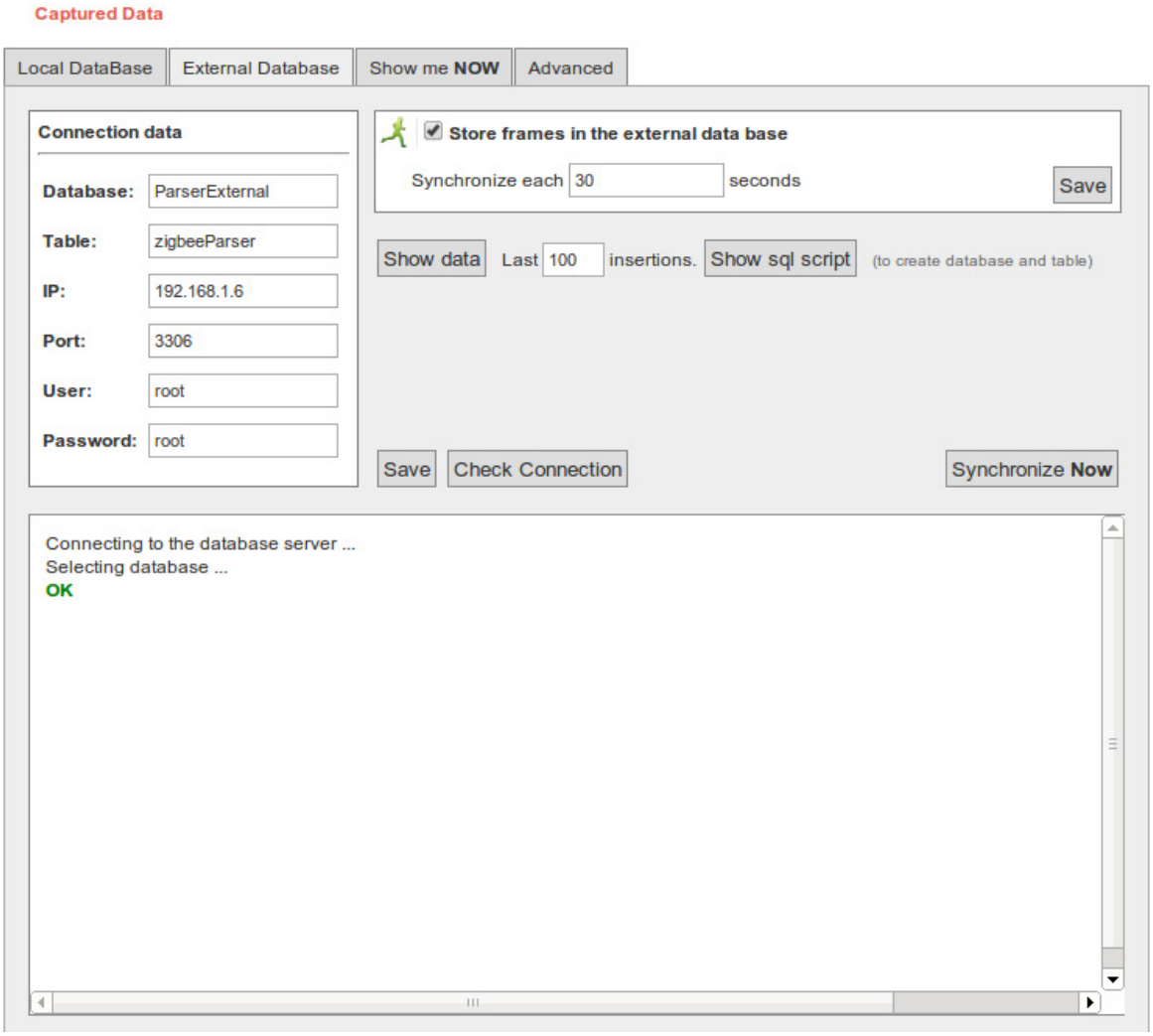


2. Insert this code in your MySQL management application.

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.

