Mesh Democase User Guide

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CHAPTER I.   INTRODUCTION

Ⅰ.1. Aim of Document

The aim of this document is to describe the DemoCase dedicated to Mesh Lite demonstration, based on B868-TinyPRO and B868-TinyPLUS radio modules.

This user manual gives a detailed description of the DemoCase regarding the hardware parts and the software functionalities. It also gives the basic principles to build and manage a mesh network with the different elements of the DemoCase.

Ⅰ.2. Reference documents

[1] M-ONE Protocol Stack User Guide	1vv0300819
[2] Mesh Manager User Guide	1vv0300823
[3] B868-TinyPRO : Technical Manual	1vv0300816_TinyOne Pro 868MHz User Guide
[4] B868-TinyPLUS : Technical Manual	1vv0300817_TinyOne Plus 868MHz User Guide

Ⅰ.3. Document change log

Revision	Date	Changes
ISSUE # 0	29/07/09	First Release

I.4. Glossary

ACP	Adjacent Channel Power
BER	Bit Error Rate
Bits/s	Bits per second (1000 bits/s = 1Kbps)
CER	Character Error Rate
dBm	Power level in decibel milliwatt (10 log (P/1mW))
EMC	Electro Magnetic Compatibility
EPROM	Electrical Programmable Read Only Memory
ETR	ETSI Technical Report
ETSI	European Telecommunication Standard Institute
FM	Frequency Modulation
FSK	Audio Frequency Shift Keying
GFSK	Gaussian Frequency Shift Keying
GMSK	Gaussian Minimum Shift Keying
IF	Intermediary Frequency
ISM	Industrial, Scientific and Medical
kbps	kilobits/s
LBT	Listen Before Talk
LNA	Low Noise Amplifier
MHz	Mega Hertz (1 MHz = 1000 kHz)
PLL	Phase Lock Loop
PROM	Programmable Read Only Memory
NRZ	Non return to Zero
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RSSI	Receive Strength Signal Indicator
Rx	Reception
SRD	Short Range Device
Tx	Transmission
SMD	Surface Mounted Device
VCO	Voltage Controlled Oscillator
VCTCXO	Voltage Controlled and Temperature Compensated Crystal Oscillator

CHAPTER II.   GENERAL DESCRIPTION

II.1. DemoCase Philosophy

The goal of the DemoCase is to show to customers:

  ⮀   the possibilities offered by the M-ONE embedded firmware,

  ⮀   the know-how of Telit RF regarding innovating embedded network technology.

This DemoCase allows customers to create a mesh network and test the Mesh Lite functionalities. The application available is serial link data transmission and telemetry.

All the devices proposed into the DemoCase are based on B868-TinyPRO and B868-TinyPLUS radio modules.

II.2. Hardware Consideration

The DemoCase contains different devices combining TinyPRO and TinyPLUS radio modules :

- _B868-TinyPRO_ : it is a 500mW radio module, allowing range up to 4 kms.
- _B868-TinyPLUS_ : it is a 25mW radio module, allowing range up to 1,5 km.

For the current DemoCase, and more generally for Mesh Lite applications, both modules are configured as followed :

- Center Frequency : 869.525 MHz
- Bandwidth : 250 kHz
- RF Datarate : 38.4 kbps

For more information on these products, please refer to the dedicated documentation [1] [3] [4] available on the Telit web site.
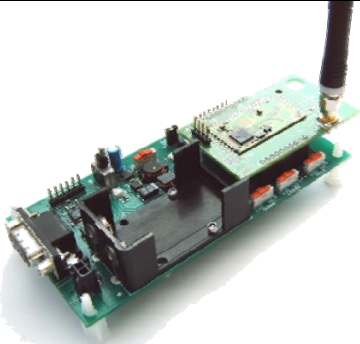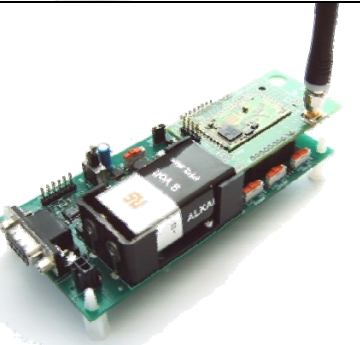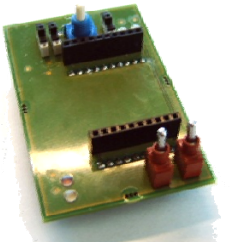
II.3. Mesh Lite Consideration

Mesh Lite protocol is based on a cluster tree network architecture. It hosts 4 types of devices:

- _Coordinator_: this is the master of the network. Most of the network parameters are set into the Coordinator, which broadcasts the configuration to the other devices. There is only one Coordinator in a network and obviously, it doesn't have any parent, only children.

