WLAN Performance Optimization with 7signal Sapphire

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CTO
## Challenges with WLAN operation

1. Too aggressive rate control

2. Automated algorithms need clear improvements (channels, power, ...)

3. Available radio settings are not utilized since their impacts are not understood

4. Interference due to lacking channel coordination and Bluetooth devices

5. Too dense beacons load air unnecessarily

6. Mobile networks interfere 2.4 GHz band WLAN’s through 3\textsuperscript{rd} harmonic distortion

7. Support for legacy devices (802.11b/a) seriously degrades benefits of new stds

8. Lacking interoperability may take down whole network performance

9. Modest access point antenna solutions

10. Performance Management capabilities and culture is completely missing

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For more details, see 7signal contribution at IEEE802.11HEW SG May 2013

Problems present themselves as unhappy end users at certain time and place

- Empty network may work well, but under load performance collapses
- Performance varies significantly over the time
- A lot can be done to improve Quality of Experience with **Optimization**

**Night time throughputs are about 40Mbit/s**

**One hour average downlink throughput drops down to 0.2Mbit/s**
WLAN performance optimization requires data and a systematic approach

• **Requirements**
  - Meaningful, continuous and consistent data
  - Skilled wireless engineer
  - System level approach

• **A clear strategy is needed**
  - “Cause – Consequence” is not straightforward. QoE in wireless has “analog” nature
  - Performance varies continuously; every day, hour, minute
  - QoE = Reach the set targets often enough: Time averages, SLAs

• **Key Performance Indicators (KPIs) measure the success**
  - Objective is to make selected KPIs improve and reach the target level
  - If used KPIs correlate with QoE, end user experience improves
  - No silver bullets, trial and error, takes rounds

• **Assess top-down**
  - From application layer L7 to physical layer L1

• **Optimize ground-up**
  - From physical layer L1 to application layer L7
Both active and passive measurements are needed for complete view

Ensure that network is capable providing high quality service

- Utilize especially “Active/Synthetic” Eye measurements (“automated end user”)
- Optimize until target levels have been achieved

Ensure that clients can utilize the delivered service

- “Passive”, client and AP level measurements
- Optimize network and configure clients to achieve this

Proactively maintain service at the target level

- Follow Key Performance Indicators (KPIs) and SLA tables and take actions
- Proactive corrections are needed when metrics degrade
## High level 7signal optimization flow

| 1. Preparations and baseline | • Ensure that APs and antennas are positioned correctly  
• Collect baseline data for a few days  
• Check WLAN SW release, upgrade to more recent if very old |
|-------------------------------|--------------------------------------------------|
| 2. Channel plan               | • Maximize available spectrum, organize channels for max capacity potential  
• Use manual channel plan in dense areas |
| 3. Minimize utilization       | • Minimize utilization due to unnecessary 802.11 traffic  
• # of SSIDs, standards, beaconing, probing, data rates, protection, client roaming,… |
| 4. Adjust power levels        | • Adjust AP power levels & TPC settings for improved SNR at both ends |
| 5. Reduce non-WLAN interference | • Remove non-WLAN interference, as much as possible  
• There is always interference, understand whether it has significant impact or not |
| 6. Improve radio robustness   | • Make radio more robust towards remaining interference/noise  
• Increased power, dropping max MCS, fragmentation, directional antennas |
| 7. Prioritize and balance traffic | • QoS categories, AP power levels, load balancing, SSID strategy, roaming |
| 8. LAN/WAN capabilities       | • Ensure sufficient LAN/WAN capacity and performance are present |
| 9. Introduce HW changes       | • If performance is not sufficient, consider HW changes  
• Directional antennas, add/move APs, replace equipment, end user devices  
• It can be made to perform! |
CASE STUDY:

AVANS UNIVERSITY OF APPLIED SCIENCES
SELECTED 5 GHZ OPTIMIZATION RESULTS, FLOOR AVERAGES
Optimization changes at Avans

