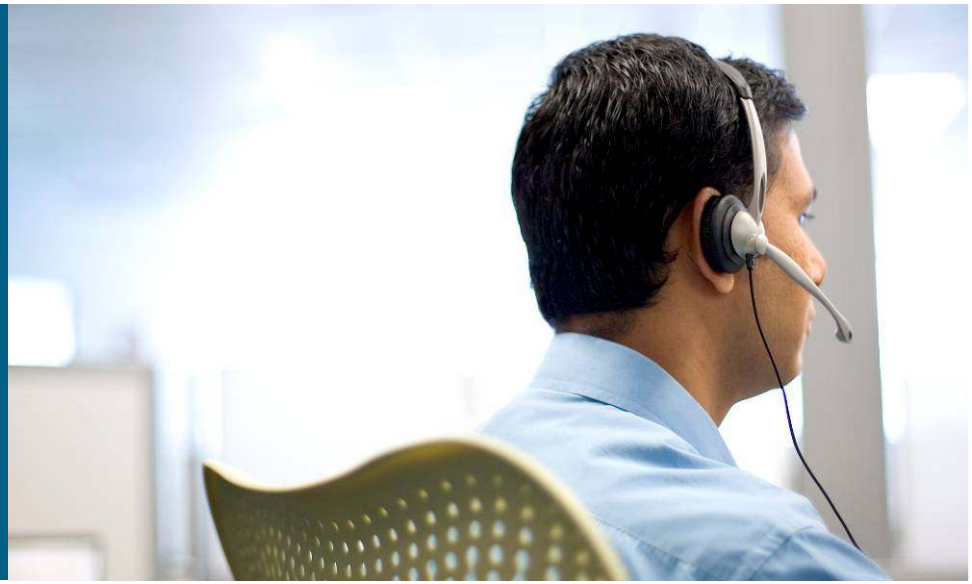
Wireless Mesh Design & Deployment



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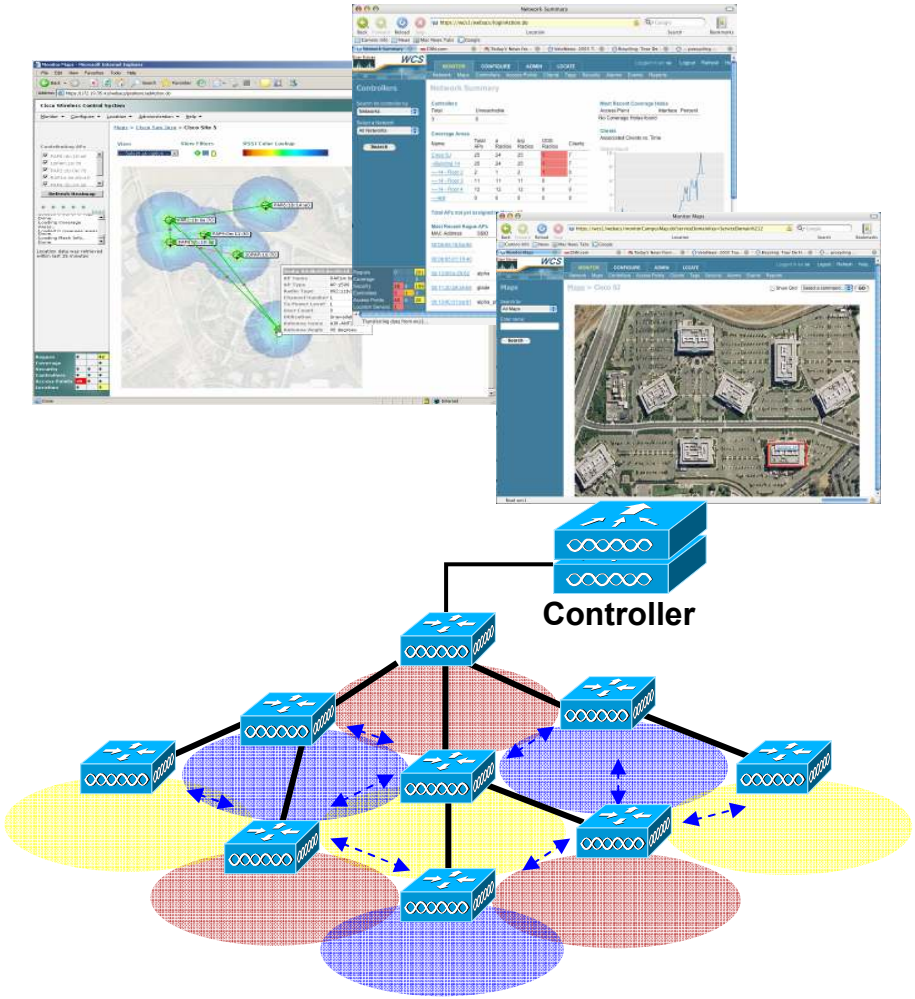
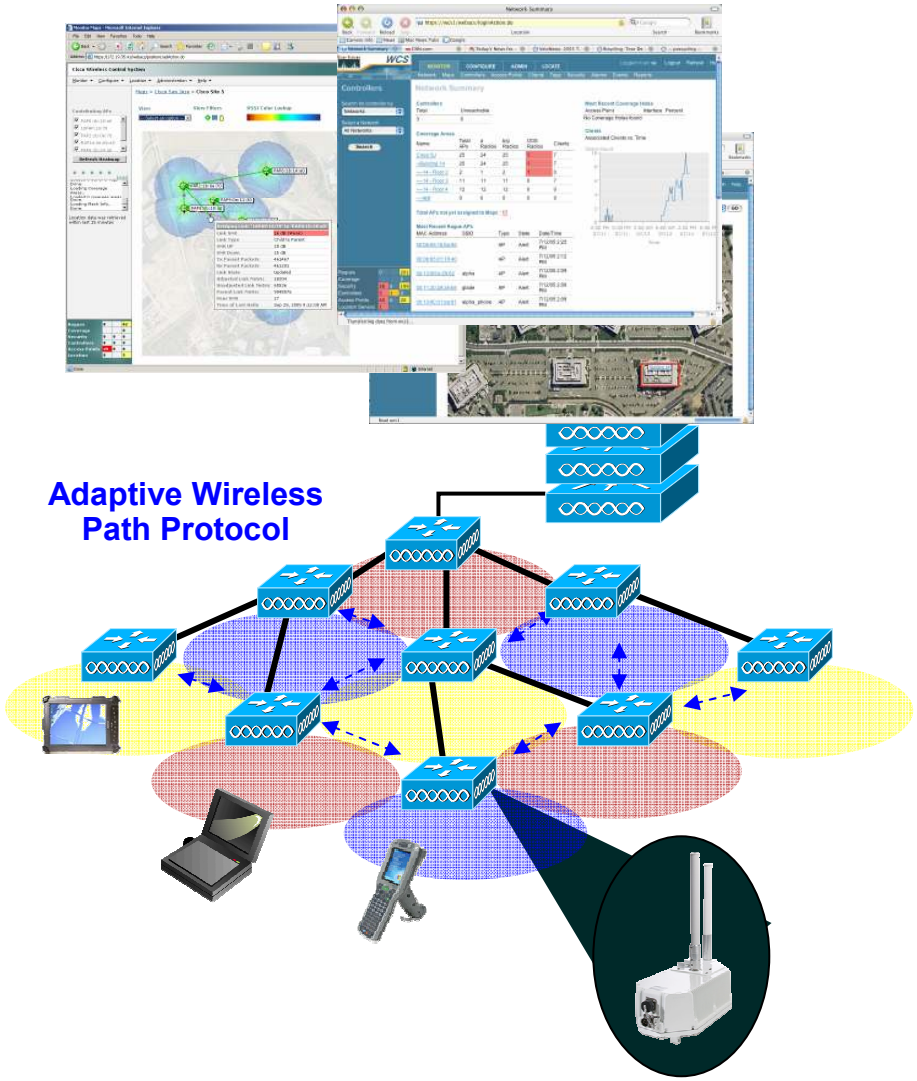
Cisco Networkers Solutions Forum 2007

