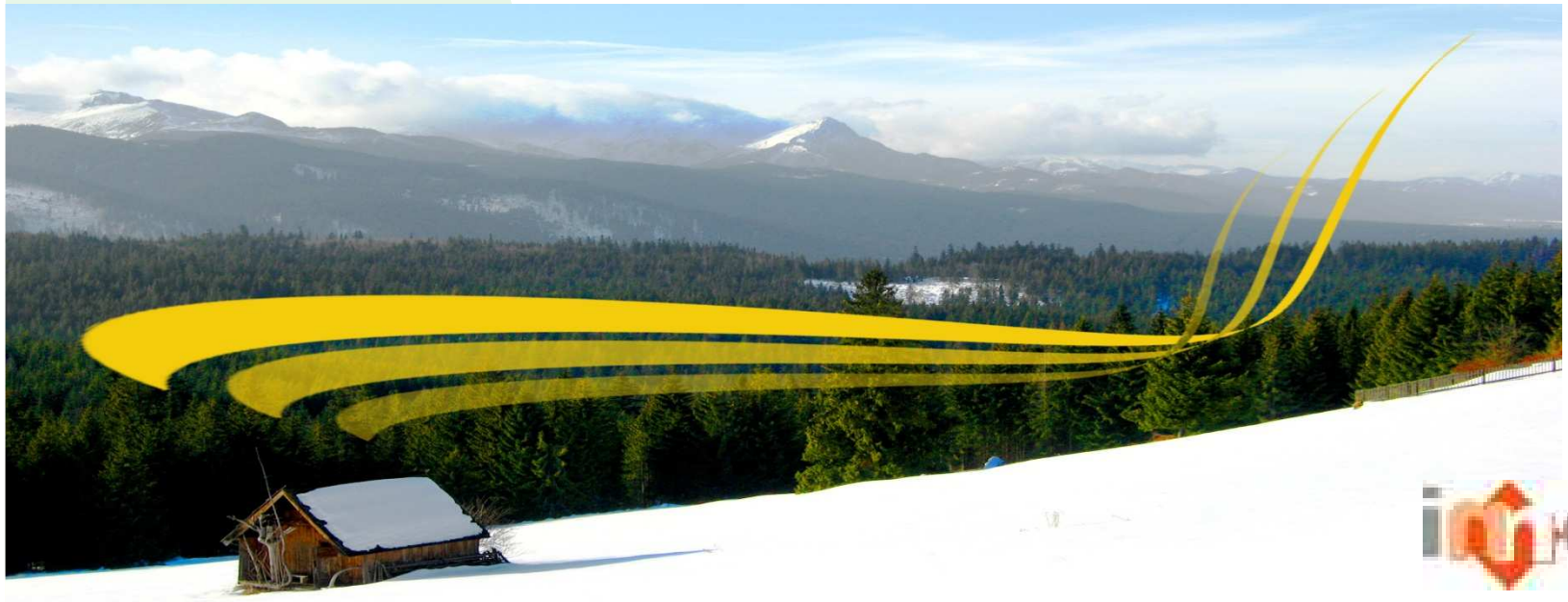
ADHOCSYS

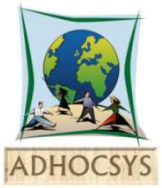
Low Cost and High Performance Multi-hop Wireless Mesh Network Solution in Rural and Mountain Areas.
Lessons Learnt, Future Challenges and Application to Disaster and Emergency Management.



Agenda of the presentation

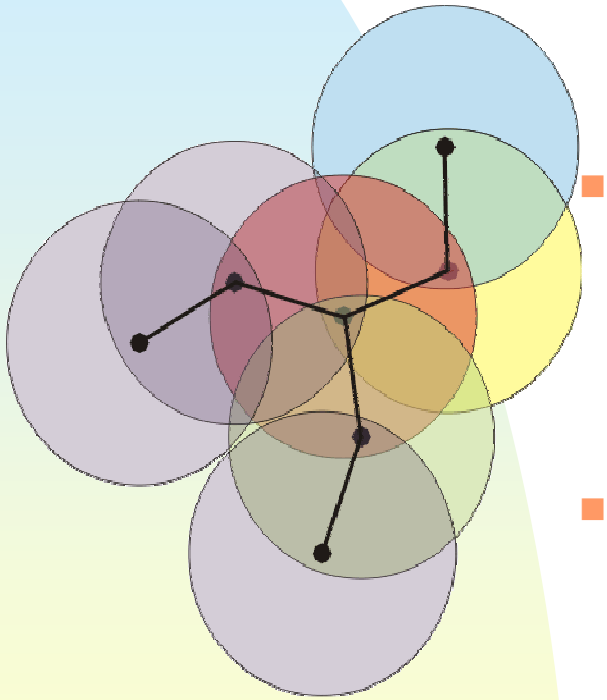
- Project overview
- Network architecture
- OLSR extensions
- QoS issues
- Pilot network
- Future Activities

ADHOCSYS Main Objective



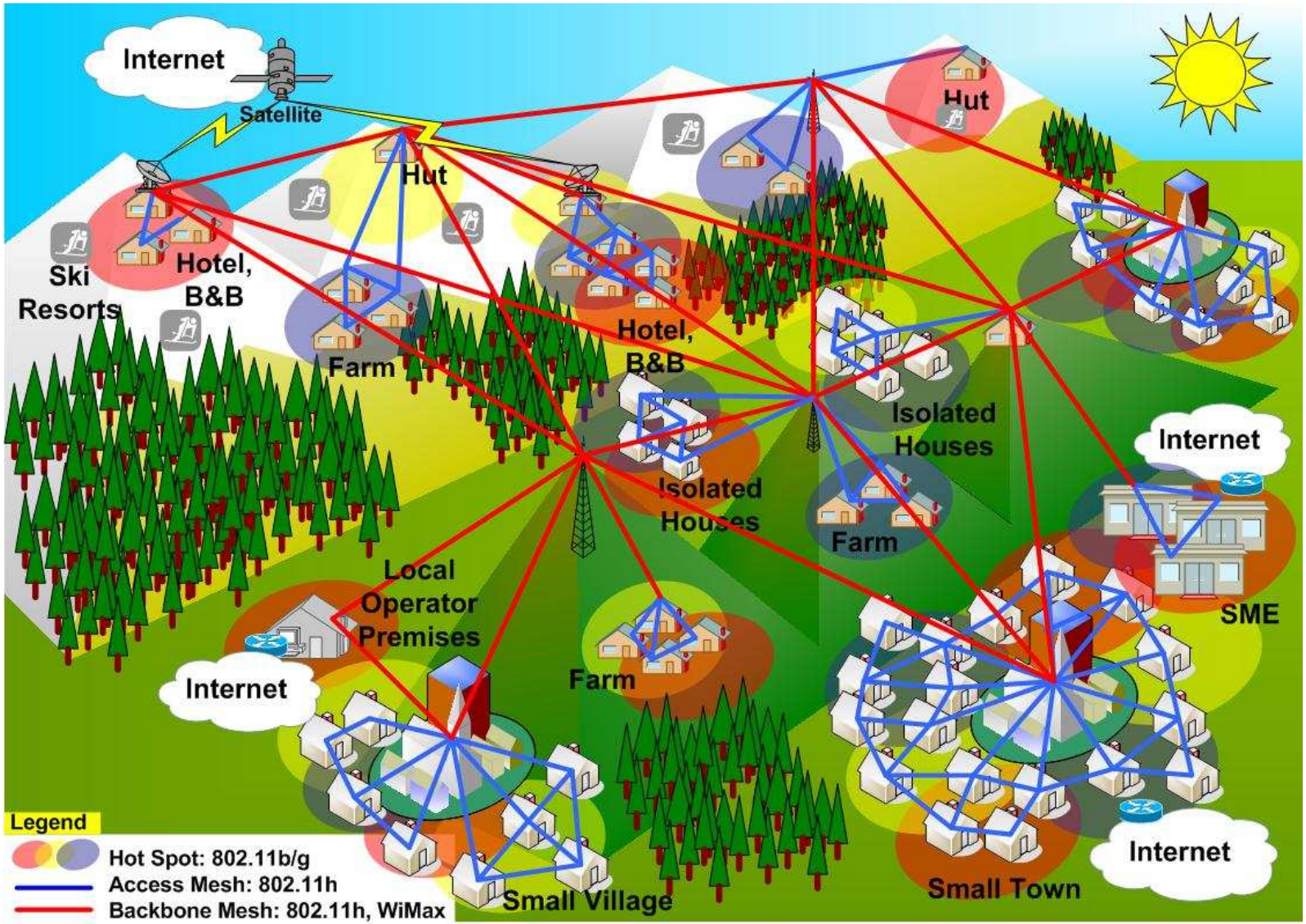
- Provide a reliable broadband Internet access solution to people who live in rural and mountain regions where xDSL is not available or non-profitable
- Consider also people living outside towns and villages and occasional visitors
- Cheap solution, able to use off-the-shelf hardware equipments
- Open source software

ADHOCSYS solution



- Proposed solution : reliable wireless broadband ad hoc network with fixed nodes as routers
- Reliability is achieved by introducing redundancy, and by exploiting it through an enhanced ad hoc routing algorithm, implemented as an extension to OLSR
- If any node or link which takes part in routing fails, the end users still experience non-interrupted services.