- **Change 1**
  - 4-channel plan on 2.4 GHz (Learning Center floors 0, 1, 2)

- **Change 2**
  - Beacon interval to 300 milliseconds
  - Remove 802.11b support and disable MCS 0, 8 and 16

- **Change 3**
  - Adjust AP radio power levels

- **Change 4**
  - Complete campus 4-channel plan on 2.4 GHz
  - Add more channels on 5 GHz (Learning Center)

- **Change 5**
  - At 5 GHz, turn on HT40+
  - At 2.4 GHz Balance client counts by AP power level settings

For details, see 7signal contribution at IEEE802.11HEW SG July 2013

https://mentor.ieee.org/802.11/dcn/13/11-13-0803-00-0hew-wlan-network-behavior-under-heavy-load.ppt
FTP (TCP) downlink throughput

- 100-900% improvements

900% improvement in 1st floor

100% improvement in ground floor

Shown floor averages include several APs
Voice Quality (MOS), Uplink

- Improvements of about 0.15 - 0.85 MOS
- No drops any more

+0.15MOS in ground
+0.8MOS in 1st floor

Shown floor averages include several APs
Network latency (RTT)

- 50% improvement in the 1st floor
- 25% improvement in ground floor

Shown floor averages include several APs
Overall WLAN traffic airtime utilization

- Overall air time utilization is 50% lower
- Idle network bandwidth consumption minimized

Shown floor averages include several APs
Retransmissions by Clients toward AP

- Performance was improved by about 50% before #5
- Enabling HT40 degraded AP retry performance
- High peak hour values remain

Shown floor averages include several APs
Retransmissions by AP towards clients

- Enabling HT40 degraded AP retry performance
- High peak hour values remain

Shown floor averages include several APs

High peak hours values remain

Target is below 10%
### BEFORE

**SLA, 5 GHz/Learning center, 1st floor averages, 8am-6pm**

<table>
<thead>
<tr>
<th>DAY</th>
<th>AV008 Beacon availability in managed AP scan</th>
<th>AC001 Radio attach success rate</th>
<th>AC002 IP address retrieval success rate</th>
<th>QURT007 Ping success rate</th>
<th>RE004 FTP test success rate</th>
<th>RE005 VoIP test success rate</th>
<th>QURT004 Ping RTT</th>
<th>QUAP001 FTP DL throughput</th>
<th>QUAP002 FTP UL throughput</th>
<th>QUAP005 VoIP MOS downlink (listening)</th>
<th>QUAP006 VoIP MOS uplink (talking)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-05-29</td>
<td>100.0%</td>
<td>47.8%</td>
<td>100.0%</td>
<td>89.7%</td>
<td>97.7%</td>
<td>99.7%</td>
<td>98.1%</td>
<td>82.4%</td>
<td>86.2%</td>
<td>78.5%</td>
<td>74.7%</td>
</tr>
<tr>
<td>2013-05-28</td>
<td>97.5%</td>
<td>41.6%</td>
<td>100.0%</td>
<td>88.6%</td>
<td>98.9%</td>
<td>100.0%</td>
<td>98.8%</td>
<td>93.5%</td>
<td>95.5%</td>
<td>83.8%</td>
<td>73.8%</td>
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<tr>
<td>2013-05-27</td>
<td>100.0%</td>
<td>44.4%</td>
<td>100.0%</td>
<td>85.8%</td>
<td>97.5%</td>
<td>100.0%</td>
<td>96.4%</td>
<td>92.5%</td>
<td>89.7%</td>
<td>80.0%</td>
<td>81.4%</td>
</tr>
</tbody>
</table>

