Tips, Techniques, and Tools for Troubleshooting Wireless LANs

**MANAGE**
Vendor WMNS or 3rd-Party overlay systems to evaluate and supply pertinent data for WLAN Troubleshooting

**INTERROGATE**
Frame Captures for Wired and/or Wireless to understand details of Communication Flows

**ANALYZE**
Layer 1 Spectrum Analysis to evaluate both Modulated and Unmodulated Radio Frequency Interference

**INVESTIGATE**
Wi-Fi Scanners, Built-in Tools, CLI Commands, GUI Tools to evaluate Wi-Fi networks

**MEASURE**
Using performance/throughput testing on Wireless and Wired to document issues and where they exist

**VALIDATE**
Survey software to map RF Coverage, visualize RSSI, SNR, CCI, Capacity, and if WLAN meets ALL Requirements

**REQUIREMENTS**
Primary Coverage, Secondary Coverage, SNR, Data Rates, Density, Capacity
Keith R. Parsons

Wireless LAN Professionals, Inc.

80+ Network Certifications

CWNE #3 – CWNP and CWNE Boards

19 years Design, Troubleshoot & Train on WLANs

@keithrparsons on Twitter

http://WLANPros.com
Troubleshooting Process Steps

**Identify**
- Determine problem exists
- Ask Questions & Collect Info
- Correctly Identify Issue

**Locate**
- Tied to physical space
- Tied to specific devices
- Use OSI model to define layer

**Solve**
- Formulate & Implement plans
- May include changes to drivers, configurations or designs

**Document**
- Document initial issues, processes, diagnostics & resolutions
- Follow up with those involved

**Re-Create**
- If you can't recreate the issue, return to step one and ask more questions

**Isolate**
- Identify OSI Layer, Specific devices, Specific locations, Driver versions

**Verify**
- Extensive testing to confirm and verify the solution did indeed solve the issue at hand

2020 BICSI FALL Conference & Exhibition
Occam’s Razor
“More things should not be used than are necessary”
“Too Much Plane for One Man to Fly!”
“Surgeries are becoming too complex...”

<table>
<thead>
<tr>
<th>Surgical Safety Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before induction of anaesthesia</strong></td>
</tr>
<tr>
<td>(with at least nurse and anaesthetist)</td>
</tr>
<tr>
<td><strong>Has the patient confirmed his/her identity, site, procedure, and consent?</strong></td>
</tr>
<tr>
<td>□ Yes</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Is the site marked?</strong></td>
</tr>
<tr>
<td>□ Yes</td>
</tr>
<tr>
<td><strong>Is the anaesthesia machine and medication check complete?</strong></td>
</tr>
<tr>
<td>□ Yes</td>
</tr>
<tr>
<td><strong>Is the pulse oximeter on the patient and functioning?</strong></td>
</tr>
<tr>
<td>□ Yes</td>
</tr>
<tr>
<td><strong>Does the patient have a:</strong></td>
</tr>
<tr>
<td><strong>Known allergy?</strong></td>
</tr>
<tr>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes</td>
</tr>
<tr>
<td><strong>Difficult airway or aspiration risk?</strong></td>
</tr>
<tr>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes, and equipment/assistance available</td>
</tr>
<tr>
<td><strong>Risk of &gt; 500 ml blood loss (7 ml/kg in children?</strong></td>
</tr>
<tr>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes, and two IVs/central access and fluids planned</td>
</tr>
</tbody>
</table>

2020 BICSI Conference & Exhibition
Lee Badman

The Soon To Be Famous

Cocktail Napkin

Wi-Fi Big Picture

March 19, 2016
WIRELESS LAN TROUBLESHOOTING - POTENTIAL CAUSES

WIRELESS

RF MEDIUM

- DFS
- IRRM
- MCS Process
- Contention Process
- Overhead

Wi-Fi Device Client
- Mobile Location
- Association Process
- Authentication
- Encryption