- _Router_: this device is able to route a message from its parent to one of its child, from a child to another child or from a child to the parent. A Router has only one parent and could host up to 100 children. The parent of a Router can be the Coordinator or another Router. Depending of the configuration, the total number of Routers in a network could reach up to 100.

- _EndPoint_: an EndPoint is a termination of the network, i.e. it doesn't have any child. An EndPoint could either have a Router or the Coordinator as parent. It can only communicate via its parent.

- _Sniffer_: it is an optional EndPoint configured to accept all received radio frames, even if it isn't the recipient. This device is used to monitor the network. A temporary Sniffer can be made from a classical EndPoint of the network during the installation and then retrieve a normal operation as any other EndPoint.

Mesh Lite uses beacons to manage the network. It is Low Power capable and a same network can mix either powered or low power devices.

For more information, please refer to the dedicated documentation [1] available on Telit web site.

II.4. 'Mesh Manager' Consideration

Mesh Manager is the PC software to configure and monitor a Mesh Lite network. Four operating modules are available with some dedicate functions and interactive ones.

- _Mesh tree view_: tree view of the mesh network with auto discovery.
- _Mesh terminal_: customized terminal to exchange every type of frames over the mesh network.
- _Mesh Scope_: real time scan to track all frames exchanged with route information.
- _Mesh Configuration wizard_: the easiest way to configure and add a module to an existing network or to build a complete new network.

For installation and detailed use, refer to the dedicated documentation [2] available on the Telit web site.

II.5. List of Equipment

The DemoCase contains the following items:

- 1 Coordinator (DemoBoard named '*COORD*' populated with B868-TinyPRO module),
- 1 Sniffer (USB Dongle named '*S1*' populated with B868-TinyPLUS module),
- 2 Routers (DemoBoards named '*R1*' and '*R2*' populated with B868-TinyPRO modules),
- 2 EndPoints (DemoBoards named '*E1*' and '*E2*' populated with B868-TinyPLUS modules),
- 2 I/O management boards (with LEDs and switches),
- 5 SMA antennas (for DemoBoards),
- 5 classical serial cables (for DemoBoards),
- 3 power supply blocks (for Coordinator and Routers),
- 2 primary +9V batteries (for EndPoints only),

CHAPTER III.   DETAILED DESCRIPTION OF THE EQUIPMENT

III.1. DemoCase Description

Due to power consumption consideration, Coordinator, R1, and R2 <u>must</u> be supplied with power supply blocks. E1 and E2 are supplied with +9V primary battery. Sniffer is directly connected and supplied by the PC USB port.

EQUIPMENT	PICTURE	FUNCTIONALITIES
DemoBoard **COORD, R1, R2**		- Populated with TinyPRO module - Supplied with +12V block - RS232 Serial Link (through classical serial cable) - Serial data transmission functionality
DemoBoard **E1, E2**		- Populated with TinyPLUS module - Can be plugged with I/O management board - Supplied with +9V battery RS232 Serial Link (through classical serial cable) - Serial data transmission and telemetry functionalities
USB Dongle **S1**		- Populated with TinyPLUS module - Supplied by USB port - Sniffer and serial data transmission functionalities
I/O management board		- To be plugged on DemoBoard with E1 and E2 only - Allow telemetry application
Classical serial cable		- For DemoBoard serial connection

Power supply block		- AC adaptor delivering +12VDC - Molex connector for direct connection to DemoBoard