ADHOCSYS Network Architecture

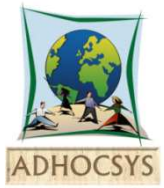


ADHOCSYS issues

- The objective is to build a working and reliable solution in a realistic environmental scenario, where
- Reliability of nodes and of links can be compromised by extreme weather conditions such as snow, wind, lightning, drained batteries, power outages
- Network reliability is achieved by introducing redundant gateway connections (multi-homing), multi-path, power-aware routing, link break detection, support for multiple interfaces, load balancing, and automatic channel assignment

ADHOCSYS pilot network

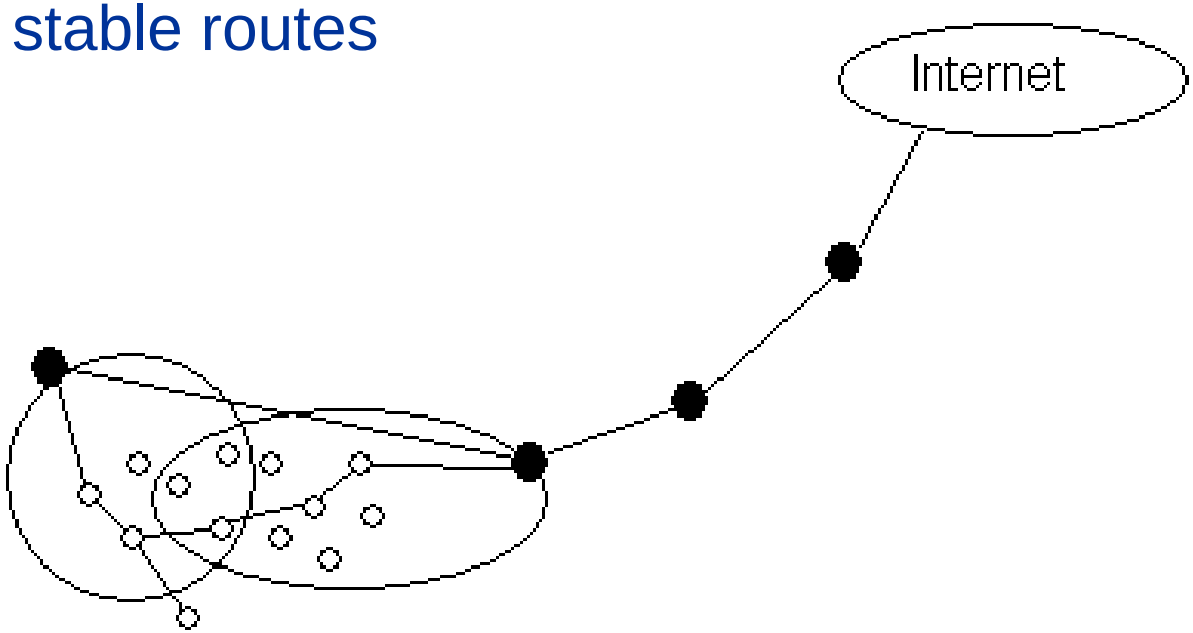
ADHOCSYS results (1)



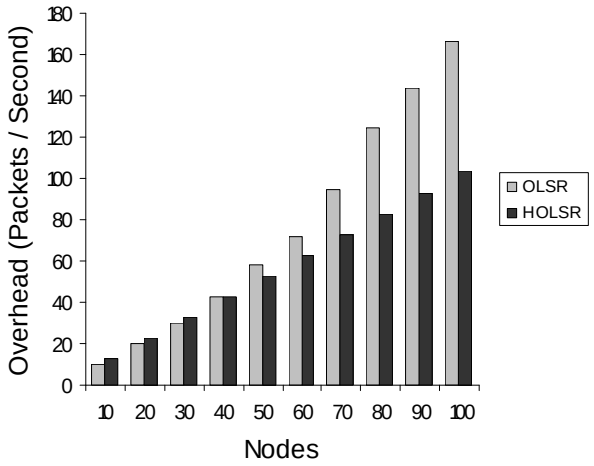
- Better understanding of operational scenario and network requirements
- Algorithms and implementations to improve network reliability
- Working prototype of an ADHOCSYS Linux Box
- Working pilot network
- Experimental results

ADHOCSYS results (2)

- Wireless ad hoc networks with fixed nodes provides a promising solution for Internet access in this environment, but care must be taken in order to obtain stable routes



ADHOCSYS results (3)



- ADHOCSYS algorithms and implementations are useful:
  - The routing calculation extension can be used to adopt different metrics
  - Link break detection mechanism allows to reduce the reaction time of an OLSR network after a link break from 11 seconds to 1 second.
  - The multiple interfaces enhancement allows to use more than one link at the same time between two given nodes, resulting in increased throughput
  - The hierarchical OLSR enhancement reduces protocol overhead substantially for network with > 40 nodes (simulation)

