An IEEE 802.11 static mesh network design for isolated rural areas in developing regions

Javier Simó <jsimo@ehas.org>
Pablo Osuna < posuna@ehas.org>
Joaquín Seoane <joaquin@ehas.org>
Andrés Martínez < andresmf@ehas.org>

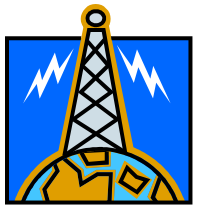
Rural Areas in Latin América: Environmental characteristics

- SHORTAGE AND HIGH COST OF QUALIFIED TECHNICAL STAFF
- MEDICAL STAFF WITH ISOLATION SENSATION AND HIGH ROTATION
- LACK OF ELECTRICAL INSTALLATION (UNSTABLE IF IT EXISTS)
- LONG DISTANCES AND DIFFICULT ACCESSIBILITY
- BAD WEATHER CONDITIONS (wind, rain, extreme temperatures)
- HIGH COST IN THE COMMUNICATIONS

EHAS Technologies and Services

Technologies

- Radio communications:
  - HF
  - VHF
  - **Wi-Fi**



- VoIP
- Solar energy

Services

- Distance learning
- Support to epidemiologic surveillance system
- Reference – back-reference of patients
- Teleconsultation
- Remote access to health information
- Support to the distribution of medicines

- Microwave wireless technology has became very popular during the last years, partly thanks to Wi-Fi

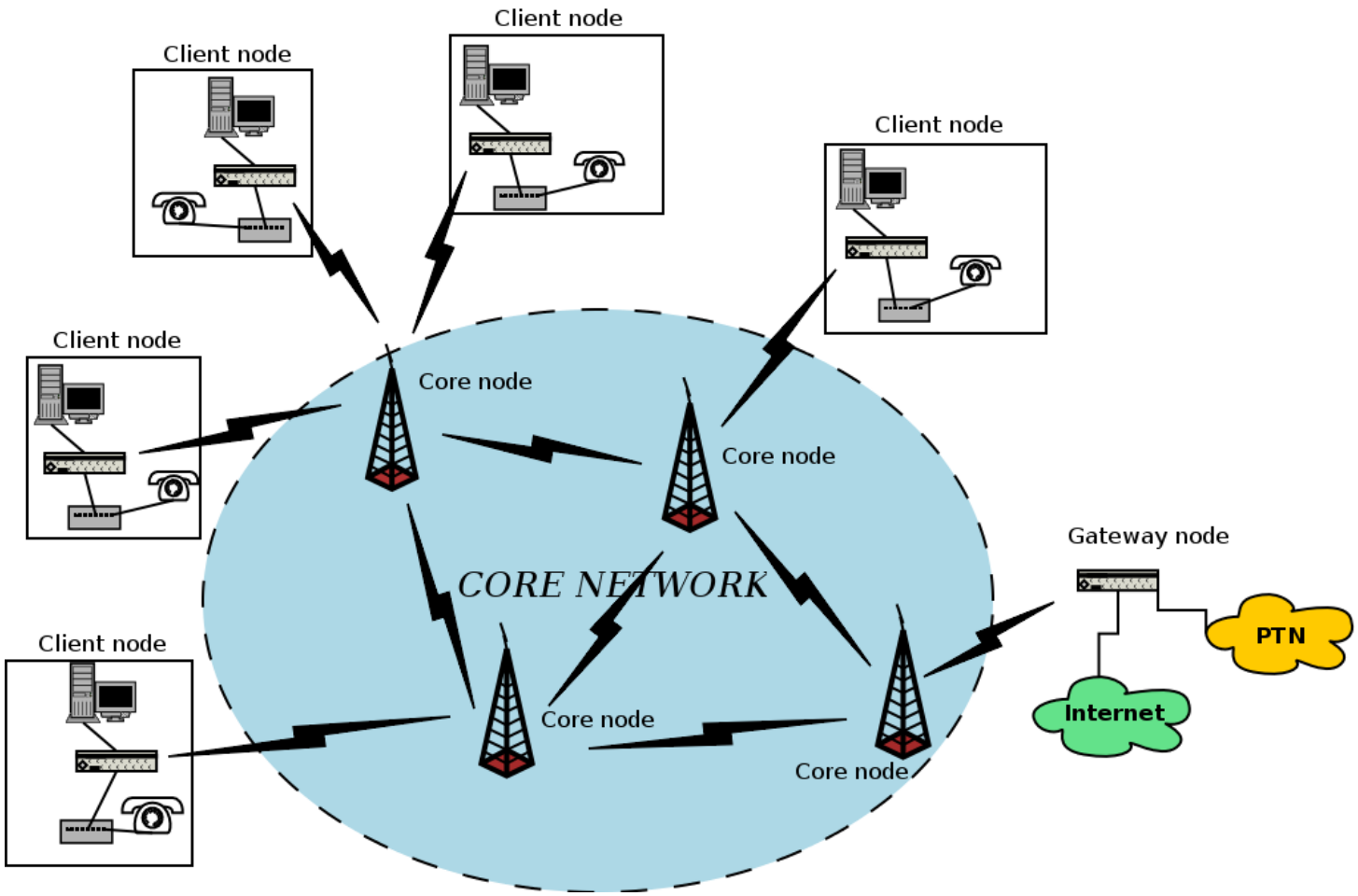
Wi-Fi: Wireless Standard that complies with recommendations 802.11 a/b/g