III.2. DIP Module

Radio modules supplied with DemoBoards are soldered on a DIP receptacle. This DIP module can be used for a specific integration, other than DemoCase. Below is detailed its mechanical characteristics.
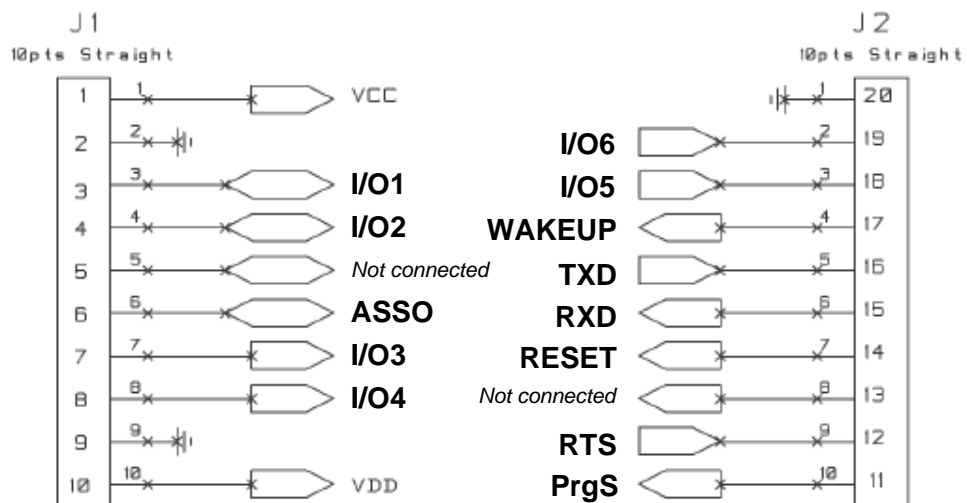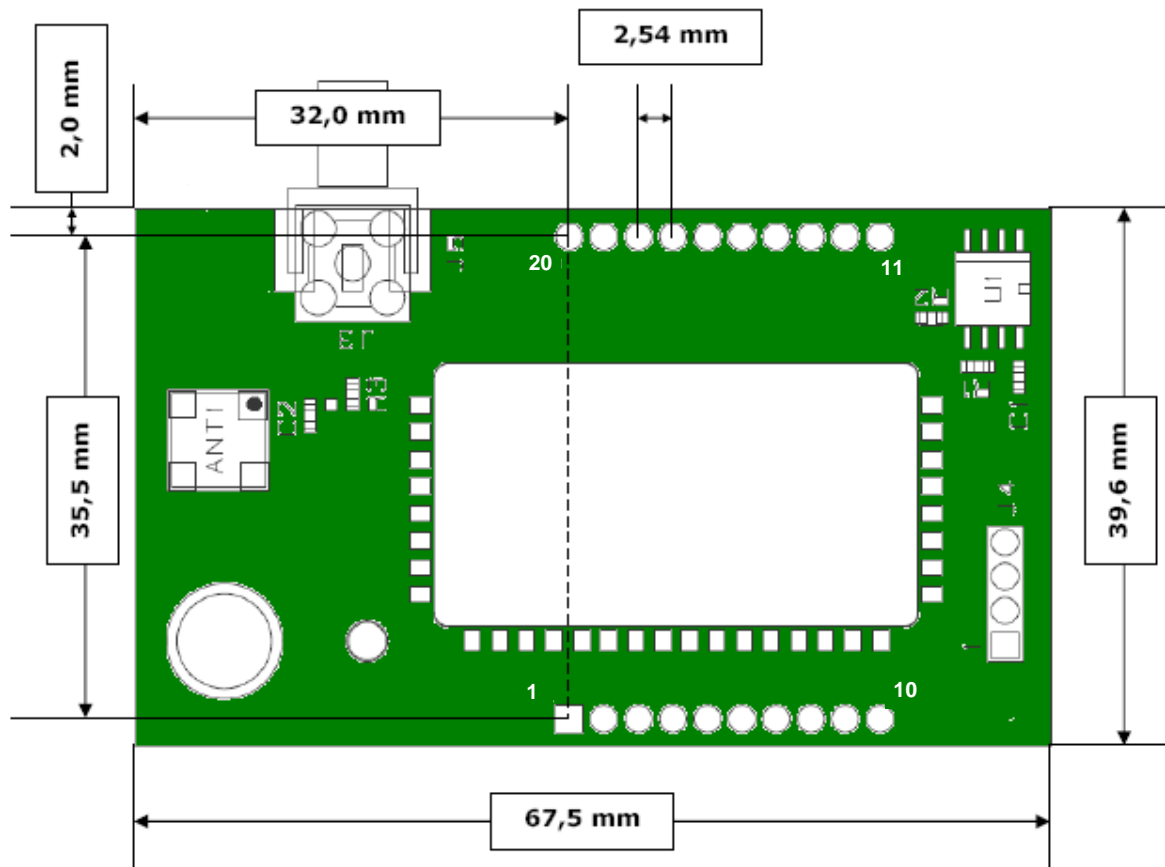
III.3. I/O Management Board

This board is used for an easy access to the Inputs/Outputs of the DIP module. It is dedicated to EndPoints only (E1 & E2). It is very to test the telemetry functionality available on the Mesh Lite.