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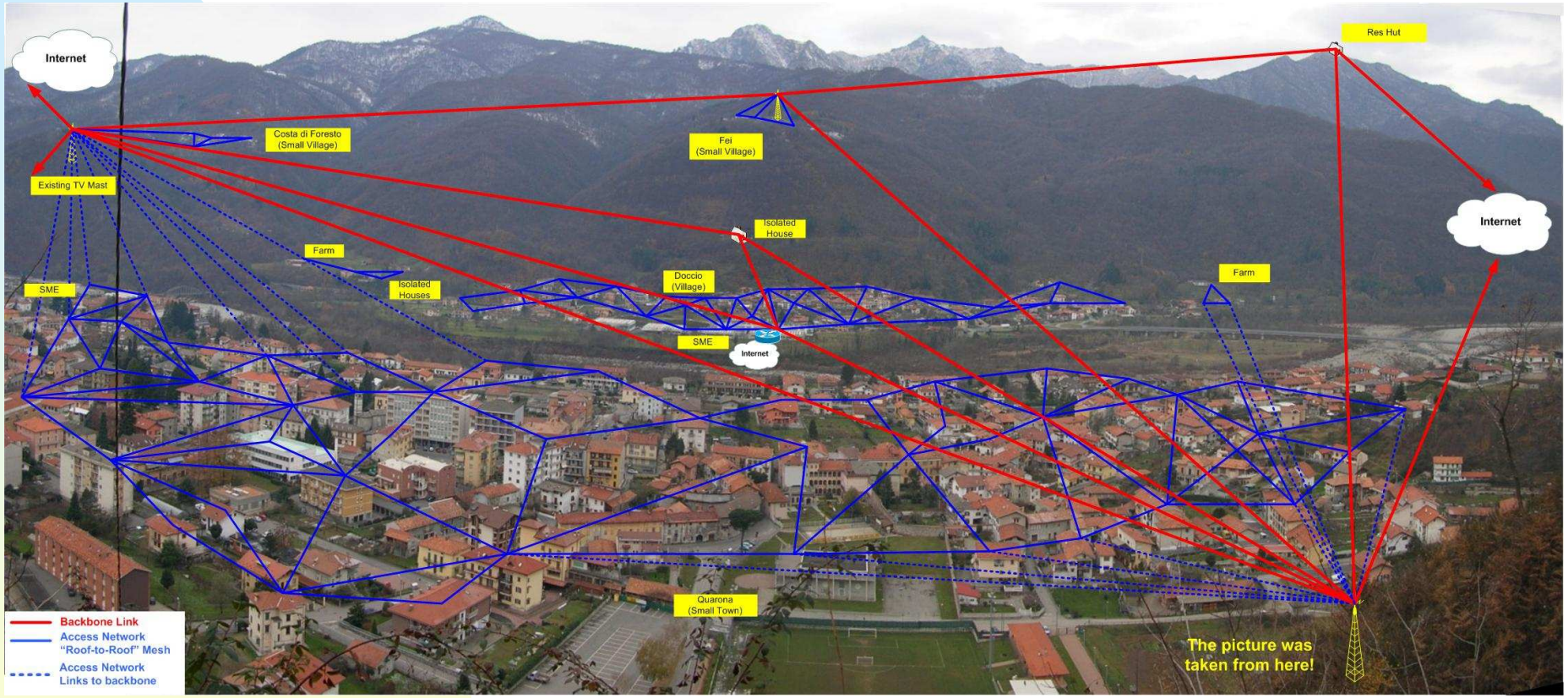
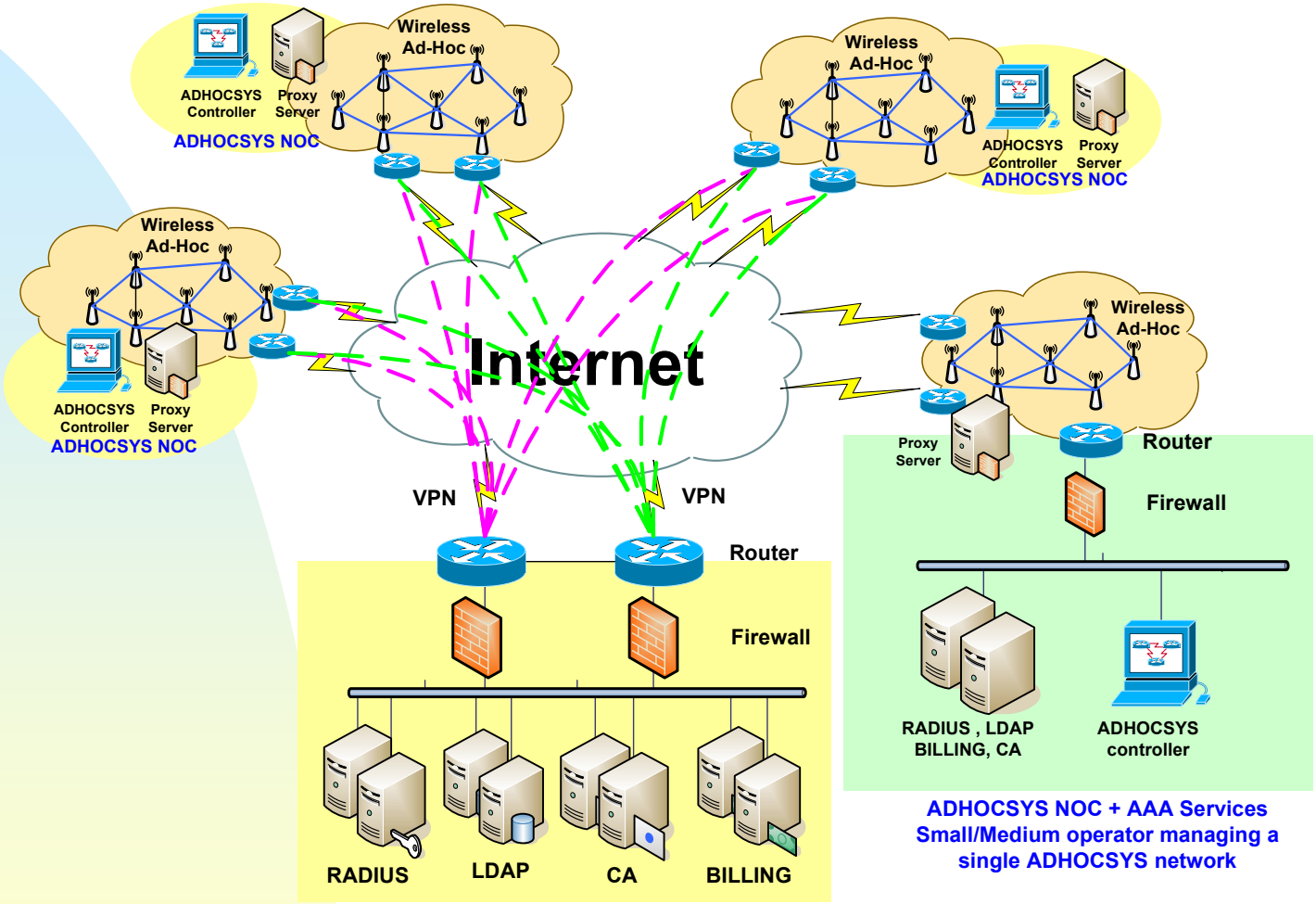
Network architecture

- A wireless backbone (a few long wireless links) connecting together towns and villages
- An access network (many short links) in each town/village connecting all inhabitants
- Internet gateways connected directly to the backbone or the access network
- Scenario I: large scale networks, with several access networks interconnected by the backbone network
- Scenario II: small scale networks, where an access network is directly connected to the Internet

Network Illustration



Network functional structure



ADHOCSYS centralized AAA Services
Medium/Large Operator managing many
ADHOCSYS networks

ADHOCSYS NOC + AAA Services
Small/Medium operator managing a
single ADHOCSYS network

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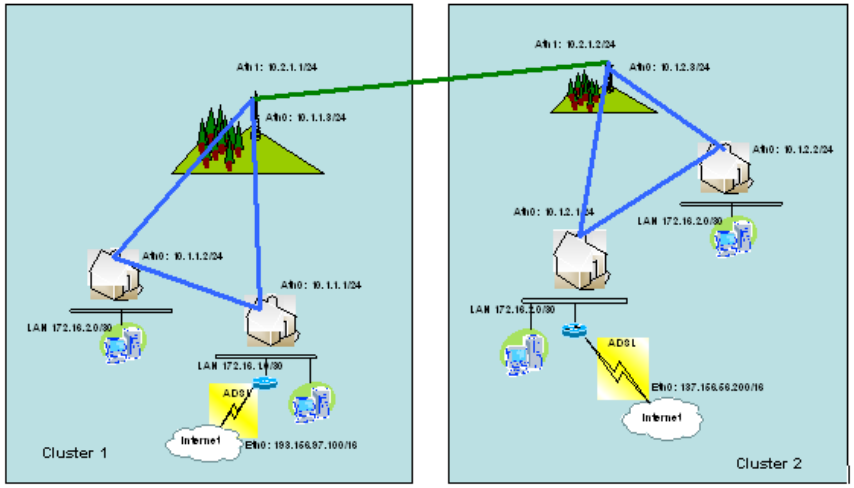
List of OLSR extensions

- Hierarchical OLSR
- Multi-homing
- Multiple interfaces
- Metric-based routing table calculation
- Link break notification
- Link quality detection
- Power-aware routing
- Load balancing

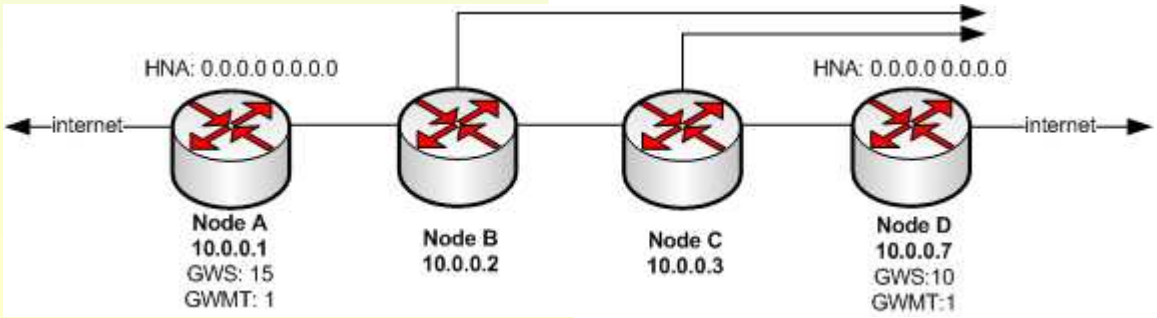
Hierarchical OLSR (1)

- Hierarchical topology is introduced to increase scalability. A two level hierarchy is considered
- The network is divided into different clusters, connected by cluster-heads, which act as border gateways. The cluster-heads aggregate IP addresses in each cluster and are responsible for communications between clusters



Multi-homing

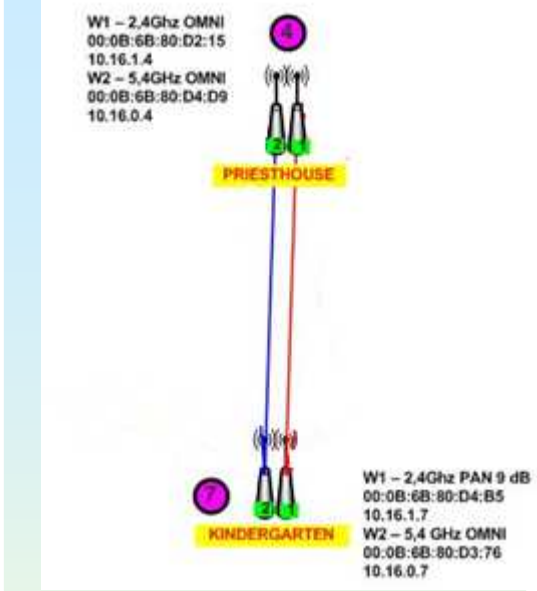
- With standard OLSR, a node is able to observe several gateways, and the closest one is always selected as the default gateway
- The ADHOCSYS policy for selecting a default gateway considers, besides the number of hops, the traffic load at each gateway and along the path
- The load status of each gateway is calculated using the output of IPTraf or Vnstat logger tools. The log file is parsed by the LINKINFO plug-in, and the resulting information is included in the LINKINFO message
- The test shows that the selection of the least loaded gateway increases the performance of the involved node, from 35.7 KB/s, to 128 KB/s

