RF Design for the Mobile Devices explosion

T-VT1/L3

Alexey Zaytsev
TME, Cisco WNG
the Main driver of the Wi-Fi networks evolution currently and further by 2016

15-19 billions

Connected mobile devices

Mobile devices

Mobile Apps increase >>> Mobile devices increase

M2M
Coverage & Capacity for High Density
“Normal” Enterprise Planning

- Total occupancy of 32 users
- $900 \text{ ft}^2 / 32 \text{ (users)} = 1 \text{ user every } 28 \text{ ft}^2$

>>> 1 user every 3 sq.m in some countries 6+ sq.m per employee by laws
High Density environment

Contrast “normal” with these assumptions

If sitting in a theater style seat, place your hand on the back of the seat in front of you – that’s about 36 inches, 3 feet

The average seat width is 24 Inches

3 ft x 2 ft, lets assume 1m x 1m or 1 m²

In the user seating – that’s 1 device per 1m²

Note: signal difference in high density scenario between empty room and room full of people can be 10-15dBm

The “New Normal” is more than 1 device per User
High Density tips for Large venues

- Overlapping cells should use non-overlapping channels (shown is the use of the 3 non-overlapping channels in the 2.4 GHz domain)
- Use APs with Directional Antennas to create WLAN cells within the seating areas
- Do not bond channels in the 2.4 GHz range, use 5GHz
- Use down-tilt to control the vertical RF beam width
- Design and Install for both 2.4 GHz and 5 GHz support
- Use correct design guides for mobile devices, but overall target for cell edge: RSSI -67dBm, SNR 25dBm, cells overlap 10-15% for data, 15-20% for voice
- 5GHz preferred for private Wi-Fi applications to isolate from regular access network
- Use functionality like CleanAir, ClientLink, BandSelect
- Utilize gigabit Ethernet uplinks for 802.11n APs. FastEthernet uplink can be a bottleneck for an aggregation of 802.11n clients.

Site Survey must be done for Each Floor! Don’t use copy-past!
Seating sections in the lower bowl are served by different APs.

**Examples:**
- Single Tier & Two Tiered

**Two Tiered design**
- 1020 Seats

Seating sections in the lower bowl are served by different APs.

**Single Tier design**
- 322 Seats (red)
- 480 Seats (blue)

Dividing up the coverage area depends on where AP/Antennas may be mounted.

One AP per section.

**Principles for High Density are Important. Call Cisco AS for Stadium projects.**
Antenna Radiation Patterns

• Antenna choice plays a critical part in design for proper coverage
AP vs Smartphone vs Laptop
transmit power for coverage considerations

Note: 6dBm difference eq. 2x Coverage
AP vs Smartphone vs Laptop
transmit power for coverage considerations

Solution:
consider AP transmit power equal or less transmit power of the least powerful device in the WLAN
range manipulation can be done via antenna gain change

Note: 6dBm eq 2x Coverage
• Range versus rate is something that we are generally working to maximize in a coverage design.

• In High Density Design, the reverse is actually true – we want to minimize the propagation of a cell.

• Minimizing the cell size is a function of limiting the propagation, there are 3 ways to do this–
  1. Limiting supported rates
  2. Managing the power of the radio’s (AP and Client)
  3. Using the right antenna’s to shape both Tx and Rx cell size and isolate

• Properly applied, this will maximize channel re-use in a small space.

Channel Efficiency

Channel Utilization – is the aggregate of every radio on the channel that can be heard above -85 dBm – this means clients too.
SSID Design / high density impact to WLAN performance plus VLANs

Traffic can be directed from a SSID to a VLAN, it is useful. BUT, be very accurate with number SSID increase!

**SSID**:
- AP sends Beacons from each SSID each 100 ms by default,
- Beacons are being sent on basic data rates
  
  \[(\text{airtime for 1, 2Mbps data rates is huge})\]

So,
- decrease AP transmit power,
- decrease number of SSIDs,
- remove basic data rates,
- sometimes makes sense to increase Beacon pooling time
  
  (test with terminals! Not all will support this)

**RF Design for 2.4GHz**

Traffic can be directed from a SSID to a VLAN, it is useful. BUT, be Very accurate with number SSID increase!

