Simplifying Wi-Fi Troubleshooting

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Wi-Fi Technology Evolution

First 21 years was all about speed, now it is **efficiency**
## Wi-Fi Technology Evolution (cont.)

<table>
<thead>
<tr>
<th>New Name</th>
<th>Standard</th>
<th>Modulation Meth.</th>
<th>Max. data rate</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>WiFi 1</td>
<td>802.11b</td>
<td>DSSS/HR-DSSS</td>
<td>11 Mbit/s</td>
<td>2,4 GHz</td>
</tr>
<tr>
<td>WiFi 2</td>
<td>802.11a</td>
<td>OFDM</td>
<td>54 Mbit/s</td>
<td>5 GHz</td>
</tr>
<tr>
<td>WiFi 3</td>
<td>802.11g</td>
<td>OFDM</td>
<td>54 Mbit/s</td>
<td>2,4 GHz</td>
</tr>
<tr>
<td>WiFi 4</td>
<td>802.11n</td>
<td>OFDM</td>
<td>600 Mbit/s</td>
<td>2,4 GHz &amp; 5 GHz</td>
</tr>
<tr>
<td>WiFi 5</td>
<td>802.11ac</td>
<td>OFDM</td>
<td>6.900 Mbit/s</td>
<td>5 GHz</td>
</tr>
<tr>
<td>WiFi 6</td>
<td>802.11ax</td>
<td>OFDM &amp; OFDMA</td>
<td>9.600 Mbit/s</td>
<td>2,4 GHz &amp; 5 GHz</td>
</tr>
</tbody>
</table>
# 802.11ac versus 802.11ax

<table>
<thead>
<tr>
<th></th>
<th>11ac (Wi-Fi 5)</th>
<th>11ax (Wi-Fi 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency Band</strong></td>
<td>5 GHz</td>
<td>2,4 &amp; 5GHz</td>
</tr>
<tr>
<td><strong>Channel Wide</strong></td>
<td>20,40, 80, 160 MHz</td>
<td>20,40, 80, 160 MHz</td>
</tr>
<tr>
<td><strong>Spatial Streams Max</strong></td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>MIMO Use Mode</strong></td>
<td>Multi-user</td>
<td>MU-MIMO und OFDMA</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>+ 256 QAM</td>
<td>1024 QAM</td>
</tr>
<tr>
<td><strong>Sub-Carrier</strong></td>
<td>312,5 KHz</td>
<td>78,125KHz</td>
</tr>
<tr>
<td><strong>Beam forming</strong></td>
<td>optional, standardised</td>
<td>optional, standardised</td>
</tr>
<tr>
<td><strong>PHY Data Rate (Max)</strong></td>
<td>6.933 Mbps</td>
<td>Bis 9.607 Mbps</td>
</tr>
<tr>
<td><strong>Automatic Power Save</strong></td>
<td>Same like 11.a/b/g/n</td>
<td>Target Wakeup Time (TWT)</td>
</tr>
</tbody>
</table>

802.11ax = High Efficiency (HE)
Wifi6 (802.11ax) – What’s New?

- **OFDMA**: Network Capacity
  - Frequency/subcarrier
  - Time

- **1024-QAM**: Max. data rate

- **MU-MIMO**: Network Capacity
  - BSS Colouring
  - Network Capacity
  - Adjacent Wi-Fi

- **Effective. Power use (TWT)**: Battery Live

- **Long OFDM Symbol**: Outdoor Reliability
  - Max. data rate
Multi-User OFDM

WLAN Frame

Subcarriers

Channel White

Client 1
Client 2
Client 3
Client 4
Multi-User OFDMA

Subcarriers

Resource Unit

Client 1
Client 2
Client 3
Client 4
Simplifying Wi-Fi Troubleshooting
WLAN Troubleshooting starts with...

• What’s the problem?
• What are the requirements for this specific WLAN situation?
  – Location
  – Application
  – Number of Users
  – Signal quality
• What is different to ‘normal’?
What’s Different to ‘Normal’, Starts With Planning

- WLAN requirements
- Planning
  - Pre-Deployment Survey, cabling for AP’s, floorplan with AP-location etc.
- AP deployment
- Post-deployment Survey

*** Critical ***
It’s possible to certify the cabling, but not Wi-Fi. But you can validate the Wi-Fi deployment
Wi-Fi Troubleshooting Starts Simply - Walkthrough?

Wi-Fi Walkthrough’s are used to:

- Perform a passive scan
- Detect and identify all Wi-Fi devices
- Verify coverage
- Gain visibility on metrics like Noise, SNR, Utilization, etc.
PROBLEM: Signal Quality

We start with the big picture and move to the easier things!
Signal Coverage

Identifying Coverage Problems:

- Troubleshoot a problem area
- Survey a site
- Find the difference to ‘normal’

Site Survey for troubleshooting could be simple!
Site Survey for Troubleshooting Could be Simple!