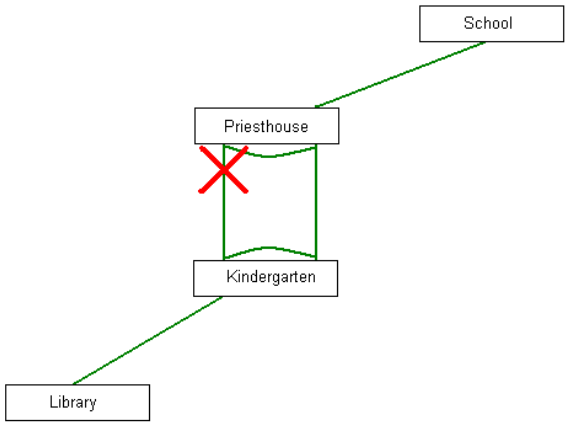


Multiple interfaces (1)

- Standard OLSR has only a partial support for multiple interfaces. Routes to all interfaces are established, but only one channel is used for carrying user data traffic at any time
- In ADHOCSYS, several interfaces can be installed to achieve higher reliability and higher throughput
- ADHOCSYS treats each interface independently. Every interface advertises itself as a main address, and also advertises other interfaces located on the same node as its neighbours. To other nodes in the network, the two interfaces will look like two distinct nodes

Multiple interfaces (2)





- We have measured the throughput between two nodes, copying a 3MB file in both directions.
- With standard OLSR, the copy has been performed at 176.2KB/s on one direction and 166.9KB/s on the other direction
- With our enhanced version, it has been performed at 396.3KB/s on one direction and 288.3KB/s on the other direction

Better reliability has also been observed: the number of seconds to find an alternative route decreases from 24 to 12 when the main interface stops working

Link break notification (1)

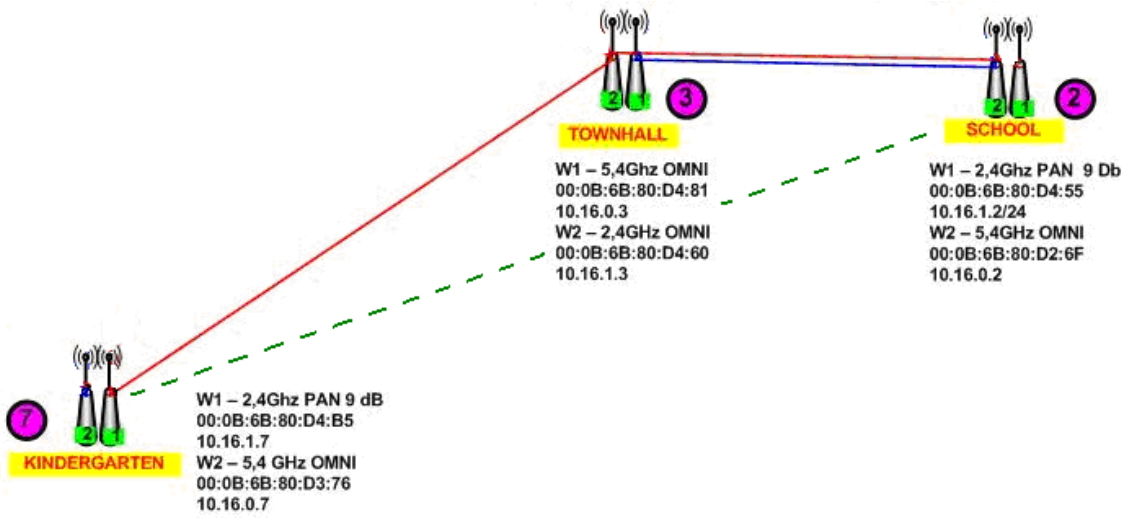
- Link break detection, in the current version of OLSR, is based on HELLO messages. OLSR will remove a neighbour node if a number of consecutive HELLO messages are absent
- We have implemented a link break indicator based on RSSI monitoring, to quickly detect broken links
- The ADHOCSYS link break detection mechanism operates independently from OLSR and communicates link status information through a shared memory segment
- The link break indicator is based upon the iwspy tool

Link break notification (2)

- Tests have been performed by deliberately breaking links and measuring the reaction time, using the *ping* utility to verify the connection between the nodes.
- Using the standard version of OLSR, about 11 seconds have passed after the link break, before a new route has been established.
- Using our enhanced version of OLSR, the new route has been established in a time period less than one second

Link quality detection (1)

- The goal is to exclude poor links from routes, in order to enhance the overall network throughput.
- The direct link shows 25% packets loss, and an average round-trip time of 31.2 ms. Standard OLSR selects the direct link 65% of the times



Link quality detection (2)

- With our link quality enhancement, the two hops path is selected 80% of the times.
- With standard OLSR, the percentage of lost packets decreases from 25% to 9%, and the average round trip time increases from 31.2 to 39.8 ms
- With our link quality enhancement, the percentage of lost packets decreases to 3%, and the average round trip time is 37.4 ms.

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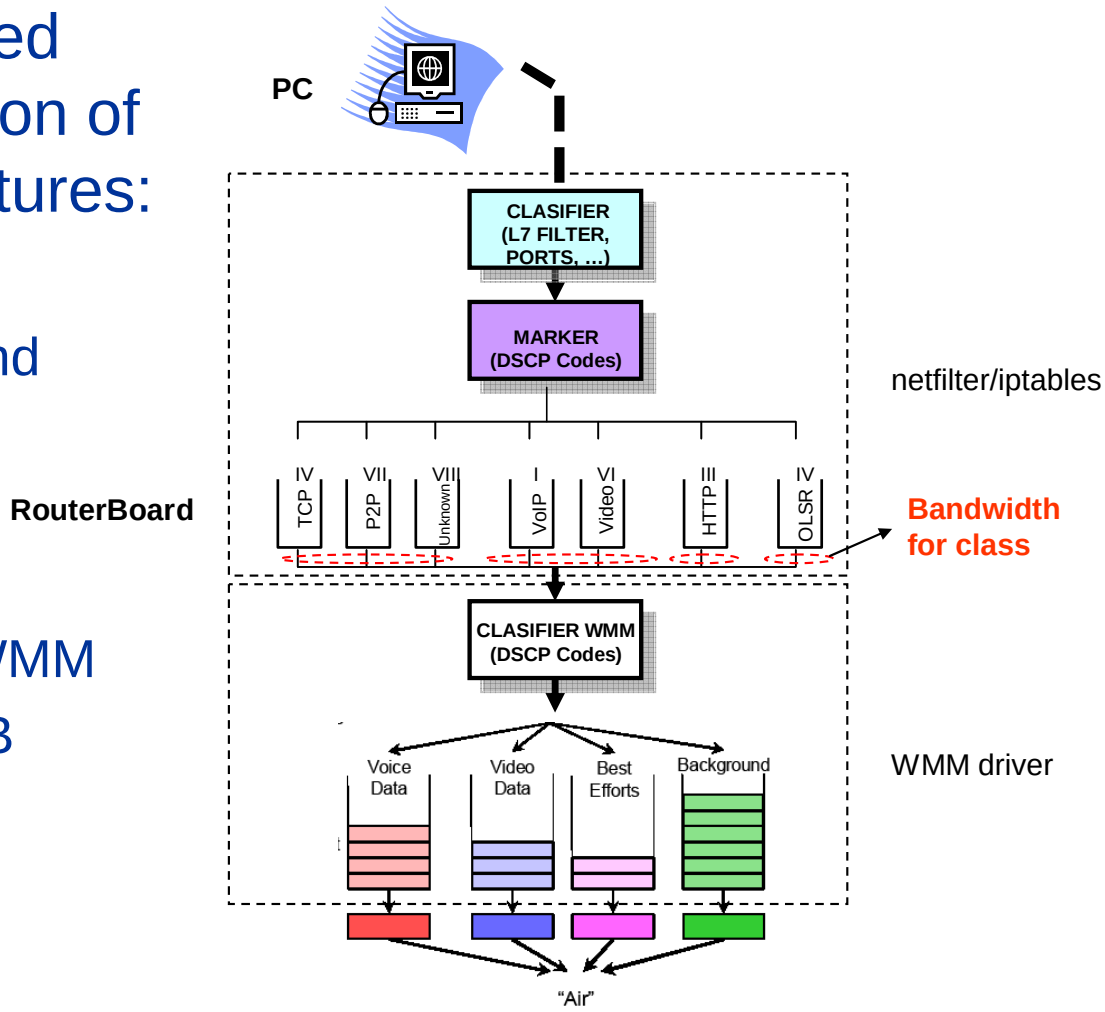
QoS Requirements

