Wireless Mesh Design & Deployment

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The Industry’s 1st Intelligent Wireless Mesh Solution

- Engineered with Ease of Deployment & Management as Top-of-Mind
  - Identical Indoor/Outdoor Management
  - Based on LWAPP

- Self-Configuring, Self-Healing Mesh
  - Zero-Touch Configuration
  - Cisco’s new Adaptive Wireless Path (AWP) Protocol

- Robust Embedded Security

- Provides Seamless L3 Mobility
Wireless Mesh Networking Architecture

Scalable Architecture

Client Innovation

Best-in-Class Management

Secure Control

Dynamic Foundation

Reliable Hardware
Outdoor Wireless Mesh Solution Components

Cisco Wireless Control Systems
- Wireless Mesh Management System
- Enables network-wide policy configuration and device management
- Supports SNMP and Syslog

Cisco Wireless LAN Controller
- Links the Wireless Mesh APs to the wired network
- Handles RF algorithms and optimization
- Seamless L3 Mobility
- Provides Security and Mobility Mgt

Roof-top Access Point
- Serves as “Root” or “Gateway” AP to the wired network
- Typically located on roof-tops or towers
- Connects up to 32 “Pole-top” APs using 802.11a

Mesh Access Point
- Provides 802.11b/g client access
- Connects to Root AP via 802.11a
- Takes AC or DC power; PoE capable
- Ethernet port for connecting peripheral devices

Reliable Hardware Industry Proven Devices at Every Layer
Aironet 1500 Lightweight Mesh AP

- Fixed Configuration, Dual Radio Outdoor AP
  - 802.11b/g - access; 802.11a - backhaul
  - S/W Upgradeable to 4.9GHz in Beringer (Mar 06)

- NEMA-4/IP66 Enclosure
  - Dimensions 13” x 6” x 8”
  - Weight < 12 lbs
  - Horizontal/Vertical swivel mounting brackets

- Industrial Grade Power Supply
  - Local AC Power (95 – 260 VAC, 47 to 63 Hz)
  - Street Light Power Tap
  - DC Power over CAT5 (48 VDC)

- Wind Loads
  - Sustaining: 100 Mph
  - Gusts: 160 Mph

- Temperature ranges -40C to +55C

Cisco’s Intensive MDVT and EDVT Standards

Reliable Hardware
Aironet 1500 Lightweight Mesh AP, Cont.

- Bi-directional Amplifier for increased Transmit/Receive Power
  - 2.4 GHz - 24dBm
  - 5GHz - 28dBm
- Embedded 4.9 GHz Band
  - Firmware Upgrade required
  - 20 MHz channel, 17 dBm Power
- Two SKUs
  - AIR-LAP 1510 AG-A-K9 FCC Conf.
  - AIR-LAP 1510 AG-N-K9 Non FCC
- Europe SKU DFS/TPC support
  - 2.4 GHz channels 12, 13 & 14
Dynamic, Intelligent Path Selection

- Adaptive Wireless Path (AWP) Protocol
  - Cisco AWP is part of the IEEE 802.11s committee (SEE Mesh)
- AWP establishes an optimal path to Root
- Each AP carries feasible successor(s) if topology or link health changes
  - Note: AWP uses a “parent sticky” value to mitigate route flaps
How is the network formed?

- Upon boot, an AP checks its state, if it is a RAP it enters the “Maintain state”
- Otherwise, it actively solicits neighboring APs (Seek state)
- AP selects the best parent from the available list of parents
- AP Authenticates to the Mesh
- The AP then enters “Maintain” state; responds to solicitations
  Solicitation makes convergence faster, leaving more time for data transfer

Adaptive Wireless Path Protocol

Dynamic Foundation Extensible Hybrid Distance-Vector Protocol
Understanding Path Selection

- Routing uses a concept of “Ease” (inverse of Cost)
- Route with the highest Adjusted Ease is taken
- Unadjusted ease is the minimum of all unadjusted links in the path to the RAP
- Adjusted ease is a hop count adjusted ease
  - Minimize latency
  - Minimize errors
  - Minimize use of the shared channel

To prevent flopping of the link, a premium of 20% is given to the selected parent

Dynamic Foundation: Adaptive Wireless Path Protocol Creates the “Best” Path
Providing Security at Each Step

- Dynamic WLAN VLAN Assignment + 802.11i WPA/WPA2 Security
  - Identity-based Networking for VLAN Assignment
  - 16 MBSSIDs for various authentication types
- HW-based AES encrypted Backhaul Links
- AP Authentication protects against “imitation APs”
- Encrypted Control Traffic between AP and Controller
- IPSec VPNs for “confidential” mesh client traffic
  - Cisco’s new Mobile VPN Client provides IPSec roaming between mobile infrastructures

Delivering Mission-Critical WiFi Access
Adding Controller Intelligence to Outdoor Networks