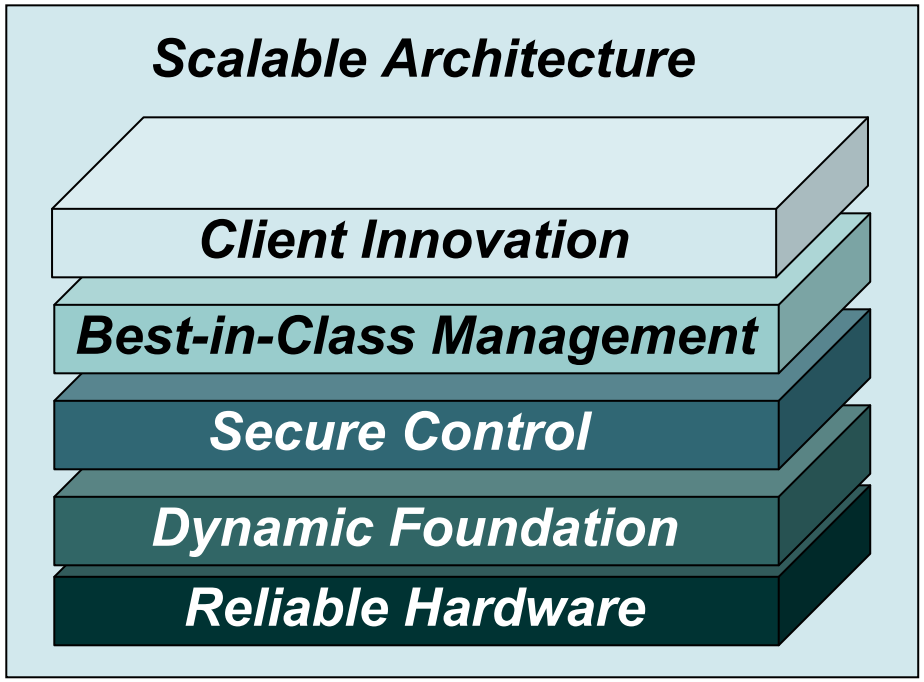
The Industry's 1st Intelligent Wireless Mesh Solution



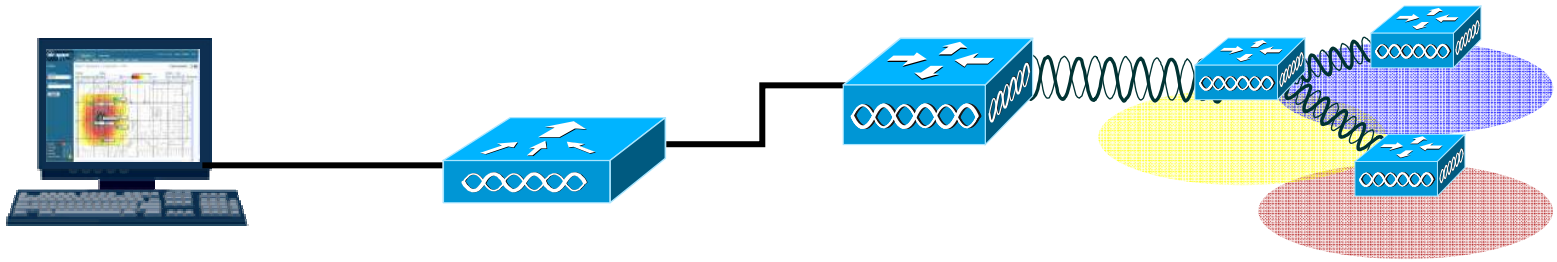
- Engineered with Ease of Deployment & Management as Top-of-Mind
  - Identical Indoor/Outdoor Management
  - Based on LWAPP
- Self-Configuring, Self-Healing Mesh
  - Zero-Touch Configuration
  - Cisco's new Adaptive Wireless Path (AWP) Protocol
- Robust Embedded Security
- Provides Seamless L3 Mobility