**Example:**
If client can hear i.e. 4 APs on the same RF channel

\[4 \times 5 = 20 \text{ Beacons each 100ms}\]

As a result WLAN capacity can be consumed by Beacons only up to 30-40%!
Channel Throughput by Protocol

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Throughput (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11b</td>
<td>7.2</td>
</tr>
<tr>
<td>802.11b/g mix</td>
<td>13</td>
</tr>
<tr>
<td>802.11g</td>
<td>25</td>
</tr>
<tr>
<td>802.11a</td>
<td>25</td>
</tr>
<tr>
<td>802.11n (HT20 1ss MCS7)</td>
<td>35</td>
</tr>
<tr>
<td>802.11n (HT20 2ss MCS15)</td>
<td>70*</td>
</tr>
</tbody>
</table>

- If your application requires 3 Mbps then you can get 2 seats on 802.11b or 4 seats on b/g mix
- 6 - 7 seats on a pure 802.11g channel – or 802.11a
- This assumes that the channel is performing at peak efficiency

* Two spatial streams – note most PDA’s are SISO (MCS 7) 35 Mbps max
Special Technologies for High Density
Cisco BandSelect Technology

Access Point assisted 5 GHz band selection for dual-band clients

**Challenge**
- Dual-Band clients persistently connect to 2.4 GHz

**Solution**
- BandSelect directs clients to 5 GHz, optimizing RF usage
  - Better usage of the higher capacity 5 GHz band
  - Frees up 2.4 GHz for single-band clients

Optimized RF utilization by moving 5 GHz capable client out of the congested 2.4 GHz channels
What is BandSelect Technology?

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Cisco ClientLink Technology

- Silicon-level intelligence that focuses DL RF energy (Beamforming) directly to 802.11a/g/n clients
  - Higher Signal Strength ➤ Higher Throughput (up to 85%)
  - Higher Signal Strength ➤ More Range (~20%)

What is ClientLink Technology?

ClientLink 2.0 supports 802.11n clients
Cisco ClientLink Technology, deeper view

MRC operations on AP

Client Link – Increase of Client SNR and Bandwidth

Sum Signal boost of mobile device signal

MIMO 1x1:1
Cisco CleanAir: Self-Healing & Optimizing

Channels 11, 6 and 1 are optimized for maximum performance and minimum interference.

CleanAir – Manage Interference for more Capacity and Reliability
Cisco CleanAir: Self-Healing & Optimizing

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Interferers in 2.4GHz

<table>
<thead>
<tr>
<th>Interference Type</th>
<th>Throughput Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Near (9 m)</td>
</tr>
<tr>
<td>TDD Phone</td>
<td>100%</td>
</tr>
<tr>
<td>Video Camera</td>
<td>100%</td>
</tr>
<tr>
<td>Wi-Fi (busy neighbor)</td>
<td>90%</td>
</tr>
<tr>
<td>Microwave Oven</td>
<td>63%</td>
</tr>
<tr>
<td>BT Headset</td>
<td>20%</td>
</tr>
<tr>
<td>DECT Phone</td>
<td>18%</td>
</tr>
</tbody>
</table>
Cisco CleanAir: Self-Healing & Optimizing

CleanAir – Manage Interference for more Capacity and Reliability

Channels 1, 6, and 11 are optimized for maximum performance and minimum interference on Channel 6. Air Quality is affected. RRM is browsing the list of preferred channels to resolve conflict.

Wireless LAN Controller

Channels 1, 6, and 11 are optimized for performance and browsing the list of preferred channels to resolve conflict.

Scanning available channels…

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CleanAir – Manage Interference for more Capacity and Reliability

Conflict resolved. Information is being relayed to RRM. Conflicting channel is blocked from future use.
WLAN architecture and integration into E2E Solution
Connected Venue

Wireless Services Block
Connected Venue
Wireless LAN Characteristics

- We can use a Multi-tier network architecture
- Support for Multi-chassis Link Aggregation for scalable WLC failover in case of link or switch failure
- APs, Controllers, support for Cisco Discovery Protocol to ease troubleshooting
- Comprehensive end-to-end wired and wireless network management using Cisco Prime Infrastructure
- Support for Real Time Location Services when coupled with Cisco’s Mobility Services Engine
Connected Venue
Centralized Wireless LAN Model

- Centralized WLAN deployment Model using Light-weight APs and Wireless Controllers
- All APs are centrally managed at the controllers
- SSIDs are assigned to a service or application
- Wireless client traffic is tunneled from the AP to the WLC and mapped to wired VLANs
- Traffic is securely routed from their VLAN to the appropriate destination
High Density example: MWC12
MWC2012 – The Highlights

