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Abstract

This is the abstract of the thesis in English. Please, use less than 150 words.

Resum

Vet aquí el resum de la tesi en català. Si us plau, utilitzeu menys de 150 paraules.

Prefaci

Contents

List of Figures

List of Tables

List of Abbreviations

WMN Wireless Mesh Networks

AP Access Point

BSS Basic Service Set

MANET Mobile Ad-Hoc Network

GSF Gracia Sense fils

QMP Quick Mesh Project

NAT Network Address Translation

BMX6 BatMan-eXperimental version 6

OLSR6 Optimized Linked State Routing version 6

DRP Dynamic Routing Protocol

IID Internal IDentifier

Chapter 1

INTRODUCTION

TODO

Chapter 2

STATE OF THE ART

This project consists on studying how are, currently, being build the open mesh networks in cities and what mechanisms we have to contribute or improve them. There are many different ways to improve this networks, namely, we can use different hardware, different software, build applications which run over them, etc.

First of all, we will analyze how these networks are, and how are they operating to have a better idea of what we want to improve.

2.1 Mesh and MANET networks

2.1.1 Definition and properties

When we talk about mesh networks, we refer to networks where all the participant are also routers. If we had to set a single definition the following can be a good one:

"*A Mesh network is one where all nodes (participants) are routers, meaning that all the nodes accept and forward packets from other nodes according to the routing rules.*" [Escrich, 2012a]

More specifically, we want to talk about Wireless Mesh Networks (WMN) which may refer also to the users of the network, and can be defined as follows:

"*Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may but need not connect to the Internet.*" [Huynh,]

To summarize, we have that mesh networks are basically networks which are not defined by the topology (physical layer) or the kind of links between two nodes (link layer). They are defined by the way the nodes operate among them, there are not master/slave or node/supernode distinctions and so, all the nodes have a similar function. In addition, the clients (end users) do not notice any difference (between mesh or other kind of networks) when they connect to the mesh, they are totally transparent for them.

As mentioned above, there are only two different kind of nodes: mesh routers and mesh gateways. They operate in exactly the same way when they have to route packets within the network, the only difference is that the gateways may be connected to a wider network, namely, the Internet and they can route packets to this other network. So, mesh routers just route packets inside the mesh while mesh gateways can also route packets to the outside.

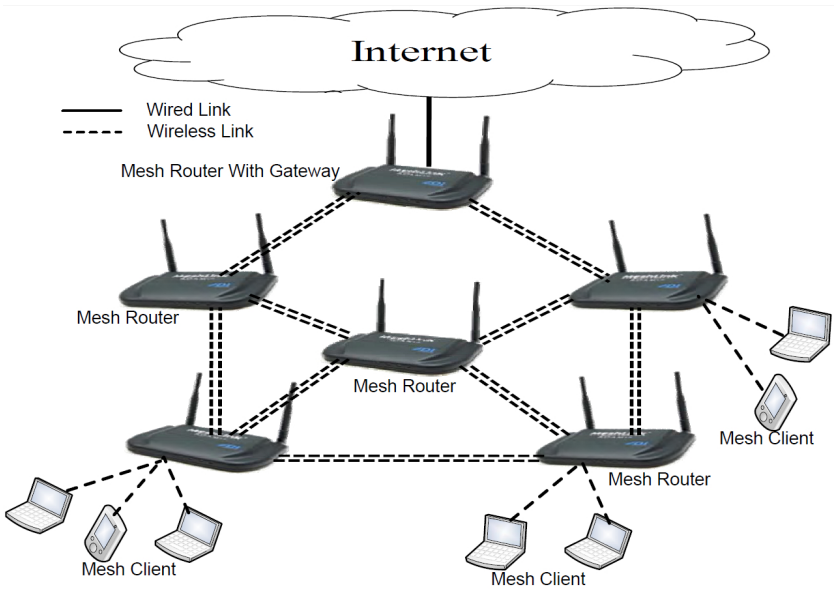

Figure 2.1: Wireless Mesh Network Example

http://www.intechopen.com/source/html/37888/media/wmn11.jpg

Then, we can say that WMN are a subtype of mesh networks. They have all the properties of these networks with the only difference that all the nodes are connected wirelessly.

2.1.2 Operating modes

Mesh networks can operate in two different modes: Infrastructure mode and Ad-Hoc mode.

- **Infrastructure Mode:** In this mode we have a central point named Access Point (AP) that creates a Basic Service Set (BSS) zone in which all the packets have to go through the AP. This zone is identified by the MAC address of the AP, which is called BSSID in this context. Furthermore, we can say that a master/slave model is followed in infrastructure mode.

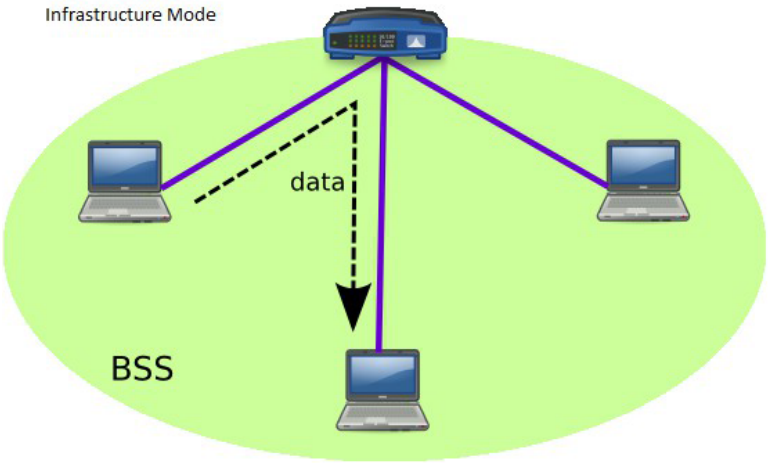

Figure 2.2: Infrastructure Mode BSS

[Escrich, 2012b]

- **Ad-Hoc Mode:** In Ad-Hoc mode, all the participants play the same role. Therefore, every single node connects with all the nodes it can, and so the central point idea disappears. To identify which participants are in the same network we just need to find those who have the same BSSID. At this point, all the machines directly connected can exchange information but, a layer 3 routing protocol is required to allow the communication between nodes which are not connected directly.

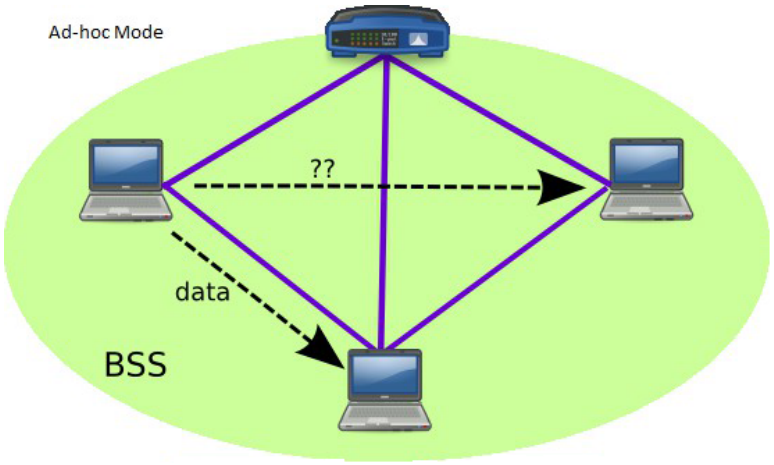

Figure 2.3: Ad-Hoc Mode BSS

[Escrich, 2012b]

2.1.3 MANET Networks

MANET is a subtype of a mesh network. That is to say, when we have a mesh network which uses a wireless system to interconnect the nodes and is built in Ad-hoc mode, we talk about MANET. Another way to define it can be: A MANET network is a WMN which operates in Ad-Hoc mode.

Usually, when we talk about MANET we are also referring to networks which have a self-configuring property. This property relies on the fact that the routers within the network are free-to-move anytime and to anywhere. A good definition could be this:

"A Mobile Ad hoc NETwork (MANET) is a kind of wireless ad-hoc network, and is a self-configuring network of mobile routers (and associated hosts) con-

nected by wireless links - the union of which forms an arbitrary topology."[Ramesh et al., 2010]

2.2 Open MANET Networks in Barcelona

Nowadays, in Barcelona (and in some other cities) some MANET networks are being deployed. We will study this case in particular because is the one we are more familiar with. In general terms, all the deployments work in the same manner and so, studying one single case can give us a general a idea of all of them.

Normally, all these deployments only differ in some points, these are the more relevant ones:

- The funding scheme
- The kind of hardware
- The firmware used

2.2.1 Funding scheme in Barcelona's MANET networks

There are some examples of MANET networks successfully deployed in Barcelona:

- Gràcia
- Sants
- Poble Nou
- Sant Joan Despí

All these networks have been deployed using the same funding scheme, promoted by the Guifi.net foundation, and is, somehow, based on crowd-funding. Basically, anyone can install a new node and join to the mesh. There is just one restriction: you have to have direct vision with, at least, another node in the network. If you achieve this requirement, you can buy and install the node yourself and you expand the network. So, this is crowd-funding because every person joining the network funds its own equipment, which has the only requirement of being compatible with the firmware used. Since many people has no experience on installing and configuring the nodes, and despite the fact that both the hardware and software are specially designed to allow non-technical people to use it without problems, the foundation provides technical support for those who do not achieve in the installation.

2.2.2 The Kind of hardware in Barcelona's MANET networks

Being that the users are the owners of the network and so, the people who buy the equipment, usually low-cost hardware is used. Low-cost does not mean, low-quality, in fact some of the hardware used have very high features and a very good performance. Normally, the hardware used is from Ubiquity Networks (NanoStation, Rocket, Bullet, etc.), but it is not strictly necessary. Actually, any hardware compatible with the linux distribution openWRT is accepted.

There are more information about some of this devices in Appendix 2.

2.2.3 The Firmware used in Barcelona's MANET networks

This is maybe the most important difference between all the deployments around the world. In most of them, there is a common point: all the firmwares are openWRT based, but they have some differences. Particularly, in Barcelona the first deployments used the Gracia Sense fils (GSF) firmware, developed since 2003 for the Gracia Sense Fils Wireless Community[1]. Some year later, the firmware became outdated since the protocol versions where old and the configuration of the nodes was hard. Then, they decided to create a new firmware with bigger scope, they named it QMP and is the one being used currently (some nodes have to be migrated to QMP yet).

QMP has been chosen in Barcelona because is a firmware that covers perfectly the needs in the deployments carried out there, and has been developed by themselves. Nowadays, in most of the deployments a new firmware is designed specially for them, and despite the fact that many of them could be used in other deployments, it does not normally happen. It is not an efficient way to work, and because of it a new initiative has just started, it is called "libre-mesh"[2]. This initiative tries to build a new firmware based on three existent ones: QMP (Spain), AlterMesh (Argentina) and eigenNet (Italy). It can be a good opportunity to merge all the best points of every firmware a create a new version that fits in many different scenarios.

