Wireless Workshop

MUM 2012 – New Orleans
Uldis Cernevskis
MikroTik
Topics

- Quickset for Wireless
- Transparent wireless links
- Useful configuration settings and features
Workshop Equipment

- RB951-2n
- 2 x RB SXT G-5HnD
- Laptop
Quickset

- Few clicks to setup MikroTik router
- AP and CPE modes
- Point to Point Bridge mode (starting from RouterOS v5.21)
How to get Quickset Winbox
How to get Quickset Web-interface
Quickset feature support

- RB SXT
- RB Groove
- RB Metal
- RB 711, RB 411
- Other RouterBoards (using first wireless interface)
Quickset Setup
AP Quickset

• Access router by browser or Winbox
• Configure AP settings
  – IP address, gateway
  – Wireless (SSID, frequency, band, security, etc.)
  – NAT
  – Additional configuration
AP Quickset Demo
AP Quickset Demo

• SSID “Workshop”
• IP 10.0.100.1
• Login demo and no password
CPE Quickset

• Access router by browser or Winbox
• Configure CPE settings:
  – Router or Bridge
  – IP address, gateway
  – Wireless (SSID, band, security)
CPE Quickset Demo
Point to Point Bridge Quicket

Client/CPE

Wireless

Server/AP

Client Network

Internet
Server/AP Bridge Quickset

• Access router by browser or Winbox
• Configure Server/AP settings:
  – Wireless Bridge Mode to Server/AP
  – IP address, gateway
  – Wireless (SSID, band, frequency, security)
Client/CPE Bridge Quicket

• Access router by browser or Winbox
• Configure Client/CPE settings:
  – Wireless Bridge Mode to Client/CPE
  – IP address, gateway
  – Wireless (SSID, band, security)
Client/CPE Bridge Quickset Demo

<table>
<thead>
<tr>
<th>Address</th>
<th>SSID</th>
<th>Band</th>
<th>Protocol</th>
<th>Frequency</th>
<th>Signal Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:0C:42:6F:34:56</td>
<td>PTP</td>
<td>5GHz-A 20MHz</td>
<td>802.11</td>
<td>5605</td>
<td>-10</td>
</tr>
<tr>
<td>FR 00:0C:42:6F:34:56</td>
<td>wave</td>
<td>5GHz-A 20MHz</td>
<td>802.11</td>
<td>5260</td>
<td>-8</td>
</tr>
<tr>
<td>FR 00:0C:42:6F:34:56</td>
<td>Demo</td>
<td>5GHz-A 20MHz</td>
<td>802.11</td>
<td>5300</td>
<td>-8</td>
</tr>
<tr>
<td>FR 00:0C:42:6F:34:56</td>
<td>Demo</td>
<td>5GHz-A 20MHz</td>
<td>802.11</td>
<td>5300</td>
<td>-8</td>
</tr>
<tr>
<td>FR 00:0C:42:6F:34:56</td>
<td>Demo</td>
<td>5GHz-A 20MHz</td>
<td>802.11</td>
<td>5160</td>
<td>-8</td>
</tr>
<tr>
<td>FR 00:0C:42:6F:34:56</td>
<td>Demo</td>
<td>5GHz-A 20MHz</td>
<td>802.11</td>
<td>5180</td>
<td>-8</td>
</tr>
</tbody>
</table>

Configuration:
- Address Acquisition: DHCP
- Address Source: Any
- IP Address: 0.0.0.0
- Gateway: 0.0.0.0
- Router Identity: ClientCPE
- Password: [Blank]
- Confirm Password: [Blank]
Point to Point Bridge Quickset Setup

Client/CPE

Wireless

Server/AP

Setup Diagram with labels for Client/CPE and Server/AP connected through wireless.
Connection Types

Point to Point (PTP)  Point to Multi Point (PTMP)
PTP/PTMP connection modes

• AP-bridge/Bridge <-> Station
• AP-bridge/Bridge <-> Station-wds/Station-bridge
• AP-bridge/Bridge <-> Station-pseudobridge
• AP-bridge/Bridge <-> AP-bridge/Bridge
• AP-bridge <-> WDS-slave
RouterOS license requirements

• PTP link requires at least Level 3
  – Example: Bridge <-> Station

• PTMP link requires on AP at least Level 4 and on clients at least Level 3
  – Example: AP-bridge <-> Station
Regular PTMP setup