Yellow LED
Connected to ASSO

ACTION Switch (0 or 1)

Red LED
Not used

PROG Switch (0 or 1)

Switch between
Potentiometer and
thermistance

Green LED
Connected to I/O6

Push button (0 or 1)
Connected to I/O1

Blue LED
Connected to I/O5

Switch (0 or 1)
Connected to I/O2

Potentiometer for
analog input
Connected to I/O4

Switch (0 or 1)
Connected to

Thermistance for
temperature input
Connected to I/O4

They are positioned between the mother board and the DIP module, as shown on the following picture :

DIP

I/O management
board

Mother board

CHAPTER IV.   TUTORIAL

The DemoCase is provided with a typical preconfigured mesh network. It allows very quick start to enjoy the functionalities of Telit RF Mesh Lite associated to the Mesh Manager software.

The following tutorial allows discovering both the Mesh Lite and the Mesh Manager. Each step is dedicated to learn a particular functionality.

Doing this, you will learn about <u>Mesh Lite</u> network and <u>Mesh Manager</u> tool

⇩   ⇩   ⇩

PART 1	✓ Learn and see what a beacon is ✓ Understand the Coordinator and Sniffer role	✓ Discover the Mesh Scope tool to see all radio frames heard by Sniffer
PART 2	✓ See what a Router is and understand association process ✓ Explanation of device LED signification	✓ Use the zoom functionality of the Mesh Scope to track frame type, frame sender, frame Router, and RSSI
PART 3	✓ Know what an EndPoint is ✓ Extend the Mesh network	✓ Use the Mesh Tree View display ✓ Use the automatic network discovery
PART 4	✓ Exchange data through the network ✓ Understand the routing rules ✓ Use telemetry functionality	✓ Combined use of the Mesh Terminal and Mesh Scope to send, receive and track frames over the network.
PART 5	✓ Add manually the last module of the DemoCase ✓ Discover the register table and chose the good setting ✓ Make a binding	✓ Use the Mesh Configuration Wizard to select the good setting and send the configuration to the new module memory

The network architecture will progress as following during the tutorial:

PART1	PART2	PART3 (begin)	PART3 (end)	PART5

COORD
+-S1
	COORD
	+-S1
	+-R1
	  +-R2
		COORD
		+-S1
		+-R1
		  +-R2
		+-E1
			COORD
			+-S1
			+-R1
			  +-R2
			+-E1
				COORD
				+-S1
				+-R1
				  +-R2
				   +-E2
				+-E1
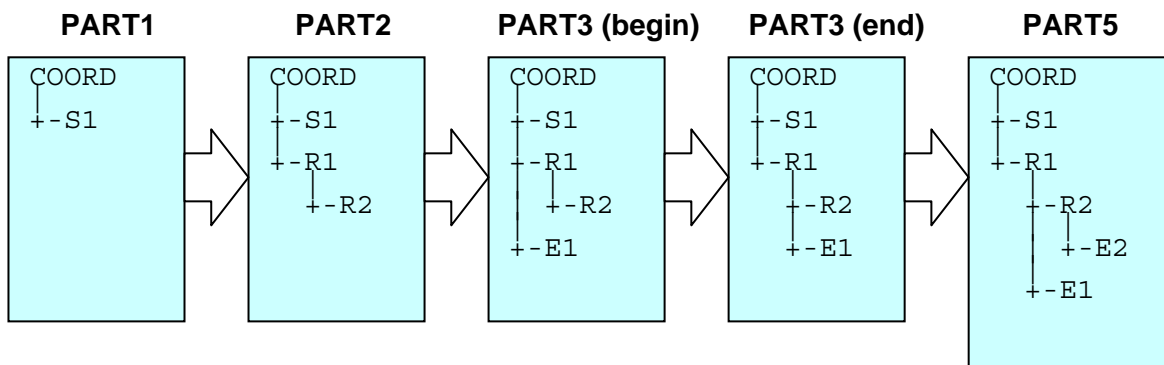
IV.1. PART1 - Start Coordinator and Sniffer and monitor the beacon with Mesh Manager

o *Requirement*

The Coordinator sends a beacon each 5 seconds. This frame contains network information used by any module who wants to join the network. Each module that is capable to have children has to send periodical beacon to synchronize and keep alive its children.

