Wireless System Network Design
Training Goal

The goal of this presentation is to provide education and guidance on designing a wireless network with Pakedge products. At the end of this presentation the viewer should be able to design a wireless network based on what IP devices are on the end-user network.

**Audience:**
Technical Personnel
Training Outline

• Wireless Network Design Background Information:
  – Topic 1: What is WiFi?
  – Topic 2: Wireless in Residential Projects
  – Topic 3: RF Interference
  – Topic 4: Wireless Technology Options
  – Topic 5: WiFi Troubleshooting
• How to Design a Wireless Network
• Macrocell Wireless
• Managed Macrocell Wireless
Topic 1: What is WiFi?

- IEEE 802.11(a/b/g/n):
  - Extension of a wired network.
  - Client always determines when to disassociate and associate with access points as dictated by the standard.
  - Access point factors needed for client association:
    - MAC Address: unique identifier set by manufacturer
    - SSID: Identifier for WLAN
    - Channel: RF radio signal
# Topic 1: What is WiFi? (cont.)

<table>
<thead>
<tr>
<th>Wi-Fi</th>
<th>Frequency Band</th>
<th>Theoretical Maximum Data Rate</th>
<th>Realistic Maximum Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11a</td>
<td>5 GHz</td>
<td>54 Mbps</td>
<td>~24 Mbps</td>
</tr>
<tr>
<td>802.11b</td>
<td>2.4 GHz</td>
<td>11 Mbps</td>
<td>~5 Mbps</td>
</tr>
<tr>
<td>802.11g</td>
<td>2.4 GHz</td>
<td>54 Mbps</td>
<td>~24 Mbps</td>
</tr>
<tr>
<td>802.11n</td>
<td>2.4 and 5GHz</td>
<td>450 Mbps (3x3)</td>
<td>~120-175 Mbps</td>
</tr>
<tr>
<td></td>
<td>Single Radio, Dual Radio, Dual Concurrent, Depends on Antenna Array: 2x2, 3x3, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>802.11ac</td>
<td>5 GHz</td>
<td>1.3 Gbps</td>
<td>~450-900 Mbps</td>
</tr>
</tbody>
</table>
Topic 1: What is WiFi? (cont.)

- IEEE 802.11b/g (2.4GHz)
  - Only channels 1, 6 and 11 are truly non-overlapping.
  - Co-channel interference appears between channels 1, 6, and 11.
Topic 1: What is WiFi? (cont.)

- **IEEE 802.11a (5.0GHz)**
  - More Channels
  - Typical Channels: 36-64
  - Less Range
  - Less Interference (most clients are on 2.4Ghz)

![Channel Diagram]

5GHz
Topic 1: What is WiFi? (cont.)

• IEEE 802.11n
  – Single radio 2.4GHz
  – Dual radio 2.4 and 5.0GHz
  – Simultaneous/Concurrent broadcasting
  – 802.11 b/g/n mode: typical operation
  – Factors that affect throughput and range:
    • Frequency Band
    • Antenna array size: 2x2, 3x3
    • Client network interface card
    • Power supplied to access points (802.3af vs. 802.3at)
Topic 2: WiFi in Residential Projects

- PRIMARY GOAL: Client Roaming and Connectivity
- All wireless technologies for the residential space are focused on assisting the client to disassociate and associate seamlessly from one access point to another.
- True roaming only occurs when a client only “sees” a single access point MAC address, SSID and channel.
- Wireless can be unpredictable at times so wire connections whenever possible.
Topic 3: RF Interference

• Sources of RF Interference:
  – Building materials: Brick, lathe & plaster, metal studs, radiant floor heating, marble, granite, concrete, etc. Results in ~20-40% coverage reduction.
  – Competing WiFi networks.
  – Electronic Devices: Baby monitors, microwaves, 2.4Ghz Phones, Zigbee, etc.

• Signal to Noise Ratio (SNR):
  – Best determinant of signal quality.
  – Interference will degrade SNR.
  – Signal amplifiers typically increase noise which degrades SNR.
  – Radio must be tuned/filtered to provide good SNR.
  – Typical Values:
    • VOICE: RSSI < -67, SNR > 25
    • DATA: RSSI < -70, SNR > 20
Topic 4: Wireless Technology Options

Enterprise-Grade Wireless Access Points

Pakedge Enterprise-Grade Wireless Access Points provide high-range, enterprise-level wireless communication between devices throughout a network. Combined with the C36 Wireless Network Controller, the Pakedge portfolio of wireless products allows an entire network with multiple APs to function wirelessly and without interference.
Topic 5: WiFi Troubleshooting

• Symptoms:
  – Unable to join nearby networks.
  – Weak or very low signal.
  – Not able to access the Internet even after connecting to the Wi-Fi network.