802.11
- Pre-Shared Key
- TKIP Encryption
- AES/CCMP Encryption

Wired Medium
- Access Point Fixed Location
- Wired Medium
- Edge Switch

LOCAL NETWORK

- QoS
- DHCP
- TCP/UDP
- DNS
- Tagged Port
- Untagged Port
- 802.1X Authentication Database

INTERNET

- QoS
- WLAN Controller
- Captive Portal

- Apps
- DNS
- WAN Router
- Captive Portal

End User
- 802.11
- AES/CCMP
- Protected Port
- Controlled Port

wirelessLAN Professionals
# Potential Wireless LAN Troubleshooting Causes

<table>
<thead>
<tr>
<th>Wired/Wireless</th>
<th>Location</th>
<th>Potential Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wireless</strong></td>
<td>End User</td>
<td>Skills, Knowledge, Perceptions, Device On/Off, Understanding of Concepts &amp; Device capabilities, Wi-Fi vs Cellular</td>
</tr>
<tr>
<td><strong>Mobile</strong></td>
<td>Wi-Fi Client Device</td>
<td>Drivers, Radio Capabilities, Profiles, Supported PHY, QoS, Power Save, Applications, Location, Vendor IE Support, Chipset Behavior, Roaming Algorithms, Auto-Negotiated MCS, MDM, Protection</td>
</tr>
<tr>
<td><strong>RF Media</strong></td>
<td>RSSI, SNR, S/NR, Primary &amp; Secondary Coverage, CCI/ACI</td>
<td>Retry Rates, Average MCS, Jitter, Latency, Consistency, Regulatory Domains, Non-Wi-Fi Interference, Spectrum Analysis</td>
</tr>
<tr>
<td><strong>Per Frame Tx</strong></td>
<td>preamble detect, energy detect, triggers, NAV timers, TXOP, AIFS, random slots, QoS, WMM, duration ID, Ch Capacity, Non-Wi-Fi interference</td>
<td></td>
</tr>
<tr>
<td><strong>Per Frame Tx</strong></td>
<td>MCS Process</td>
<td>Per Frame Decisions - Modulation Technique, Coding Technique, Ch Width, Guard Interval, Spatial Streams, Tx Power, ACK vs No ACK, TX decides</td>
</tr>
<tr>
<td><strong>Per Time</strong></td>
<td>Radio Resource Mgmt</td>
<td>Per Period Decisions - Channel, Tx Power, CC, ACI, Noise, Duty Cycle, Retry Rates, CRC's, Load, Ch Width, DFS, User Traffic, Reg Domain, KPI's, Thresholds, Neighbor Discovery, Interference, Timing</td>
</tr>
<tr>
<td><strong>Per Time</strong></td>
<td>DIFS Process</td>
<td>802.11 is NOT primary User - AP Scans for 60-Seconds, AP Enabled, Continuous Scanning, If RADAR detected, send CSA, Change to new CH, After 30-min can return, after 60-second scan</td>
</tr>
<tr>
<td><strong>Per Frame Tx</strong></td>
<td>Single Frame on RF</td>
<td>Overhead to delivery IP Payload - AIFS, CW, BPSK Preamble, RTS, SIFS, Preamble BPSK, CTS, SIFS, Preamble, Preamble VHT, Header MBR, Payload PHY rate, CRC, SIFS, Preamble, ACK</td>
</tr>
<tr>
<td><strong>Per Timers</strong></td>
<td>Association Process</td>
<td>Beacon, Probe Request, Probe Response, Authentication Request, Authentication Response, Association Request, Association Response, Decide on which AP by: RSSI, SNR, Auth Method, Encrypt Method, Channel Switch Announcement, Error Rates, MCS/Data Rates Supported, Heinuristics, Internal Lists, De-Authentication, Dis-Associate, 802.11 k, v, r, MBR, Proprietary Methods!</td>
</tr>
<tr>
<td><strong>Per Changes</strong></td>
<td>802.11 k, v, r</td>
<td>AP's try to influence the roaming decisions via 'standard' modes</td>
</tr>
<tr>
<td><strong>From LAN</strong></td>
<td>Authentication Process</td>
