Wireless High Performance

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Venice (IT)
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Wi4Net - Totalconn

- Mikrotik Italian distributor
- Training and Consulting
- Building Certified Devices for EU market
- Wireless distribution
- E-commerce Web site [www.wi4net.it](http://www.wi4net.it)
Andrea Grittini

- Graduated in Computer Science
- Working with wireless since 2003
- Startup of one of the first Italian WISP
- Mikrotik distributor since 2005
- Mikrotik Certified in MTCNA, MTCRE, MTCWE, MTCTCE
- More 10 trainings a year, with more than 60 graduates
Goal

Wireless New possibilities

Wireless Plan tools
Topics

• MIMO & 802.11ac
• Our tests on 802.11ac

• Optimizing wireless projects:
  – Channel planning for indoor coverage
  – Indoor wireless levels
  – Outdoor link planning
Mimo 802.11n

- MIMO is an abbreviation for **Multiple-Input Multiple-Output**, which refers to the ability of equipment to handle multiple data input and multiple data output operation.

- Wi-Fi 802.11n devices make use of multiple antennas to send and receive more than one communication signal **simultaneously**

- **2x2, 3x3 up to 4x4 streams**
802.11ac is the future

- Broadcom chipsets supports 80Mhz 802.11ac
- Qualcomm/Atheros supports 80Mhz 802.11ac
- Openwrt implements the 20/40/80Mhz driver
- Mikrotik? NV2, routeros and routerboards will be a very strong «plus».
802.11n support 40MHz

- 40MHz = 2 aggregated 20MHz channels
- takes advantage of the reserved channel space through bonding to gain more than double the data rate of 2 20MHz channels
RouterOs 802.11n up to 60MHz

- 50MHz = 2 aggregated 25MHz channels
- More than 300Mbps aggregated throughput
With Custom Channel

Scan list name

Channel name

Custom Frequency

Channel bandwidth

Band

Channel bonding
Custom Channel

- Any name
- Completely definable
- Up to 30MHz
- Rate x2

Wireless High Performance
802.11ac 80MHz
### 802.11ac

<table>
<thead>
<tr>
<th>Bandwidth</th>
<th>20 MHz</th>
<th>40 MHz</th>
<th>80 MHz</th>
<th>160 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># of Spatial Streams</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>86.7 Mbps</td>
<td>200 Mbps</td>
<td>433.3 Mbps</td>
<td>866.7 Mbps</td>
</tr>
<tr>
<td>2</td>
<td>173.3 Mbps</td>
<td>400 Mbps</td>
<td>866.7 Mbps</td>
<td>1733 Mbps</td>
</tr>
<tr>
<td>3</td>
<td>288.9 Mbps</td>
<td>600 Mbps</td>
<td>1300 Mbps</td>
<td>2340 Mbps</td>
</tr>
<tr>
<td>4</td>
<td>346.7 Mbps</td>
<td>800 Mbps</td>
<td>1733 Mbps</td>
<td>3466 Mbps</td>
</tr>
<tr>
<td>5</td>
<td>433.3 Mbps</td>
<td>1000 Mbps</td>
<td>2166 Mbps</td>
<td>4333 Mbps</td>
</tr>
<tr>
<td>6</td>
<td>577.8 Mbps</td>
<td>1200 Mbps</td>
<td>2340 Mbps</td>
<td>5200 Mbps</td>
</tr>
<tr>
<td>7</td>
<td>606.7 Mbps</td>
<td>1400 Mbps</td>
<td>3033 Mbps</td>
<td>6066.7 Mbps</td>
</tr>
<tr>
<td>8</td>
<td>693.3 Mbps</td>
<td>1600 Mbps</td>
<td>3466 Mbps</td>
<td>6933 Mbps</td>
</tr>
</tbody>
</table>
## MIMO and 802.11ac

<table>
<thead>
<tr>
<th>MIMO</th>
<th>802.11ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x2 40MHz</td>
<td>300Mbps</td>
</tr>
<tr>
<td>3x3 40Mhz</td>
<td>450Mbps</td>
</tr>
<tr>
<td>2x2 50Mhz ROs</td>
<td>375Mbps</td>
</tr>
</tbody>
</table>

+33%

- In the same condition

Wireless High Performance  14
802.11ac channels

- Problem: channels are often already busy!
## Theoretical throughput for two Spatial Stream (in Mb/s)

<table>
<thead>
<tr>
<th>MCS index</th>
<th>Modulation type</th>
<th>Coding rate</th>
<th>20 MHz channels</th>
<th>40 MHz channels</th>
<th>80 MHz channels</th>
<th>160 MHz channels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>800 ns GI</td>
<td>400 ns GI</td>
<td>800 ns GI</td>
<td>400 ns GI</td>
</tr>
<tr>
<td>6</td>
<td>64-QAM</td>
<td>3/4</td>
<td>117</td>
<td>130</td>
<td>243</td>
<td>270</td>
</tr>
<tr>
<td>7</td>
<td>64-QAM</td>
<td>5/6</td>
<td>130</td>
<td>144.4</td>
<td>270</td>
<td>300</td>
</tr>
<tr>
<td>8</td>
<td>256-QAM</td>
<td>3/4</td>
<td>156</td>
<td>173.4</td>
<td>324</td>
<td>360</td>
</tr>
<tr>
<td>9</td>
<td>256-QAM</td>
<td>5/6</td>
<td>N/A</td>
<td>N/A</td>
<td>360</td>
<td>400</td>
</tr>
</tbody>
</table>
802.11ac protocol introduce the 256QAM modulation, in order to send more data at the same time.

