Experimental Evaluation of a Wireless Community Mesh Network

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Outline

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2. QMPSU and Methodology
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What is Guifi.net?

Guifi.net Highlights

- Community Network.
- Started in 2004 in a rural area (Osona) in Catalonia, Spain.
- Hybrid (wired/wireless) links manually set up, OSPF & BGP routing protocols.
- Services: Internet, P2P, Voice, NTP...
- Sustained growth: 22,341 working nodes.
- Keys of success:
  - Web page with doc. and soft.
  - Distribution of IP addresses.
  - Confederation of networks.
  - Mailing lists, events (guifi-labs, annual meeting (SAX)...
  - Legal aspects:
    - Wireless Commons License.
    - Foundation and Telco Operator.

http://guifi.net/en
What is QMPSU? (qMp at Sants UPC)

- **Production** network, part of Guifi.net.
- Started in 2011 in the quarter of Sants: urban area in Barcelona, Spain.
- **Goal**: Open source WMN easy to deploy.
- qMp distribution based on OpenWRT/Linux.
- **Architecture**:
  - Most hardware consist of NanoStations M5, 802.11an.
  - BatMan-eXperimental BMX6 routing protocol.
- In 2012 **UPC** attached to Sants its research WMN developed in EU CONFINE Project (http://confine-project.eu).
- Growing network, around **50 nodes**, 6 km².
QMPSU and Methodology

Methodology

http://tomir.ac.upc.edu/qmpsu

Data gathered with ssh and standard system commands (iw dump/scan, bmX6, ...).

Collected hourly during 5 moths (more than 3,000 captures).

Available in a public web page.

Output of the command iw dump.

# iw dev wlan0 station dump
Station dc:9f:db:26:6a:40
inactive time: 10 ms
rx bytes: 3568971019
rx packets: 135222757
tx bytes: 3147225400
tx packets: 167098650
tx retries: 457952780
tx failed: 104548
signal: -72 dBm
signal avg: -73 dBm
tx bitrate: 162.0 Mbps MCS 12 40Mhz
rx bitrate: 120.0 Mbps MCS 11 40Mhz
Station dc:9f:db:08:8d:a9
...

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Topology

Number of Nodes and Links

QMPSU is rather dynamic:
- It is growing.
- Diversity of links.
- Unplanned nodes locations.
- Re-configurations by the users.
- Failures: Hangs, upgrades, electricity cuts, etc.

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Figures:
- Average growth from 30 to 50 nodes, 60 to 90 bidir. links (20% unidir.).
- Presence: % a node/link is observed.
  - Nodes 69, 42 (60%) with presence > 50%
  - Bidir. links: 187, 67 (35%) with presence > 50%
  - Unidir. links: 172, 9 (5%) with presence > 50%
Out-degree and Link Length

Average out degree ECDF. Link length distribution.

- **Out-degree**: obtained averaging the ECDFs.
- Does not fit a power law (preferential attachment). Links are set up “opportunistically”.
- **Boxplots** (range, median and quartiles) show the dispersion.
- 90% of the nodes have more than 1 link, and around 40% of the nodes have at least 4 links.
- **Link length** is fitted by a mixture of 2 exponentials, mean $\approx 420$ m.
**Topology**

**Hops and Mincut to Gateways**

Average ECDF of the number of hops to the gateway.

- **Hops to the gateway**: derived from routing tables.
- 67% of the nodes have ≤ 3 hops to the gateway, mean 2.9.
- **max-min-cut** minimum number of edges to disconnect gateways.
- 75% of the nodes have a max-min-cut ≥ 2 links.
- **Dispersion** of the max-min-cut: due to a link not very stable between Sants and UPC.

Average ECDF of the max-min-cut from a node to any of its gateways.
Traffic in the 3 busiest links.

Traffic in the busy hour.

- Traffic is well fitted by a mixture of 2 exponentials: 65% with mean $\mu_1 = 8$ kbps and 35% with mean $\mu_2 = 88$ kbps (overall mean 36 kbps).
- Two groups of links: single and backbone links.
- Traffic sent in the busy hour is also fitted by a mixture of 2 exponentials, mean 56 kbps.
Wireless Links

**Link Throughput**

- **netperf** TCP_STREAM test using IPv6 link local. Only **wireless links**. One link at a time.
- Fitted with an **exponential distribution** with mean 14.4 Mbps.
- Throughput measurements almost no affected by the traffic.

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**Link throughput CECDF.**

**Throughput in the 3 busiest links.**
Wireless Links

Link Throughput Asymmetry and Vs Signal Power

- Link throughput asymmetry (each direction of the same link).
- Link throughput (top) and average bitrate of Rx packets (bottom) vs signal power.

- Boxplot: Absolute value of the link throughput deviation over the mean. 25% of the links have a deviation higher than 30%.
- Throughput & bitrate inc. almost linearly with inc. signal power.
- Throughput is around 1/5 av. bitrate.
- 20 Mbps can be achieved with signal power around -70 dBm.
Wireless Links

Throughput to Gateways

ECDF of the average throughput to the gateway.

- 75% of nodes have a throughput > 5 Mbps, average 10.9 Mbps.
- Throughput tend to reduce as the number of hops increases. The line is rather irregular, due to the diversity of the links.
Wireless Links

Channel Occupancy

Number of other stations per scan.
- **2.4 GHz** band is much more crowded (only 3 non-overlapping channels of 20 MHz are available, 19 in 5 GHz).
- **QMPSU** only use **5 GHz** band. Can interfere too with stations in adjacent channels (channel bonding).
- Mean of **3.8** other stations in the same channel, **2.6** from QMPSU.

Channel occupancy.

ECDF of the number of interfering stations.
Conclusions

- **Experimental** evaluation of QMPSU.
- **Production community WMN, 802.11an**, growing network, around 50 nodes, 6 km².
- **Data available** in a public web page.
- Network rather **dynamic**, specially **unidir. links** (around 20%).
- **Well connected** (resilient): Average out degree 4.2, average max-min-cut to gateway 3.1.
- **Link length** and **traffic** is fitted by a **mixture of two exp.**
- **Average link throughput** is **exp. distributed**, mean 14.4 Mbps.
- **Link throughput** is rather **asymmetric**: 25% of the links have a deviation higher than 30% from the mean.

- **Successful network** with high potential to grow. We characterize the network, useful e.g. for **realistic simulations**.