[1] More information at: http://graciasensefils.net/
[2] More information at: http://libre-mesh.org/

2.3 QMP firmware basics

2.3.1 Main Features

QMP [3] is an Operating System designed for embedded devices, a firmware. The main features of this firmware are:

- OpenWRT based
- 802.11a/b/g/n support
- IPv6 native
- IPv4 tunneled over IPv6
- Auto configuration system
- Web GUI to monitor and configure
- Visualization tools (maps, graphs, etc.)
- Automatic dynamic routing (zero-conf)
- BGP (Border Gateway Protocol) support
- Open Source

2.3.2 Quick Deployments

QMP has been specially designed and developed to achieve quick network deployments. To do so, they have created the auto configuration feature which plays a very important role within the firmware. When we talk about quick deployments, we mean that we have to accomplish these requirements:

- The deployment must be performed as fast as possible.
- It must be able to be done by non-technical people.
- It must be possible in most situations.

[3] http://qmp.cat

2.3.3 Addressing

QMP uses three different kind of IP addresses:

- IPv6 ULA: IPv6 private range to be used internally in the mesh. These IPs are used for the communication among the nodes in the mesh network, and so they are not neither valid nor routable outside.
- IPv6 RIPE: IPv6 public IPs range (6to6 tunneling). These are globally valid and routable.
- IPv4: IPv4 private range to connect with the final user (4to6 tunneling). They are assigned to the final users attached to a node in the mesh, when they transmit any packet that has to travel throughout the mesh it is encapsulated in an IPv6 packet (tunneling).

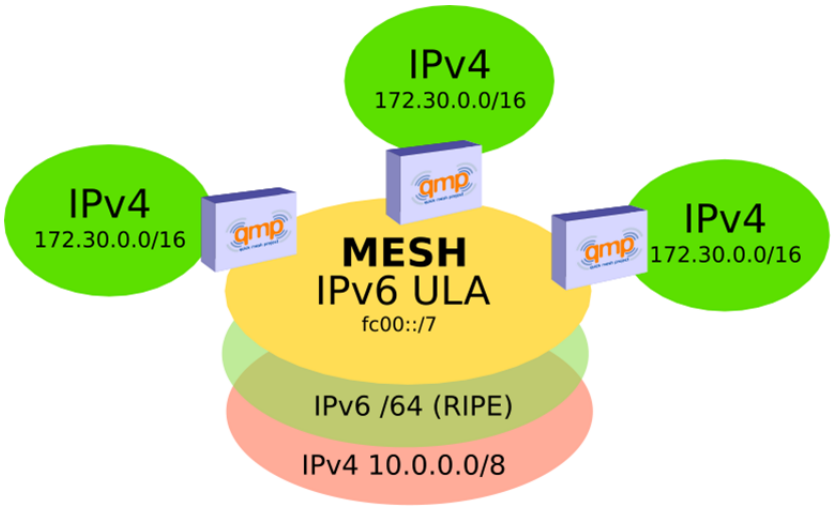

Figure 2.4: QMP Addressing

[Escrich, 2012b]

2.3.4 Operating modes

The firmware has two different operating modes, depending on the scenario we should choose one or the other:

- Roaming for fast deployments: All the access points in this mode will have the same IP and the same ESSID in order to allow users mobility, namely,

they will not lose the connection although they switch from an AP to another. Every AP implements a Network Address Translation (NAT) and so, two users attached to different APs will not have direct vision between them.

- Community: Every node will have a randomly assigned IPs range and will announce this range through the mesh. There is not NAT, every user has direct vision with the others (1 hope away from the IPv4 network layer point of view), but mobility is not allowed (no roaming).

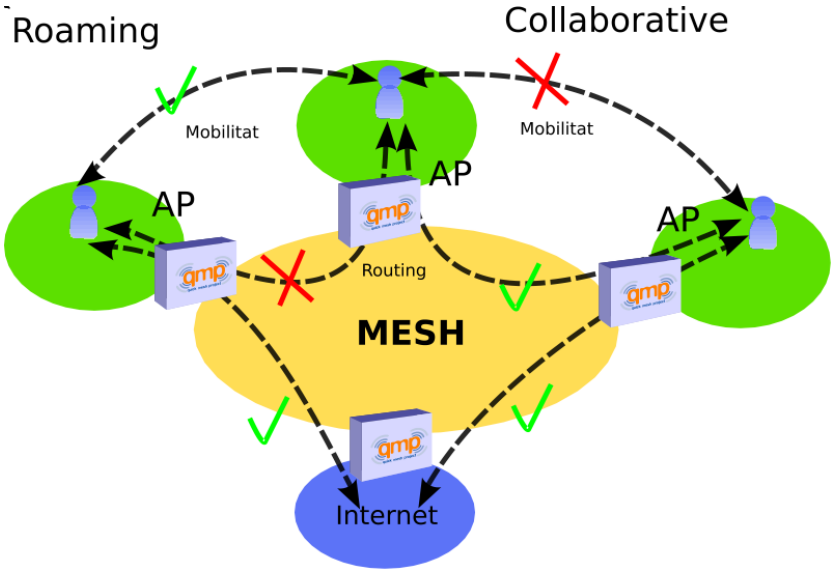

Figure 2.5: QMP Operating Modes

[Escrich, 2012b]

2.3.5 DRP

The firmware uses different protocols:

- BMX6 as the main DRP.
- Optimized Linked State Routing version 6 (OLSR6) as a backup DRP.
- Babel as a backup DRP but optional.

Usually, two networks are built in parallel the main one using BMX6 and the backup on using OLSR6. There are two reasons for that:

1. To prevent that a node gets isolated (no neighbors) due to a single BMX6 failure.

2. To make performance measurements of both protocols in exactly the same environment. This was very useful at the beginning of the project to decide which protocol was better in every scenario.

All these three protocols use IPv6 ULA to talk to other nodes and are isolated at the link layer (MAC) using VLANs. It allows the protocols to work in parallel (if necessary) without interfering with the other protocols.

2.3.6 BMX6

Since BMX6 is the main DRP we are going to analyze it deeply:

BMX6 is a table-driven routing protocol for wireless mesh networks. [...] its goal is to compose a path from source to destination by deciding on each node which will be the next hop. BMX6 is a distance vector protocol, since the information each node manages is [...] destination node, next hop and cost. [Neumann et al., 2012]

In terms of dissemination - how the nodes exchange the information - we can distinguish between two different states: transient and steady.

- Transient phase: the nodes exchange information related to the environment: Internal IDentifier (IID), nodes description, links, etc. Thanks to this information, ever single node builds a dictionary table that translates between IID to the global hashes of the full node description.

- Steady phase: every node has local information state (IID-to-hash dictionary) and global information state as hash-to-description. So, during this phase there is just a small exchange of packets that inform about link metrics and network changes. Thank to the tables set up in transient phase, those packet do not need to use the 128 bit IPv6 address as the identifier, they can use the 16 bit IID which produces a much lower overhead.

To summarize, we can say say that BMX6 controls the overhead better than other protocols (some experiments demonstrate that, for example: [Neumann et al., 2012]) there is a big overhead at the very beginning (transient state) and later it becomes very low during the steady state. So the main features of this protocol are:

- Pro-active: Uses UDP flooding to periodically send Originator Messages (OGM) and build a routing table.
- Destination-sequenced, Distance-vector (DSDV): Every node just knows which neighbor is better to reach another, namely, they do not need to know the entire topology, just the best paths.
- Does not use IP as node identifier, it uses global identifiers using SHA2 hashing.

In terms of the kind of frames used by BMX6 we have two different types: periodic messages, periodically generated on every node and occasional messages, exchanged only when necessary. The most used are the periodical which are the following:

Frame name	**Description**
HELLO_ADV	Hello advertisement. Used for letting neighboring nodes detect the link quality in transmit direction (from sending to receiving node).
RP_ADV	Rx probe advertisement. Used for reporting about reception rate of hello messages from neighboring nodes.
OGM_ADV	OGM advertisement. Used for updating periodically route and metric information over the mesh.
OGM_ACK	OGM acknowledgment. Used for acknowledging the previously reception of a full OGM_ADV frame.

Table 2.1: BMX6 Frames

[Escrich, 2012a]

Chapter 3

CONTRIBUTION

As we mentioned in previous chapters, we wanted to find ways to contribute to current open mesh networks, by providing ideas, introducing new hardware (or new ways to use the existing one) or building applications that run over the network.

We can divide the contribution of this project in three different points:

1. Study and documentation of the Mobile Node project
2. Installation of a node within Poblenou Mesh
3. Development of an audio and/or video streaming Android application

3.1 Mobile Node Project

The mobile node is a portable and auto-configurable transmission unit with wireless technology that offers mobility in the urban space. This node is designed to contribute to the digital mesh through existing networks. Furthermore, it provides connectivity with a wide range of different hardware: fixed nodes, other mobile nodes, smartphones, pc, tablets, etc.

The basic idea that lies behind the concept of the mobile node, is the socialization and modeling of the networks according to the interests and needs of communities and citizens, completely changing the paradigm. At present, networks are designed and deployed based on corporate and/or government interests, this fact does not allow the home user to control its data flows and, much less, get involved

in the process.

In other words, what we are doing with the Mobile Node, is making the most of the hardware and firmware we have, combining them and using the resulting device in a different way. So, a mobile node, in our context, is a device that can be used to expand networks already deployed and give coverage to a zone where there was no coverage at this time. Therefore, we are taking advantage of the ”Auto-configuration” feature of QMP to provide Internet Access rapidly.

The main advantage of this device, is the speed and freedom that offers. Given this features, the most common usage will be as a temporary solution to cover a particular zone during a certain period of time. It can be very useful in events, congresses, concerts, parties, etc. Which will take just a few hours or days. Using this device in cities like Barcelona, where fixed mesh networks are quite extended, will allow the organizers of the events to provide Internet Access to the attendants in a very fast, easy and cheap manner.

Although covering events is, perhaps, the main usage we can give to our mobile node it is not the only one. Since we are talking about open networks, with open firmware we have the freedom to use them as we prefer. Normally, the mobile nodes are supplied using batteries which will last just some hours, but it is not strictly necessary to use them that way. We could join a community or create a new one and model our own networks using mobile nodes, there are no restrictions considering that a mobile node is nothing but the same hardware and the same firmware used in a different way.

Given all these facts, that is the reason why we talk about changing the paradigm and start modeling the networks according to the interests of those who are going to use them.

So, the biggest contribution we did in that field, was to write a document talking about the project, its origins, how to build our first mobile node, the hardware we need, how to configure some devices and build a small mesh, the prototypes that are being tested nowadays, etc. Since this is a project which is being carried out by Efraín Foglia with the support of Mobility Lab, we just took all the information and started doing experiments to build the networks and the nodes, but did

not do anything new. So we created a document gathering all the information that will allow beginners to start learning and working in that field. This document can be found at appendix 2.

Chapter 4

RESULTS

TODO

Chapter 5

CONCLUSIONS

TODO

Chapter 6

FUTURE WORK

TODO

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Chapter 7

APPENDIXES

.1 Appendix 1: Pilot Charter

Pilot Charter - Mobile Node

Fernando Gros González

6 de diciembre de 2012

1. Opportunity/Idea

The opportunity of carrying out this project resides in the BuB branch of the Commons for Europe initiative. This project was initially impulsed by Guifi.net and exo.cat among others and now has been introduced in this BuB4EU in order to receive this «last push». The main idea is to create a free transmission workstation that can be used in the urban space and contributes to the digital mesh through other networks.