- Missing Coverage area
- Interference
  - Channel 1/6/11??
- Pass/Fail results
Signal to Noise Ratio

Signal to Noise Ratio can be affected by:

• Signal Strength
• Noise Levels
• Easy to discover
Identifying Signal to Noise Ratio problems:

• Use a dedicated Wi-Fi test tool that will allow you to measure Signal Strength and Noise

Note: Not many Wi-Fi adapters can measure Noise anymore
Co-Channel Interference

Why is it a problem?

• Clients and AP’s have to time-share
  – Wi-Fi is Half-Duplex
Co-Channel Interference (Cont.)

Identifying CCI Issues:
- Use a Wi-Fi test tool that will determine the number of AP’s per channel, and their signal strength
- Perform a site survey
Co-Channel Interference (Cont.)

Resolving CCI Issues:

• Allow the controller to assign channels automatically
• Use a planning tool
  – Depending on the building, CCI is 3D!
Adjacent Channel Interference

Why is it a problem?

- Interference between channels
  - Clients and AP’s have to time-share
  - Mostly happens on the 2.4 GHz
Adjacent Channel Interference (Cont.)

**Identifying ACI Issues:**

- Use a Wi-Fi test tool that will determine number of AP’s per overlapping channel, and their Signal Strength
- Perform a site survey
Adjacent Channel Interference (Cont.)

Resolving ACI Issues:

- Enable Band Steering
- Allow the Controller to Assign Channels Automatically
- Use a Planning tool
Non-Wi-Fi Interference

Why is it a problem?

• Don’t obey the same airtime sharing rules
• Significant source of interference
• Critical for 2.4GHz
  Check DFS (Radar-Detection) for 5GHz
PROBLEM: WLAN Connection

The most common problem
Duplicate the Problem: Dedicated Test Tool

Useful Information:
- Connection Status and Time
- Authentication Status and Time
- Gateway Status and Response Time
- DHCP Status and Response Time
- DNS Status and Response Time
- Target Found
- Connection PHY Data Rate
- Retry Rate
Identifying Security Configuration Problems:

- Problem User Device
  - Passphrase
  - Credentials and Certificates
  - Device is on the Authorized List
- Dedicated Wi-Fi Test Tool
  - Authentication Server availability
PROBLEM: WLAN not available
Access Point is working?

The non-Wi-Fi problem
Wired Issues

Identifying Wired Issues:

- Perform a Connection Test
- Verify connectivity to a specific IP address or URL
- Verify PoE and Switch Power Load
Wired Issues (Cont.)

Resolving Wired Issues:

- Configuration and availability of the DHCP or DNS server
- Configuration of your Ethernet switch and VLAN’s
- PoE configuration
- Physical condition of the Ethernet cables
- Ethernet cable length (328 ft or 100 m)
- Switch power load
Uncertainty Grows with Multi-Gig Deployments

• What is Multi-Gig?
  – Switch ports delivering >1Gbps link speed
  – 1 / 2.5 / 5 / 10 Gbps
  – Driver: need to deliver >1 Gbps to APs, certain IoT devices, etc.
  – “new bandwidth over old media”

• What’s the problem?
  – Not all cable plants will support it.
  – Requires Cat5e minimum
  – Excess noise (insufficient SNR) results in “downshifting” to lower speed.
  – Difficult to troubleshoot

“The quality, length, and install workmanship is also a major factor when it comes to multigigabit. When you begin pushing the copper to run at faster speeds, flaws in the cable plant become more easily exposed.”
Cable SNR Test for Multi-Gig Media Assurance

- From AutoTest, drill in on Link
- Shows Link metrics
- Verify configurations
- Measures Multi-Gig parameters
  - Delay Skew
  - SNR
Cable SNR Test for Multi-Gig Media Assurance

- Example “bad” result
- “Channel B” (pair) < threshold
PROBLEM: WLAN Security

The most forgotten problem?
Locate Unauthorized Devices

How it works:

- Focus scan on desired device
- Measure Signal Strength
- Walk toward the stronger signal
- Until the signal won’t increase

Note: Using an External Directional Antenna could make the location process easier
Identify the Root Cause

Common Reasons for Wi-Fi Connection Problems:

- Signal Coverage
- Signal to Noise Ratio (SNR)
- Legacy 802.11 Devices
- Security
- Capacity
- Wired Issues
PROBLEM: AP Not Working

Testing the cabling and PoE
# PoE for Wi-Fi 6 – The New Challenge

<table>
<thead>
<tr>
<th>IEEE Standard</th>
<th>Input Power (Watt)</th>
<th>Output Power (Watt)</th>
<th>EA Class</th>
<th>Powered Device Type</th>
<th># of pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.3 af (PoE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12,95</td>
<td>15,4</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3,84</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>6,49</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12,95</td>
<td>15,4</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>802.3 at (PoE+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25,5</td>
<td>30</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>802.3 bt (PoE++, 4-pair PoE, 4PPoE, UPOE)</td>
<td>40</td>
<td>45</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>60</td>
<td>6</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>802.3 bt (higher-power PoE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>62</td>
<td>75</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>73</td>
<td>90</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
# PoE Consumer (Power Device)