The beacon is very useful for low power device because it allows to quickly synchronize a module after a sleep period.

The beacon contains also the number of pending messages for each child. So a module doesn't need to pool its parent to know if any message is waiting. This allows very low power and fast operations.

Finally, beacon can be considered as a precious newsletter used to broadcast periodically the network information to all the modules.

o *Application*

Switch on the Coordinator. Then, connect S1 Sniffer to one USB serial port of your computer. The Coordinator doesn't need to be connected to a serial port.

Open the serial Com Port from Mesh Manager using the icon, an interactive window appears and displays all available Com Ports found on your computer. Select the desired one and click 'Connect' to start the communication with S1.

At this step it is possible to start immediately the Mesh Scope tool with the icon.

The scope module displays all frames intercepted by the Sniffer module. At this step, only the Coordinator beacon appears in blue on the left side of the scope. This beacon broadcasts the network information that will allow to add new module in the next step.

IV.2. PART2 - Add Routers to the network and monitor the association process

o _**Requirement**_

When a new module joins the network, it is necessary to make an association that establishes a virtual link between the new module and its parent. As soon as association is complete, a route is opened and available to exchange information between the parent and the child.

For Routers, the association process also includes the book of a time slot to send beacons to its potential future children.

o _**Application**_

Now, switch on R1 then R2 Routers, it isn't necessary to connected then to the computer. At start-up, they will immediately search for a valid parent to associate to. The status of the association procedure can be either monitored by the LED flashing on the device or using the Mesh Manager interface.

Monitor the association behavior using flashing LED:

- Fast blink (2 per second) indicates that no network has been found at this time.
- Slow blink (1 per second) indicates that a valid network is found and the module is looking for the best parent in this network.
- LED ON (fixed) indicates that association is successful and that the module is ready to transmit data over the network.

Monitor the association behavior using Mesh Manager interface:

From PC side, you can also monitor the behavior of the association of each module switched on. Watching the Mesh Scope, the association frames (in red) are seen followed by the apparition of new beacons (in blue) from added Router modules. If you have missed those frames, you can switch OFF then ON R2 module and watch again the association process. The Scope tool is completed by a zoom function very useful to track each frame exchanged through the network. The track bar placed above the Mesh Scope windows allows zooming in the desired part of the chronogram. When an interesting event occurs (association in red for example) you can stop the Mesh Scope with ⏸ icon and then use the zoom track bar. Zoom-in frames are displayed on the other diagram. Thanks to the zoom function, detailed information is available on each frame by flying above with the mouse.

Note: the Scanner can be started and stopped at any time by pressing the Space Bar.

IV.3. PART3 - Extend the Mesh network and use the Mesh Manager Tree View

o _**Requirement**_

Thanks to the association process, all Routers can build a list of all their children. This table is first used to route frames through the network but is also very useful to reconstitute the complete network architecture. When a module moves from a parent to another, a new association is started to update both the old and new parent lists.

o _**Application**_

Mesh Manager include a network tree view with automatic discovery. Click on the illustrated icon to launch the discovery tool. Beginning by the Coordinator, the discovery tool asks to each module the list of its children. The architecture of discovered network is displayed in the Tree View. This procedure asks only a few seconds to complete for a network like the demo one.
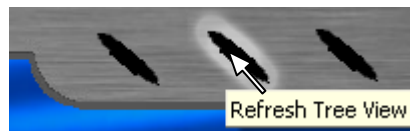
When discovery is finished you can see the network architecture at this step.

It is possible now to extend the network and then discover the new modules added.

Plug an I/O management board on E1 DemoBoard. Switch on EndPoint E1. This module has no preconfigured parent, so it will look after the best parent to make association. When association is complete (check LED or Mesh Scope as learned in previous part), initiate a new network discovery to see the new module and the place it has chosen.

Mesh Tree View is not only a discovery and display tool, it is also able to give details about a specific device or move a device into the network. These options are available by selecting the desired module in the Tree View, and then right click to access the popup menu.