• Resolution:
  – Disable then enable WiFi on the computer/device.
  – Verify that the computer is in the range of the access point or wireless router.
  – If possible, unplug Access Point and the switch and leave unplugged for about 10 seconds. Plug back in and check for connectivity.
  – A bad Ethernet cable from the modem to the router or from the access point to the switch may be the problem especially if no other device on the network can connect wirelessly so using another Ethernet cable may fix the problem.
  – If other devices can connect to the wireless network without any problems, check for a possible update for the driver for the wireless card on the non-working computer/device.
  – Try using another wireless security. For example instead of using WEP use WPA or WPA2.
  – Check the settings on the access point and change the channel. There may be another device on the network causing conflict and not allowing the device to connect. For example, instead of using “Auto” to select a channel, switch to 1, 6 or 11.
  – If there is another Pakedge access point in range, try connecting to the other access point and if you get connectivity, it may be a bad access point especially if no other device on the network can connect to it.
How to Design a Wireless Network

Steps Taken to Design a Network:

1) Conduct Site Survey: Identify potential interference sources.

2) Compensate for Interference: Reduce, avoid or overpower interference.

3) Select the WiFi System: Based on customer’s roaming preference and budget.
   - Basic
     • Stand alone W3G, W6x, W7x
   - Intermediate
     • W6 w/ C36 Wireless Controller
   - Integrated
     • W7 w/ C36 Wireless Controller

4) Determine Quantity of Access Points: Based on the approximate square footage, number of floors, form factor, data port location and interference levels.

5) Verify the System: Test the wireless system with all applicable devices.

6) Describe System to Customer: Explain the wireless capabilities to the end-user.
How to Design a Wireless Network

Step 1: Conduct a Site Survey

• Identify all potential RF interference:
  • Devices: Baby monitors, microwaves, 2.4Ghz Phones, Zigbee, etc.
  • Building Materials: Brick, lathe & plaster, metal studs, radiant floor heating, marble, granite, concrete, etc.

• Use a WiFi sniffer ([www.netstumbler.com](http://www.netstumbler.com) or [www.inssider.com](http://www.inssider.com)) to detect competing channels:
  – Received Signal Strength Indicator (RSSI):
    • Best performance: RSSI ~ -30
    • Poor Performance: RSSI > -65
How to Design a Wireless Network

Step 2: Compensate for Interference

• Reduce Interference:
  – Remove competing 2.4Ghz devices as described previously.

• Avoid Interference:
  – Use non-competing channels as determined from the site survey. Typically alternate channels 1, 6 and 11.

• Overpower Interference:
  – Place additional access points to overpower competing wireless signals and compensate for building materials which result in ~20-40% coverage reduction.

• Deploy a controlled WiFi system:
  – Use C36 Wireless Controller to adapt to challenging RF Environments.
## How to Design a Wireless Network

### Step 3: Select the WiFi System

- Select the WiFi system based on the customer’s roaming preference and budget.

<table>
<thead>
<tr>
<th>Wi-Fi System</th>
<th>Pakedge Access Point</th>
<th>Roaming Ability</th>
<th>Cost</th>
<th>Ease of Deployment</th>
<th>Globally Configured</th>
<th>Controlled Wifi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Wi-Fi</td>
<td>WAP-W3x, W6x, W7x, W8x</td>
<td>Good</td>
<td>$</td>
<td>Easy</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Intermediate Wi-Fi</td>
<td>W6x with C36 Wi-Fi Controller</td>
<td>Better</td>
<td>$$</td>
<td>Easiest</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Integrated Wi-Fi</td>
<td>W7x with C36 Wi-Fi Controller</td>
<td>Best</td>
<td>$$$</td>
<td>Easiest</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
How to Design a Wireless Network

Step 4: Determine Quantity of Access Points

• Approximate Square Footage per Access Point:
  – Macrocell: 3,000-5,000ft².

• Adjust for Interference:
  – RF and building material interference will reduce signal strength ~20-40%. Provide additional access points to compensate.

• AP Form Factor
  – Considerations:
    • Interior Design: Aesthetics may take priority over performance.
    • Environment: Exterior or interior location.
    • Data Port Locations: Limited available Ethernet ports.

  – Housing Options:
    • Wall mount
    • In-ceiling
    • Rack mount
    • Outdoor
How to Design a Wireless Network

Step 5: Verify the System

- **Characterize Wireless After Installation**
  - Conduct Ping tests, wireless downloads and control interfaces throughout the day with ALL client devices.

- **Verify Internet Service Provider (ISP) Speed:**
  - Slow internet access may be due to ISP, not interference. Conduct a WAN speed test with one of the following: [www.speakeasy.net/speedtest](http://www.speakeasy.net/speedtest) or [http://speedtest.net](http://speedtest.net).
How to Design a Wireless Network

Step 6: Describe System Capabilities

• Set the customer’s expectations: Explain the capabilities and limitations of the wireless system based on the product and the environment.
  – Roaming capabilities.
  – Areas of high/low interference and low/high signal strength.
  – Typical data rates at various times during the day.
  – Login and password information for client and guests.
Macrocell Wireless
“AP Finder”

• Use the “AP Finder”: Access Point Discovery Tool to locate Access Points

• Configure AP Settings:
  – IP Address
  – Subnet Mask
  – Default Gateway
Macrocell Wireless (cont.)