## Ruckus R850

<table>
<thead>
<tr>
<th>Mode</th>
<th>Power Consumption</th>
<th>System Configuration</th>
<th>Wi-Fi Radios</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Power, PoH, uPoE (Idle)</td>
<td>16.1W</td>
<td>- 5Gbps Ethernet Enabled</td>
<td>2.4GHz (4x4) Enabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1Gbps Ethernet Enabled</td>
<td>5GHz (8x8) Enabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- USB Enabled (3W)</td>
<td>(No Clients Associated)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Zigbee/BLE Enabled (0.5W)</td>
<td></td>
</tr>
<tr>
<td>DC Power, PoH, uPoE (Max)</td>
<td>31.0W</td>
<td>- 5Gbps Ethernet Enabled</td>
<td>2.4GHz (4x4) Tx 20 dBm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1Gbps Ethernet Enabled</td>
<td>5GHz (8x8) Tx 22 dBm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- USB Enabled (3W)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Zigbee/BLE Enabled (0.5W)</td>
<td></td>
</tr>
</tbody>
</table>

## Cisco Catalyst 9130

- 802.3at Power over Ethernet Plus (PoE+), Cisco Universal PoE (Cisco UPOE*)
- Cisco power injector, AIR-PWRINJ6=
- 802.3af PoE
- Cisco power injector, AIR-PWRINJ5+ (Note: This injector supports only 802.3af)

<table>
<thead>
<tr>
<th>Catalyst 9130AXi</th>
<th>PoE power consumption</th>
<th>2.4-GHz radio</th>
<th>5-GHz radio</th>
<th>Link speed</th>
<th>USB</th>
<th>Link Layer Discovery Protocol (LLDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.3at (PoE+)</td>
<td>4x4</td>
<td>8x8</td>
<td>5G</td>
<td>N</td>
<td>25.5W</td>
<td></td>
</tr>
<tr>
<td>802.3at (PoE+)</td>
<td>4x4</td>
<td>4x4</td>
<td>5G</td>
<td>Y [4.5W]</td>
<td>25.5W</td>
<td></td>
</tr>
<tr>
<td>802.3bt (Cisco UPOE)</td>
<td>4x4</td>
<td>8x8</td>
<td>5G</td>
<td>Y [4.5W]</td>
<td>30.5W</td>
<td></td>
</tr>
</tbody>
</table>
**PoE Switch (Power Source Equipment)**

Ruckus ICX7150-48ZP

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICX7150-48PF-4X10GR-A</td>
<td>Ruckus ICX 7150 Switch, 48×10/100/1000 Mbps PoE+ ports, 2×1 GbE RJ45 uplink-ports, 4×10 GbE SFP+ stacking/uplink-ports, <strong>740 W PoE budget</strong>, Layer 3 features (OSPF, VRRP, PIM, PBR), TAA-compliant.</td>
</tr>
<tr>
<td>ICX7150-48ZP-E8X10GR2-A</td>
<td>Ruckus ICX 7150 Z-Series switch, 16×100/1000 Mbps/2.5 Gbps PoH ports, 32×10/100/1000 PoE+ ports, 8×10 GbE SFP+ stacking/uplink-ports (max 4 for stacking), 2×920 W AC power supply, 2 fans, <strong>1480 W PoE budget</strong>, L3 features (OSPF, VRRP, PIM, PBR). TAA compliant.</td>
</tr>
</tbody>
</table>

Ruckus R850  
48 x 31,00W = 1488W  
Cisco Catalyst 9130AXE  
48 x 30,50W = 1464W

Would you use a switch on almost 100% PoE output?
Monitoring & Troubleshooting

- WLAN Management systems
  - Most WLAN AP vendors can provide ‘system’ health and alerting, (e.g. ‘red light/errors), but not a complete view or detailed understanding

- Troubleshooting needs a more flexible view
  - From the client level (not just the AP level)

- Most monitoring systems just give a ‘snap-shot’ or quick view of the RF/Wi-Fi environment
  - Not an independent analysis

- WiFi Troubleshooting needs Wi-Fi tools
  - Not ‘free-apps, packet analysis or wired based tools. Only vendor-neutral purpose-built dedicated tools can fulfil these detailed requirements
WLAN Troubleshooting Can Be Simple...

• Try to identify the root-cause of the problem as opposed to the symptom
  – User, Device, Airtime, Network (DHCP, DNS, Proxy), Server, Application, Internet, Network Performance

• Use the RIGHT tool for the RIGHT job for the users' RIGHT level of knowledge

• For a fast start for WLAN troubleshooting:
  – Ask for WLAN and RF basics training, because any good tool for network troubleshooting should be easy to use