RouterBOARD SXT Sixpack
Wireless Setup Type - Routing

INTERNET

10.0.0.1/24

10.0.0.2/24

10.0.0.3/24

10.0.1.1/24

10.0.1.2/24

10.0.2.1/24

10.0.2.2/24
Wireless Setup Type - Bridging

INTERNET

Bridge 10.0.0.2/24

Bridge 10.0.0.3/24

10.0.0.1/24

10.0.0.11/24

10.0.0.12/24
Wireless Setup Types

• Bridging
  • Advantage
    – Less IP configuration needed
  • Disadvantage
    – Clients broadcast traffic or flood can lower wireless network performance
    – Not suitable for large network

• Routing
  • Advantage
    – No broadcast traffic or flood that could lower wireless network performance
  • Disadvantage
    – More configuration needed: multiple IP networks or use of routing protocols
Transparent Wireless Links

- Less configuration needed
- Extends Layer 2 protocol to clients (wireless ethernet switch)
- Suitable for PPPoE access
Transparent Wireless Links Setups

- Bridge <-> Station-pseudobridge
- Bridge <-> Station using EOIP
- Bridge <-> Bridge
- Bridge <-> Station-wds
- Bridge <-> Station-bridge
EOIP bridging setup
Bridge <-> Bridge setup
Station-wds setup
Station-bridge setup
Station-bridge

• AP maintains forwarding table with information on what MAC addresses are reachable over which station device
• AP should have bridge-mode parameter enabled in order to accept station-bridge clients
• Can be connected only to RouterOS AP based devices
• Even less configuration needed compared to station-wds mode
Station-bridge configuration

• On AP enable the bridge-mode parameter
• Configure client to use station-bridge mode
• Bridge wireless interface with ethernet interface to make transparent link
Wireless protocol limitations on transparent links

<table>
<thead>
<tr>
<th></th>
<th>802.11</th>
<th>ROS 802.11</th>
<th>Nstreme</th>
<th>Nv2</th>
</tr>
</thead>
<tbody>
<tr>
<td>station</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>station-wds</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>station-pseudobridge</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>station-pseudobridge-clone</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>station-bridge</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>
802.11n

- Works both in 2.4 and 5ghz
- Increased data rates – up to 300Mbps or 450Mbps
- 20Mhz and 2x20Mhz channel support
- Uses multiple antennas for receive and transmit
- Frame aggregation
802.11n 2x20Mhz channel option

- Adds additional 20Mhz channel to existing channel
- Channel placed below or above the main channel frequency
- Adds support for higher data-rates – 150Mbps/300Mbps/450Mbps
- Backwards compatible with 20Mhz clients – connection made to the main channel
- Not compatible with legacy 40Mhz Turbo mode
Upgrade legacy wireless link to 802.11n?

• We recommend to upgrade your legacy wireless links to 802.11n even if you have one antenna:
  – Higher data-rate than legacy wireless, data-rates up to 65Mbps or 150Mbps
  – Real UDP traffic up to 125Mbps
  – No need to change antennas or board – only wireless card
802.11n and WDS

- 802.11n frame aggregation can’t be used together with WDS
- Max transmit speed drops from 220Mbps to 160Mbps using WDS (UDP traffic)
- Station-bridge has the same speed limitations as Station-wds

- Avoid using WDS or use Nstreme/Nv2 wireless protocol to overcome this limitation
802.11n Outdoor Setup

• For 2 chain operation suggested to use different polarization for each chain
• When dual-polarization antennas are used isolation of the antenna recommended to be at least 25db
• If possible test each chain/antenna separately before using both chains at the same time
802.11n speed with encryption

- Avoid using wireless encryption with TKIP cipher as it slows down the wireless link – speed drop from 220Mbps to 38Mbps

- Use AES cipher for 802.11n wireless encryption
AR9300 wireless support

- 3 antenna connector support for 3x3 MIMO setup
- Up to 3 Spatial Streams
- Up to MCS 23 – data-rate up to 450Mbps
- UDP transfer up to 328Mbps
AR9300 wireless support