Select Device Mode

• **Access Point Mode:**
  – Preferred mode, use for best results.
  – Best Range, use channels 1, 6 and 11

• **Wireless Bridge Mode:**
  – Connect two wired networks using wifi.

• **Wireless Distribution System (WDS) Mode:**
  – Repeater Mode: same type of access points.
  – Extension of signal on same channel.
  – Reduces throughput by half.
  – Use only if a cat5e/6 connection is unavailable.

• **Universal Repeater Mode:**
  – Repeater Mode: third party access points.
  – Possible Connectivity issues due to different chipsets.
  – Last resort option.
Macrocell Wireless (cont.)

WAP Configuration

• Typical Best Macrocell Roaming:
  – Staggered Channels: 1, 6, 11.
  – Security: WPA2-AES (best iPad roaming), NO WEP
  – Single SSID Name
  – IP address/default gateway

• Typical Macrocell AP Placement:
Macrocell Wireless (cont.)

Example 1

1) Conduct Site Survey:
   • Competing RF: No additional 2.4GHz devices or competing WiFi.
   • Construction: Standard wood and drywall.

2) Compensate for Interference:
   • Minimal interference.

3) Select WiFi System:
   • Customer desires a simple wifi system with high throughput. Central management is not required. Select Macrocell WiFi.

4) Determine Access Point Quantity:
   • Floor Plan: 3 floors, ~5,000ft2 per floor
   • Form Factor: Customer desires in-ceiling access points. Select W6C in-ceiling APs.
   • Data Port Location: Cat5e routed to the ceiling for W6C.
   • Interference: Standard construction so no interference consideration.
   • Determination: 3-4 W6C access points

5) Verify the System:
   • System was tested. Low signal strength near kitchen due to microwave. Add an additional AP near the kitchen.

6) Describe System to Customer:
   • Show access point locations and where they have the best coverage.
Macrocell Wireless (cont.)

Example 2

1) Conduct Site Survey:
   • Competing RF: 4 competing 2.4GHz WiFi networks. Channels 9 and 11 on left side of house, channels 2 and 6 on right side.
   • Construction: Brick construction.

2) Compensate for Interference:
   • Select non-interfering channels for WiFi competition.
   • Add additional access points for brick interference.

3) Select WiFi System:
   • Customer desires a simple WiFi system with high throughput. Central management is not required. Select Macrocell WiFi.

4) Determine Access Point Quantity:
   • Floor Plan: 3 floors, ~5,000ft² per floor
   • Form Factor: Customer desires invisible access points. Select W6 APs.
   • Data Port Location: Cat5e ports located in all rooms and closets.
   • Interference: Add more APs to compensate for brick and RF.
   • Determination: 4-5 W6 access points

5) Verify the System:
   • System was tested. Good client device response.

6) Describe System to Customer:
   • Show access point locations and where they have the best coverage.
C36 Wireless Controller

- Managed Wireless System:
  - **Wireless Access Points:**
    - W6, W6R, W6C, W6O
    - W7, W7x
  - **Managed Intermediate Wi-Fi:**
    - W6 with the C36 Wireless Controller
  - **Managed Integrated Wi-Fi:**
    - W7 with the C36 Wireless Controller

- Place access points similar to unmanaged APs.

- Controller Functionality:
  - WiFi Control
  - AP Mode
  - AP Identification
  - System Configuration
  - System Monitoring
C36 Wireless Controller

Centralized Wireless Management

The C36 manages all aspects of the wireless network to provide seamless wireless coverage and connectivity for complete network harmony, all from a central location.

Wireless System Monitoring

Full monitoring of the entire system keeps users aware of device health, network traffic, and clients attached to the network – ensuring Total Network Harmony.

Detailed Reporting

Create customized reports for critical parameters and event logging.
C36 Wireless Controller Configuration Screens

- View system status at a glance from one simple management dashboard.
- View critical system alerts from a simple interface to identify potential wi-fi network problems.
- Generate a customized report to view the critical parameters for your installation.
- Easily configure the Conductor IP settings.
- Easily locate and view access points on the network.
- Easily configure the IP settings of any access point on the network.
- Easily configure and VLAN tag SSIDs from one simple user interface.
Training Summary

• Wireless Network Design Background Information:
  – Topic 1: What is WiFi?
  – Topic 2: Wireless in Residential Projects
  – Topic 3: RF Interference
  – Topic 4: Wireless Technology Options
  – Topic 5: WiFi Troubleshooting

• How to Design a Wireless Network

• Macrocell Wireless

• Managed Macrocell Wireless
Thank You!

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