- Frequency bands (ISM) in 2.4 and 5.8 GHz: license-free, not exceeding power limits. Interferences problem disappears in isolated rural areas.

- Technology designed for indoors. ¿What about long distances?

It is a network formed in a spontaneous way without any communication infrastructure. Nodes connect to neighbours as they discover, and can communicate with other networks using other nodes as routers

Mesh Network Architecture

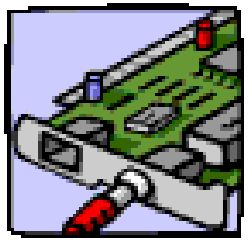


Why Mesh Networks?

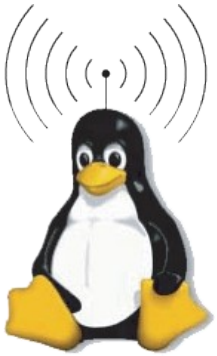
- **Very well-known technology: 802.11**
  - A lot of research around this technology. Specific protocols designed for Mesh Networks
- **Low cost technology**
  - Cheap equipment and license-free
- **Low-powered and full integration**
  - Low-powered nodes and easily integrable in waterproof systems
- **Flexibility**
  - A node only needs to see a neighbour node to join in the network
  - Ideal solution for rural isolated areas without geometric distribution
- **Robustness**
  - Descentralized structure with more than one “failure point”

Components of the Mesh Router

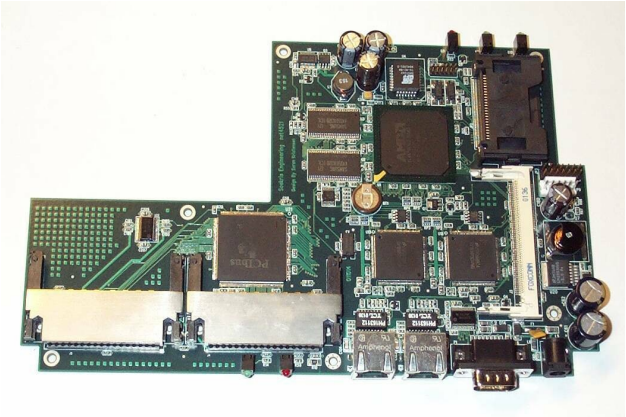
- **Hardware system**
  - Computer subsystem
  - Wireless subsystem
  - Solar subsystem
  - Structural subsystem



- **Software system**
  - IP Autoconfiguration
  - Multihop Dynamic Routing Protocol
  - Quality of service QoS
  - Security and Monitoring
  - Software Distribution



Computer subsystem



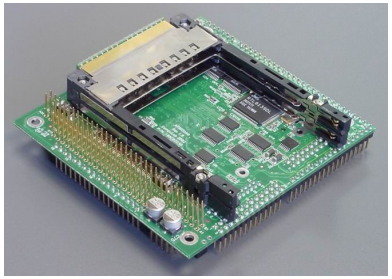
- Embedded computer optimized for routing functions
- Ideally 3 wireless interfaces

4W

X86 ARCHITECTURE

¡¡¡LOW CONSUMPTION!!!

1W!



MIPS ARCHITECTURE

ARM ARCHITECTURE

- WIRELESS CARDS

  - Running in Linux by Hostap and Madwifi drivers

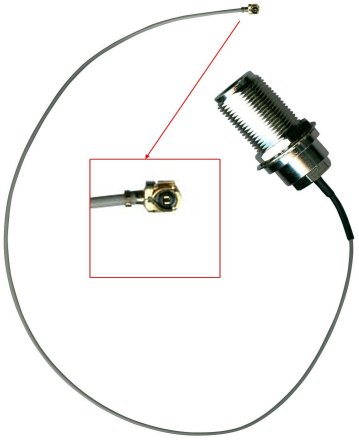
  - Madwifi allows to tweak some parameters for long distance links!!!