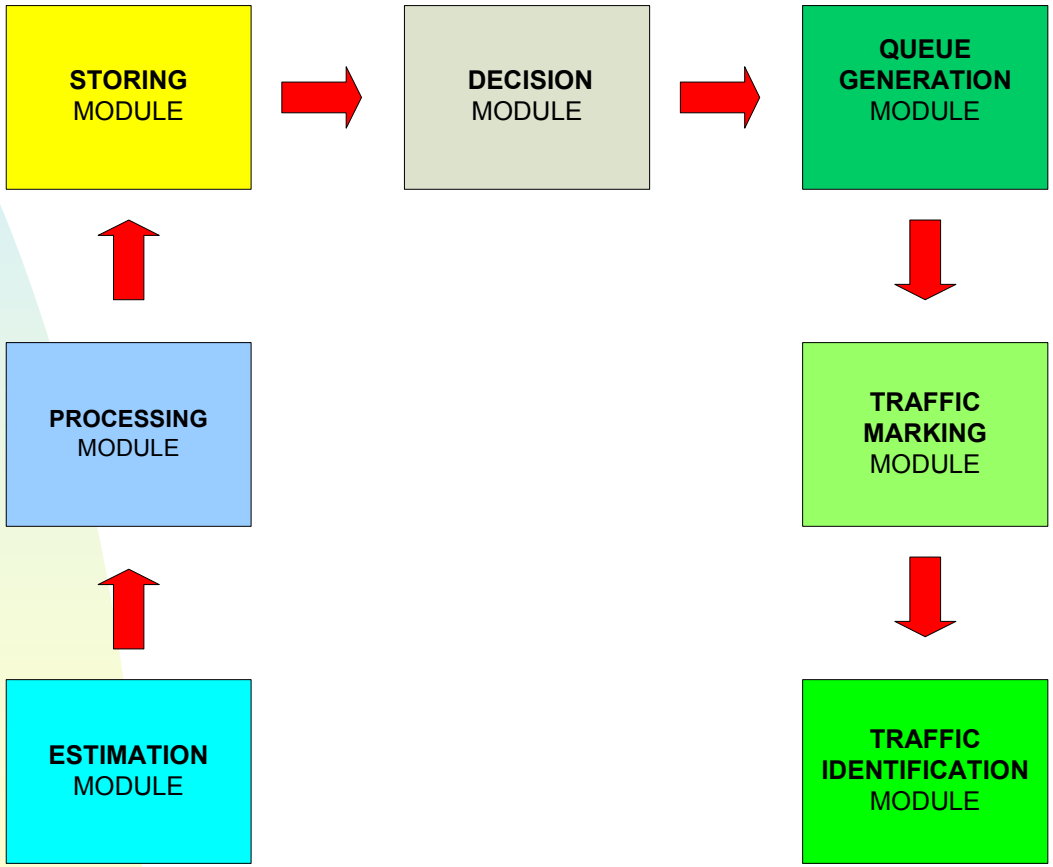
- QoS Requirements:
  - Availability of essential services to all ADHOCSYS end-users
  - Maximize the perceived quality based on network load and link status
- QoS Classes:
  - **Class I:** apps with latency constraints (voice)
  - **Class II**: apps requiring high throughput (video)
  - **Class III**: best effort apps (web browsing, e-mail)
- Precedence must be given to Class III applications

QoS Architecture & Strategy

- QoS strategy: Coordinated design and implementation of complementary QoS features:
  - Service Classification
    - Traffic classification and marking
    - CAC
  - Service Differentiation
    - Mesh network level: WMM
    - Single node level: HTB

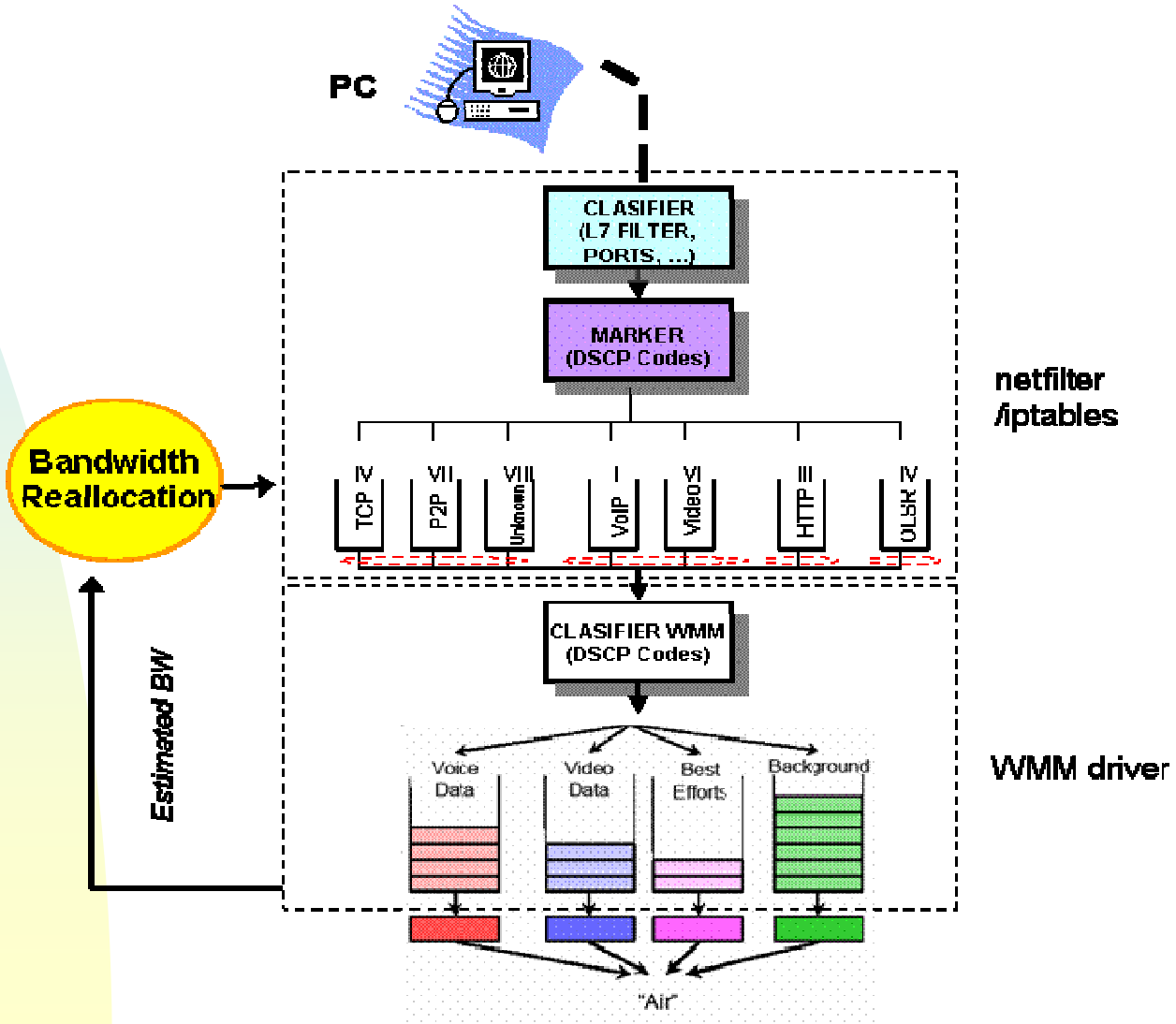


QoS Architecture Implementation

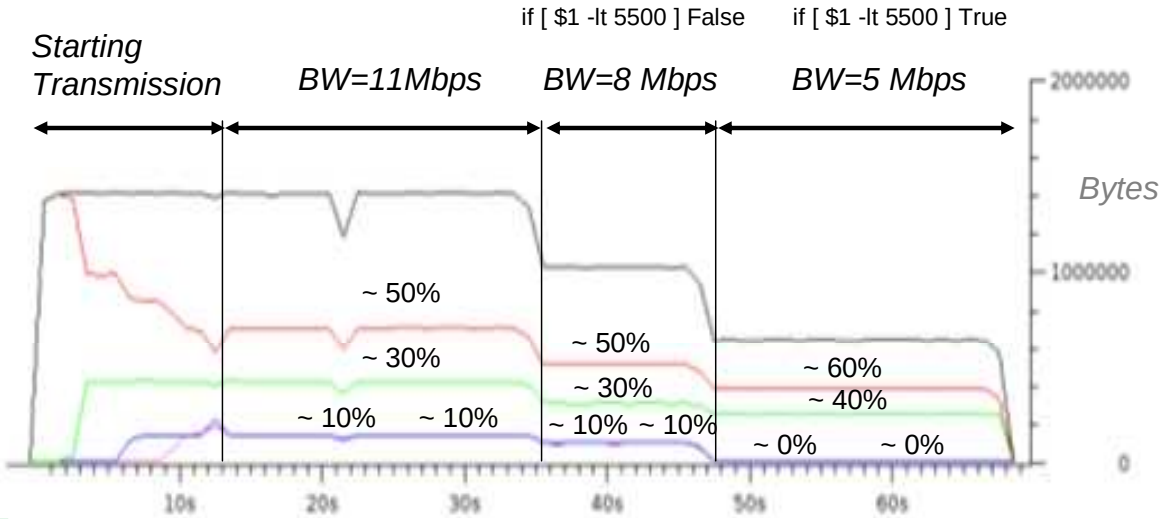


QoS performance and CAC (1)