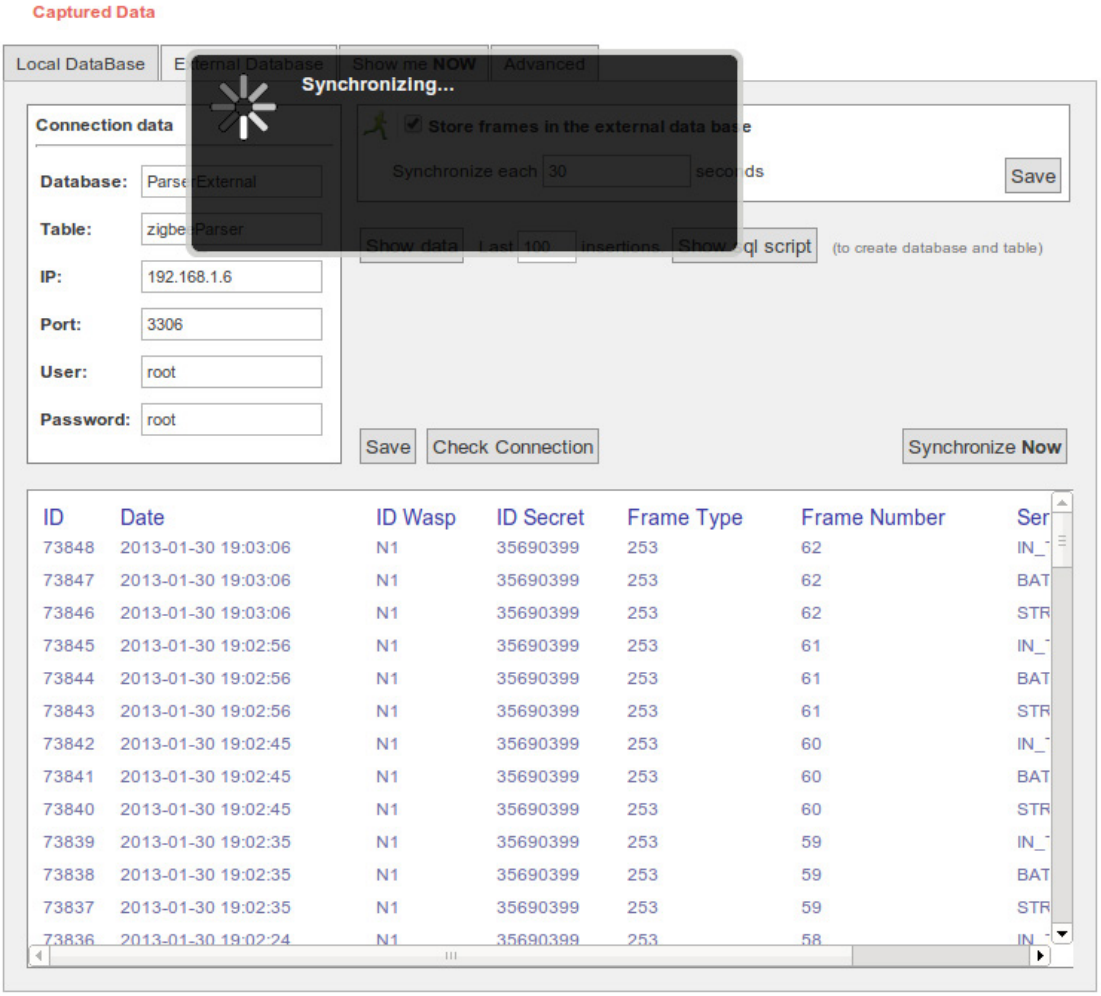
4. Now press the "Check Connection" button to see if the configuration is correct.