Wireless Mesh Networking Architecture





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

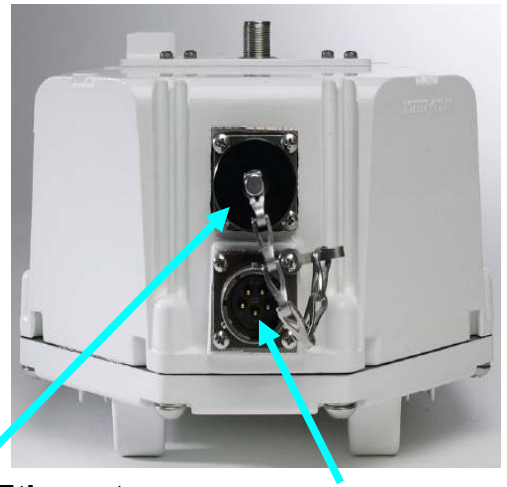
- Fixed Configuration, Dual Radio Outdoor AP
  - 802.11b/g - access; 802.11a - backhaul
  - S/W Upgradeable to 4.9GHz in Beringer (Mar 06)
- NEMA-4/IP66 Enclosure
  - Dimensions 13” x 6” x 8”
  - Weight < 12 lbs
  - Horizontal/Vertical swivel mounting brackets
- Industrial Grade Power Supply
  - Local 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

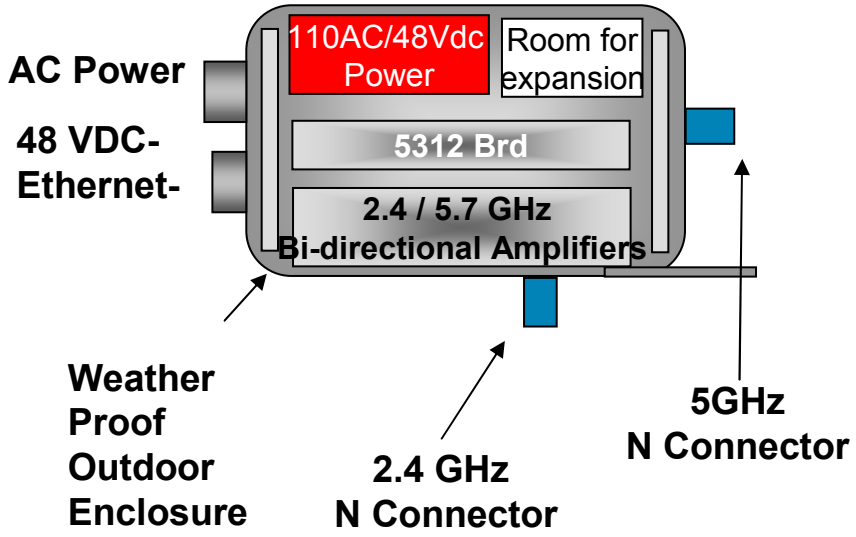
Reliable Hardware

Cisco’s Intensive MDVT and EDVT Standards

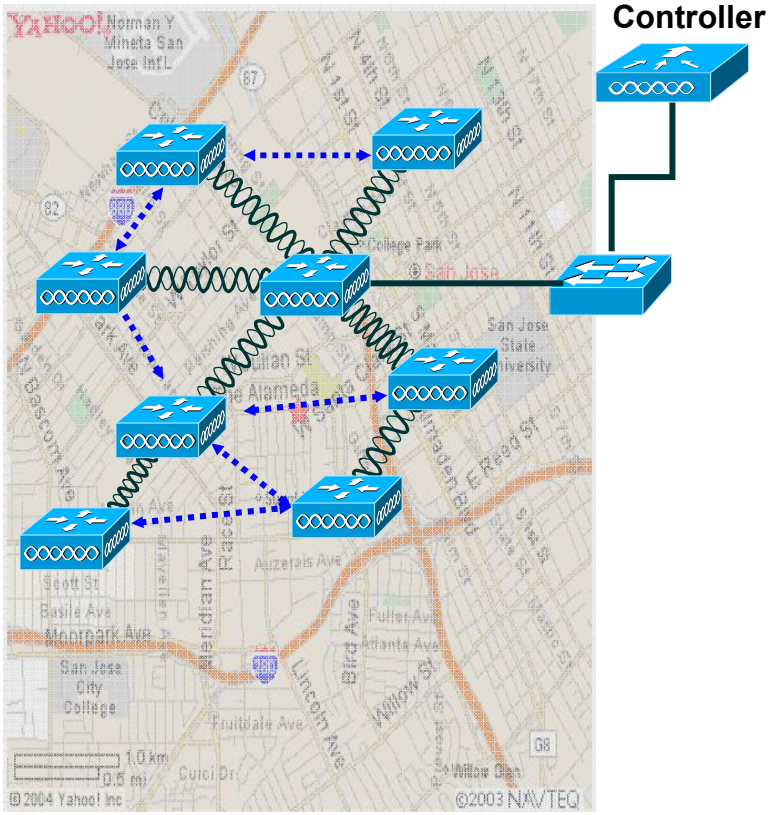
Aironet 1500 Lightweight Mesh AP, └ Cont.

