Deploying Carrier Class Home Wi-Fi Networks

IAMU Broadband Conference
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The **Internet of Things** is Growing

New generations of “connected” devices are changing home networking and bandwidth consumption

American homes will soon average over 20 devices per home

Where Does Your Network Begin?
Carrier Class Wi-Fi Whole Home Coverage

- Whole home coverage from anywhere in the house
- All services delivered via fiber connected Wi-Fi, including IPTV
- Eliminates or sharply reduces need to wire homes
- Enables support for scores of devices in the home
- Managed services with QoS and virtual technician
**What is Carrier Class Wi-Fi?**

802.11ac is just the starting point

<table>
<thead>
<tr>
<th>Carrier Class Wi-Fi Feature</th>
<th>Subscriber / Service Provider Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 GHz with 23 channels with DFS frequencies</td>
<td>7X the capacity of 2.4 GHz; HD IPTV over Wi-Fi; minimal interference</td>
</tr>
<tr>
<td>80 MHz channel width</td>
<td>Significantly higher speeds</td>
</tr>
<tr>
<td>Dynamic frequency hopping</td>
<td>Smart channel selection when interference encountered</td>
</tr>
<tr>
<td>4 x 4 Multi-User MIMO</td>
<td>Significantly improves range and speeds throughout the home</td>
</tr>
<tr>
<td>Dynamic beamforming</td>
<td>Ability to reach remote devices at the edge of the house</td>
</tr>
<tr>
<td>QoS</td>
<td>Prioritization of service by SSID for higher reliability; IPTV supported at launch</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Complete testing with set top ecosystem</td>
</tr>
<tr>
<td>Managed services</td>
<td>TR-69 management; Wi-Fi analytics</td>
</tr>
</tbody>
</table>
5GHz spectrum advantages

- 5Ghz has 23 X 20 MHz channels; 2.4GHz has 3 X 20 MHz channels
- 2.4GHz is congested, 5GHz is clean
- 2.4GHz is limited, in practice to 20 MHz channels, 5GHz has 40 and 80 MHz channels that support much higher speeds
Frequency Hopping

Dynamically eliminates interference

- Not very worthwhile in 2.4 GHz, not enough frequencies to hop to when interference is encountered—it’s all congested
- 5 GHz has lots of frequencies to hop to and has areas usually free from interference, such the DFS channels

5 GHz Wi-Fi Frequency Spectrum in the US

Channels which require DFS Radar Certification

23 x 20MHz channels, 11 x 40MHz channels, 5 x 80MHz channels

5170 MHz 5250 MHz 5330 MHz
U-NII-1  U-NII-2

5490 MHz
U-NII-2e

5730 MHz
U-NII-3

5845 MHz
Dynamic Frequency Selection (DFS)

DFS channel use is certified by the FCC

DFS frequencies are high end beachfront property
- Lots of capacity, free from interference
- DFS certification means able to avoid radar and other interferers
- Products that are not DFS certified have limited channel capacity as they can’t operate in the DFS spectrum band

DFS frequencies

5 GHz

Wi-Fi Frequency Spectrum in the US

Channels which require DFS Radar Certification

23 x 20MHz channels, 11 x 40MHz channels, 5 x 80MHz channels

5170 MHz 5250 MHz 5330 MHz
U-NII-1 U-NII-2

5490 MHz
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5845 MHz
Wi-Fi Maximum Throughput

802.11ac and 802.11n both operate at 5 GHz

802.11ac is over 2.5 times faster than 802.11n

- Multiple radios/antennas send independent streams of data.
- The greater the number of radios/antennas the higher the speed possible over the Wi-Fi

<table>
<thead>
<tr>
<th>MIMO</th>
<th>802.11n (40 MHz)</th>
<th>802.11ac (80 MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x1</td>
<td>65 Mbps</td>
<td>190 Mbps</td>
</tr>
<tr>
<td>2x2</td>
<td>130 Mbps</td>
<td>375 Mbps</td>
</tr>
<tr>
<td>3X3</td>
<td>195 Mbps</td>
<td>560 Mbps</td>
</tr>
<tr>
<td>4X4</td>
<td>258 Mbps</td>
<td>730 Mbps</td>
</tr>
</tbody>
</table>
TCP Test Results

3 level wood frame house, concrete block first floor

3,700 square feet

Carrier Class Access Point
# 1st Floor TCP Throughput Test Results

Wall mounted access point on first floor

5GHz 802.11ac, 80 MHz channel, 4X4 MIMO

<table>
<thead>
<tr>
<th>Location</th>
<th>Down</th>
<th>Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>496 Mbps</td>
<td>494 Mbps</td>
</tr>
<tr>
<td>Laundry</td>
<td>507 Mbps</td>
<td>467 Mbps</td>
</tr>
<tr>
<td>Entertainment Center</td>
<td>730 Mbps</td>
<td>716 Mbps</td>
</tr>
</tbody>
</table>
## 2nd Floor TCP Throughput Test Results