2. Description/Purpose

The project will consist on creating a mobile wireless workstation that creates or fits in an existent telecommunications infrastructure. It will have to be an auto-configurable device and will have the capability to interconnect with a wide range of different hardware. Furthermore, it will be able to work in many different spaces and without the need of an ISP.

3. Goal

Improve the actual design of the mobile node, test it, create some documentation and find a way to make it easy-to-replicate.

4. Objectives/Results

- Improve or create a new design of the mobile node.
- Allow citizens to be able to access low-cost technology with a big social return.
- Create documentation of the whole process.

5. Scope

Deploy and test this technology in Barcelona (Raval) and in London (Decision pending) and observe the results to replicate it in other cities.

6. Stakeholders

- guifi.net
- exo.cat
- qmp.cat
- ESADE
- UPF
- mobilitylab.net
- commons for europe
- Locality UK
- Creativecoop UK

7. Risks

- Prototype failures or firmware bugs that can delay the whole project.
- People unacceptance of the system or its social returns.

It is important to mention that this project is in an advanced stage and so, many of the risks that could have affected it are already mitigated.

.2 Appendix 2: Documentation

Universitat Pompeu Fabra

Mobile Node. Detailed documentation

Fernando Gros González
3/27/2013

Table of Contents

What is the Mobile Node?

The mobile node is a portable and auto-configurable transmission unit with wireless technology that offers mobility in the urban space. This node is designed to contribute to the digital mesh through existing networks. Furthermore, it provides connectivity with a wide range of different hardware: fix nodes, other mobile nodes, smartphones, pc, tablets, etc.

How was it born?

The basic idea that lies behind the concept of the mobile node, is the socialization and modeling of the networks according to the interests and needs of communities and citizens, completely changing the paradigm. At present, networks are designed and deployed based on corporate and/or government interests, this fact does not allow the home user to control its data flows and, much less, get involved in the process.

Thanks to the low costs of the equipments and to the fact that they are completely self-configuring, it is now possible to model the urban space based on people or communities who are the ones that will be using these infrastructures. It allows users to take part in the process from beginning to end, from bottom to top. Thus, the city and the data flows that govern it will be totally adapted to people, breaking the barriers that are currently imposed by the well established designs we have to deal with.

What for?

The access to independent and self-managed transmission channels in the public space has very high associated costs. Most communities are unable to meet these expenses and therefore, they cannot increase their representativeness within the society controlling their traffic. At this point, is where the project is intended to emphasize. Using bottom-up models we try to respond to this necessity by creating a new concept of “social routing” agreed on consensus, with open protocols that provide access to the physical and digital public space. This configuration, offers a model with low costs, high social representativeness and ease of reproduction.

Related texts

Foglia, E. (2011). Colisiones en la MediaCity, Prácticas sociales y artísticas sobre el trazado digital. En: Impresión Expandida / Expanded Print. (ed.) Eloi Puig, Alicia Vela y Antonia Vilà. ED: Barcelona, Universidad de Barcelona.

Foglia, E. (2010). Mobile Node: Open Portable Infrastructure, Overlapping Digital Paths. MediaCity: Interaction of Architecture, Media and Social Phenomena. ED: Weimar, Bauhaus-Universität.

Component Description

Hardware

Below there is a list of the components that form the mobile node and the other nodes that make possible to create mesh networks and its main features:

- Ubiquiti Airmax Bullet M5:
  - Description: Wireless outdoors device that transmits in the 5GHz band.
  - Details:
    - Protocols: 802.11a, 802.11n
    - Outdoor range (depending on the antenna): more than 50km
    - Transmission Frequency: 5470MHz-5825MHz
    - Maximum transmitted power: 27 dBm
    - Bandwidth: Until 100Mbps

- Ubiquiti Nanostation M5:
  - Description: Outdoors CPE (*Customer Premises Equipment*) device that transmits in the 5GHz band.
  - Details:
    - Protocols: 802.11a, 802.11n
    - Outdoor range: more than15km
    - Transmission Frequency: 4900-5800MHz
    - Maximum transmitted power: 27 dBm
    - Bandwidth: Until 150Mbps

- Ubiquiti Aircam dome:
  - Description: IP cammera Ethernet cable supplied.
  - Details:
    - Supported protocols: IPv4/v6, HTTP, UPnP, DNS, NTP, RTSP, DHCP, TCP, UDP, IGMP, RTCP, ICMP, ARP
    - Image quality: 30 FPS, HDTV 720p
    - Video compression: H.264/MPEG-4/MJPEG

- Ubiquity Aircam mini:
  - Description: IP cammera Ethernet cable supplied.
  - Details:

        - Supported protocols: IPv4/v6, HTTP, UPnP, DNS, NTP, RTSP, DHCP, TCP, UDP, IGMP, RTCP, ICMP, ARP
        - Image quality: 30 FPS, 1MP/HDTV 720p
        - Video compression: H.264/MPEG-4/MJPEG

- Arduino DUE:
    - Description: Electronic board based on a core ARM 32-bit processor that enhances the standard Arduino functionalities.
    - Details:
        - Microcontroller: AT91SAM3X8E
        - Digital I/O pins: 54 (12 have PVM output)
        - Analog input pins: 12
        - Analog output pins: 2

- Arduino WiFi Shield:
    - Description: Board that connects an Arduino to the Internet wirelessly.
        - Protocols: 802.11b, 802.11g
        - Encryption types: WEP y WPA2

- 2 batteries: Rechargeable Li-ion Emergency Power Battery:
    - Description: Battery for video camera, walkie talkie, camera, etc.
        - Capacity: 9000mAh
        - Input voltage: 12.6V
        - Output voltage: 12V

- 2 black passive screwable POE modules:
    - Description: It supplies electrical power to the device through an Ethernet port that supports PoE.
        - Connector: Ethernet RJ-45
        - Bandwidth: 10/100 Mbps

- Network cable and Ethernet RJ-45 connectors:
    - Description: Wire and connectors to assemble direct and crossover Ethernet cables.

- Female faston connectors:
    - Description: Connectors to be added to an electrical wire.

- Box with IP65 antenna:
    - Description: Outdoor compact case with an integrated antenna that operates across the 5GHz band.
    - Details:
        - Transmission frequency: 4900MHz-5900MHz
        - Maximum Gain: 20 dBi

- PC Engines ALIX 2D2:
    - Description: Low power computer board:
    - Details
        - Memory: 256 MB DDR DRAM
        - Processor: 500 MHz AMD Geode LX800

- Compex radio:
    - Description: Compact radio with a high performance and a low power consumption.
        - Transmission frequency: 2,4GHz y 5GHz
        - Protocols: 802.11 a/b/g/n
        - Chipset: Atheros AR5414

- Pigtail 15cm. UFL/N-H (female) Bulkhead:
    - Description: Connector good for most of Mini-PCI radios.
    - Details:
        - Connector type: UFL (IPEX, Hi-Rose) to N Female Bulkhead.

- Pigtail 5 GHz. UFL-SMA plug right angle 30 cm:
    - Description: Connector for box-integrated antennas and most of Mini-PCI radios.
    - Details:
        - Connector type: UFL (IPEX, Hi-Rose) to SMA right angle.

- Power supply 18v. 0,8 A (15 W) Alix 2C/3C):
    - Description: Switching power supply unit for Ubiquiti devices, Alix boards, etc.

- DMD: Dot Matrix Display
    - Description: LED panel that easily displays clocks, status screens, graphs, etc. Compatible with Arduino.

Software

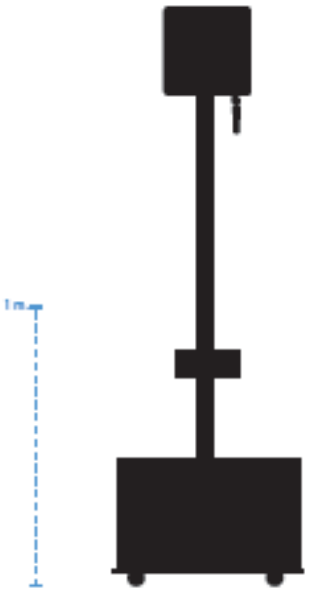
The software used by the mobile node is a firmware called Quick Mesh Project (QMP). It is a GNU/Linux operating system based on OpenWRT for embedded devices. The main features of this firmware are:

- OpenWRT based
- 802.11a/b/g/n support
- IPv6 native
- IPv4 tunneled over IPv6
- Auto configuration system
- Web GUI to monitor and configure
- Visualization tools (maps, graphs, etc.)
- Automatic dynamic routing (zero-conf)
- BGP (Border Gateway Protocol) support (half implemented)
- Open Source

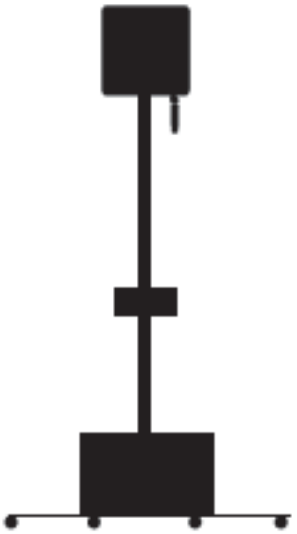
Types of Mobile Nodes

Due to the different needs identified during the development process of the prototypes, it was decided to create four different design options. Each with its own characteristics:

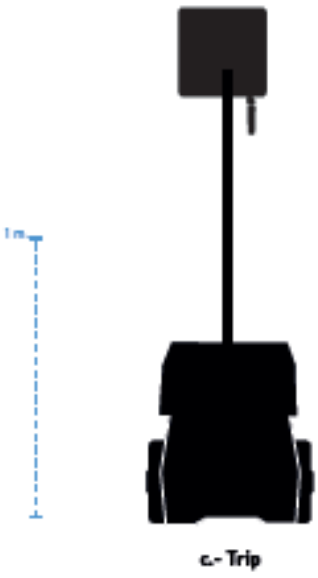
1) **Panzer**. Robust with a large electronic box which can hold more batteries. It has greater stability. 4 wheels.
2) **Tarantula**. Lighter than Panzer. It has extendable legs for stability. 4 wheels.
3) **Trip**. Special for trips. Based on existing plastic boxes. Tracker wheels very robust and computer equipment container.
4) **Cam**. Wireless high definition video camera which interconnects with mobile nodes. Lightweight and with the possibility of streaming video.