- 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

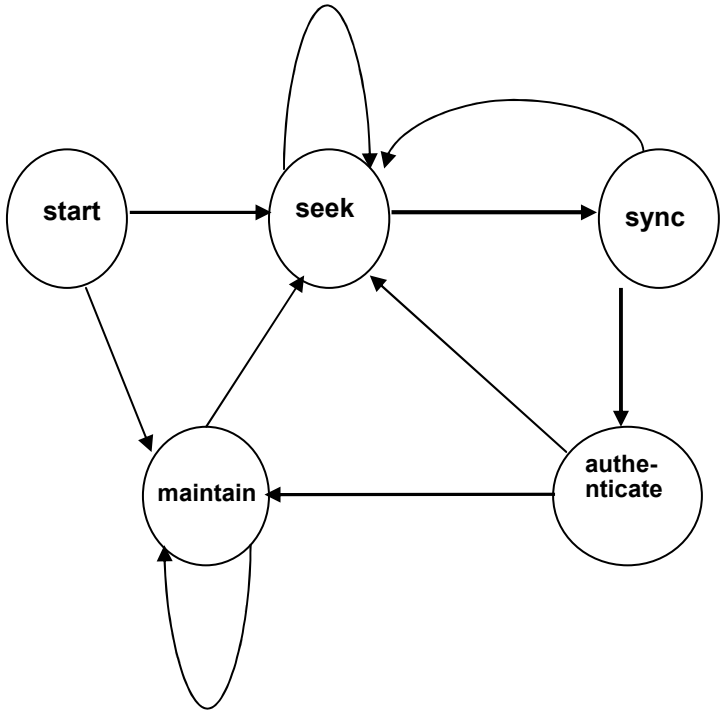
Dynamic Foundation	***Self-configuring, Self-healing, Dynamic Path Optimization***

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

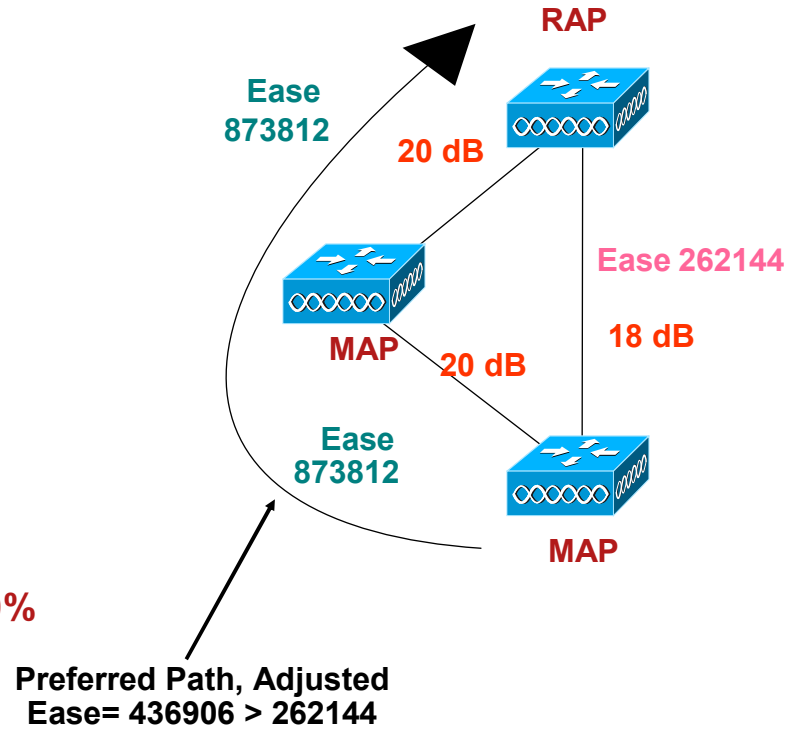


Dynamic Foundation ***Extensible Hybrid Distance-Vector Protocol***

Understanding Path Selection

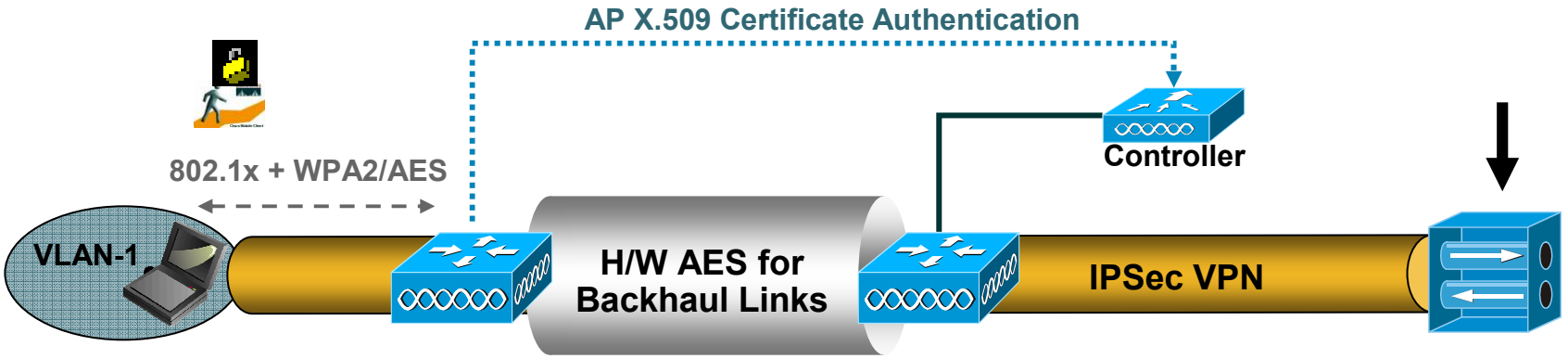
- Routing uses a concept of “Ease” (inverse of Cost)
- Route with the highest Adjusted Ease is taken
- Unadjusted ease is the minimum of all unadjusted links in the path to the RAP
- Adjusted ease is a hop count adjusted ease
  - Minimize latency
  - Minimize errors
  - Minimize use of the shared channel