<td>Open, Pre-Shared Key, 802.1X RADIUS, PSK includes Exchange of 4-Way Handshake to trigger Encryption Keys, 802.1X EAP Exchange, ending in 4-Way Handshake</td>
</tr>
<tr>
<td><strong>From LAN</strong></td>
<td>Encryption Process</td>
<td>None, TKIP, AES/COMP, Punishment for using TKIP, Confusion with Wi-Fi Alliance naming - WPAP2 PSK... is WPAP2</td>
</tr>
<tr>
<td><strong>Fixed</strong></td>
<td>Upper Layers</td>
<td>DHCP, IP, DNS, VLAN, Subnet Mask, Default Gateway, Captive Portal</td>
</tr>
<tr>
<td><strong>Fixed</strong></td>
<td>Controlled Port</td>
<td>AP Controls which 802.11 Frames can cross Wireless to Wired Boundary</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Access</td>
<td>Configurations, SSIDs, Minimum Basic Rates, Supported PHY Rates, Band Steering, Client Control, Radio Capabilities, Tx Rates, Client Isolation, Roaming, QOS</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Load Medium</td>
<td>EIA/TIA 568A/B, Category Mismatch, Validation Tests, Grounding, other issues</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Edge Switch</td>
<td>VLANs, Port Speeds, PoE, Configurations, QoS, End-to-End?</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Local Network</td>
<td>Distributed vs Centralized Forwarding, ACLs, VLANs, QoS, Tunnels, Layers, NAT</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>TCP/UDP</td>
<td>Following all TCP issues as well as UDP reasons for using each</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Quality of Service</td>
<td>Tagged Port vs Untagged Port, DSCP, WMM Categories, End-to-End QoS</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Applications</td>
<td>MTU, TCP Window, Round Trip Time, TCP Retransmission times</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>DHCP Server</td>
<td>Lease Durations, Configurations, Broadcast Storms, Latency, Performance, Address Pool Scopes, Scalability, DHCP Options, Auto Renew</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>DNS</td>
<td>Configuration, Scalability, Security, Accuracy, Customization, Control, Blacklists</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>802.11X/RADIUS</td>
<td>Configuration, Ports, Ranges, Licensing Issues, EAP types, Custom VSA, Scalability, Resources, Certificate issues, Fast/Secure Roaming types</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Active Directory</td>
<td>Accounts, Credentials, EAP Compatibility, Custom RADIUS Attributes</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Controller Functions</td>
<td>Code Versions, Bugs, Configurations, Local vs Cloud, Licensing Issues, Distributed vs Centralized Forwarding, VLAN choices</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>Firewall</td>
<td>Firewall Rules, Capacity, Compatibility, Rate Limiting, Bandwidth Shaping</td>
</tr>
<tr>
<td><strong>Local Network</strong></td>
<td>WAN Router</td>
<td>Size of Internet Pipe, Internet Destination Issues, Costs, Availability, Consistency</td>
</tr>
<tr>
<td><strong>Internet</strong></td>
<td>Internet Connection</td>
<td>Bandwidth Throttling, Jitter, Latency</td>
</tr>
<tr>
<td><strong>Internet</strong></td>
<td>Captive Portal</td>
<td>Security, Client Issues, Privacy, Friction, Triggers, Certificates, DNS, Captive Portal Location, Control, Monetization, Legal, MiFi</td>
</tr>
</tbody>
</table>
Wireless LAN Troubleshooting