a.- Panzer



b.- Tarántula



c.- Trip

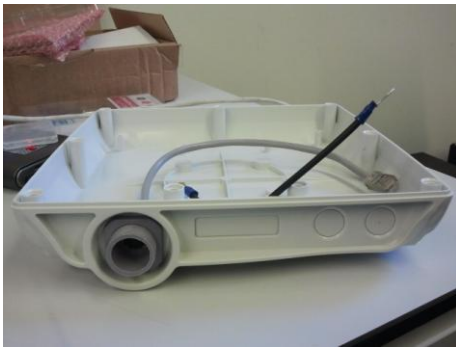
d.- Cam

Assembly

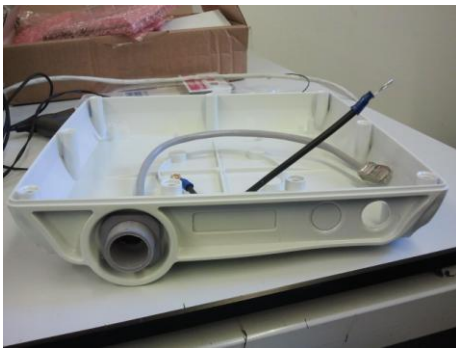
We will divide the process in several steps

Box drilling and pigtail installation

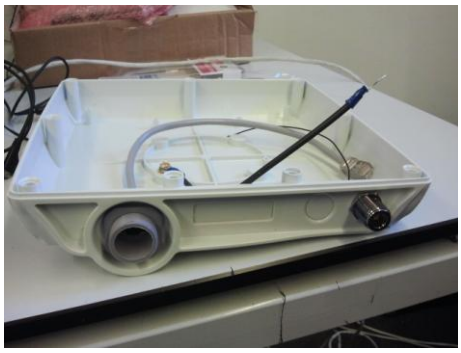
The following pictures show the process:



Undrilled box



Drilled box

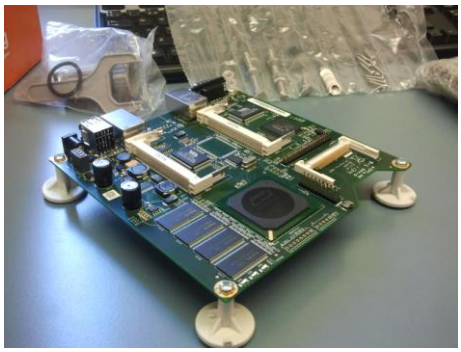


Box with pigtail installed

For this process, it is necessary a drill (or similar) to perforate the box and a cutter (or similar) to scratch and remove the remaining burr.

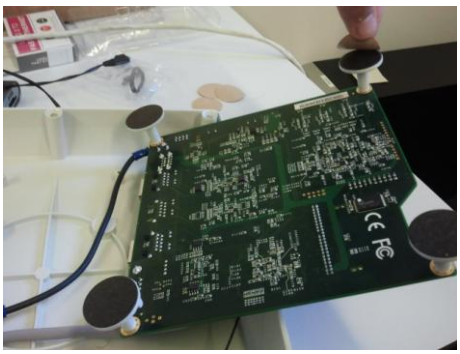
Installation of the board

It basically consists on adhere and affix the board to the box.



Affix the brackets to the board

Orientation and location of the board in the box



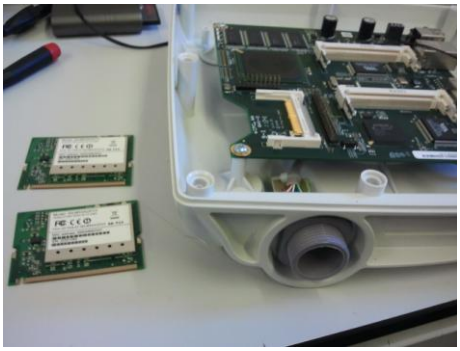
Remove the protectors of the brackets

Board affixed and wires orientation

For this process it is simply necessary a screwdriver.

Installation of the radios

Fit the radios into the appropriate slots of the motherboard:

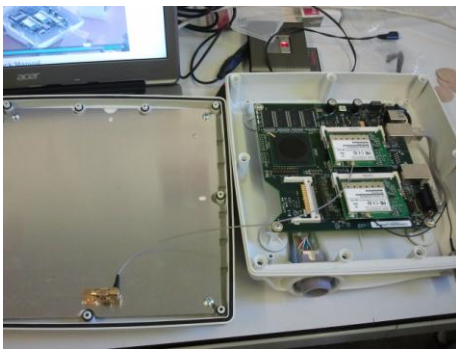


Compex radios

Radios installed on the board

Connection of the pigtails to the radios

Pigtails connected to the radios

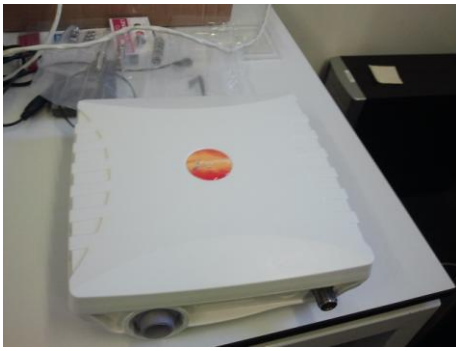


Pigtail connected to the upper cover of the box (antenna)

Installation of the flash card and switching-on

Card inserted into the slot

Power supply connected

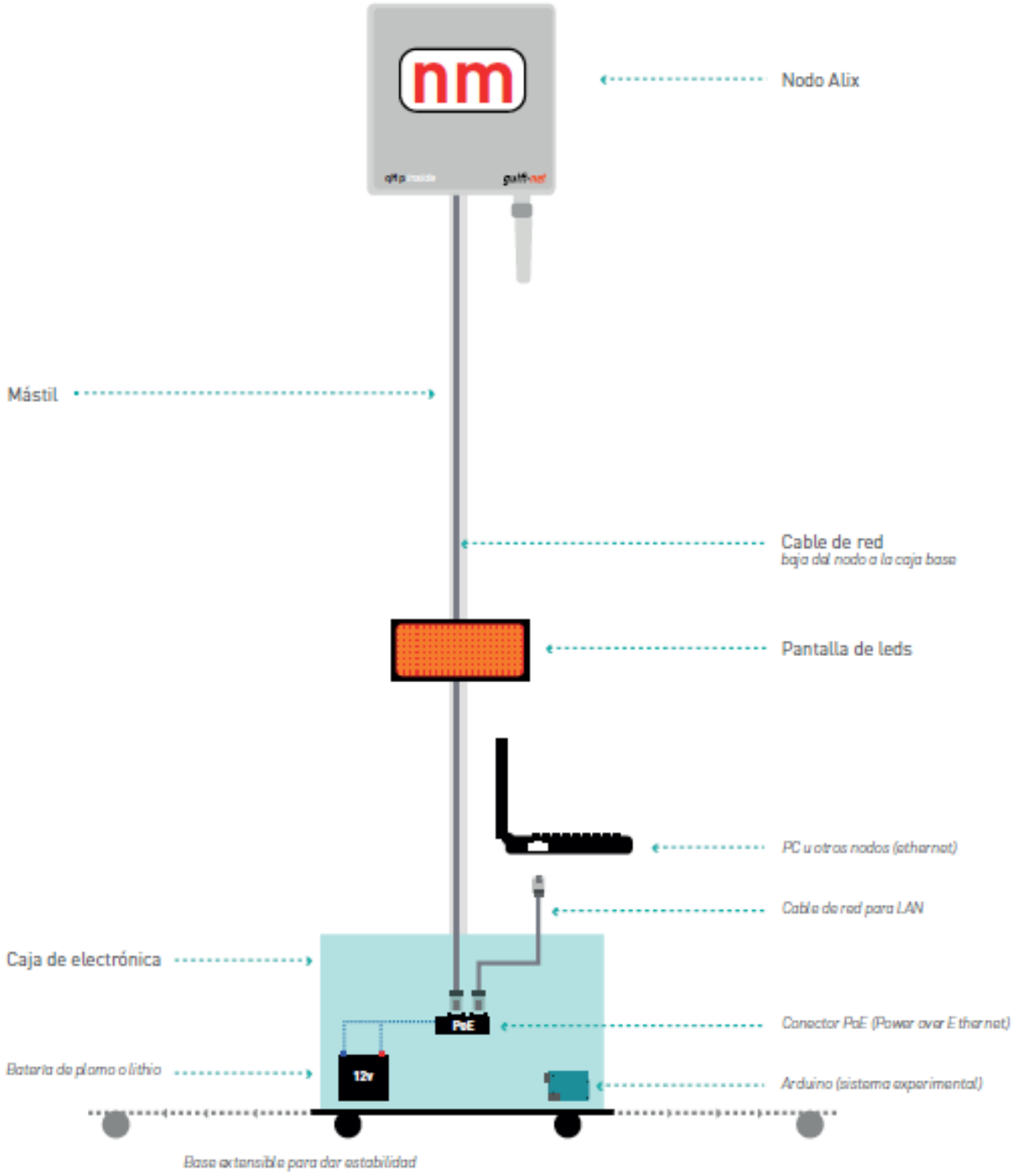


Box closing

[1] For more information see the video tutorial: http://vimeo.com/58127395

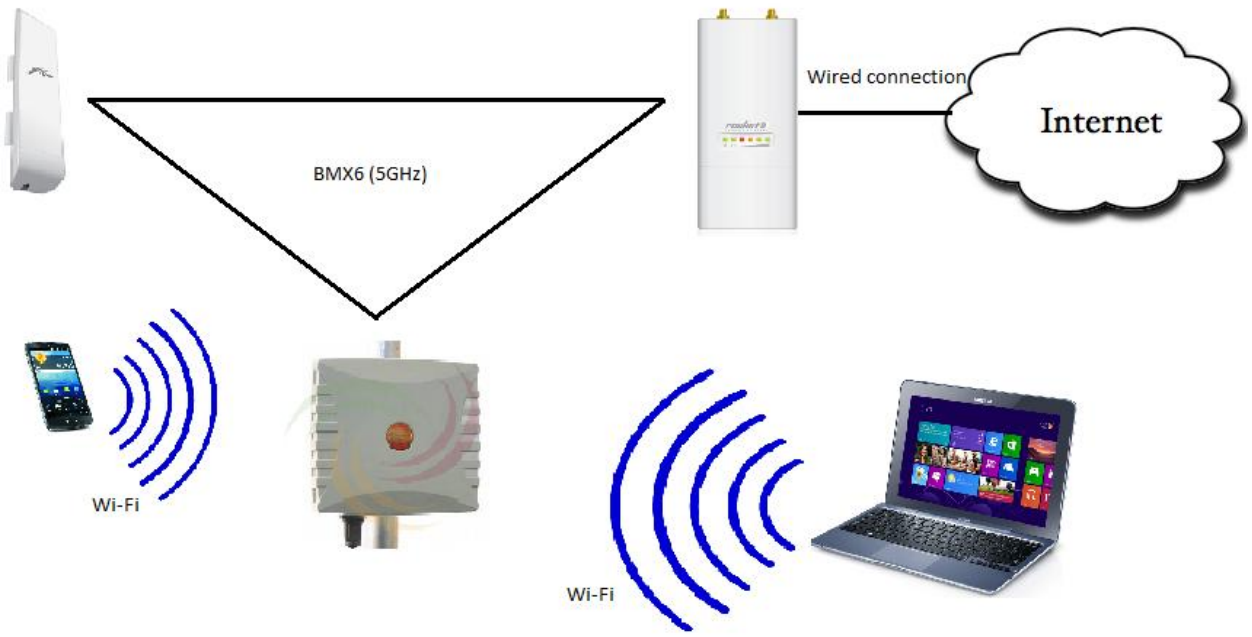
Implementation

The following illustration shows a basic implementation of the Mobile Node with Alix antenna:



It is noted that we, basically, have the alix box fixed to a mast and connected to a battery. On the other hand, we have the LED screen that displays node status information and other relevant information using arduino and a PC that lets you quickly set the node.