- Advanced Features



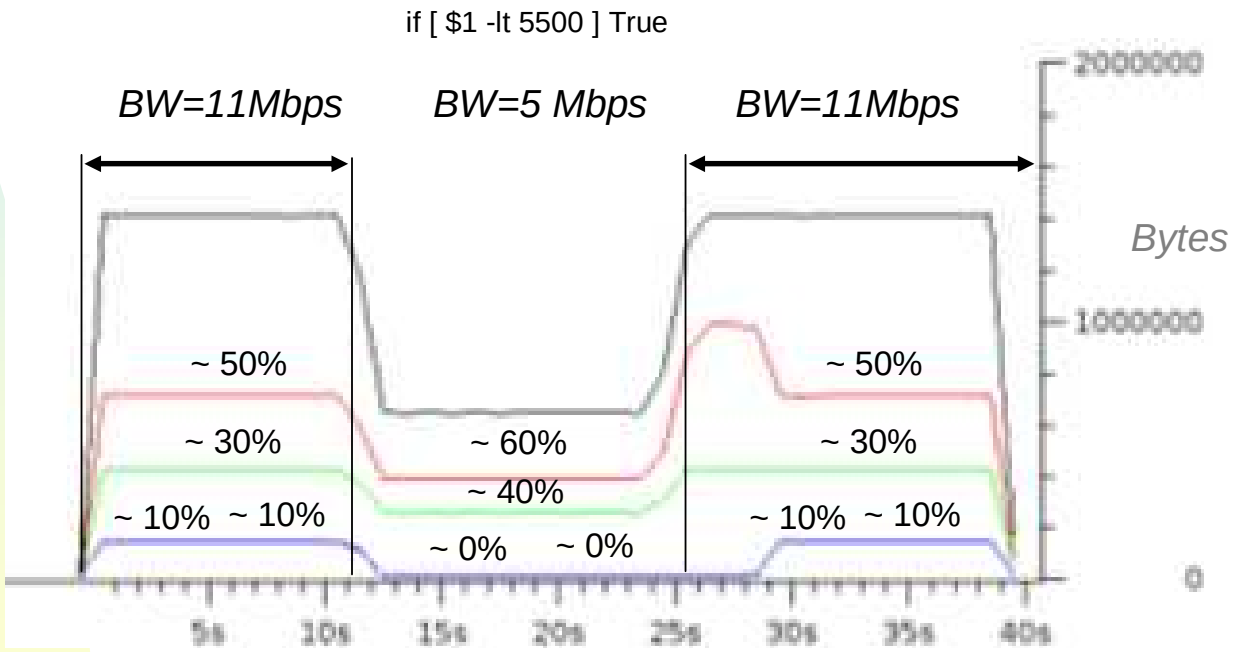
QoS performance and CAC (2)



- ADHOCSYS reacts to variations on the available bandwidth and gives priority to Internet and e-mail traffic
- 5,5 Mbps threshold used only for evaluation purposes

QoS performance and CAC (3)

- A second experiment shows that the system restores the original policies once the available bandwidth estimation is back to original values



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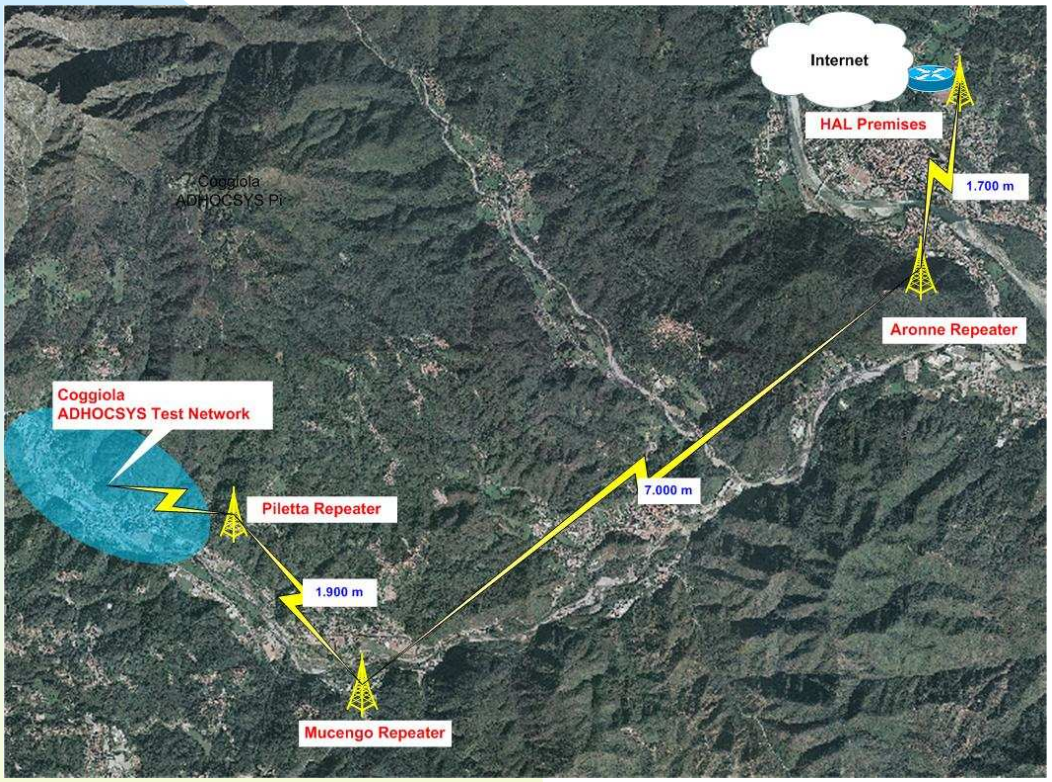
Pilot network (1)

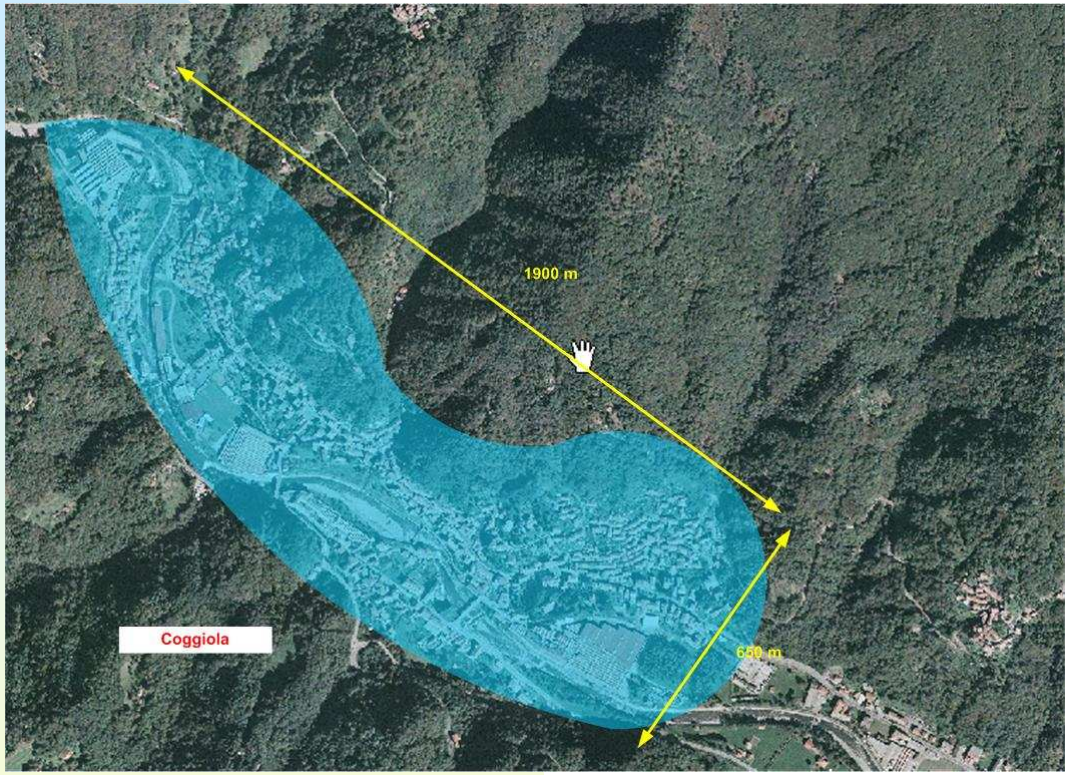
- The pilot network has been deployed in Coggiola, a digitally-divided village located in a mountain area in Piemonte region, in the north-western part of Italy