ekahau UNIVERSITY

ecse TROUBLESHOOTING

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Tools Used in ECSE-Troubleshooting Course

Free
Wireshark, Kismet, Bettercap, HORST, Client Profiler, iPerf, HTML Tests

Low Cost
Wi-Fi Analyzer Pro, WLAN Pi, Netool.IO, Apps

Professional
Ekahau Pro v.10, Ekahau Sidekick,
Wireless LAN Troubleshooting Process

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Radio Frequency Medium

- Adjacent Channel Interference
- Automated Channel Planning
- Average Data Rates
- Average MCS
- Channel Occupancy
- Co-Channel Contention/CCI
- Consistency
- Jitter
- Latency
- Multipath
- Non-Wi-Fi Interference
- Regulatory Domains
- Retry Rates
- Spatial Streams
- Spectrum Analysis
Contestation Process

• How to Access RF Medium
• AKA - “The Game”
• Preamble Detect
• Energy Detect
• Transmit Opportunity TxOp
• Wait Time
• Random Slots (CW)
• QoS
• Duration ID
RSSI, SNR, Noise, Modulation, Air Time

- Low Signal Strength → Low SNR → Less Complex Modulations → Lower Speeds → More AirTime Utilization
- Strong Signal Strength → High SNR → More Complex Modulations → Higher Speeds → Less AirTime Utilization

1 Mbps
200 Mbps
<table>
<thead>
<tr>
<th>HT</th>
<th>VHT</th>
<th>Modulation</th>
<th>Coding</th>
<th>20MHz</th>
<th>40MHz</th>
<th>80MHz</th>
<th>160MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Data Rate</td>
<td>Min. SNR</td>
<td>RSSI</td>
<td>Data Rate</td>
<td>Min. SNR</td>
<td>RSSI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>800ns</td>
<td>400ns</td>
<td></td>
<td>800ns</td>
<td>400ns</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>BPSK</td>
<td>1/2</td>
<td>6.5</td>
<td>7.2</td>
<td>2</td>
<td>-82</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>QPSK</td>
<td>1/2</td>
<td>13</td>
<td>14.4</td>
<td>5</td>
<td>-79</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>QPSK</td>
<td>3/4</td>
<td>19.5</td>
<td>21.7</td>
<td>9</td>
<td>-77</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>16-QAM</td>
<td>1/2</td>
<td>26</td>
<td>28.9</td>
<td>11</td>
<td>-74</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>16-QAM</td>
<td>3/4</td>
<td>39</td>
<td>43.3</td>
<td>15</td>
<td>-70</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>64-QAM</td>
<td>2/3</td>
<td>52</td>
<td>57.8</td>
<td>18</td>
<td>-66</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>64-QAM</td>
<td>3/4</td>
<td>58.5</td>
<td>65</td>
<td>20</td>
<td>-65</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>64-QAM</td>
<td>5/6</td>
<td>65</td>
<td>72.2</td>
<td>25</td>
<td>-64</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>256-QAM</td>
<td>3/4</td>
<td>78</td>
<td>86.7</td>
<td>29</td>
<td>-59</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>256-QAM</td>
<td>5/6</td>
<td>81</td>
<td>92.4</td>
<td>31</td>
<td>-57</td>
</tr>
</tbody>
</table>

**MCS, SNR and RSSI**

**1 Spatial Stream**

**2 Spatial Streams**

**3 Spatial Streams**
“Green Diamond” Association/Roaming Algorithms

- SSID
- RSSI
- SNR
- Authentication Method
- Channel Switch Announcements
- De-Authentication Frame
- Dis-Association Frame
- Encryption Methods
- Error Ratios
- Heuristics
- Internal Lists - White/Grey/Black
- MCS/Data Rate
- Minimum Basic Rate
- Supported Data Rates
- 802.11k, 802.11r, 802.11v
Upper Layers

- VLAN Assignment
- DHCP (Request/Response)
- Subnet Mask
- Default Gateway
- DNS
- Captive Portal?
Captive Portal

- Captive Portal Location
- Certificate Issues
- Client Issues
- Control
- Encrypted DNS
- Friction
- Legal Issues
- Mi-Fi Issues
- Monetization
- Privacy Issues
- Triggers

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## 5GHz Channels

### 5 GHz Channel Allocations

<table>
<thead>
<tr>
<th>Frequency</th>
<th>U-NII-1</th>
<th>U-NII-2a</th>
<th>U-NII-2c (Extended)</th>
<th>TDWR</th>
<th>U-NII-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 MHz</td>
<td>36</td>
<td>40</td>
<td>44</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>40 MHz</td>
<td>38</td>
<td>46</td>
<td>54</td>
<td>62</td>
<td>102</td>
</tr>
<tr>
<td>80 MHz</td>
<td>42</td>
<td>58</td>
<td>106</td>
<td>114</td>
<td>122</td>
</tr>
<tr>
<td>160 MHz</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FCC - US**
- 1,000 mW Tx Power
- Indoor & Outdoor
- No DFS needed