- EXTERNAL ANTENNAS

  - Directive and high power antennas for PtP links.

  - Cables with very low looses

  - Pigtails



Results from long distance links

Rate	Cusco - Josjojahuarina	Josjojahuarina - Don Juan
1M	68.5	69.7
2M	119	110
5.5M	205	197
11M	368	350

Tabla 1: Throughput (Kbytes/s) en 802.11b con la SR2

Rate	Master - Managed	Ad-Hoc	Pseudo - Ibss
1M	79.5	74	80.1
2M	159	152	153
5.5M	360	334	331
11M	553	341	506

Tabla 3: Throughput (Kbytes/s) en 802.11b con la Senao

Rate	Cusco - Josjojahuarina	Josjojahuarina - Don Juan
6M	275	266
9M	440	425
12M	500	499
18M	602	585
24M	759	721
36M	833	810
48M	184	-
54M	-	-

Tabla 2: Throughput (Kbytes/s) en 802.11g con la SR2

Solar and structural subsystems

COMPONENTS:

- Panel
- Regulator
- Battery
- Other accesories like cables, connectors and mechanical elements for fixing

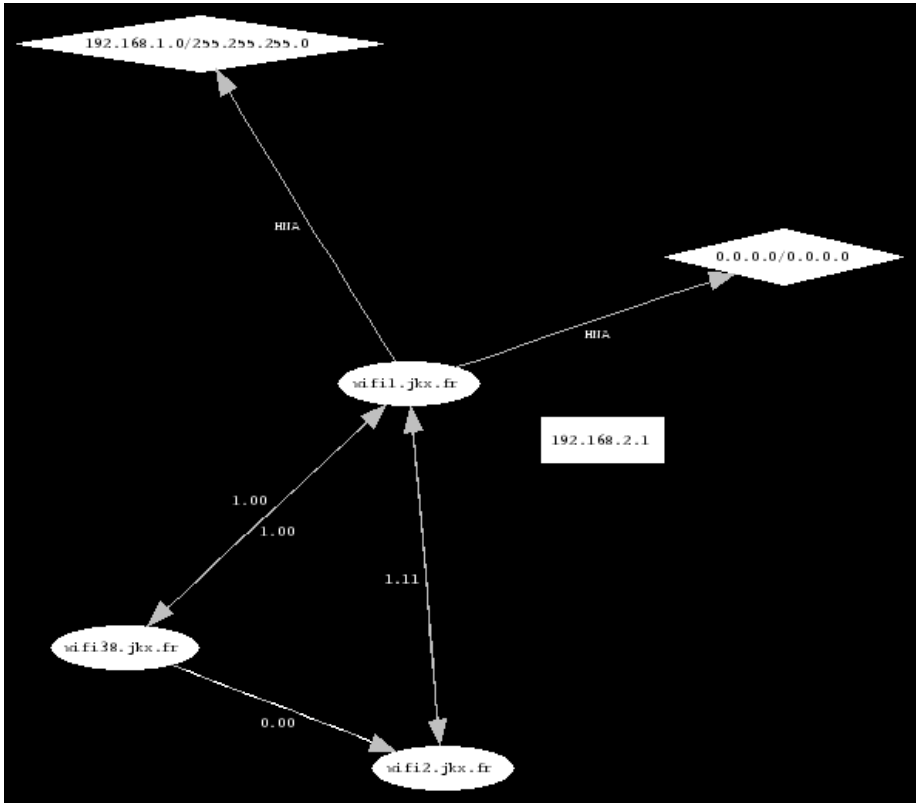
Design of the solar subsystem from consumption tests!

- NEMA-4 waterproof box
- Fixation elements
- Solar panel and antennas on it
- Robust and transportable

Suitable protection system for outdoor installation of the router!

- First version of the router: manual assignment of IP addresses
- Autoconfiguration solution
- A lot of theoretical research on this topic but not implementations available. Some approximations:
  - IPv4 with wireless cards from the same manufacturer or assigning an IP from a known range
  - DHCP Relays
  - IPv6

Reduction of network maintenance and administration!!!