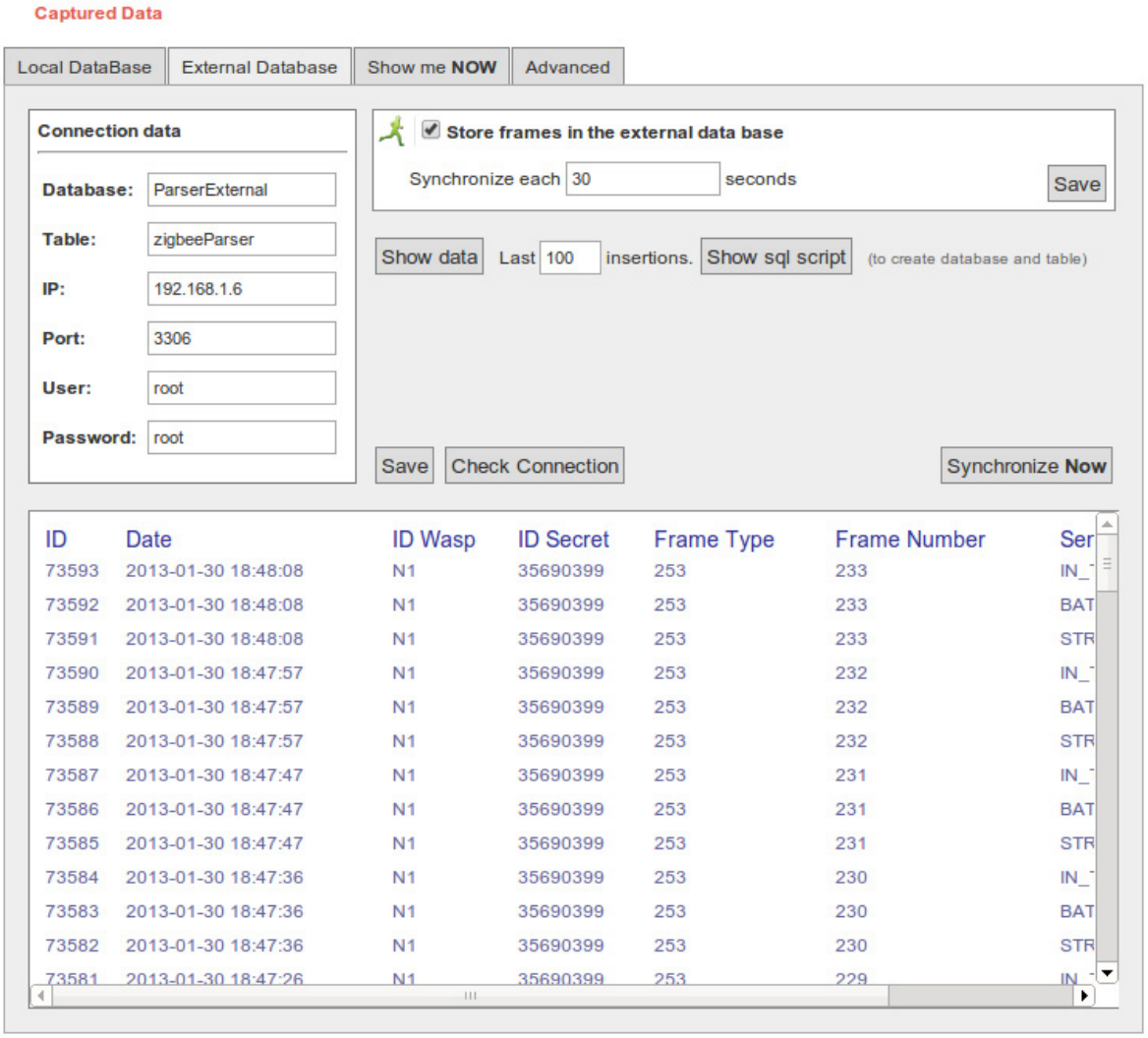
5. Set the check box "Store frames in external database", you can define the interval how often to synchronize the local database with external database and press the "Save" button.