- Ask "detail" to obtain a complete identity card of the module with hardware information, firmware version, serial etc.
- It is also possible to change the network architecture thanks to the "Move" assistant. Select for example E1 module then select "Move" in the popup menu. You are now invited to choose a new parent for the module, select R1 as new parent. After a confirmation, E1 reboots to join the new parent R1. In case of the new parent couldn't be found (not available, too far, too busy…), the module would look for another parent to stay in the network even if the desired parent could not be reached.

NB: the above functionalities are not supported by the Sniffer.

IV.4. PART4 - Exchange information through the network using Mesh Manager Terminal

o **_Requirement_**

Mesh Lite protocol is able to route a message from one side of the network to the other by consecutive jumps. This allows increasing range compared to point to point architecture.

Each frame uses the tree way to join the recipient from the sender. Even tough, it isn't necessary to route systematically by the Coordinator. The route is made by the tree but it is as short as possible using the less number of jumps.

o **_Application_**

It's time to use the built network to exchange data of any type, from any module to any one. Thanks to the Mesh Terminal, just select the frame type, then the recipient and if needed, the data payload before click "Send" button to send the composed frame. Mesh Terminal automatically do the correct encapsulation. On the other side, received frame are un-encapsulated to be displayed in a convivial appearance including receive time, frame type and sender.

For example :

- You can send a 'PING' frame to R1 and wait for the 'PONG' frame confirming the presence of R1.
- In the same way you can send 'HAYES' order like *AT/V* to check the firmware version of a module.
- You can send a 'TELEMETRY' frame to E1 to verify the value of its analog input or to light on its blue or green LED.

  IMPORTANT : Before sending telemetry frames to E1, it is important to set its I/O registers to define inputs & outputs regarding the I/O management board : I/O1, I/O2, I/O3 and I/O4 must be set as inputs, I/O5 and I/O6 must be set as outputs. Send a 'HAYES' order to E1 with *ATS345=60* payload.

Refer to the M-ONE & Mesh Manager manuals (**[1]**, **[2]**) for more information about data exchange.

In parallel, every frame exchanged can be monitored in the Mesh Scope and tracked with the zoom functionality. You can verify the number of jump and the route used for the frame to be exchanged.

IV.5. PART5 - Increase your expertise by adding manually the last module of the DemoCase

o _**Requirement**_

Many parameters could be set in Mesh Lite to match perfectly your application. To join a network, a module needs at least to know the network number and to have a module identifier (not already used in the network). Other optional parameters can be set like Low Power configuration, Association Criteria or Auto Repair functionality.

Depending of the module type, more or less parameters have to be set. The Coordinator is the module which needs the more attention because it has to know critical network information like Network Period, Base Time, Payload Size…

Routers and EndPoints need less information than the Coordinator, especially if Low Power is not requested. If Low Power is needed, Super Frame Duration, and Low Power registers must be configured.

o _**Application**_

In the DemoCase, most of parameters are already set for quick start; all modules have been configured except E2. It is proposed to configure E2 as a low power EndPoint which sends automatically a message to the computer (via S1) when a front edge occurs on I/O2.

Plug an I/O management board on E2 DemoBoard do not switch ON E2 for the moment.

Click on the icon below to start the Mesh Configuration wizard. In just a few steps, you can configure the new device.

- _Step 1_: You have to first choose the module type, here an EndPoint is desired.
- _Step 2_: 'Network ID' of the demo case is _1_. E2 is the ID desired for the last EndPoint, so fill 'ID LSB' as _E_ and 'ID MSB' at _2_. 'Default Recipient' is the destination module in case of non encapsulated frames. It is a binding association. Here, we want E2 to transmit to S1. So _S1_ is the default recipient.
- _Step 3_: Timing parameters are only needed for Coordinator and Router; here we add an EndPoint and Mesh Configuration Wizard prompts you directly to complete step 4.
- _Step 4_: Here are the parameters to select the way the new module will associate to the network. In this tutorial, we want to define manually R2 as a parent for E2. Choose 'Manual' for association type. 'Criteria' is used by the module to select the best parent if not defined. Let the default value. 'Max Failed Beacon' defines the number of consecutive non received beacons before considering loss of the link, _2_ is the default and correct value here. Define R2 as the parent of E2, _R_ is the 'LSB' and _2_ is the 'MSB'.
- _Step 5_: Payload and ACK option are only settable on Coordinator.
- _Step 6_: We want E2 to be Low Power and to wake up only for receiving its parent beacon. Choose 'Total' low power and wake up every _1_ beacon.