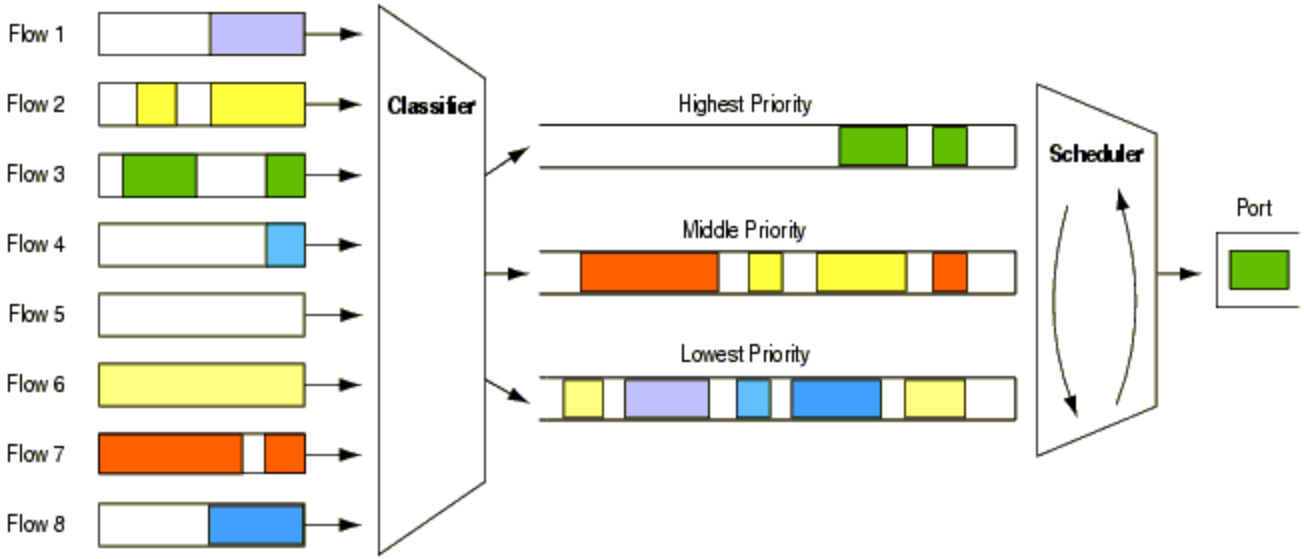
- First version of the router: static routing
- Autoconfiguration objective: Multihop Dynamic Routing Protocol
- Protocol QoS aware: ETX
- Independent from IP addresses of the nodes

Chosen solution: OLSR

- Real time traffic should be differentiated: VoIP, videoconference

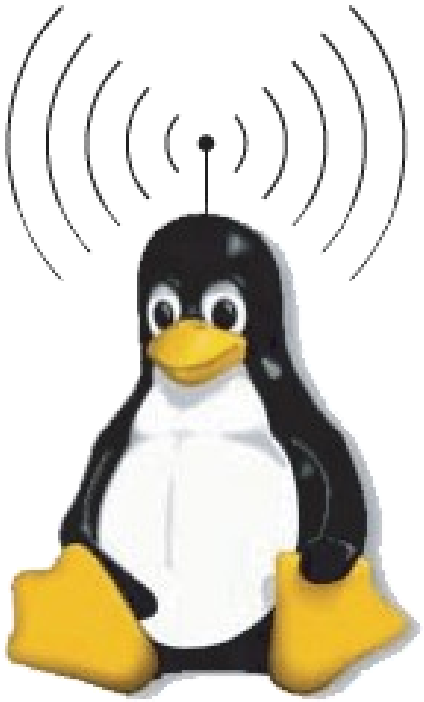
Wi-Fi has not QoS → Layer 3 (IP) Diffserv: priorities and classes

- Desirable to design an adaptative model to the fluctuations of the link
  - Shape inbound traffic



Open Source Distribution: Linux

- Optimized in size
  - pebble-EHAS (77MB)
  - nano-EHAS (<32MB)
- Includes, among other things, dynamic routing, Quality of Service and watchdog software
- It also has a software PBX for VoIP: Asterisk



Asterisk
The Open Source PBX

WI-FI SECURITY

- Layer 2:

  - WEP, used in our network, vulnerable encryption

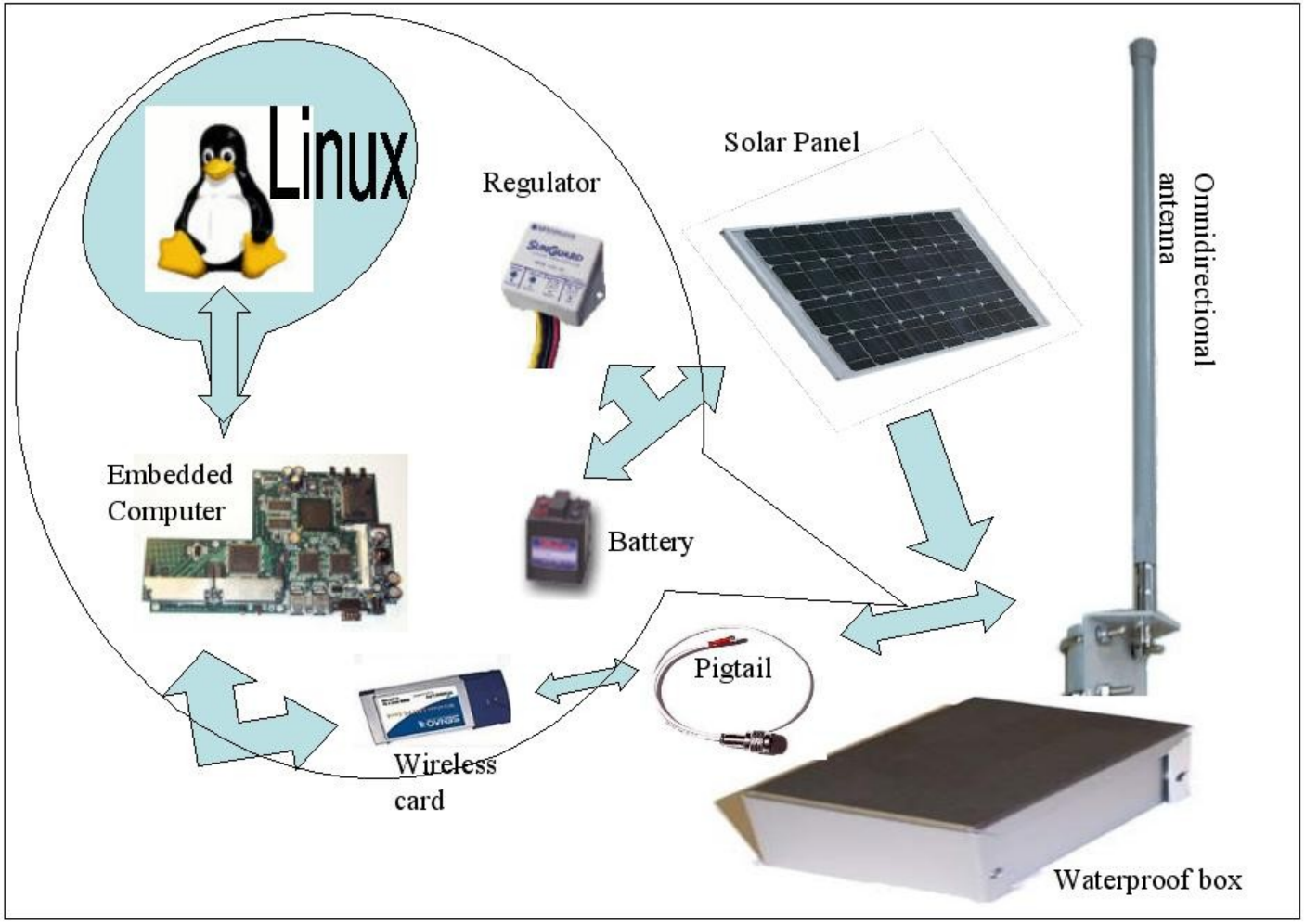
  - WPA, new solution, not valid for Ad-Hoc mode

- Others: OLSR Plugin, IPSec-VPN, SSL

MONITORING

- It allows to know in depth the availability and state of the network
- Software based in electronic mail and Zabbix
- Hardware to detect battery level, presence sensor

Mesh Router scheme



Discussion

SHORTAGE AND HIGH COST OF QUALIFIED TECHNICAL STAFF

- **Autoconfigurable solution to reduce those costs**

Maintenance cost is inversely proportional to sostenibility

MEDICAL STAFF WITH ISOLATION SENSATION AND HIGH ROTATION

- **It helps to break with the incommunication**

LACK OF ELECTRICAL INSTALLATION (UNSTABLE IF IT EXISTS)

- **Solar energy used to feed Mesh Router**

LONG DISTANCES AND DIFFICULT ACCESSIBILITY

- **Wi-Fi technology adapted to long distances**

Stable system to assure minimum of service calls

BAD WEATHER CONDITIONS (wind, rain, extreme temperature)

- **Robustness faced with bad weather conditions**

HIGH COST IN THE COMMUNICATIONS

- **Wi-Fi systems are very low cost**

Future work

- Power consumption comparison
- Implementation of a autoconfiguration mechanism
- Design and application of a QoS solution
- Research of a long distance model for Wi-Fi