With this implementation we will be able to offer coverage to a particular area by expanding an existing fixed network. A basic example of mesh network could be the following:



There is a fixed network composed for two antennas, thanks to our mobile node we can expand it and provide Wi-Fi connection to the final users.

Configuration of the nodes

To download and compile the source code of QMP we have to follow these steps:

1) Download the source code from the repository:
    a. (Recommended) `git clone git://qmp.cat/qmpfw.git qmpfw`
    b. wget -c -q -O - "http://qmp.cat/gitrevision_download?project_id=7&rev=anonymous" | tar zxvf -

2) Go to the source folder:
    a. cd qmpfw

3) (Recommended) Make a “checkout” of the “testing” branch:
    a. make .checkout_qmp QMP_GIT_BRANCH=testing

4) Compile specifying the target node type:
    a. make build T=alix
    b. To see the available targets: make list_targets
    c. If you have more than one core in your processor you can execute: make build T=alix J=N, where N is the number of cores that you want to use.

5) Finally, you will be able to find the compiled image in the images/ folder.

Nanostation M5

The steps to flash and configure the Nanostation M5 are the following:

1) Reset the device by pressing “reset” button during 10 second, until the lights start to flicker alternatively.
2) Install a tftp client, such as tftp-hpa.
3) We assign an Ip address to the wired connection of our PC within the 192.168.1.x/24 range.
4) From a terminal:
    a. `tftp 192.168.1.20` (Defaul IP of the Nanostation)
    b. `mode octet`
    c. `trace`
    d. `put *.bin` (Image compiled previously)
    e. `quit` (Exit the tftp client)

5) Change the IP address to on belonging to the 172.30.x.x/16 range
6) We open a browser and go to http://172.30.22.1 or http://admin.qmp
7) We use user: root and password: 13f
8) We can now utilize the GUI of QMP.

Rocket M5

We need to follow exactly the same steps that we followed with Nanostation M5.

Alix 2D2

Once assembled and mounted into its box, we need to install the firmware in the flash card:

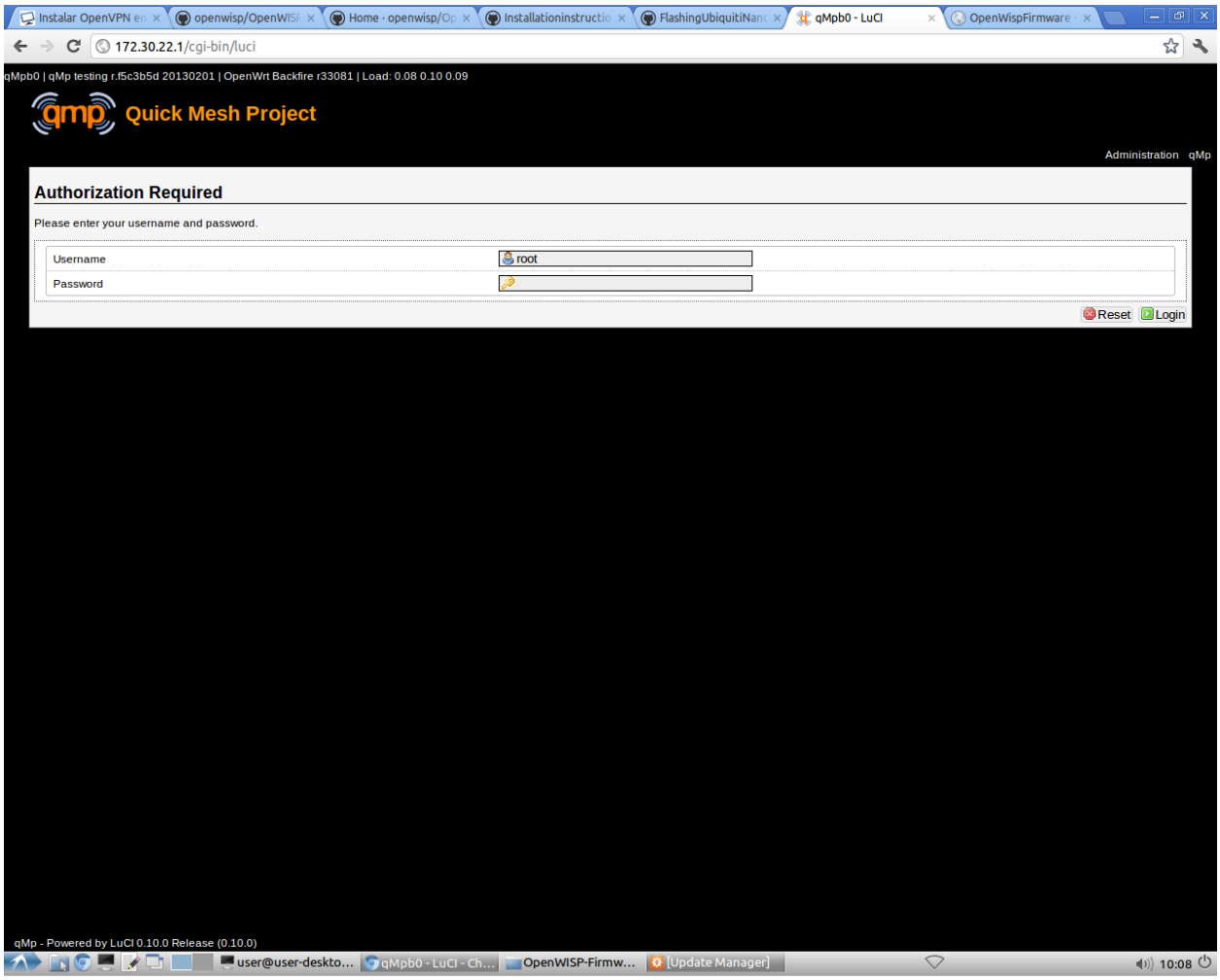
1) Connect the flash card to a PC with a card reader (internal or external).
2) We execute the command `df -lh` to see the drives list connected to the machine.
3) We identify the name associated to our flash card, for example /dev/sda
4) From the terminal we go to the folder where we have QMP firmware
5) We execute the command: `if=firmware.bin of=/dev/sda,` to dump the firmware to the flash card.
6) We execute the command: `sync,` to empty the buffers and make sure that there are not more pending operations.
7) We extract the flash card and insert it into the Alix board.
8) We switch it on and wait a reasonable time until the firmware is loaded.
9) Later, we should be able to access the GUI connecting an Ethernet wire and going to the following URL: http://172.30.22.1 (We do not need to configure any Ip since it is assigned with dhcp)

If it does not work, we will need to repeat the dump process since it is possible that an error occurred during the copy process.

Basic features of the QMP interface

Below is a brief introduction to the main aspects of the interface qmp.

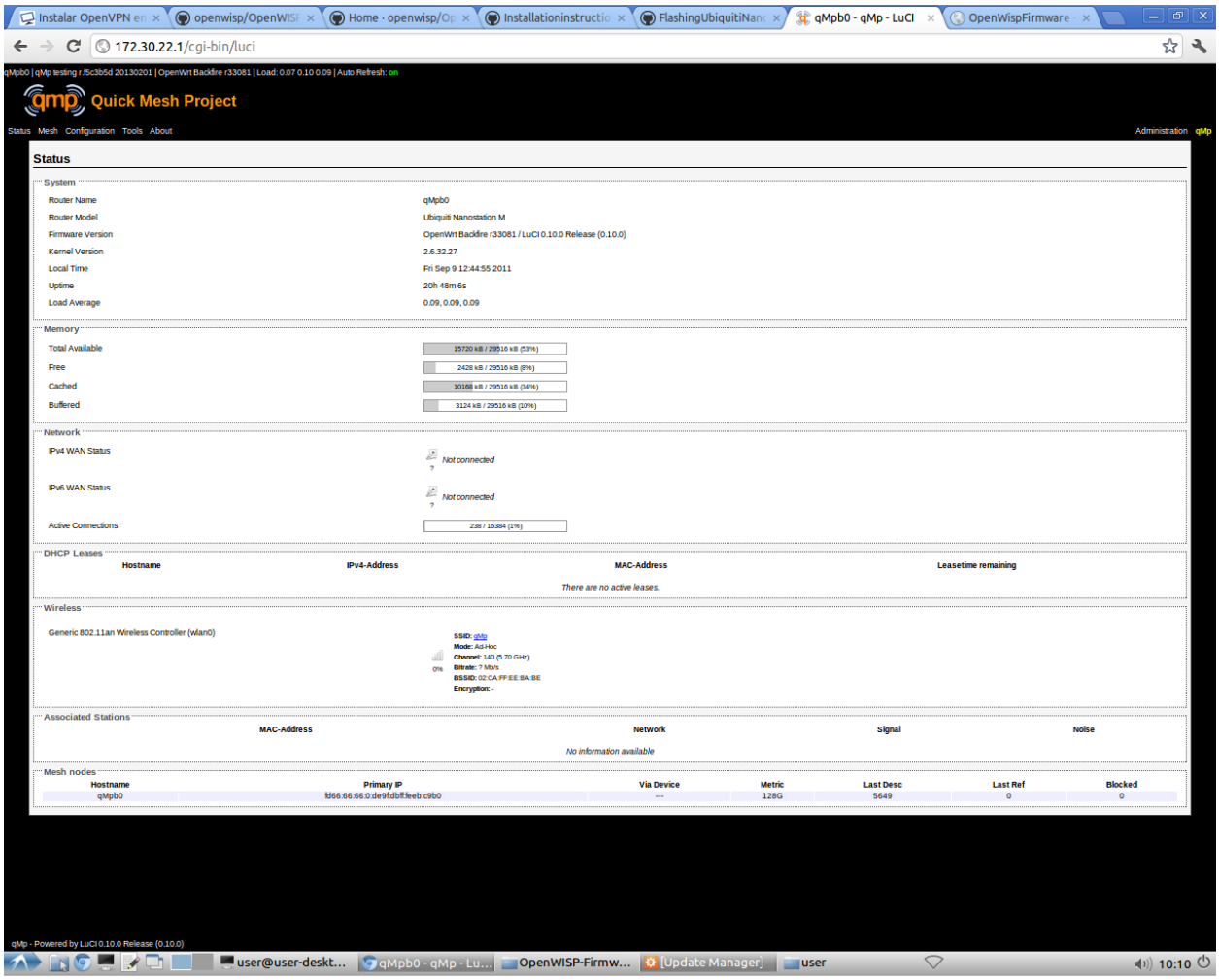
First, we have the welcome screen, where we will be asked for the username and password (U: root and P: 13f by default).