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

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



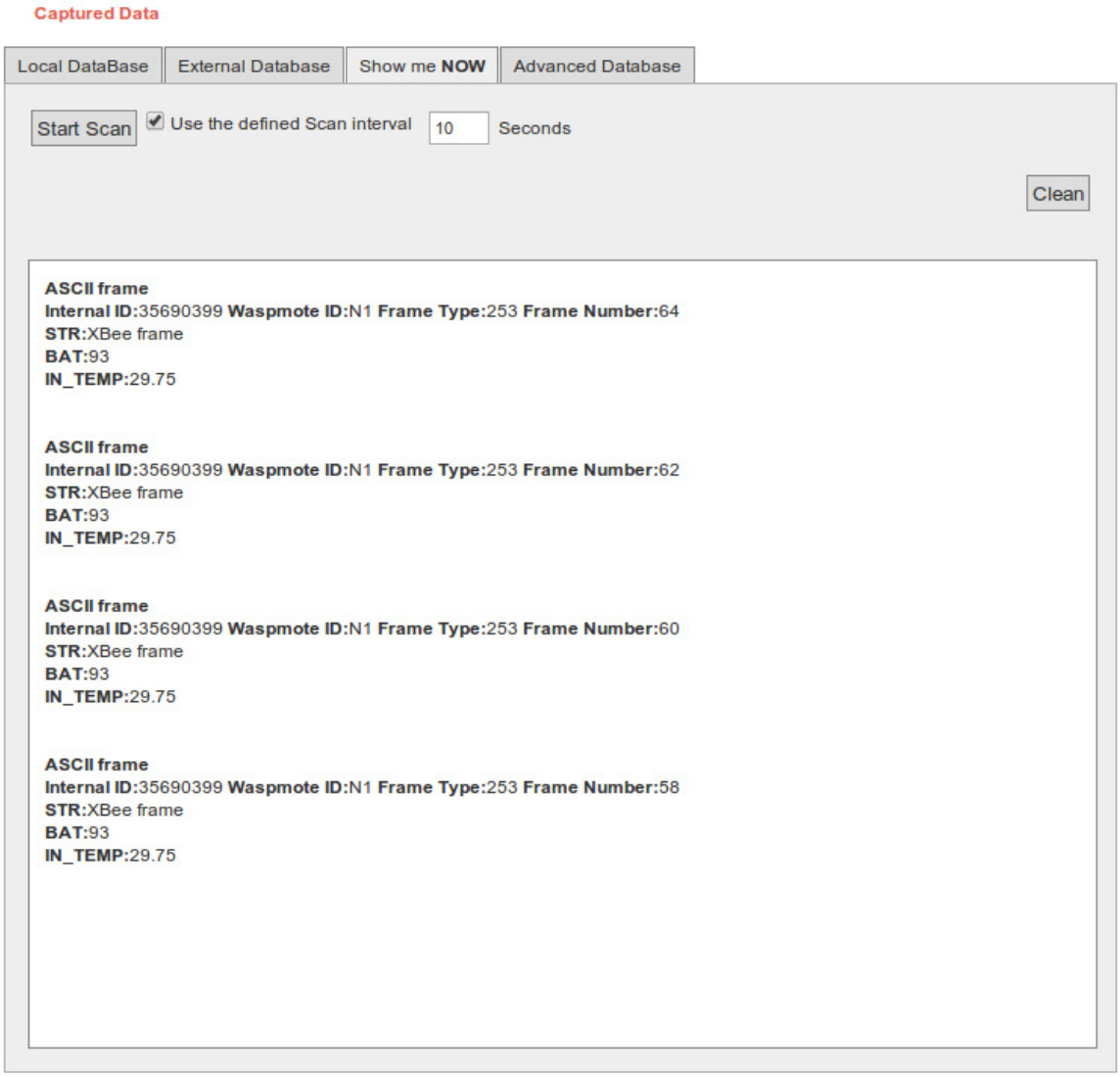
At any time you can see the last "x" records stored. Just set how many insertions you want to see and press the "Show data" button.



- **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.