Carrier class access point located on first floor

### 5GHz 802.11ac, 80 MHz channel, 4X4 MIMO

<table>
<thead>
<tr>
<th>Location</th>
<th>Down</th>
<th>Up</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kitchen</strong></td>
<td>626 Mbps</td>
<td>489 Mbps</td>
</tr>
<tr>
<td><strong>Bedroom 1</strong></td>
<td>655 Mbps</td>
<td>624 Mbps</td>
</tr>
<tr>
<td><strong>Dining Room</strong></td>
<td>373 Mbps</td>
<td>311 Mbps</td>
</tr>
<tr>
<td><strong>Bedroom 2</strong></td>
<td>698 Mbps</td>
<td>688 Mbps</td>
</tr>
</tbody>
</table>
3rd Floor TCP Throughput Test Results

Carrier class access point located on first floor

5GHz 802.11ac, 80 MHz channel, 4X4 MIMO

<table>
<thead>
<tr>
<th>Room</th>
<th>Throughput Down</th>
<th>Throughput Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master Bedroom</td>
<td>339 Mbps</td>
<td>251 Mbps</td>
</tr>
<tr>
<td>Master Bath</td>
<td>524 Mbps</td>
<td>447 Mbps</td>
</tr>
<tr>
<td>Sitting Room</td>
<td>383 Mbps</td>
<td>305 Mbps</td>
</tr>
</tbody>
</table>
Dynamic Beamforming

Beamforming

- 4X4 MIMO dynamic beamforming to concentrate Wi-Fi energy on clients at the edge of the house in remote bedrooms, offices and basements
- Beamforming supported to all 802.11ac set tops and smart TVs, as well as 802.11n Quantenna set tops

GigaCenter
Carrier Class Wi-Fi Ecosystem
Ready for the coming 802.11ac home network

802.11ac client devices

- 802.11ac clients are now commonly found in laptops and tablets, along with several new smart phones, including the new iPhone 6
- Arris, Pace and Cisco IPTV set tops currently support Quantenna 802.11n at 5GHz, these set tops can support many of the Carrier Class features supported on the GigaCenter
- All of the major set top vendors will be introducing 802.11ac set tops, many with Quantenna 4X4 in 2015
Carrier Class Wi-Fi Managed Services
Managed Services: Virtual IT Technician

**TR-069 enables visibility**
- Automated firmware upgrades
- List of wired and wireless clients connected
- LAN connectivity status (LAN ports, Wi-Fi radios)
- Ability to access connected devices remotely (embedded GUI/credentials)
- Wi-Fi management (SSIDs, Passwords, Security)
- Wi-Fi Analytics
Customer Call Resolution

Reducing average handle time and escalation

Resolving Wi-Fi related issues

- Step #1: Hardware gathers data from the home
- Step #2: Software with Wi-Fi analytics provides analysis
- Step #3: **Software recommends a solution** to the problem
- Customer service resolves the issue…**no escalation**
Fewer Truck Rolls

Preventing a truck roll in urban America saves $137
What if your customer is an hour away?

Wi-Fi issues can be tricky

- Be able to see issues caused by neighbors
- Observe signal strength as devices are moved around
- Auto-hopping to find best channel
- Prioritizing your IPTV wireless devices
Happier Customers

What if you could explain “Why” on the very first call?

Customers hate wasted calls

- Higher numbers of first call resolutions
- Prompt explanations why Netflix is buffering
- Software can “see” the issue and explain it
CSR: A Day In The Life
Possible Causes?

Airtime Congestion
- Too much traffic for the capacity of the channel

Poor Signal Strength
- Client is located too far away from router or behind a barrier that degrades service

Interference
- Competing wireless signals that overlap or adjacent channel interference. Sources may be other Wi-Fi devices or non-Wi-Fi devices, such as microwave ovens or cordless phones

Interoperability issues
- Trouble free Wi-Fi requires more than just good radios, router and client interoperability issues will arise
Step 1. Gathering Data

Channel Utilization
- Percent of channel air time being used

Interference Time
- Percent of channel air time consumed by interference

Downstream (DS) and Upstream (US) physical rates
- As a rule of thumb, this is twice the throughput due to overhead

Received Signal Strength Indicator (RSSI) per Device (STA\text{tion})
- Strength of the signal is as measured by the receiver in units of signal power (dBm)

Radio Type of Client Device (802.11b/g/n/ac)

Hardware sees the network for you
Step 2. Software Analysis

Is the Channel congested?
- Total channel utilization time
- Interference time / free time
- Per client use of air time (BW hog)

Is the Client in a poor location?
- Channel capacity per STA for Tx and Rx
- Received Signal Strength Indicator (RSSI) from STA Rx and AP Rx per STA

Is the Channel plagued by interference?
- Interference time
- Retransmission rate

Is the site crowded, is there a better channel to pick?
Step 3. Situational Analysis Shown to CSR

Observations and Recommendations

Low Downstream PHY Rate

- Poor downstream signal strength and/or interference is resulting in poor PHY rate. If this low PHY rate persists over multiple refreshes in a 5 min window, then move the client device to obtain better PHY rate.