Once you have logged in, we can see the tabs: "Status", "Mesh", "Configuration", "Tools" and "About". We also have the option to access in "QMP" or "Administrator" mode, in the first we have only some basic options that we can control, but are sufficient for many cases. In the second, we have many more options than we can manage, and customize in a more detailed way.

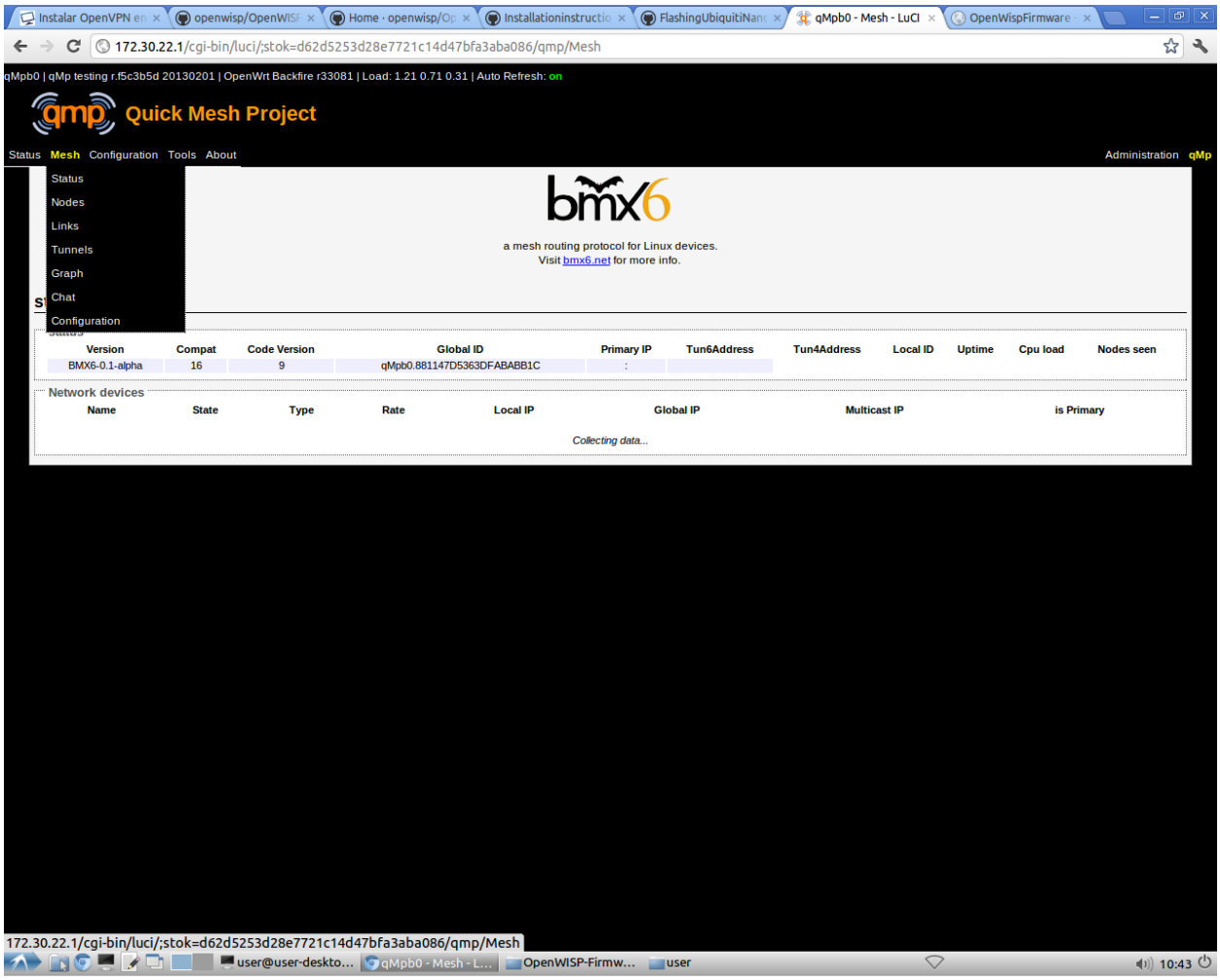
Status tab

It displays general system status: name, hardware model, firmware and kernel versions, memory status, etc. It is a purely informational tab, but it is very useful to get a general idea.



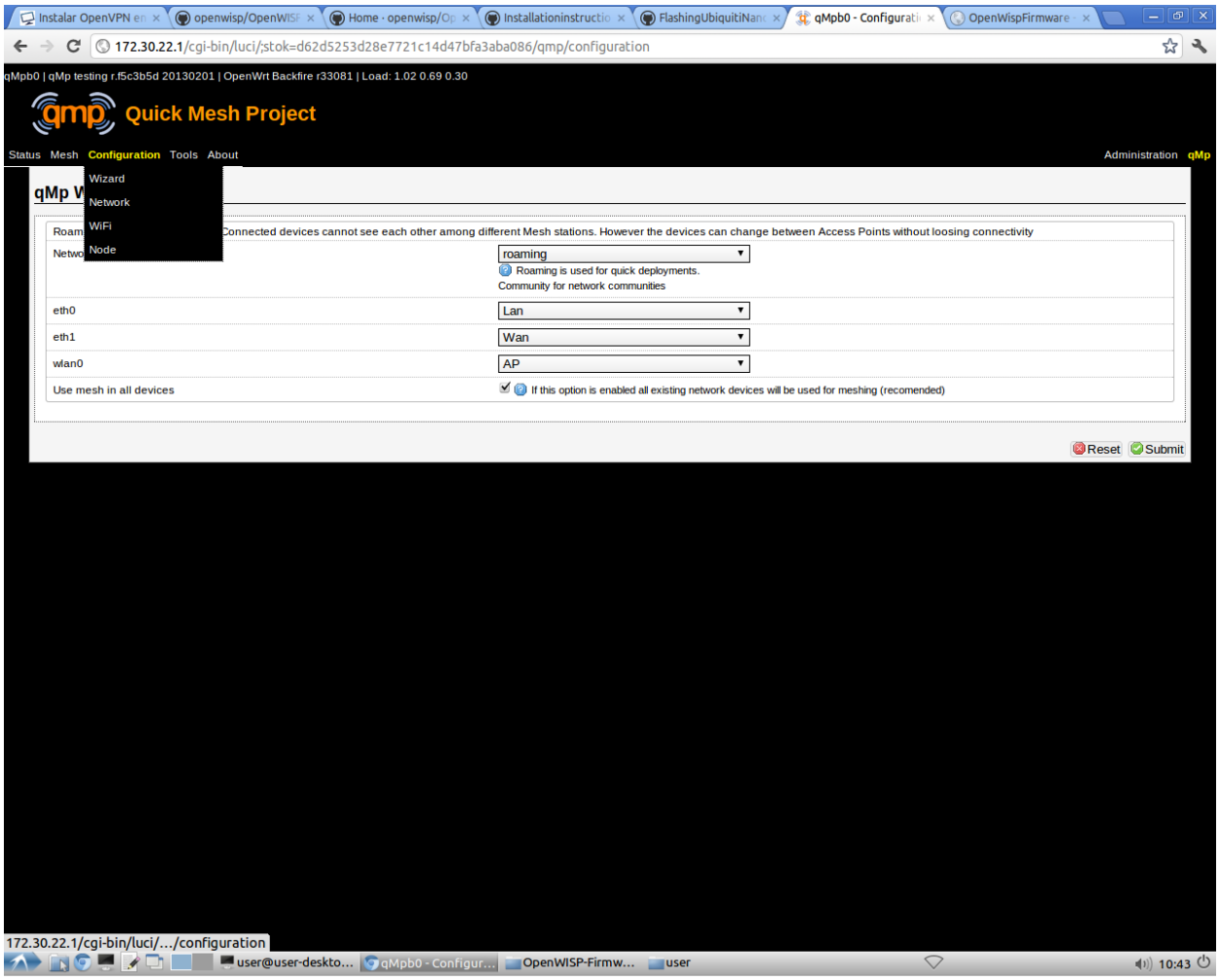
Mesh tab

This tab displays the status of the mesh network. We can observe its current status, check what nodes belong to it, see the links established among them, see a visual graph of nodes and topology, etc.



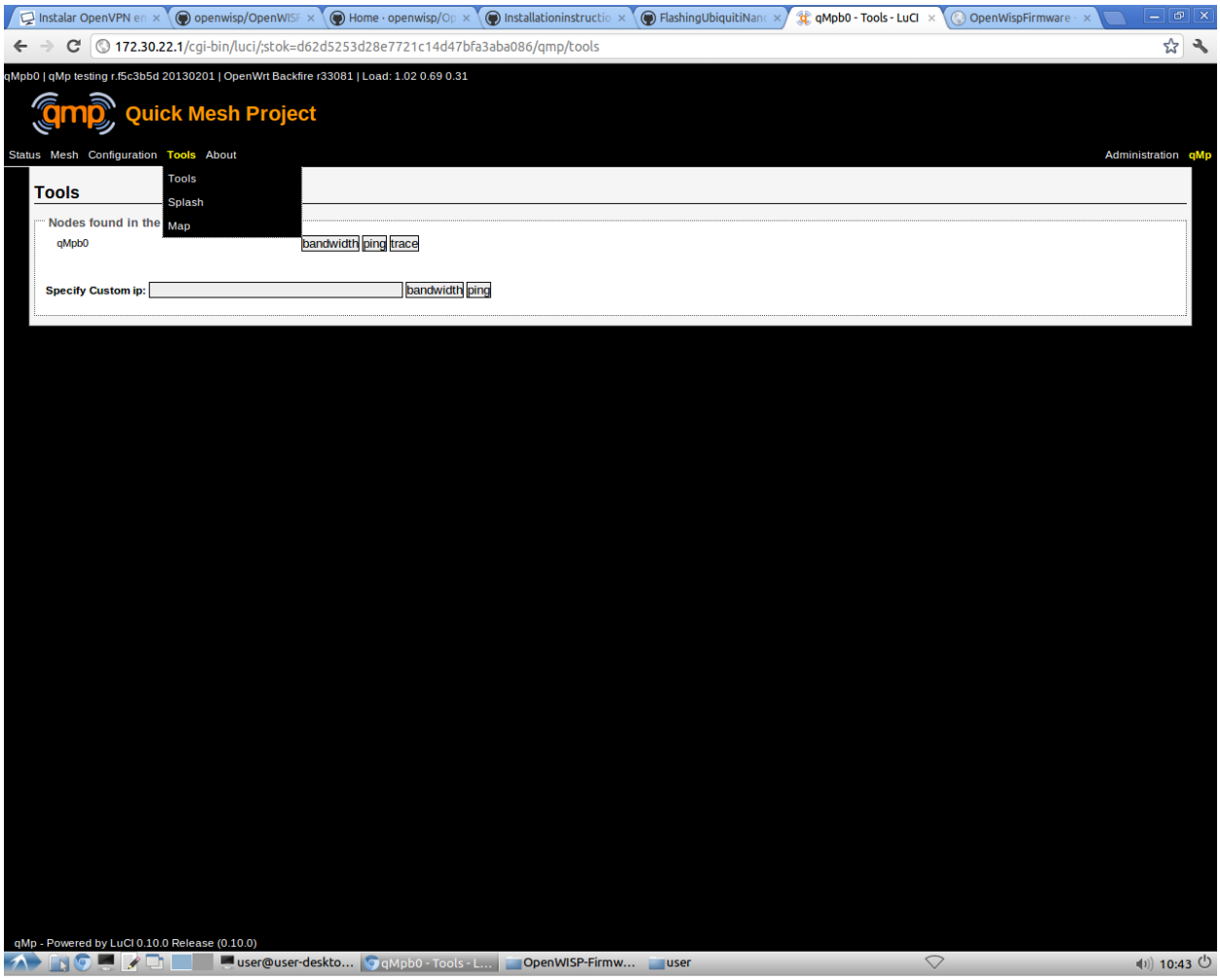
Configuration tab

This tab allows to configure the network interfaces, the Wi-Fi, the node itself and to assign the appropriate parameter in every case.