Pilot network (2)



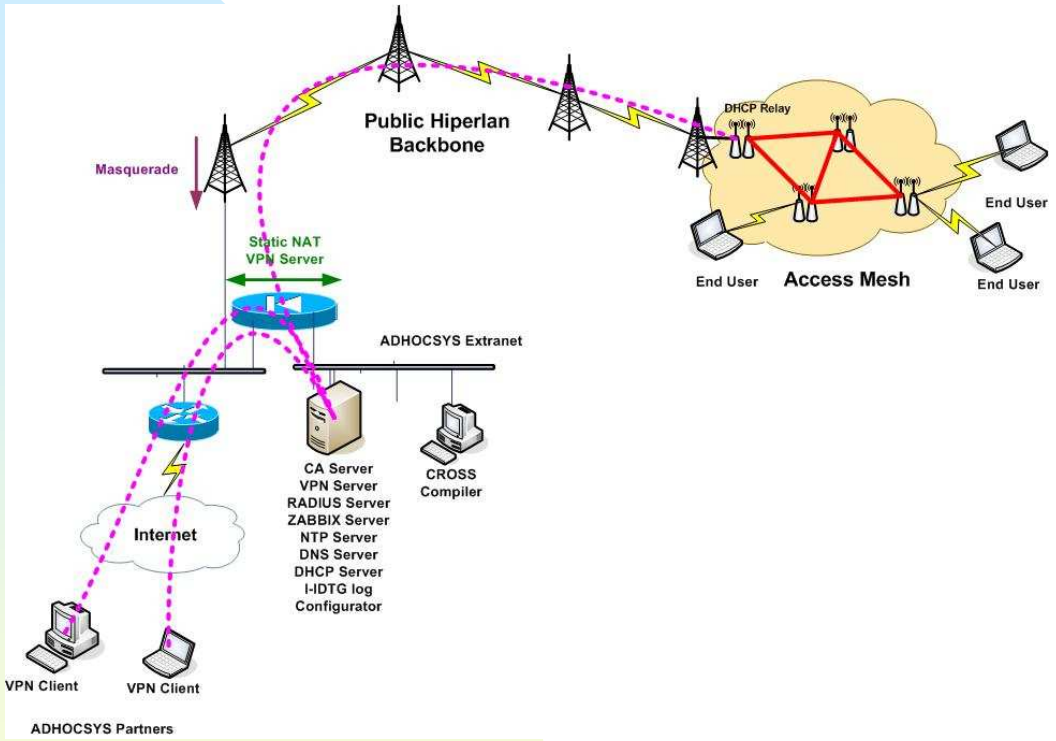
- The access network consists of 10 nodes (9 static and 1 mobile), covering almost all Coggiola territory and is connected via a wireless backbone to an Internet gateway located at Hal Service's premises in Borgosesia

Pilot network (3)



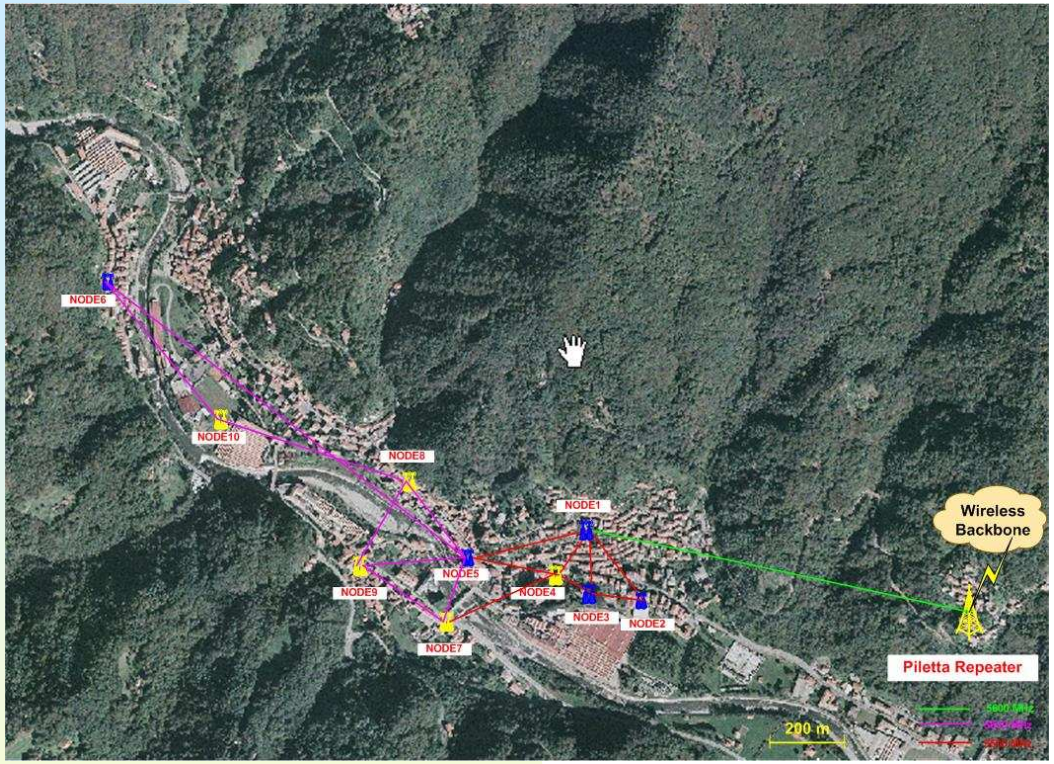
- This is a zoomed-in picture of the covered territory in Coggiola
- Prior our network deployment, the local authorities have agreed to deploy ADHOCSYS technology, as a means to provide broadband Internet connection to private inhabitants

Pilot network (4)



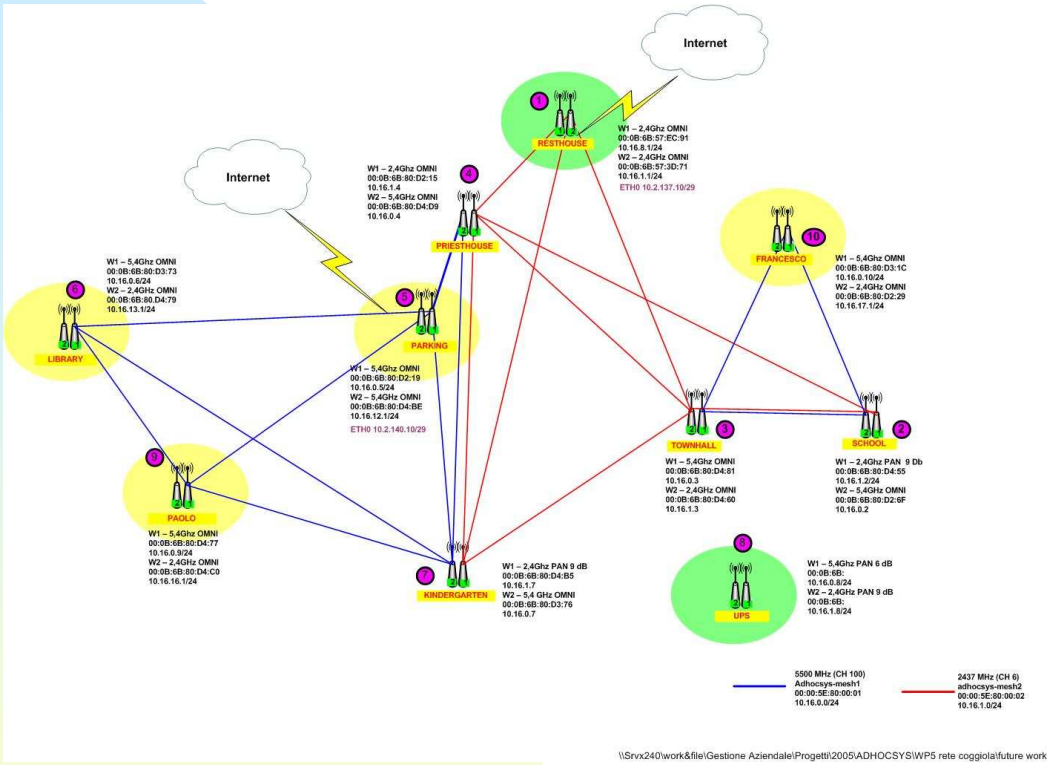
- The network consists of a server farm, a backbone, a VPN, and an access network
- The server farm runs Radius, Zabbix, Dns, Dhcp, Ntp services, and hosts the centralized configurator and the Chillispot software for allowing access to external visitors

Pilot network (5)



- A site survey has been performed to identify nodes' placement
- The nodes are mostly concentrated in the south east part of the village and are mainly installed on roofs

Pilot network (6)



- The preliminary tests have evidenced problems in longer 5 GHz links
- A part of the network has thus been built using 2.4 GHz links
- The problem has been solved upon project completion, by upgrading to the latest version of OpenWRT and MadWIFI drivers