- Automatic Service load-balancing across Wireless LAN Controllers
  LWAPP communicates controller load to APs
- Dynamic RF Optimization
  Adaptive Channel Assignment
  Intelligent TX_Pwr Levels
- Integrated Wireless IDS
- Per User/VLAN Traffic Rate Limiting

Secure Control

Delivering Mission-Critical WiFi Access
Cisco’s Award Winning Management Solution

- Identical Management Software and RM Features as Indoor Solution
- SOAP/XML interfaces for NMS integration
- Detailed AP, Radio information including Noise and Interference by Channel Neighbors lists and RSSI detail Link Metrics, PER, Tx/Rx detail
- Link Tests Tools for RAP-to-PAP troubleshooting
- SNR and Noise Floor Histograms

Best-in-Class Management
Easy to Deploy, Easy to Manage
Mesh Enhancements in WCS

- **Mesh Topology Map**
  - Coverage Areas/Maps, Mesh Link Detail, Mesh AP Detail,

- **Mesh Statistics**
  - Parent, Child, Neighbor Relationships

- **Mesh Network SNR Graphs**
  - Link Details, SNR Uplink, SNR Downlink

- **Mesh Network Link Graphs**
  - Link SNR, Unadjusted Link, Adjusted Link, Parent Link Metric

- **Mesh Client Link Test**
  - Packets, Error Rates, Signal Strengths, Noise, etc
Outdoor Coverage Area
Easily Adding Capacity and Services

- Increase AP Density
- Add Root/Gateway APs
  Pole-top APs will join new RAPs with better path metrics
- Easily add Controllers
  Up to 24 controllers can be part of an N+1 cluster
- 802.11e QoS Capable + Traffic Rate-limiting for “hog” mitigation
  802.11e QoS in Beringer (Mar ‘06)
- Architecture is ready for additional radios when extra capacity is required

**Scalable Architecture**

**Reliable, Secure, Manageable, Service-Ready Architecture**
WIRELESS MESH NETWORKING DESIGN AND DEPLOYMENT
802.11a 5GHz Backhaul Distances

- Link Budget Window: 123 ~ 130 dB
- Path Loss exponent: 2.3 to 2.7
- RAP PAP PAP
- 1000 Feet
- One Square Mile, 9 cells

1000 feet is the typical distance between the nodes.

Path Loss exponent 2.3 to 2.7
2.4 GHz Local Access Distances

Path Loss exponent 2.5 to 3.0

Link Budget Window 109 ~115 dB

Higher PLE due to Ground-level Noise and Interference

One Square Mile, 25 cells

600 feet (Typical distance)
**Data Rates**

- 18 Mbps is the default fixed rate set for the backhaul
- We recommend to use 18 Mbps as the data rate for the backhaul
- Data rates for all the APs in a **bridge group** must match

<table>
<thead>
<tr>
<th>802.11b</th>
<th>1,2,5.5,11</th>
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<tbody>
<tr>
<td>802.11g</td>
<td>1,2,5.5,11,6,9,12,18,24,36,48,54</td>
</tr>
<tr>
<td>802.11a</td>
<td>6,9,12,18,24,36,48,54</td>
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Why is 18Mbps the “Sweet Spot”
Understanding RAP Coverage Areas

- RF “Shadow” close to building; Poor SNR
- 18Mbps Coverage Area; SNR >20 dB
- Beyond RF Coverage Area; Poor SNR
Applying RAP Coverage Areas to Designs

1 hop to RAP
2 hops to RAP
2 hops to RAP
Typical Throughput and Latency

<table>
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<tr>
<th>HOPS</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>Four</th>
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<tbody>
<tr>
<td>Throughput</td>
<td>~10Mbps</td>
<td>~5Mbps</td>
<td>~3Mbps</td>
<td>up to 1Mbps *</td>
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Avg 2-3 msec latency per hops

* more data to be collected
Practical Mesh Coverage Models

- A Wired POP Bldg might have 4 RAPs
- Each RAP has 20-25 Mesh APs (MAPs)
- Each “Path Tree” on same 11a Channel
- Almost all MAPs within 1-2 hops of RAP
How Designs Affect Mesh Convergence

Mesh is in “Maintain State” and passing traffic…

…wiring closet switch port is ‘disabled’

(True story)
How Designs Affect Mesh Convergence, Cont.

...RAP becomes disconnected from Wired Network
How Designs Affect Mesh Convergence, Cont.

...Mesh APs and old RAP, now a MAP, link to surrounding RAP Trees
Mesh AP Re-convergence Sequence

1. Sense Disconnect
2. Scan Backhaul for Neighbors
3. Establish Optimal Path (Ease) to new RAP
4. Authenticate to Parent; establish Mesh Tree
5. Re-DHCP (if necessary)
6. Connect to Controller
7. Begin Passing Traffic

- Static IP Address
- DHCP (Single VLAN)
- DHCP (Multiple VLANs)
Demo