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***

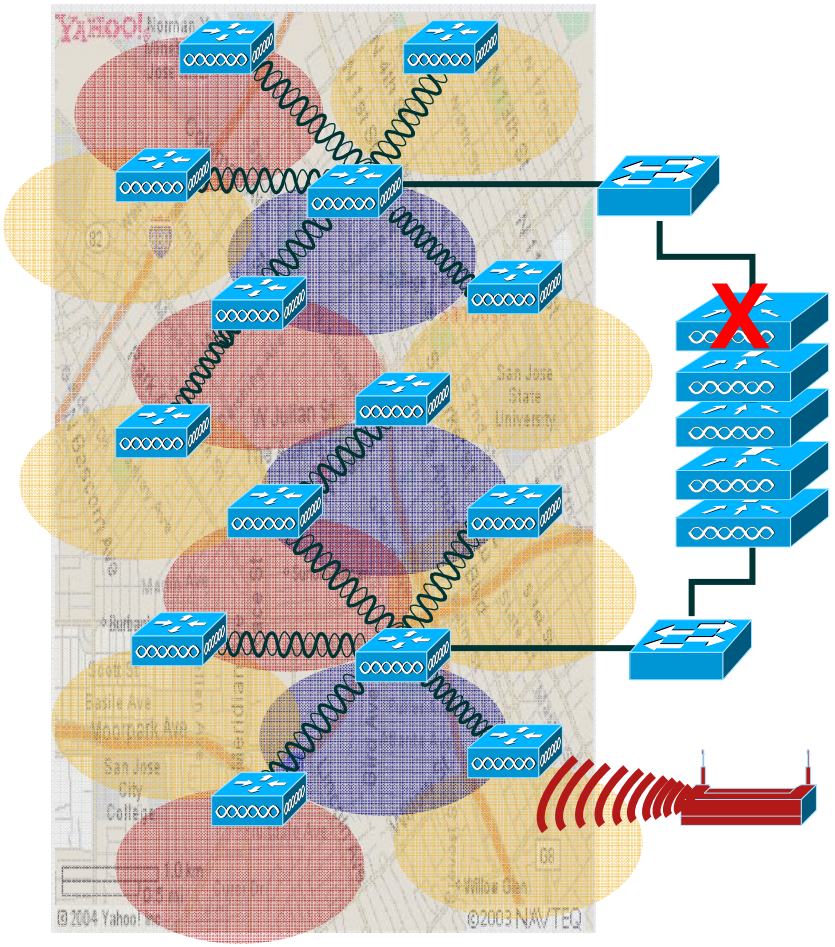
Providing Security at Each Step



- 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

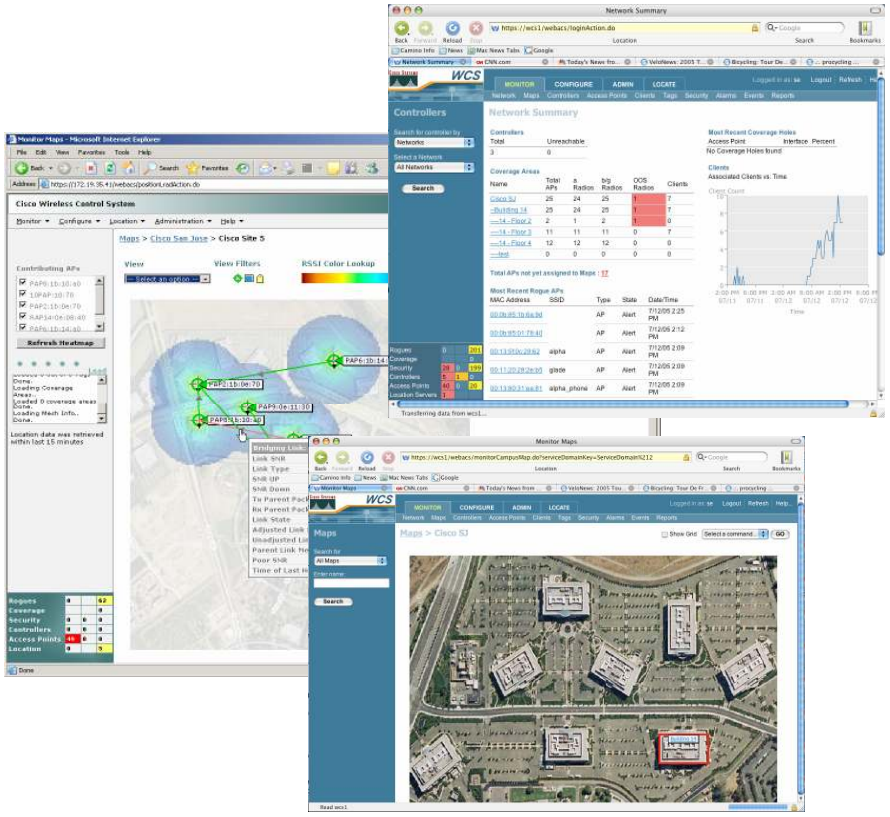
Secure Control ***Delivering Mission-Critical WiFi Access***