Tools tab

It allows to configure the options, the splash screen, etc.

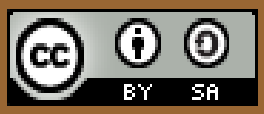


.3 Appendix 3: QMP Presentation

Mobile Node Pilot

Fernando Gros González

04-03-2013

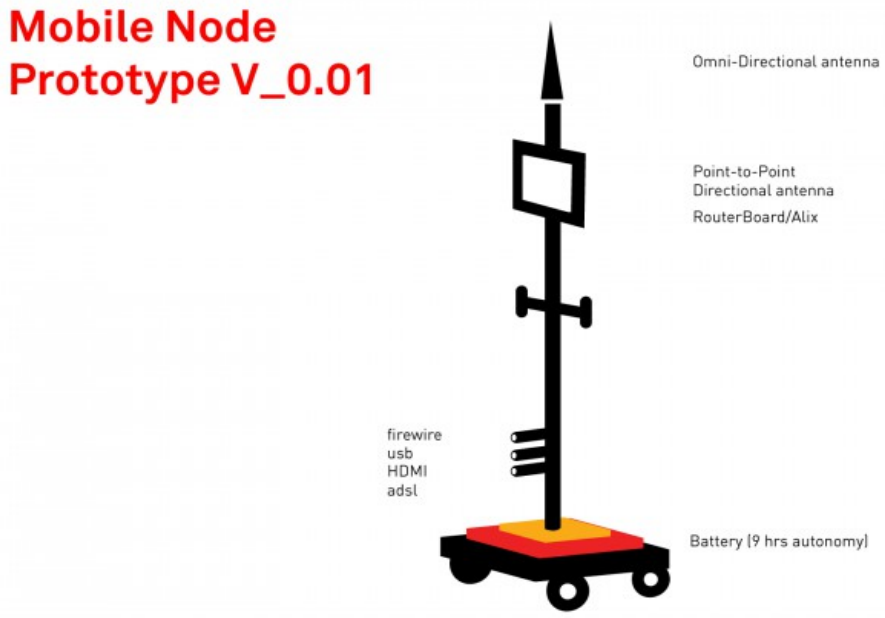


Outline

- Introduction
- Mesh and Manet Networks
- QMP
  - Main features
  - Quick deployments
  - Addressing
  - Modes
  - Dynamic Routing Protocol
  - BMX6
- Mobile Node
- Information sources

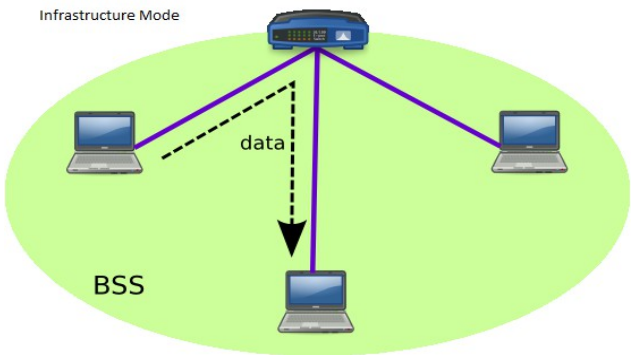
Introduction

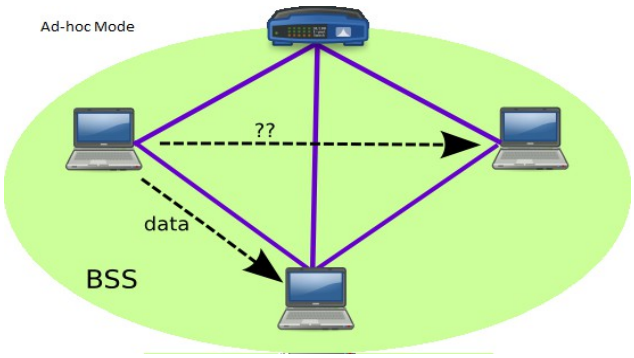
- The main idea within the Mobile Node Pilot is to create a free transmission workstation that can be used in the urban space and contributes to the digital mesh through other networks.



Mesh and Manet Networks (I)

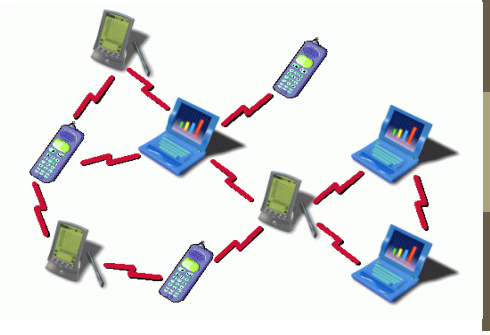
- A mesh network is a network where all the participants are also routers. They are, normally, level 3 networks (Network layer) although they can also be link layer networks.
- Every node has to be connected, at least, to another node in the network, independently of the method (Cable, Wi-Fi, OF, etc.)
- It is not strictly necessary that this kind of networks use the Ad-hoc mode, they can use infrastructure mode too, although it is useless in many cases.





Mesh and Manet Networks (II)

- When we have a mesh network which uses a wireless system to interconnect the nodes and is built in Ad-hoc mode, we talk about MANET (Mobile Ad-hoc Network).
- So a MANET network:
  - *" is a self-configuring infrastructureless network of mobile devices connected by wireless."* (Wikipedia)
- In order to allow this self-configuring feature, we use Dynamic Routing protocols (DRP) which are specially optimized for MANET deployments.



QMP

Main Features

- OpenWRT based
- 802.11a/b/g/n support
- IPv6 native
- IPv4 tunneled over IPv6
- Auto configuration system
- Web GUI to monitor and configure
- Visualization tools (maps, graphs, etc.)
- Automatic dynamic routing (zero-conf)
- BGP (Border Gateway Protocol) support (half implemented)
- Open Source

QMP

Quick Deployments

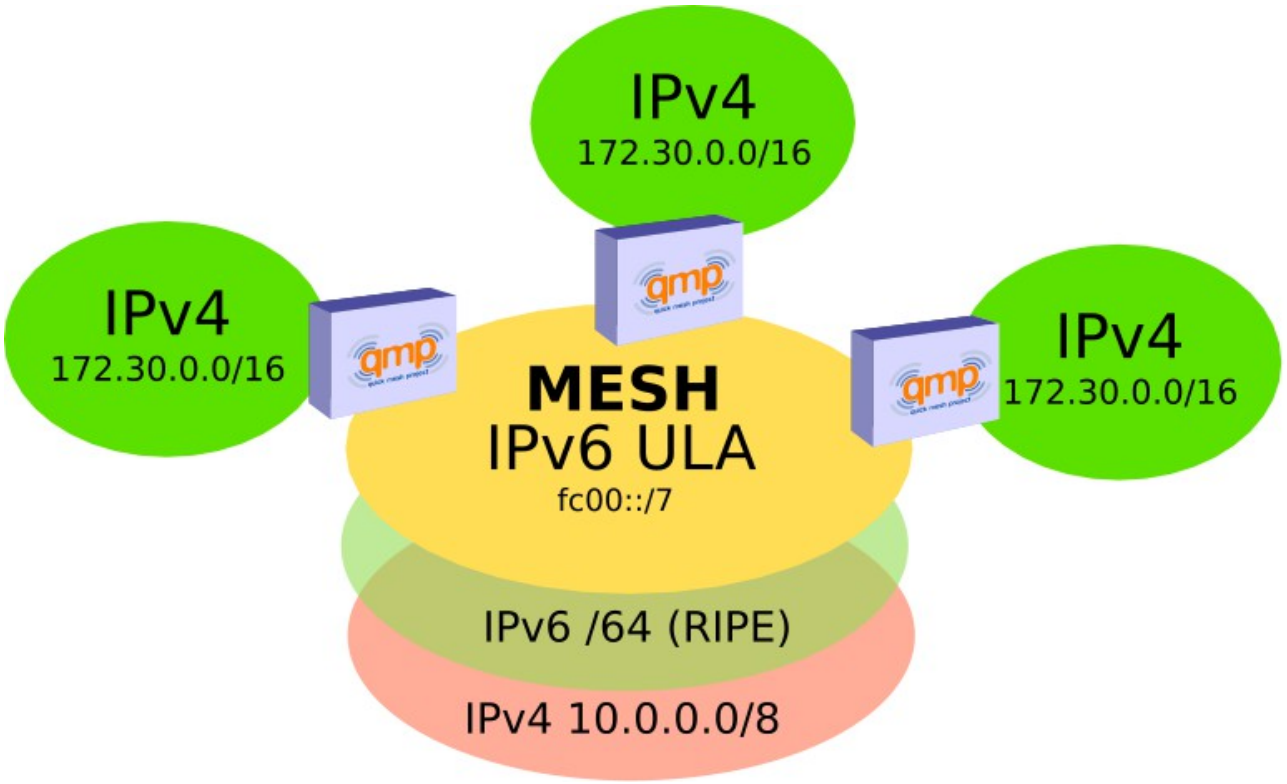
- One of the scenarios QMP has been developed for is: Quick deployments.
- Achieve the following requirements:
  - The deployment must be performed as fast as possible.
  - It must be able to be done by non-technical people.
  - It must be possible in most situations.

QMP

Addressing

- Qmp uses three different kind of IP addresses:
  - IPv6 ULA: IPv6 private range to be used internally in the mesh. These IPs are used for the communication among the nodes in the mesh network, and so they are not neither valid nor routable outside.
  - IPv6 RIPE: IPv6 public IPs range (6to6 tunneling). These are globally valid and routable.
  - IPv4: IPv4 private range to connect with the final user (4to6 tunneling). They are assigned to the final users attached to a node in the mesh, when they transmit any packet that has to travel throughout the mesh it is encapsulated in an IPv6 packet (tunneling).