Centralized configurator

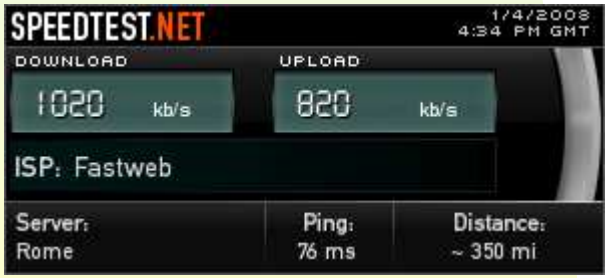
- A centralized configurator has been developed in this project, and has been used to configure the pilot network nodes

Tests on network performance (1)

- RSSI @ source: ranging from 36 to 20. Some poor-quality links have low values (9, 7, 5)
- Packet loss: 0%– 6% on most links. Some poor-quality links lose up to 26%
- Avg Latency: most links from 1.40ms 3.50ms. In some cases up to 25ms
- Traceroute tests have been performed in order to verify multi-hop connectivity
- Iperf has been used to generate and measure saturation bandwidth in UDP and maximum TCP bandwidth between directly connected nodes and over multi-hop paths

End-user's experience in the pilot network

- End-users within the coverage of ADHOCSYS networks are able to access the Internet using PCs, laptops, PDAs etc
- Users must be authenticated by ADHOCSYS authentication servers
- Tests have been performed with 3 contemporary users, and an acceptable connection speed (1Mbps) has been observed between type-3 nodes and remote web sites, with both FTP and HTTP, with the ability for browsing, using e-mail, VoIP services, etc

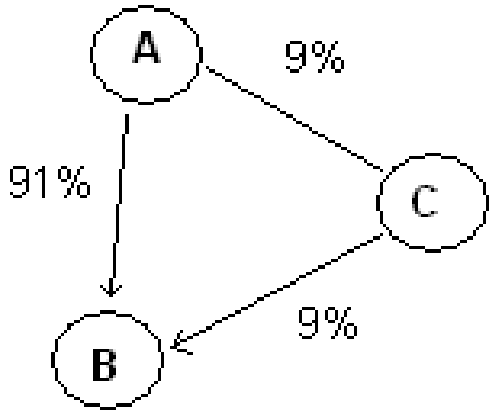


Limitations observed - OLSR

- Some of the links in the pilot network are not very stable. This is common in wireless mesh networks due to environmental factors (e.g. trees growing, strong wind, show, ice, etc.)
- This causes problems to standard OLSR, since routes are computed on a hop-count basis. Unstable links are considered available for short periods, depending on the number of HELLO packets that are correctly exchanged among nodes
- ADHOCSYS extensions partially solve this problem via the link quality and routing calculation enhancements

Limitations observed - OLSR

- Problems with route stability have been observed even in small portions of the pilot network
- The problem seems to be a bug in the original OLSR implementation
- Some tests that have been performed after the project was terminated, using a **more recent implementation of OLSR, show better stability**



ADHOCSYS Conclusions

- The goal of the project has been achieved, i.e.
  - Internet access using a wireless ad hoc network with static nodes
- The ADHOCSYS consortium masters technology, hardware, software and deployment of this solution
- The enhanced OLSR performs as designed
- Increased features needed to support crisis management scenario
  - Link and route stability (partially solved)
  - QoS in real-life networks (Continually improrved)
  - New tools and facilities
  - Improved security – See FP7 SECRICOM

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ADHOCSYS future activities

- Linux Box certification
- Public presentation pilot network in Italy
- More deployments in Italy and maybe elsewhere
- Services: installation of ADHOCSYS wireless networks
- Improvement of Security Solutions

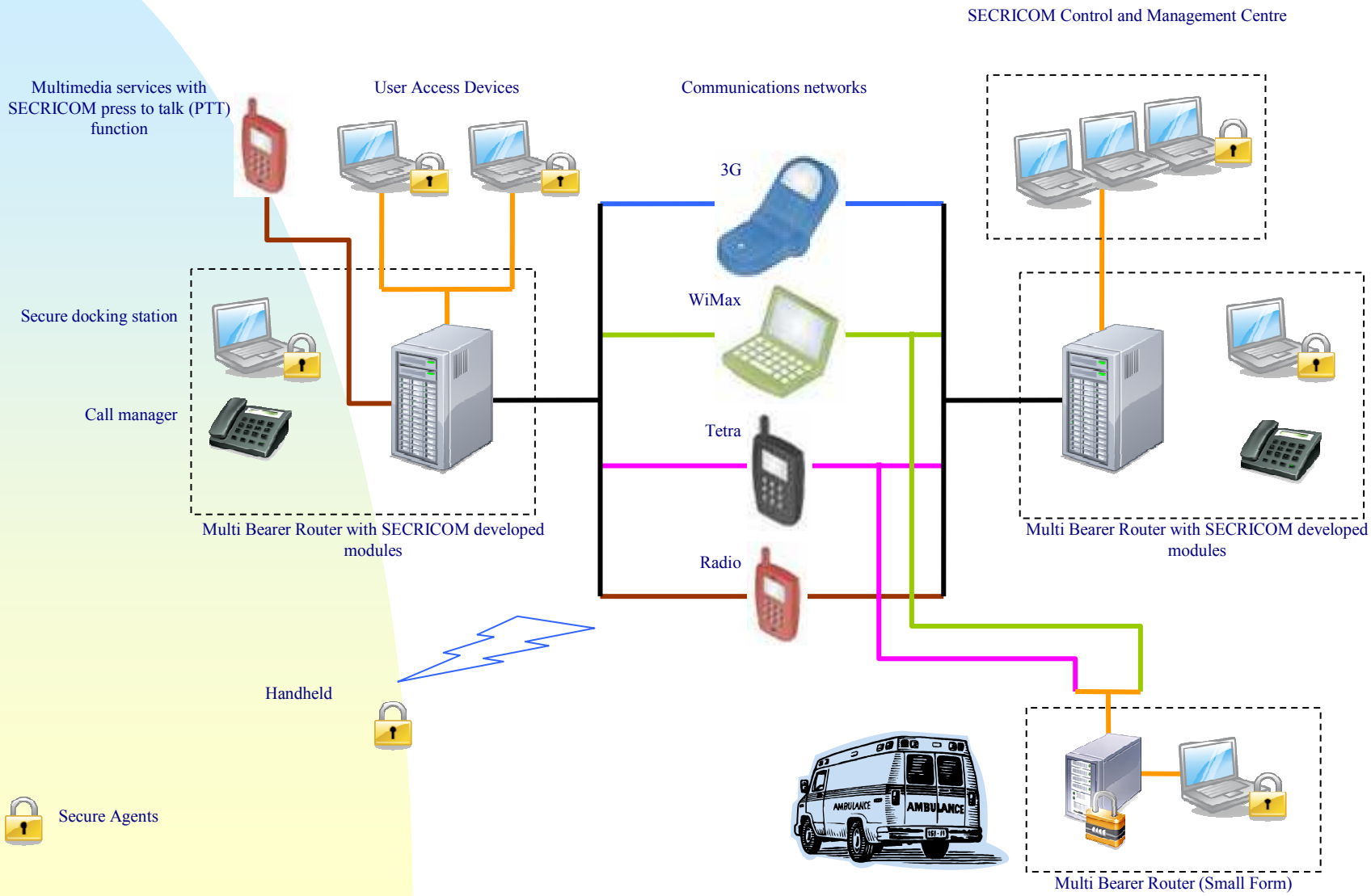
SECRICOM - Seamless Communication for Crisis Management

- FP7 Security Call
- Wireless Communication for EU Crisis Management
- 13 Partners
- Starting date: 1st September 2008
- 44 months duration

SECRICOM - Seamless Communication for Crisis Management

- Creation of secure wireless fault tolerant communication system for mobile devices based on push-to-talk system;
- Secure distributed system;
- Secure docking module – system on chip design.
- These innovations will be extended by:
  - IPV6 based secure communication;
  - Internetwork interfaces, interoperable, recoverable and extendable network;
  - Communication infrastructure monitoring and control centre equipped with localization of actors;
- Working infrastructure – the objective of SECRICOM project will be ensured by:
  - Integration of research results;
  - Demonstrator creation and presentation.

SECRICOM - Seamless Communication for Crisis Management



SECRICOM - Seamless Communication for Crisis Management

Expected results

- The SECRICOM will develop and demonstrate a secure communications infrastructure for public safety organisations and their users.
- Achievements will include:
  - The exploitation of existing publicly available communication network infrastructure with interface towards emerging SDR systems;
  - Interoperability between heterogeneous secure communication systems;
  - A parallel distributed mobile agent-based transaction system for effective procurement;
  - Infrastructure based on custom chip-level security.

ADHOCSYS

Thank you !

Contact Details

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