<table>
<thead>
<tr>
<th>Bandwidth Test (Running)</th>
<th>Interface &lt;wlan2&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test To: 2.2.2.1</td>
<td>Current Tx Power</td>
</tr>
<tr>
<td>Protocol: udp</td>
<td>Status</td>
</tr>
<tr>
<td>Local UDP Tx Size: 1500</td>
<td>Advanced Status</td>
</tr>
<tr>
<td>Remote UDP Tx Size: 1500</td>
<td>Traffic</td>
</tr>
<tr>
<td>Direction: receive</td>
<td></td>
</tr>
<tr>
<td>TCP Connection Count: 20</td>
<td></td>
</tr>
<tr>
<td>Local Tx Speed:</td>
<td></td>
</tr>
<tr>
<td>Remote Tx Speed:</td>
<td></td>
</tr>
<tr>
<td>User:</td>
<td></td>
</tr>
<tr>
<td>Password:</td>
<td></td>
</tr>
<tr>
<td>Lost Packets: 1765</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx Current: 0 bps/329.1 Mbps</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx 10s Average: 0 bps/327.9 Mbps</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx Total Average: 0 bps/280.0 Mbps</td>
<td></td>
</tr>
<tr>
<td>Tx: 329.1 Mbps</td>
<td></td>
</tr>
<tr>
<td>Rx: 329.1 Mbps</td>
<td></td>
</tr>
<tr>
<td>running...</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Band: 5GHz-N</td>
<td></td>
</tr>
<tr>
<td>Frequency: 5450 MHz</td>
<td></td>
</tr>
<tr>
<td>Wireless Protocol: nstreme</td>
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</tr>
<tr>
<td>Tx/Rx Rate: 450.0Mbps/450.0Mbps</td>
<td></td>
</tr>
<tr>
<td>SSID: RB800_nv2</td>
<td></td>
</tr>
<tr>
<td>BSSID: 00:0B:6B:7E:50:4D</td>
<td></td>
</tr>
<tr>
<td>Radio Name: 000B6B7E504D</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx Signal Strength: -61/-48 dBm</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx Signal Strength Ch0: -68/-54 dBm</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx Signal Strength Ch1: -64/-50 dBm</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx Signal Strength Ch2: -69/-54 dBm</td>
<td></td>
</tr>
<tr>
<td>Noise Floor: -114 dBm</td>
<td></td>
</tr>
<tr>
<td>Signal To Noise: 66 dB</td>
<td></td>
</tr>
<tr>
<td>Tx/Rx CCQ: 95/100 %</td>
<td></td>
</tr>
<tr>
<td>Overall Tx CCQ: 95 %</td>
<td></td>
</tr>
<tr>
<td>Distance:</td>
<td></td>
</tr>
<tr>
<td>RouterOS Version: 5.8</td>
<td></td>
</tr>
<tr>
<td>Last IP: 2.2.2.1</td>
<td></td>
</tr>
<tr>
<td>WDS Link:</td>
<td></td>
</tr>
</tbody>
</table>
Hidden node issue

• In PTMP setups when client doesn’t see other clients traffic and sends at the same time AP gets “collisions” – lowers performance
• Use hw-protection CTS/RTS or “CTS to self”
• Use Nstreme or Nv2 protocol
NV2

• Proprietary wireless protocol developed by MikroTik
• Based on TDMA (Time Division Multiple Access) media access technology
• Works on Atheros chipset cards:
  – AR5413 and newer chipset cards (R52)
  – N chipset cards (R52n,R52Hn)
• Supported from RouterOS v5
TDMA benefits

- More throughput
- Lower latency
- Suited well for Point-to-MultiPoint networks
- Solves hidden node problems
Nv2 compatibility and coexistence with other wireless protocols

• Only RouterOS devices will be able to participate in Nv2 network
• Only RouterOS devices will see Nv2 AP when scanning
• Nv2 network will disturb other networks in the same channel
• Nv2 network may be affected by any (Nv2 or not) other networks in the same channel
• Nv2 enabled device will not connect to any other TDMA based network
Nv2 UDP on RB800
Nv2 TCP on RB800
Split horizon feature

- To disable communication between WDS devices usually you would need to add bridge firewall rules which might be complex.
- Another solution is to use split horizon feature in the bridge ports configuration – packets will not be forwarded between ports with the same horizon value.
Split horizon feature

- Create bridge interface
- Add internet access interface to the bridge port
- Add each WDS interface to the bridge port and specify the same horizon value, for example 1
- If you wish to allow communication from every WDS clients to a specific WDS client then add that specific WDS to the bridge port without horizon value
HT TX/RX chain configuration

- When board has both antennas connected it is suggested to use all the TX/RX chains to get the best speed and stability.

- In order to use only chain1 the chain0 RX should be always enabled in order to make the wireless link to work.
RouterBoard wireless boards

• Every wireless RouterBoard has RouterOS default-configuration script enabled on the first boot.
• For wireless boards default-configuration enables all available wireless chains.
• Make sure that you have antennas connected to all antenna connectors to avoid damaging wireless cards amplifier!
• Also if you use only one chain on the board make sure you don’t enable it if you don’t have antenna connected to it.
WPA2 Private Pre Shared Key

• Allows to specify for a MAC address different pre-shared key from the pre-shared key in the security profile
• It is possible to specify for each MAC address different pre-shared key
• Increases the security level of the AP
• Can be given also by RADIUS
WPA2 Private Pre Shared Key