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

Cisco's Award Winning Management Solution



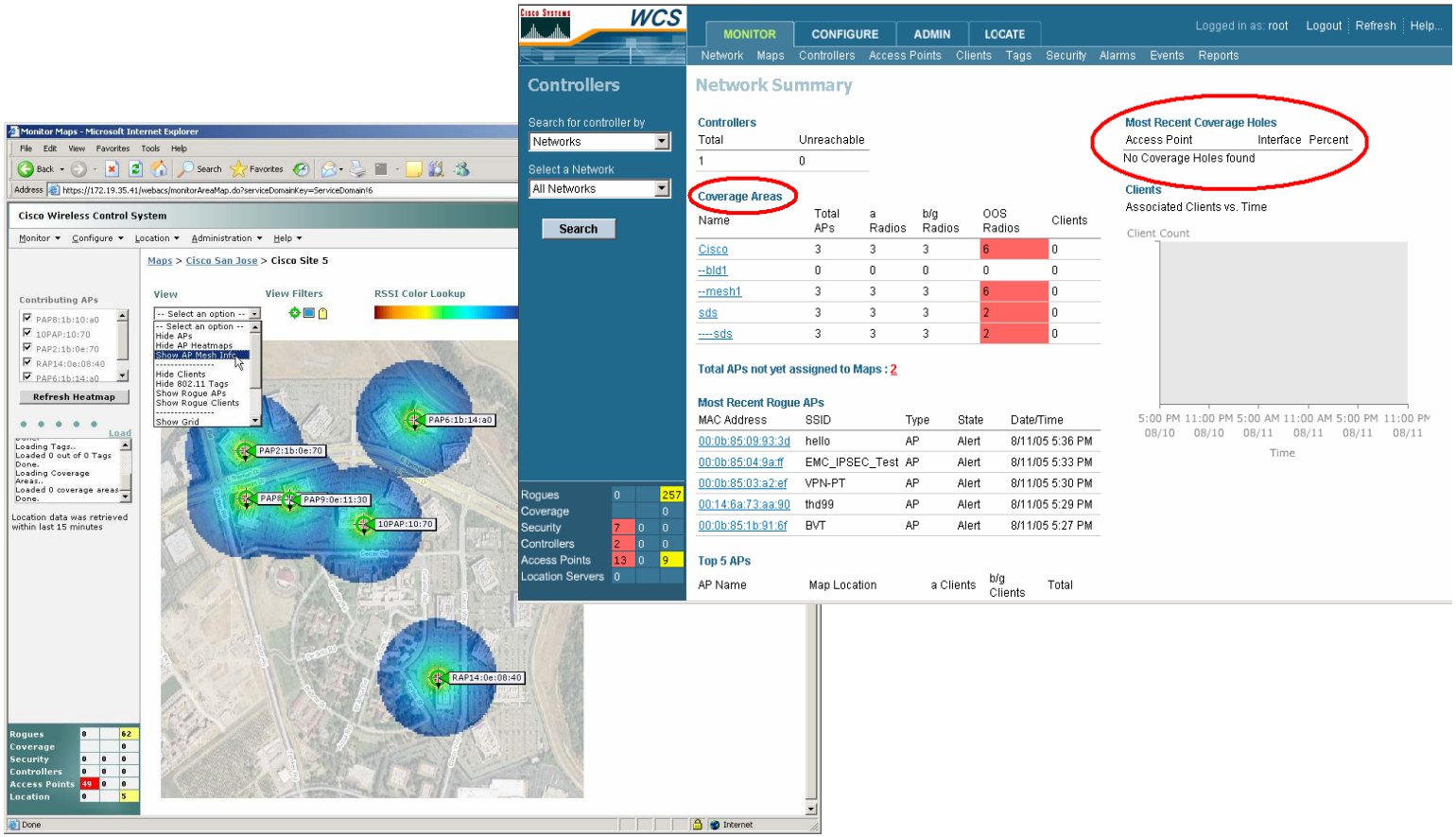
- Identical Management Software and RM Features as Indoor Solution
- SOAP/XML interfaces for NMS integration
- Detailed AP, Radio information including
  - Noise and Interference by Channel
  - Neighbors lists and RSSI detail
  - Link Metrics, PER, Tx/Rx detail
- Link Tests Tools for RAP-to-PAP troubleshooting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