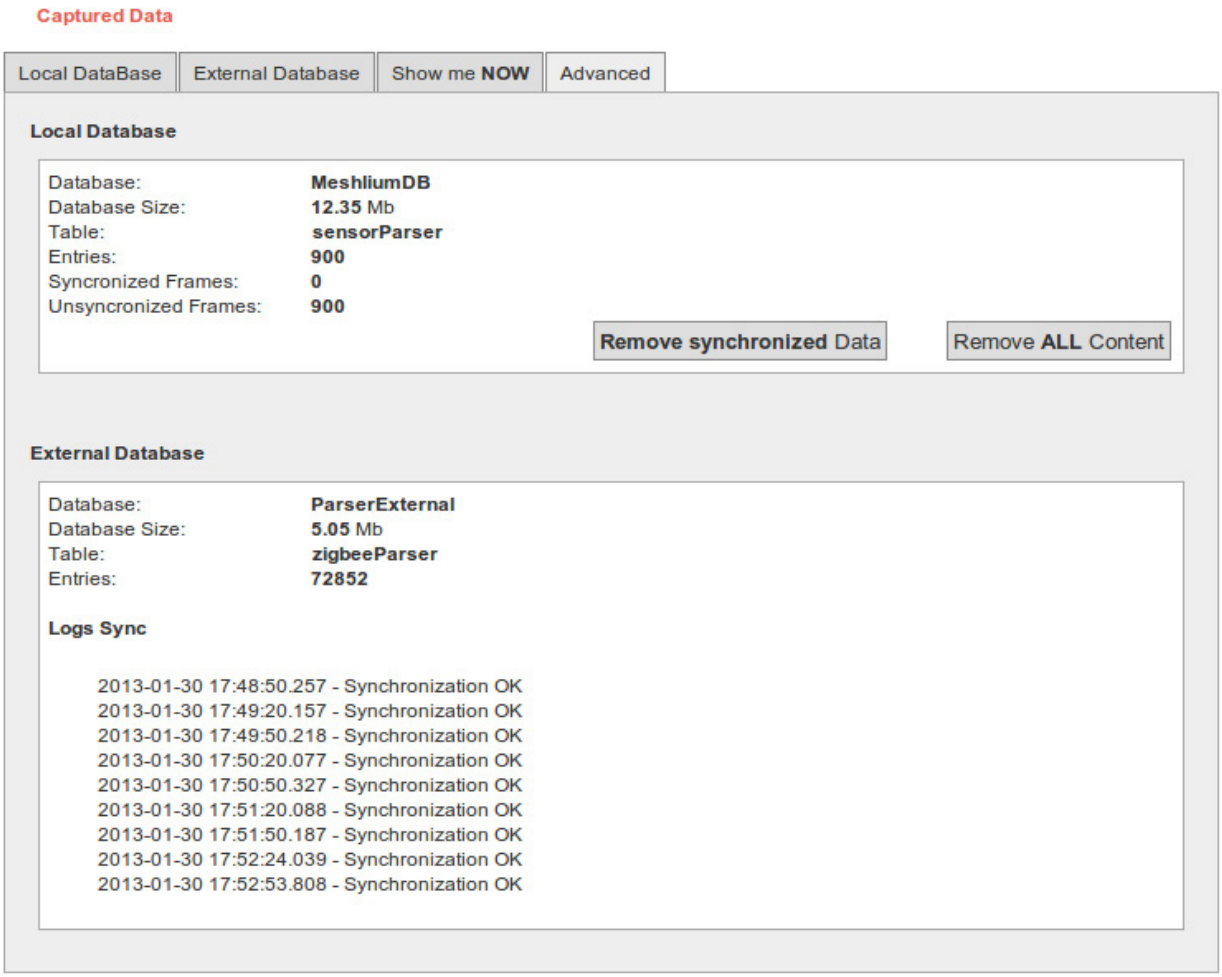


- ## Advanced Database

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

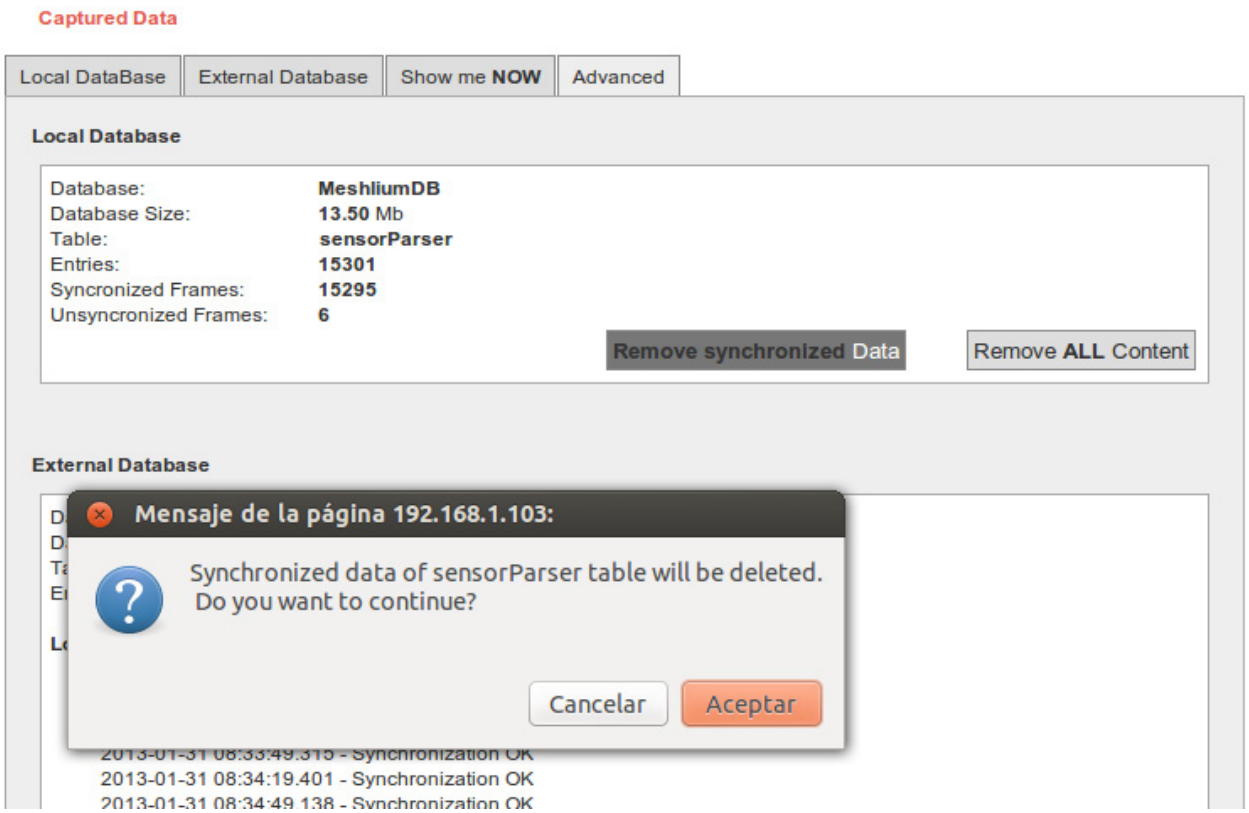
It displays information about the Loca and Externall database, showing the following information:

- 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

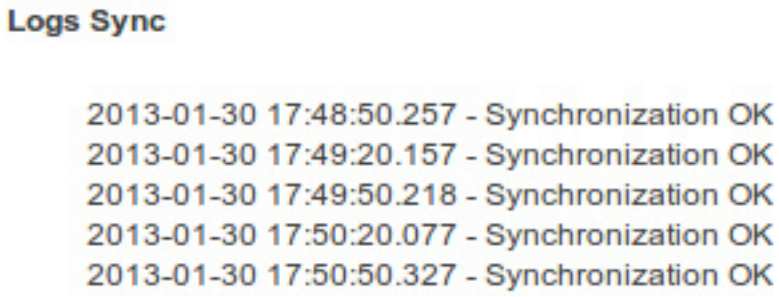


From this tab, **you can delete all the information contained in the Local database or Remove synchronized data**. Before performing these actions, a confirmation message will be displayed.

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

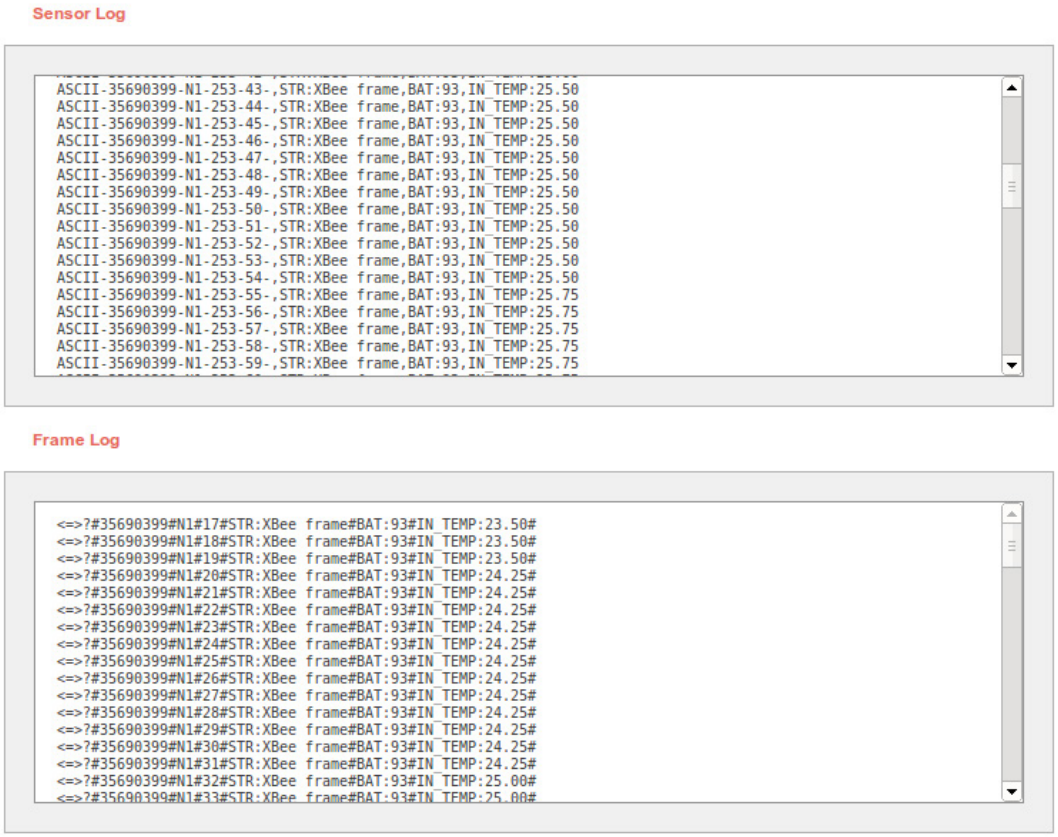


In addition can display a log of the date of the last synchronization between the local database and external database was successful.



- **Capturer logs**

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



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#
```

- ## Sensors

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

By default Meshlium recognize all Libelium official sensors frames. All sensors frames that Meshlium 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`

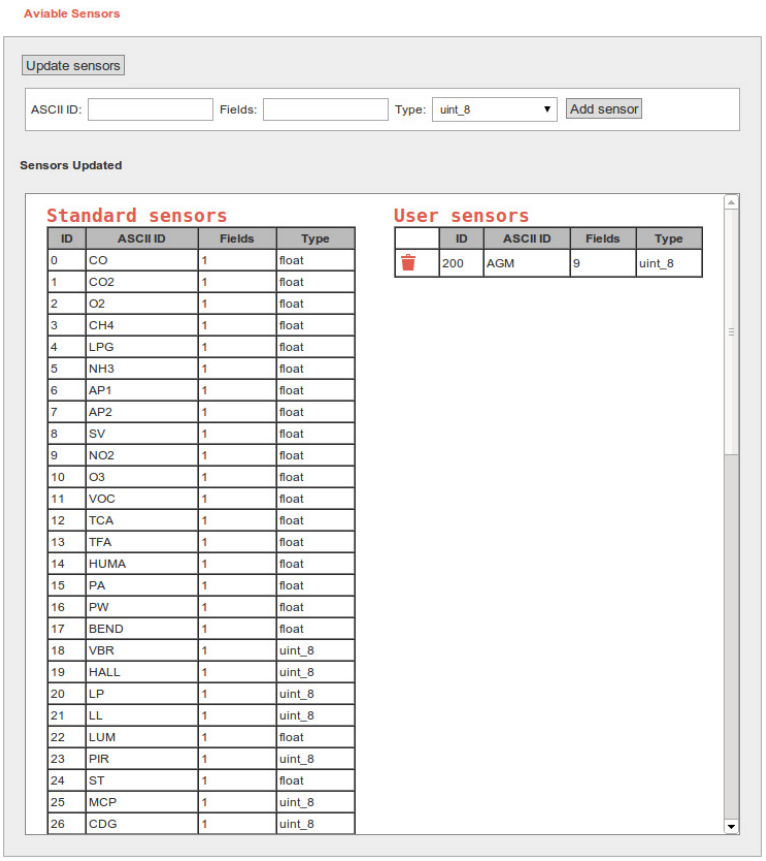
The button "update sensors" update the Libelium official sensor. User sensors remaining unchanged.

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"



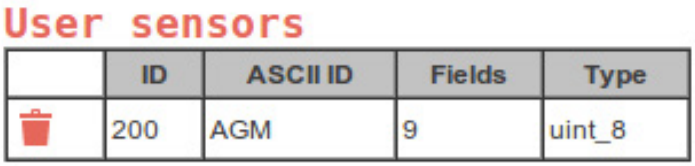
ID	ASCII ID	Fields	Type
0	CO	1	float
1	CO2	1	float
2	O2	1	float
3	CH4	1	float
4	LPG	1	float
5	NH3	1	float
6	AP1	1	float
7	AP2	1	float
8	SV	1	float
9	NO2	1	float
10	O3	1	float
11	VOC	1	float
12	TCA	1	float
13	TFA	1	float
14	HUMA	1	float
15	PA	1	float
16	PW	1	float
17	BEND	1	float
18	VBR	1	uint_8
19	HALL	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

	ID	ASCII ID	Fields	Type
	200	AGM	9	uint_8

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: *More extensive information about how to build frames is available on the Waspmote Data Frame Guide.*

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



- ## 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 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
```