Higher signal strength required!!
Our tests on 802.11ac radio

- 2 Compex WPJ433 board with 802.11ac mpcie 5 GHz radio
- 2 RB2011 to generate traffic on gbit port
- 80 MHz channel
- 2x2 MIMO transmission
Our Test on 802.11ac

With 80Mhz channel: 620Mbps (310+310) of real traffic

Same performance in lab and in a short range «real» installation
We are actually testing long-range (some km)
Packet latency (802.11) reasonable but high
**802.11ac**

**Advantages**
- Introduce 80Mhz channel width (up to 866Mbps)
- +33% in same condition
- Uses QAM256 and better aggregation protocol

**Disadvantages**
- Only 5GHz frequency (not supported on 2.4)
- Crowded frequency
- Higher signal strength to use QAM256
Wireless Planning and Optimization tools
Optimization tools

Installers need to grant to their clients that the installation they are proposing will be successful.

We developed algorithms useful for:

• **Channel planning** for 2.4G and 5G, mainly for indoor

• **Wireless coverage** planning at 2.4GHz and 5GHz

• Complete **link planning**, outdoor
Channel planning

• Assignment of different frequencies to cells is an usual problem of wireless planning
• Artificial Intelligence techniques are useful to plan bandwidth usage

Min-Max algorithm, with specialized heuristic function
  – List of possible channels
  – List of APS and their positions
  – Rules: wider channels are better, nearest machines needs far channels
An online tool – sample map
Some result: 2 + 5Ghz

- First image: starting situation
- Second image: AI engine proposes a (good)solution
- No channel overlaps
More complex: 2Ghz + overlap

<table>
<thead>
<tr>
<th>Name</th>
<th>Enabled</th>
<th>Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2ghz sector</td>
<td>Yes</td>
<td>1 - 2412/20Mhz</td>
</tr>
<tr>
<td>2ghz spot</td>
<td>Yes</td>
<td>3 - 2422/20Mhz</td>
</tr>
<tr>
<td>2ghz spot2</td>
<td>Yes</td>
<td>4 - 2427/20Mhz</td>
</tr>
<tr>
<td>2ghz spot3</td>
<td>Yes</td>
<td>7 - 2442/20Mhz</td>
</tr>
<tr>
<td>2ghz spot4</td>
<td>Yes</td>
<td>8 - 2447/20Mhz</td>
</tr>
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<td>Yes</td>
<td>1 - 2412/20Mhz</td>
</tr>
<tr>
<td>2ghz spot</td>
<td>Yes</td>
<td>13 - 2484/20Mhz</td>
</tr>
<tr>
<td>2ghz spot2</td>
<td>Yes</td>
<td>9 - 2452/20Mhz</td>
</tr>
<tr>
<td>2ghz spot3</td>
<td>Yes</td>
<td>12 - 2467/20Mhz</td>
</tr>
<tr>
<td>2ghz spot4</td>
<td>Yes</td>
<td>5 - 2432/20Mhz</td>
</tr>
</tbody>
</table>
Estimated band

- We cannot avoid channels overlap
- Overlaps are limited as more as possible, and only between «far» routers
- % of real bandwidth usable can be computed («layer» is referred to different floors for palaces)
Indoor Wireless Coverage

Ray tracing algorithms:

- Purpose: plan rough indoor coverage in complex environments (walls/reflections)
- Map is treated as bitmap: computation proceeds with interlaced raster (like image on a TV screen).
- Walls and AP’s are defined using vector graphics.
Simulation

- Model: «ray tracing for lights» similar to CAD rendering
- Access Points are «sources»
- Signal level for each point is computed considering all walls and Aps
- Attenuation and reflection model is different than the ones used for light

- **Slow**: simulation can require from few seconds to some minutes
- **Accurate**: wireless level is accurate and precise
Example: a single wall
Example: a building

Minimum signal level is set to -94dBm

Simulation includes walls and windows

Punctual 2G/5G levels can be read on Mousemove

Color change
Level set to 5Db
A look outside the building
Minimum level raised to -120Dbm, reversed colors
Outdoor link planning

For outdoor planning you need:

- Optical visibility check
- Link signal planning
- Editable maps to dinamically test sites for antennas

Try online our **free** planning tools.

[https://Wi4tools.wi4net.it](https://Wi4tools.wi4net.it)
Thanks for your attention!

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