THE annual event for the mobile industry, over 1sq km of exhibition space

2012 was another record breaking event

67,200 attendees
12,500 developers
2,400 press & analysts
1,500 exhibitor companies

- Build the WiFi infrastructure for public and press access during the MWC event
- The area is approximately 1x1 km, but only selected areas, approx 20% covered
- Cisco to cover public spaces and support the venue partner on the indoor pavilions where exhibitor booths are located
The WiFi Network, clients and traffic details

276 Access Points deployed (+ 30%)*

30,000 unique users, approx 11,000 per day (+ 15%)

3,990 peak associations (+ 11%)

51% iOS devices (42% last year) 10% Samsung, 5% HTC, 4% RIM

84% WiFi devices were 802.11n capable

60% operating on 2.4Ghz (was 71%) for general users

55% operating on 5Ghz (was 45%) for press and media

Peak Internet throughput approached 350Mbps

Offload / traffic over the 4 days totaled 2.7Tb

Press & exhibitors rate limited to 5Mbps, visitors to 2Mbps

* Delta on MWC2011
2.4Ghz utilization across the venue was over 80%

In line with expectations, 2.4Ghz was oversubscribed

BandSelect feature on access points was tuned to aggressively move clients to 5Ghz where possible

Attendees were provided with information to set correct expectation on 2.4Ghz usability
Equipment List

- **120 x LAP1142**: General areas where directional antennas not required
- **60 x LAP1262**: General areas where directional antennas required
- **50 x CAP3502**: General areas where CleanAir monitoring and directional antennas required
- **40 x CAP3602**: High density / high visibility areas where directional antennas not required
- **6 x CAP1552**: Outdoor area along the main Avenue

Total: 276 AP

- **6 x CT5508**: Redundant Wireless Controllers (active/active)
- **8 x 3750G**: PoE switches for high density / high visibility areas
- **3 x ASR1k**: ISGs + NAT
- **4 x UCS**: Management and Monitoring, NCS, MSE, PRTG, SYSLOG
Visibility for clients, rogues, tags, WiFi devices, RF interferers

Device location information was captured and used for network fault finding and device location
# Cisco UWN elements

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Capacity</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco 1600</td>
<td>- Indoor APs -</td>
<td>5 to 200 APs</td>
<td>500 Mbps</td>
</tr>
<tr>
<td>Cisco 2600</td>
<td>- Indoor APs -</td>
<td>5 to 50 APs</td>
<td>500 Mbps</td>
</tr>
<tr>
<td>Cisco 3600</td>
<td>- Indoor APs -</td>
<td>5 to 75 APs</td>
<td>500 Mbps</td>
</tr>
<tr>
<td>Cisco 1550</td>
<td>- Outdoor APs -</td>
<td>5 to 75 APs</td>
<td>500 Mbps</td>
</tr>
<tr>
<td>WiSM2</td>
<td>- Cloud controller</td>
<td>300 to 6000 APs</td>
<td>1 Gbps</td>
</tr>
<tr>
<td>MSE</td>
<td>- Location -</td>
<td>300 to 6000 APs</td>
<td>10 Gbps</td>
</tr>
<tr>
<td>ISE</td>
<td>- AAA, NAC, Guest Access, Profiling, Posture, integration to MDM</td>
<td>- 300 to 6000 APs</td>
<td>- 64,000 clients</td>
</tr>
</tbody>
</table>
Key Takeaways

1. Proper and Full Site Survey is the Main Key for success in a High Density project.

2. High level of end-user Isolation is very important > use proper antennas

3. Smaller cells > more capacity,
   but remember issues, which we discussed!

4. Avoid too high transmit power of your APs > highest level is eq or less the least power wifi device in the network

5. Use 5GHz as much as possible,
   but 2.4GHz currently must have for mobile devices

6. Appropriate technologies will highly support wlan reliability, availability and will increase user experience: BandSelect, ClientLink, CleanAir,
1. Cisco Design zone for Mobility

2. Wireless LAN Design Guide for High Density Client Environments in Higher Education
http://www.cisco.com/web/strategy/docs/education/cisco_wlan_design_guide.pdf

3. Cisco Location services Design Guide
Děkujeme za pozornost.

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