Channel Utilization

<table>
<thead>
<tr>
<th>DeviceType</th>
<th>Hostname</th>
<th>IP Address</th>
<th>Mode</th>
<th>SSID</th>
<th>DS PHY Rate (Mbps)</th>
<th>US PHY Rate (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone</td>
<td>Dot13_iThing</td>
<td>192.168.1.13</td>
<td>SQA_Test</td>
<td></td>
<td>11</td>
<td>2</td>
</tr>
</tbody>
</table>

Notes: The PHY rate is always higher than the actual data rate due to Ethernet, IP and Wi-Fi protocol overhead.
## Wi-Fi Advisor: Diagnostics with Recommendations

<table>
<thead>
<tr>
<th>Observation</th>
<th>Explanation / Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 None</td>
<td>No current issues</td>
</tr>
<tr>
<td>2 Weak Signal Strength with Low Downstream PHY Rate</td>
<td>Move the client device to obtain better signal strength. Move the GigaCenter location if moving the client device does not help (requires technician).</td>
</tr>
<tr>
<td>3 Low Downstream PHY Rate</td>
<td>Poor downstream signal strength and/or interference is resulting in poor PHY rate. If this low PHY rate persists over multiple refreshes in a 5 min window, then move the client device to obtain better PHY rate.</td>
</tr>
<tr>
<td>4 High Radio Interference</td>
<td>Manually switch channels or set Channel Mode to Auto, and determine if performance improves.</td>
</tr>
<tr>
<td>5 High Radio Interference - 5.0 GHz</td>
<td>Turn on DFS channels if DFS is not enabled. Note: While not all clients can use DFS channels, DFS channels typically have the lowest interference of all Wi-Fi Channels. If you cannot turn on DFS, manually switch channels or set Channel Mode to Auto, and determine if performance improves.</td>
</tr>
<tr>
<td>Observation</td>
<td>Explanation / Recommendation</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------</td>
</tr>
</tbody>
</table>
| **6** High Radio Interference - 5.0 GHz | You have an unusually high level of 5GHz interference but cannot use DFS channels due to incompatibility with some clients. If manual or auto switching of channels does not work, try the following steps:  
If only one client is impacted, move the client to a lower interference location.  
If all clients are impacted, move the GigaCenter location away from the interference (requires technician).  
Note: Even small movement of the GigaCenter location can significantly improve performance in a high interference environment. |
| **7** High Radio Interference - 2.4 GHz | You have an unusually high amount of interference in your environment. If switching channels does not work, try the following steps:  
If only one client is impacted, move the client to a lower interference location.  
If all clients are impacted, move the GigaCenter location away from the interference (requires technician).  
Note: Even small movement of the GigaCenter location can significantly improve performance in a high interference environment. |
| **8** High Utilization with Legacy Mode - 2.4 GHz | Legacy clients might be responsible for high utilization due to their inefficient usage of airtime. Upgrade legacy clients to 802.11n. |
| **9** High Utilization with Legacy Mode - 5.0 GHz | Legacy clients might be responsible for high utilization due to their inefficient usage of airtime. Upgrade legacy clients to 802.11ac. |
Managed Services Revenue Opportunity
Calix 2014 User Group Attendees Survey

Do you plan to extend your network into the home by offering a Managed Wi-Fi router and home control services?

- Yes
- No
GVTC Home WiFi

When you're looking for a simple, reliable way to create your home network setup, turn to GVTC’s Total Home Networking. One of our certified trained technicians will connect up to three devices for a one-time fee of $19.95, and you can add more devices for an additional cost of $9.95 per device.
## Managed Wi-Fi Service Offsets Support Costs

**Calix customers are charging $55 to $80 per hour**

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salary and payroll taxes</td>
<td>$43,000.00</td>
</tr>
<tr>
<td>Overhead</td>
<td>$10,000.00</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td><strong>$53,750.00</strong></td>
</tr>
<tr>
<td>Cost per hour based on 2,000 hours per year</td>
<td><strong>$26.88/hour</strong></td>
</tr>
<tr>
<td>Cost per day</td>
<td>$215</td>
</tr>
<tr>
<td>Reduced cost per day with 2 billable hours</td>
<td>$215-$130=$85</td>
</tr>
</tbody>
</table>

### Managed Wi-Fi Service Revenue

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average billable rate</td>
<td>$65 per hour</td>
</tr>
<tr>
<td>Billable hours per day</td>
<td>2</td>
</tr>
<tr>
<td>Daily revenue</td>
<td>$130</td>
</tr>
</tbody>
</table>