**IED - Canada**
- FCC - Except Outdoor License Req. >200 mW
- Same as FCC

**ACMA - Australia**
- 200 mW EIRP - Indoor
- 200 mW EIRP - DFS & TPC
- 100 mW EIRP - DFS-Only Indoor
- 500 mW - DFS-Only - No TPC Indoor/Outdoor

**ETSI - EU**
- 100 mW
- No DFS/TPC - Indoor
- 200 mW EIRP - DFS/TPC

**DFS Channels**
- 250 mw w/6dBi Indoor & Outdoor
- DFS Required

**TDWR**
- 120, 124, 128
- US - Allowed
- Now Allowed
- 1,000 mW Tx Power Indoor & Outdoor
- No DFS needed

**QRS - Outdoor**
- 200 mW EIRP - DFS & TPC

**CAC Scan Time**
- 10-min TDWR

---

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DFS Channels

802.11 is NOT Primary User

• AP Scans for 60-Seconds
• AP Enabled on Channel
• Continuous Scanning
• If Radar Detected
• Send Channel Switch Announcement
• Change to New Channel
• After 30-Min Can Return
• After 60-Second Scan
• Repeat

• Check your regulatory domain for details!
Sample Single Frame Transmission

- AIFS - Arbitration Inter-frame Space
- Contention Window (CW)
- Preamble - BPSK
- RTS - Lowest Basic
- SIFS - Fixed Tme
- Preamble - BPSK
- CTS - Lowest Basic
- SIFS - Fixed Tme
- Preamble - BPSK
- Preamble - VHT
- Header - MBR
- Payload - PHY Rate
- CRC
- SIFS - Fixed Tme
- Preamble - BPSK
- ACK - MBR
Association is to Wireless

what a

Link Light is to Wired
Wi-Fi Client Joining WLAN

- **802.11 Association**
  - Probe Request/Probe Response
  - Client Decides on AP
  - Authentication Request/Response
  - Association Request/Response

- **Authentication**
  - Open
  - PSK
  - 802.1X

- **Encryption**
  - None
  - TKIP
  - AES/CCMP

- **Port Control**
  - Can Pass Traffic Through Access Point

- **Upper Layers**
  - DHCP
  - VLANs
  - Default Gateway
  - DNS

- **LAN Access**
  - Can Pass Traffic on Local Network

- **Captive Portal**
  - After everything is completed for 802.11 Association, Authentication and Encryption, as well as all Upper Layers... then Captive Portal

- **Full Network Access**
  - Can Pass Traffic on Local Network
Potential Wireless LAN Troubleshooting Causes
Local Network and Internet
Evolution in Cabling
Survey Says: Top Wireless Issues

End User Issues
- Connect to Wrong SSID
- Incorrect PSK
- Incorrect 802.1X Credentials
- Wireless Not Turned On

Network Issues
- Incorrect VLANs, No IP Address or APIPA DNS Issues, DHCP Issues, NAT Errors Firewall or Bandwidth Shaping Issues

Wi-Fi Client Device Issues
- Sticky Client Issues
- Client Driver Issues
- Roaming Issues
- MDM Issues

WLAN Infrastructure Issues
- Low Coverage, No Secondary Coverage
- Band Steering Not Working
- High Retry Rates, Low Average MCS
- MBR too High/Low, AP Tx Power Issues
- AP Code Issues, WMM Not Configured
Wired vs Wireless

**Wired Issues**
Use appropriate tools to check Network connectivity in Upper Layers

**Wireless Issues**
Use appropriate tools to check Layer1 RF and Layer 2 MAC issues
Wired or Wireless Problem?

- **IP Address**
  Does target Wi-Fi Client Devices have an IP Address?