### AFTER

**SLA, 5 GHz/Learning center, 1st floor averages, 8am-6pm**

<table>
<thead>
<tr>
<th>DAY</th>
<th>AV008 Beacon availability in managed AP scan</th>
<th>AC001 Radio attach success rate</th>
<th>AC002 IP address retrieval success rate</th>
<th>QURT007 Ping success rate</th>
<th>RE004 FTP test success rate</th>
<th>RE005 VoIP test success rate</th>
<th>QURT004 Ping RTT</th>
<th>QUAP001 FTP DL throughput</th>
<th>QUAP002 FTP UL throughput</th>
<th>QUAP005 VoIP MOS downlink (listening)</th>
<th>QUAP006 VoIP MOS uplink (talking)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-06-19</td>
<td>100.0%</td>
<td>88.6%</td>
<td>100.0%</td>
<td>98.7%</td>
<td>99.7%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>97.9%</td>
<td>95.2%</td>
</tr>
<tr>
<td>2013-06-18</td>
<td>100.0%</td>
<td>92.7%</td>
<td>100.0%</td>
<td>99.2%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>98.8%</td>
<td>94.3%</td>
</tr>
<tr>
<td>2013-06-17</td>
<td>100.0%</td>
<td>79.6%</td>
<td>100.0%</td>
<td>96.5%</td>
<td>99.6%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>93.8%</td>
<td>94.7%</td>
</tr>
</tbody>
</table>

- Significant improvements in SLA

Shown floor averages include several APs
# Key achievements in daily averages

<table>
<thead>
<tr>
<th>Key Performance Indicator</th>
<th>Ground 2.4 GHz</th>
<th>1st 2.4 GHz</th>
<th>Ground 5 GHz</th>
<th>1st floor 5 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTP (TCP) downlink throughput</td>
<td>+40%</td>
<td>0%</td>
<td>+70%</td>
<td>+270%</td>
</tr>
<tr>
<td>FTP (TCP) uplink throughput</td>
<td>+40%</td>
<td>5%**</td>
<td>+85%</td>
<td>+700%</td>
</tr>
<tr>
<td>HTTP downlink throughput</td>
<td>+25%</td>
<td>+25%</td>
<td>+50%</td>
<td>+90%</td>
</tr>
<tr>
<td>VoIP MOS downlink (MOS)</td>
<td>+0.1</td>
<td>+0.1</td>
<td>+0.05</td>
<td>+0.05</td>
</tr>
<tr>
<td>VoIP MOS uplink (MOS)</td>
<td>+0.1</td>
<td>+0.1</td>
<td>0</td>
<td>+0.07</td>
</tr>
<tr>
<td>UDP jitter</td>
<td>-40%</td>
<td>-40%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>UDP packet loss</td>
<td>-80%</td>
<td>-80%</td>
<td>&gt;+200%*</td>
<td>-90%</td>
</tr>
<tr>
<td>Latency</td>
<td>-50%</td>
<td>-10%*</td>
<td>-25%</td>
<td>-50%</td>
</tr>
<tr>
<td>AP retransmissions</td>
<td>-45%</td>
<td>-10%</td>
<td>+40%***</td>
<td>+40%***</td>
</tr>
<tr>
<td>Client retransmissions</td>
<td>-20%</td>
<td>-20%</td>
<td>-15%</td>
<td>-15%</td>
</tr>
<tr>
<td>WLAN air time utilization</td>
<td>-55%</td>
<td>-55%</td>
<td>-50%</td>
<td>-50%</td>
</tr>
</tbody>
</table>

* = Packet loss increased clearly. Was at 0.3% at the end
** = Last change had negative impact. Need to be revisited
*** = AP retransmissions increased clearly after enabling HT40
Summary

• Every network is **different**
• Performance fingerprint is **unique** in each network
• Performance varies **constantly**
• Continuous data reveals **trends**
• **Surprising** findings in data are common
• Wireless engineers should focus on **analysis and actions**
• **Every network** can be improved
• **Clear strategy** for optimization is needed
• Each change must be **validated**
• Getting **ahead of the end user tickets** is the key
• Optimization may offer **almost instant gains** up to 1000%
• Assurance **keeps the performance up – continuously!**