Best-in-Class Management ***Easy to Deploy, Easy to Manage***

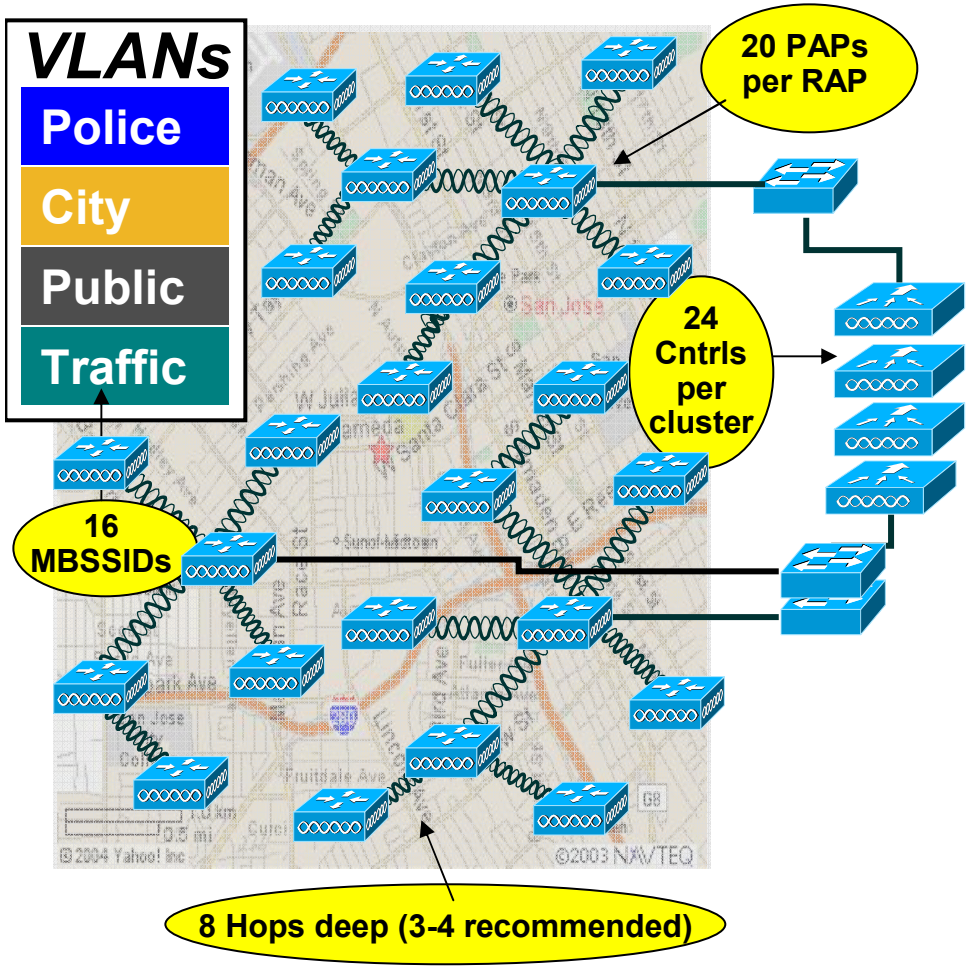
Mesh Enhancements in WCS

- **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

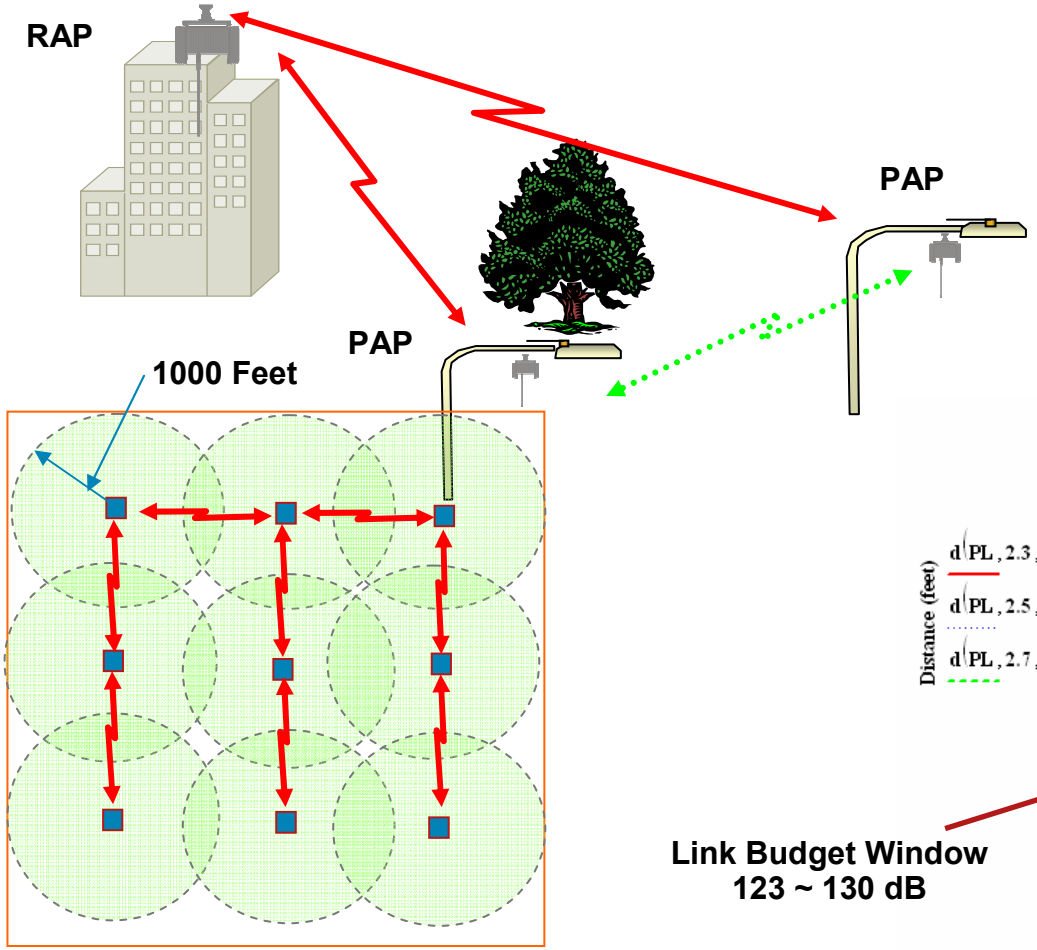


- Increase AP Density
- Add Root/Gateway APs
  - Pole-top APs will join new RAPs with better path metrics
- Easily add Controllers
  - Up to 24 controllers can be part of an N+1 cluster
- 802.11e QoS Capable + Traffic Rate-limiting for “hog” mitigation
  - 802.11e QoS in Beringer (Mar ‘06)
- Architecture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

Scalable Architecture	***Reliable, Secure, Manageable, Service-Ready Architecture***