QMP

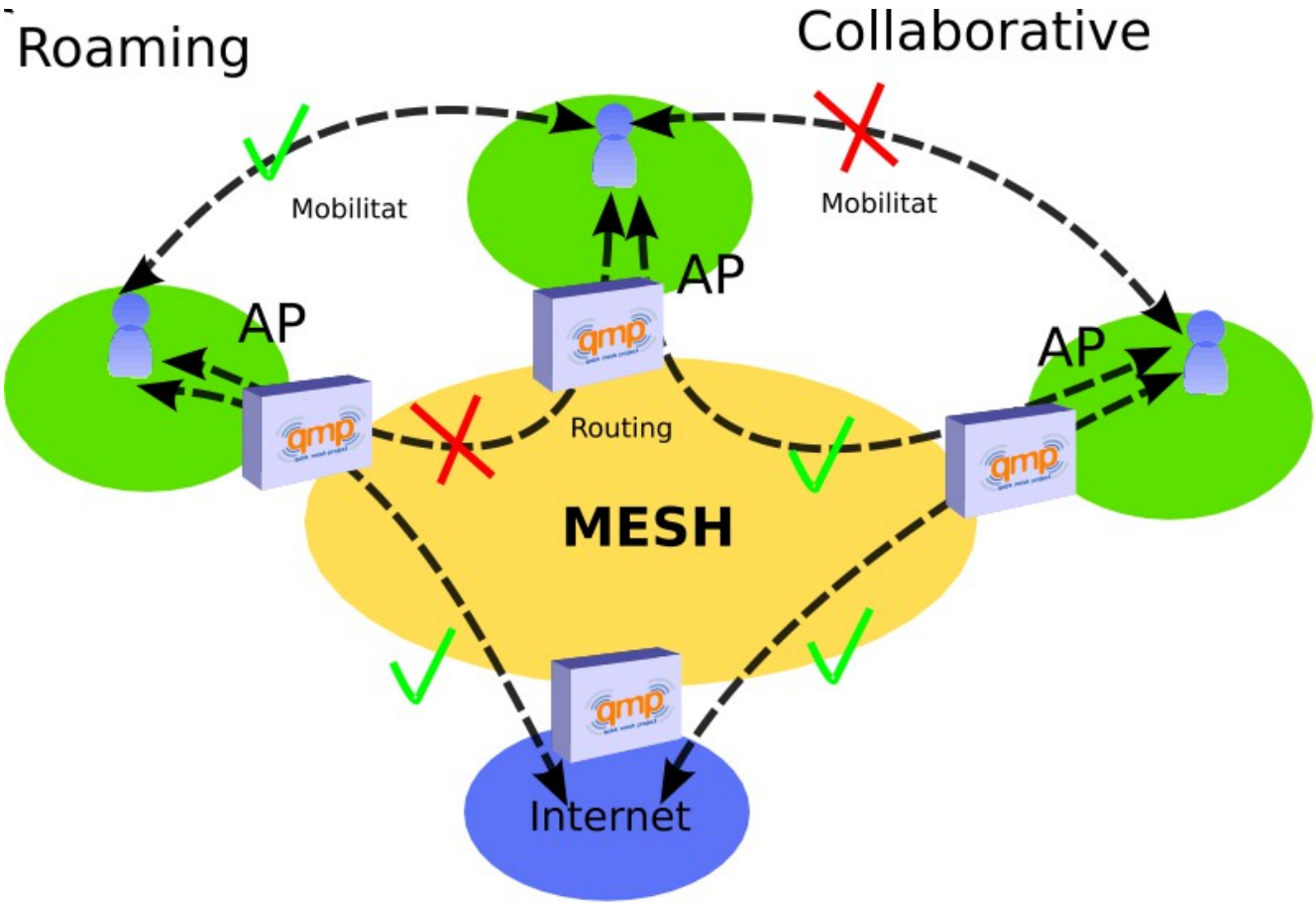

IPv4
172.30.0.0/16
IPv4
172.30.0.0/16
IPv4
172.30.0.0/16
qmp
qmp
qmp
MESH
IPv6 ULA
fc00::/7
IPv6 /64 (RIPE)
IPv4 10.0.0.0/8

QMP

Modes

- *Roaming* for fast deployments:
  - All the access points in this mode will have the same IP and the same ESSID in order to allow users mobility, namely, they won't lose the connection although they switch from an AP to another.
  - Every AP implements a NAT and so, two users attached to different APs won't have direct vision between them.
- *Community:*
  - Every node will have a randomly assigned IPs range and will announce this range through the mesh.
  - There is not NAT, every user has direct vision with the others (1 hope away from the IPv4 network layer point of view), but mobility is not allowed (no roaming).

QMP


Roaming
Collaborative
Mobilitat
Mobilitat
AP
AP
AP
Routing
MESH
Internet

QMP

Dynamic Routing Protocol

- The QMP firmware, uses the following protocols:
  - BMX6 as the main DRP.
  - OLSR6 as a backup DRP.
  - Babel as a backup DRP but optional.
-
- All three use IPv6 ULA to talk to other nodes and are isolated at the link layer (MAC) using VLANs.

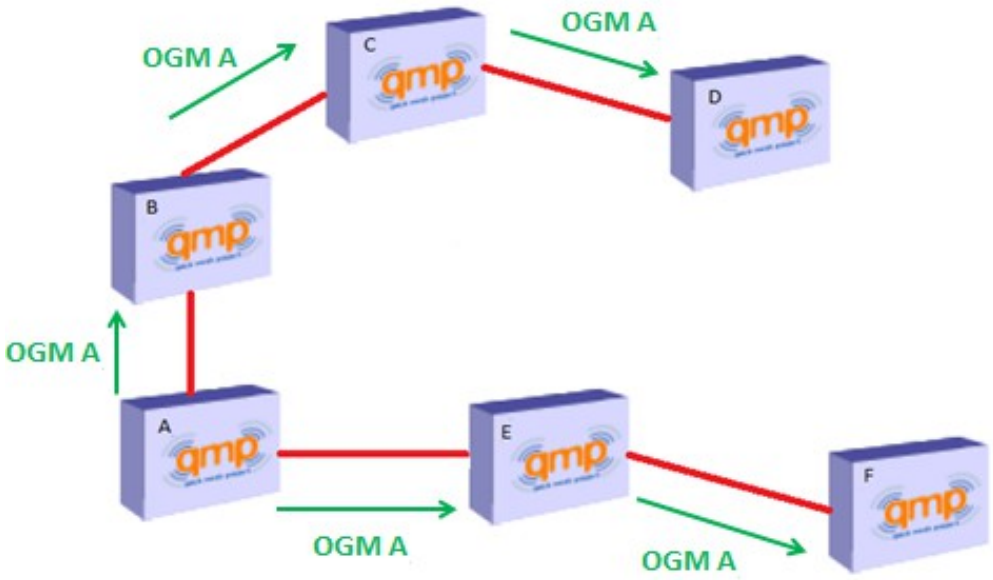
bmx6

OLSR Optimized Link State Routing

QMP

BMX6

- Pro-active: Uses UDP flooding to periodically send Originator Messages (OGM) and build a routing table.
- Destination-sequenced, Distance-vector (DSDV): Every node just knows which neighbor is better to reach another, namely, they do not need to know the entire topology, just the best paths.
- Does not use IP as node identifier, it uses global identifiers using SHA2 hashing.



Best Path to A					
Step	B	C	E	D	F
1	A	-	A	-	-
2	A	B	A	-	E
3	A	B	A	C	E

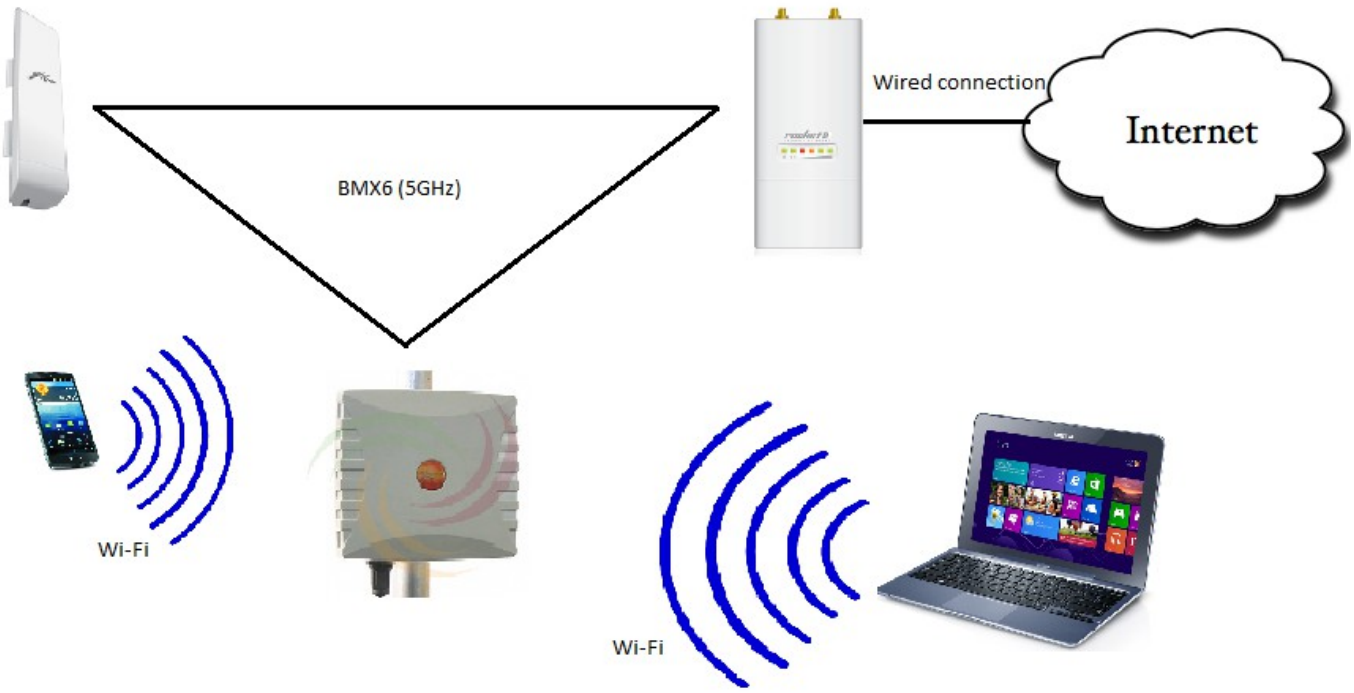
QMP

Frame name	Description
HELLO ADV	Hello advertisement. Used for letting neighboring nodes detect the link quality in transmit direction (from sending to receiving node).
RP ADV	Rx probe advertisement. Used for reporting about reception rate of hello messages from neighboring nodes.
OGM ADV	OGM advertisement. Used for updating periodically route and metric information over the mesh.
OGM ACK	OGM acknowledgement. Used for acknowledging the previously reception of a full OGM ADV frame.

Mobile Node

- The main goal of creating a node which has mobility is giving coverage to zones or event that are not covered with the existing fixed infrastructure. And so it has a lot of social implications, for citizens and cities:
  - Giving Wi-FI access to people in a concert or any other event (indoor or outdoors).
  - Allow people broadcast something taking place with their Smartphone (apps like bambuser) or using IP cameras.
  - Giving coverage in a protest, moving the node along with the people.
  - Etc!!
- We always need a fixed infrastructure to be able to expand the mesh by adding this node. Cities like Barcelona are creating this kind of infrastructures.

Mobile Node



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