Private Pre Shared Key: keykeykey2

WPA Pre-Shared Key: keykeykey1

WPA2 Pre-Shared Key: keykeykey1
Rate-selection – legacy

- Rate-selection default value for RouterOS versions older than v5.9
- Works when wireless link is good in all data-rates
- Doesn’t switch so well from B standard to G standard data-rates
- Doesn't switch from A/G to N data rates where frame aggregation can be used
- Doesn’t switch from 20mhz to 40mhz in N data-rates, for example, when mcs13-15 doesn’t work stable
<table>
<thead>
<tr>
<th>Modulation</th>
<th>Rate</th>
<th>Streams</th>
<th>Modulation</th>
<th>Data rate (Mbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20 MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>800ns</td>
</tr>
<tr>
<td>BPSK</td>
<td>1</td>
<td>1</td>
<td>16-QAM</td>
<td>26</td>
</tr>
<tr>
<td>QPSK</td>
<td>2</td>
<td>1</td>
<td>64-QAM</td>
<td>52</td>
</tr>
<tr>
<td>QPSK</td>
<td>5.5</td>
<td>1</td>
<td>64-QAM</td>
<td>58.5</td>
</tr>
<tr>
<td>QPSK</td>
<td>11</td>
<td>1</td>
<td>64-QAM</td>
<td>65</td>
</tr>
<tr>
<td>BPSK</td>
<td>6</td>
<td>2</td>
<td>16-QAM</td>
<td>13</td>
</tr>
<tr>
<td>BPSK</td>
<td>9</td>
<td>2</td>
<td>QPSK</td>
<td>26</td>
</tr>
<tr>
<td>QPSK</td>
<td>12</td>
<td>2</td>
<td>QPSK</td>
<td>39</td>
</tr>
<tr>
<td>QPSK</td>
<td>18</td>
<td>3</td>
<td>16-QAM</td>
<td>52</td>
</tr>
<tr>
<td>16-QAM</td>
<td>24</td>
<td>2</td>
<td>16-QAM</td>
<td>78</td>
</tr>
<tr>
<td>16-QAM</td>
<td>36</td>
<td>2</td>
<td>64-QAM</td>
<td>104</td>
</tr>
<tr>
<td>64-QAM</td>
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<td>2</td>
<td>64-QAM</td>
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<tr>
<td>64-QAM</td>
<td>54</td>
<td>2</td>
<td>64-QAM</td>
<td>130</td>
</tr>
</tbody>
</table>
Rate-selection – advanced

- Rate-selection default value for RouterOS versions newer than v5.8
- Next data-rate is calculated/tested simultaneously in all data-rate “blocks” and used the best from the gathered results
- For 1 stream link on 20mhz the switch to N rates goes faster allowing to utilize frame aggregation feature
- Data-rate could go up very fast and doesn’t suffer from problems, like in, legacy when mcs13-15 didn’t work well for 20mhz it couldn’t switch to 40mhz
## Rate-selection – advanced

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Rate</th>
<th>Streams</th>
<th>Data rate (Mbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>800ns</td>
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<tr>
<td>BPSK</td>
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<td>1</td>
<td>6.5</td>
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<td>QPSK</td>
<td>2</td>
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<td>13.0</td>
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<td>QPSK</td>
<td>5.5</td>
<td>1</td>
<td>19.5</td>
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<tr>
<td>Value</td>
<td>AP</td>
<td>Client</td>
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<tr>
<td>------------</td>
<td>---------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
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<tr>
<td>unspecified</td>
<td>establish nstreme or 802.11 network based on old nstreme setting</td>
<td>connect to nstreme or 802.11 network based on old nstreme setting</td>
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</tr>
<tr>
<td>any</td>
<td>same as unspecified</td>
<td>scan for all matching networks, no matter what protocol, connect using protocol of chosen network</td>
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<tr>
<td>802.11</td>
<td>establish 802.11 network</td>
<td>connect to 802.11 networks only</td>
<td></td>
</tr>
<tr>
<td>nstreme</td>
<td>establish Nstreme network</td>
<td>connect to Nstreme networks only</td>
<td></td>
</tr>
<tr>
<td>nv2</td>
<td>establish Nv2 network</td>
<td>connect to Nv2 networks only</td>
<td></td>
</tr>
<tr>
<td>nv2-nstreme</td>
<td>establish Nv2 network</td>
<td>scan for Nv2 networks, if suitable network found - connect, otherwise scan for Nstreme networks, if suitable network found - connect</td>
<td></td>
</tr>
<tr>
<td>nv2-nstreme-802.11</td>
<td>establish Nv2 network</td>
<td>scan for Nv2 networks, if suitable network found - connect, otherwise scan for Nstreme networks and if suitable network found - connect</td>
<td></td>
</tr>
</tbody>
</table>
Bridge MAC address