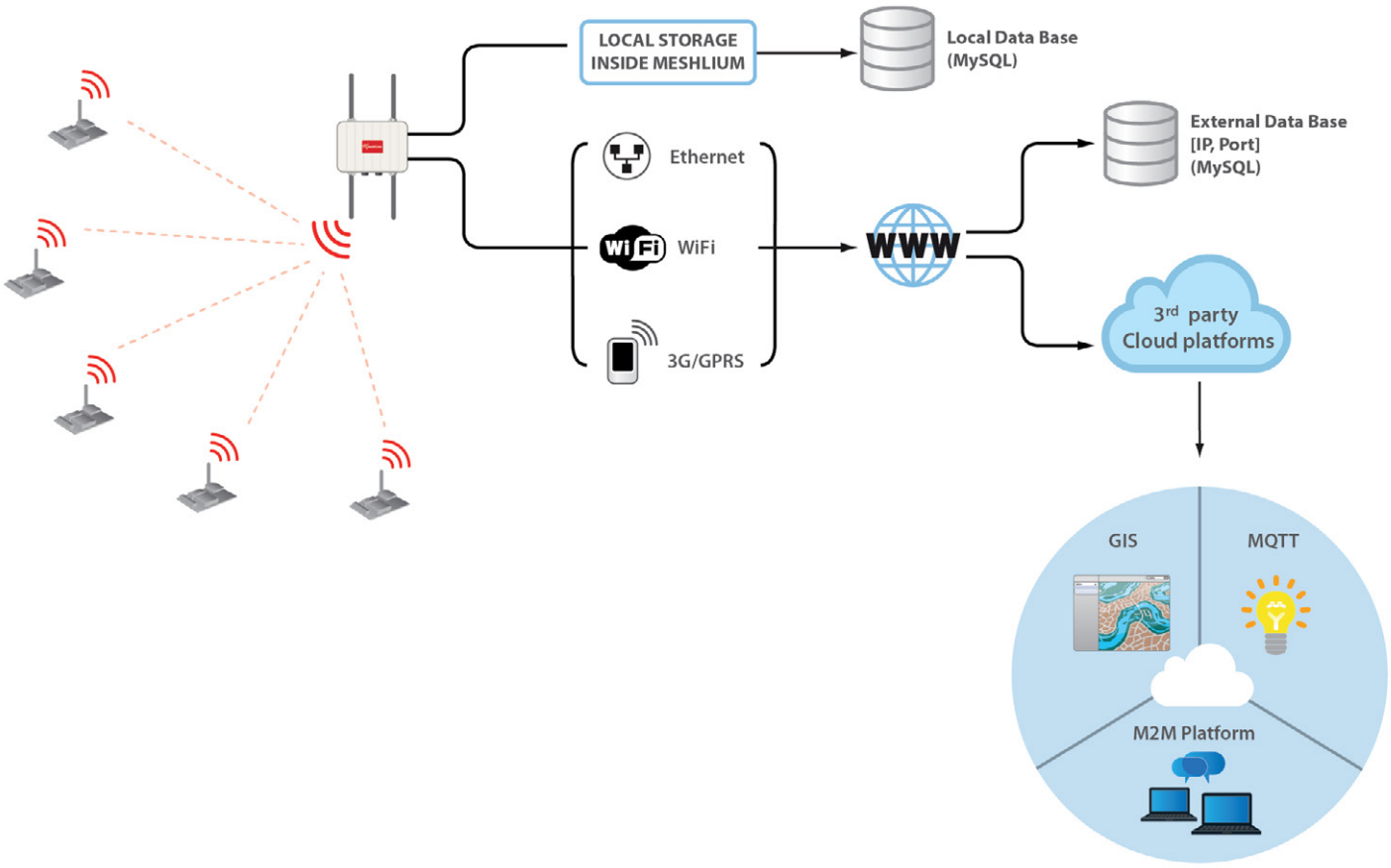
Important: If you want to create a "ZigBee sending" daemon that is executed each time Meshlium starts you have to deactivate the "ZigBee Capturer" daemon (/etc/init.d/ZigbeeScanD.sh) as the radio has to be used by one process at a time.

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

- ## 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 here:

http://www.libelium.com/development/meshlium/documentation/meshlium-technical-guide/



Cloud connector diagram