- **Ping Wi-Fi Client**
  Can you Ping your Wi-Fi Client Device from the Wired Network?

- **MCS of Wi-Fi Client**
  Is the MCS of Wi-Fi client showing stress
  MCS 5-9 means 64-QAM or Better
  MCS of <5 means difficulty over RF

- **Compare Throughput**
  Compare Wi-Fi connection data rate to Internet Speed Test

- **Check RSSI & SNR**
  Both from the Client’s point of view as well as from the Access Points’

- **Isolated?**
  Is the issues isolated to only Wi-Fi devices or across network
  Especially check network services
Wi-Fi Signal Demo Lab

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ping</td>
<td>9 ms</td>
</tr>
<tr>
<td>Download</td>
<td>1.00 Mbps</td>
</tr>
<tr>
<td>Upload</td>
<td>0.70 Mbps</td>
</tr>
</tbody>
</table>

**Premier*Guest**

- **Excellent** Signal Quality
- **Channel** 157 (80) Mbps
- **MCS Index** 9
- **IP Address** 10.250.45.67
- **Signal** -49 dB
- **Noise** -90 dB
- **SNR (dB)** 41
Doctor’s Visit / Triage

START Adult Triage

- Able to walk?
  - Yes: MINOR → SECONDARY TRIAGE
  - No:
    - Spontaneous breathing
      - No: Position airway → APNEA
      - Yes:
        - Respiratory Rate
          - >30: IMMEDIATE
          - <30:
            - Perfusion
              - Radial pulse absent, or capillary refill > 2 sec: IMMEDIATE
              - Radial pulse present, or capillary refill ≤ 2 sec:
                - Mental status
                  - Doesn’t obey commands: IMMEDIATE
                  - Obey commands: DELAYED

Triage Categories

- EXPECTANT
  - Black Triage Tag Color
  - Victim unlikely to survive given severity of injuries, level of available care, or both
  - Pain relief should be provided

- IMMEDIATE
  - Red Triage Tag Color
  - Victim can be helped by immediate intervention and transport
  - Requires medical attention within minutes for survival (up to 60)
  - Includes compromises to patient’s Airway, Breathing, Circulation

- DELAYED
  - Yellow Triage Tag Color
  - Victim’s transport can be delayed
  - Includes serious and potentially life-threatening injuries, but status not expected to deteriorate significantly over several hours

- MINOR
  - Green Triage Tag Color
  - Victim with relatively minor injuries
  - Status unlikely to deteriorate over days
  - May be able to assist in own care
  - “Walking Wounded”
Blood Pressure - Channel Utilization

Pulse - Retry Rates

Temperature - MCS Rates
## 802.11n and 802.11ac

### MCS, SNR and RSSI

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Wireless LAN Troubleshooting Process

**MANAGE**
Vendor WMNS or 3rd-Party overlay systems to evaluate and supply pertinent data for WLAN Troubleshooting

**INTERROGATE**
Frame Captures for Wired and/or Wireless to understand details of Communication Flows

**ANALYZE**
Layer 1 Spectrum Analysis to evaluate both Modulated and Unmodulated Radio Frequency Interference

**REQUIREMENTS**
- Primary Coverage
- Secondary Coverage
- SNR
- Data Rates
- Density
- Capacity

**INVESTIGATE**
Wi-Fi Scanners, Built-in Tools, CLI Commands, GUI Tools to evaluate Wi-Fi networks

**MEASURE**
Using performance/throughput testing on Wireless and Wired to document issues and where they exist

**VALIDATE**
Survey software to map RF Coverage, visualize RSSI, SNR, CCI, Capacity, and if WLAN meets ALL Requirements
That’s All Folks!

Resources from this presentation:
http://WLANPros.com/troubleshooting

Keith R. Parsons
Managing Director
Wireless LAN Professionals, Inc.

Personal keith@wlanpros.com
Twitter http://twitter.com/keithrparsons
LinkedIn http://linkedin.com/in/keithrparsons
Website http://WirelessLANProfessionals.com