• Bridge MAC address is taken from the first added and running bridge port interface
• If the bridge port gets invalid the bridge takes MAC address from the next active bridge port
• When the first bridge port gets active again the MAC address of bridge is changed back to first ports MAC address
• Bridge MAC address changes could cause IP connectivity to bridge IP address
• Use Admin MAC setting to lock the MAC address to one specific that do not change
Bridge MAC address

<table>
<thead>
<tr>
<th>General</th>
<th>STP</th>
<th>Status</th>
<th>Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type:</td>
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</tr>
<tr>
<td>MTU:</td>
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<td></td>
</tr>
<tr>
<td>L2 MTU:</td>
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<tr>
<td>MAC Address:</td>
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<td>Admin. MAC Address:</td>
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<th>Status</th>
<th>Traffic</th>
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<td>Admin. MAC Address:</td>
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</table>
Signal reading for each chain

- "signal-strength" - combination of all active chains on the control and extension channels
- "signal-strenght-ch0" - chain 0 control channel
- "signal-strenght-ch1" - chain 1 control channel
- "signal-strenght-ch2" - chain 2 control channel
- No separate signal readings for extension channel
- Tx chains signal readings gathered from the remote RouterOS wireless device

![Signal reading interface](image)
TX-power for N cards

- When using two chains at the same time the tx-power is increased by 3dB – see total-tx-power column
- When using three chains at the same time tx-power is increased by 5db
Frequency-offset feature

- Frequency-offset feature is designed for easier frequency selection on wireless cards with built-in frequency converter

```bash
interface wireless set wlan3 frequency-offset=+300
```
Antenna-mode selection for RB751U and RB751G

- RB 751U and RB751G has 3 built-in wireless antennas
  - Chain0:
    - one antenna for TX
    - one antenna for RX
  - Chain1:
    - one antenna for TX/RX
    - MMCX connector for external antenna

- Note that enabling the external antenna disables the built-in Chain1 antenna
Antenna-mode selection for RB751U and RB751G
Spectral Scan/History

• Uses RouterOS
• Uses Atheros Merlin 802.11n chipset wireless cards
• Frequency span depending on card:
  – 5ghz: 4790-6085mhz
  – 2ghz: 2182-2549mhz
• Scan with 10mhz frequency increments for improved data quality
• Audio monitor
Spectral Scan using the Dude
Wireless-signal LED feature

• Wireless signal LEDs supported added for RB400 series, RB711, RB SXT and RB Groove:
  – 1 LED - on, if wireless client is connected to AP (usually \( \geq -89\text{dBm} \))
  – 2 LEDs - on, if signal strength \( \geq -82\text{dBm} \)
  – 3 LEDs - on, if signal strength \( \geq -75\text{dBm} \)
  – 4 LEDs - on, if signal strength \( \geq -68\text{dBm} \)
  – 5 LEDs - on, if signal strength \( \geq -61\text{dBm} \)
Wireless-status LED

• Used for RB751/RB751G
  – ON when no activity
  – Blinks when there is TX/RX traffic (interval depends on traffic activity – minimal 100ms)
  – OFF for 1s and ON for 2s – no wireless connection made to the wireless card
Registration table entries

- Wireless registration table in Winbox is refreshed every 5s
- Use specific client registration table entry for monitoring the settings every second
- Historical measurements of signal for each previously used data-rate
Bandwidth Test max speed
Wireless Advanced Channels

- Located under 'interface wireless channels'
- Custom center frequency support with 0.5Mhz step
- Custom channel width range from 2.5-30mhz with 0.5mhz step
- Only Atheros AR92xx support and center frequency range 2192-2734mhz and 4800-6100mhz
- Custom 'scan-list' feature
- Support added in RouterOS v6
- Superchannel license required to use advanced channels
Wireless Advanced Channels

• Custom scan-list options:
  – default, numeric frequency range, advanced channel name, advanced channel list name

• Example: Scan 10 and 20mhz option on the client
  – /interface wireless channels

    add frequency=5180 width=20 band=5ghz-a list=20mhz-list
    add frequency=5200 width=20 band=5ghz-a list=20mhz-list
    add frequency=5180 width=10 band=5ghz-a list=10mhz-list
    add frequency=5200 width=10 band=5ghz-a list=10mhz-list

    /interface wireless set wlan1 scan-list=20mhz-list,10mhz-list
Wireless Advanced Channels