At this stage, you are ready to configure E2. Follow this procedure :

1.   Plug the module to a serial link (change the port number in Mesh Manager if needed).
2.   Switch ON E2.
3.   Just after (within 1 second), put the PROG switch on the I/O management board to 'ON' position, the Asso Led should still blink, if no: reset PROG switch to OFF, switch off E2 and redo.
4.   Click the 'Send configuration to a radio module' icon of Mesh Configuration Wizard: it sends the full setting in the memory of E2, you can also save this configuration in a file for future reference.
5.   Power OFF the device and put back the PROG switch.
6.   Re opens the Sniffer serial com port if previously changed.

When completed, switch on E2. After the association process, you can refresh the Tree View to see E2 as a new child of R2.

We have configured E2 as Low Power, so that it is necessary to configure R2 in 'Low Power children Side'. In this configuration, R2 will send message to E2 only when E2 is awake. All downward messages for E2 are buffered by R2 to be send only during awake slot. To do this, you have to send an Hayes frame to R2 with Mesh Terminal. Send 'HAYES' to 'R2' with *ATS340=1* as data payload (this is the Hayes order to switch R2 in 'Low Power Child Side'). Refer to the M-ONE manual (**[1]**) for more information about Hayes order.

Your low power EndPoint E2 is now ready to use. As previously for E1, it is important to set I/O registers of E2: I/O1, I/O2, I/O3 and I/O4 must be set as inputs, I/O5 and I/O6 must be set as outputs. Furthermore, I/O2 is set as interrupt input. For that, send a 'HAYES' order to E2 with *ATS345=60* payload then with *ATS346=8* payload.

You can now work with E2 EndPoint. Put the switch connected to I/O2 to 'ON' position : it will wake up the module and send automatically its inputs status to the default recipient, which is S1 : as S1 is connected to the PC, you will have the status displayed on the Mesh Manager.

It is also possible to send a message to E2. Try for example to send 'PING' frame to E2 and wait for the 'PONG' response. You observe that response could take a few seconds to arrive due to the low power setting. However the response time of all other devices (including R2) is kept very short.

CHAPTER V.   GLOSSARY

- *Beacon:* beacon is a frame periodically sent by the Coordinator and each Router to their children. This frame contains network information to synchronize and keep alive the children. The beacon information is also used by any module who wants to join the network. The beacon is very useful for low power device because it allows to quickly synchronize a module after a sleep period. The beacon contains also the number of pending messages for each child. So a module doesn't need to pool its parent to know if any message is waiting. This allows very low power and fast operations. Finally, beacon can be considered as a precious newsletter used to broadcast periodically the network information to all the modules.

- "Direct" and "Indirect" child: in the detailed module card, accessible from the tree view, you can read the number of direct and indirect child of a Router. The direct children are the children that are directly associated to the Router. Only one jump is necessary for a frame to go to, or to come back, from a direct child. Indirect children are all the other modules lower in the network. There are the children of the direct children. A frame need at least two jumps to go from a Router to an indirect child.

- "Sent by" and "Routed by": In the Mesh Scope, radio frames could be tracked reading information like "Sent by A, Routed by B". It means that 'A' is the module that has generated the frame while 'B' is the module that insures the propagation of this message over the network. A message can ask several jumps to go from 'A' to the final recipient. The progression of this message could be tracked with the following messages "Sent by A, Routed by A" then "Sent by A, Routed by B" then "Sent by A, Routed by C". This behavior occurs when a frame created by 'A' need 3 jumps to join the final recipient. Here, the 3 jumps are: A->B then B->C then C-> final recipient.

- Data Payload: Depending of the frame type, you should complete the data payload field in the Mesh Terminal module. The reason is that all Mesh network messages are encapsulated, i.e. all frames contain a header and a data payload. The header contains information about the frame type, the recipient and the sender of the message while the data payload contains the message. As a mail comparison, the header is the envelope with the recipient address while the data payload is the letter inside the envelope.

- Binding: In the Mesh Configuration Wizard, you are prompted to choose a default recipient, this allows to make binding. A binding is a virtual link between 2 modules. Each frame of the module will be automatically sent to the default recipient what ever the network architecture between the 2 binded modules. This is very useful to associate, for example, a switch remote to a light. In this case, the remote module can move in the network (change of parent) and the binding option insure that the remote still control the same light.