WIRELESS MESH NETWORKING DESIGN AND DEPLOYMENT

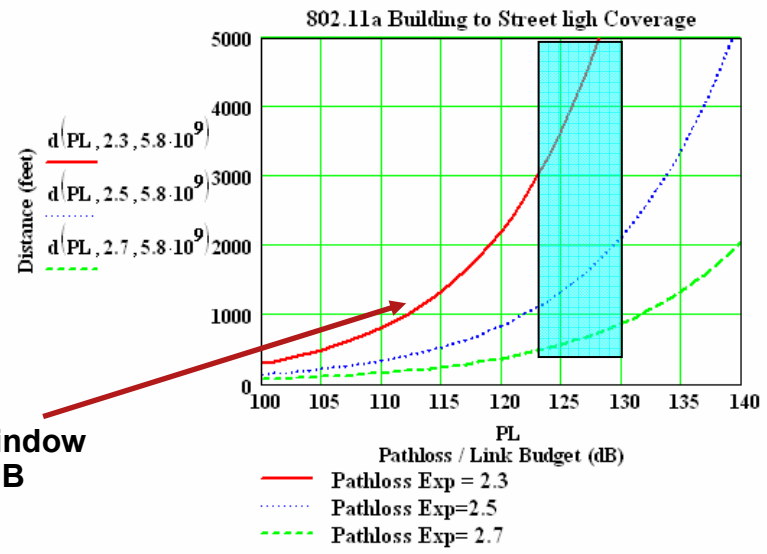
802.11a 5GHz Backhaul Distances



One Square Mile, 9 cells

1000 feet is the typical distance between the nodes

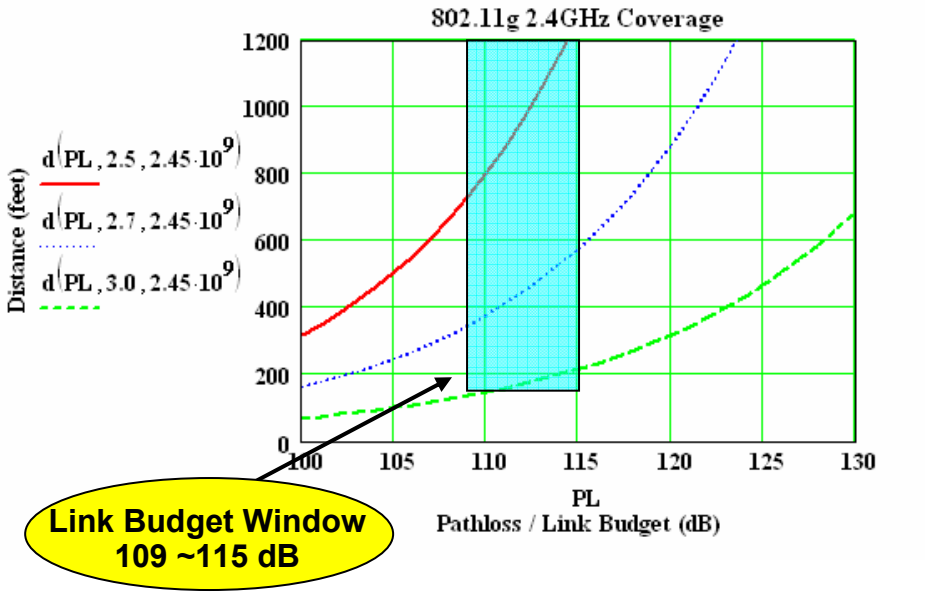
Path Loss exponent 2.3 to 2.7



Link Budget Window
123 ~ 130 dB

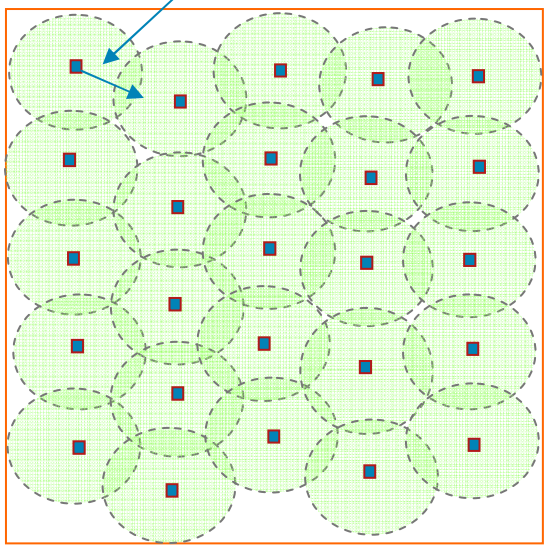
2.4 GHz Local Access Distances

Path Loss exponent 2.5 to 3.0



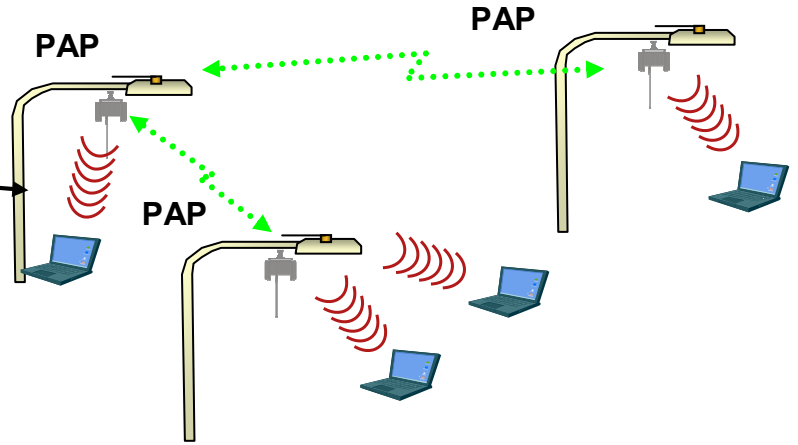
Link Budget Window
109 ~115 dB

600 feet (Typical distance)



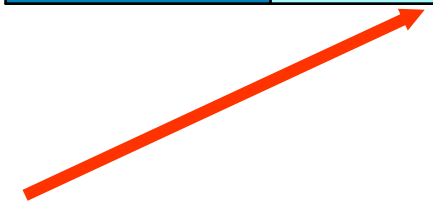
One Square Mile, 25 cells

Higher PLE due to Ground-level Noise and Interference



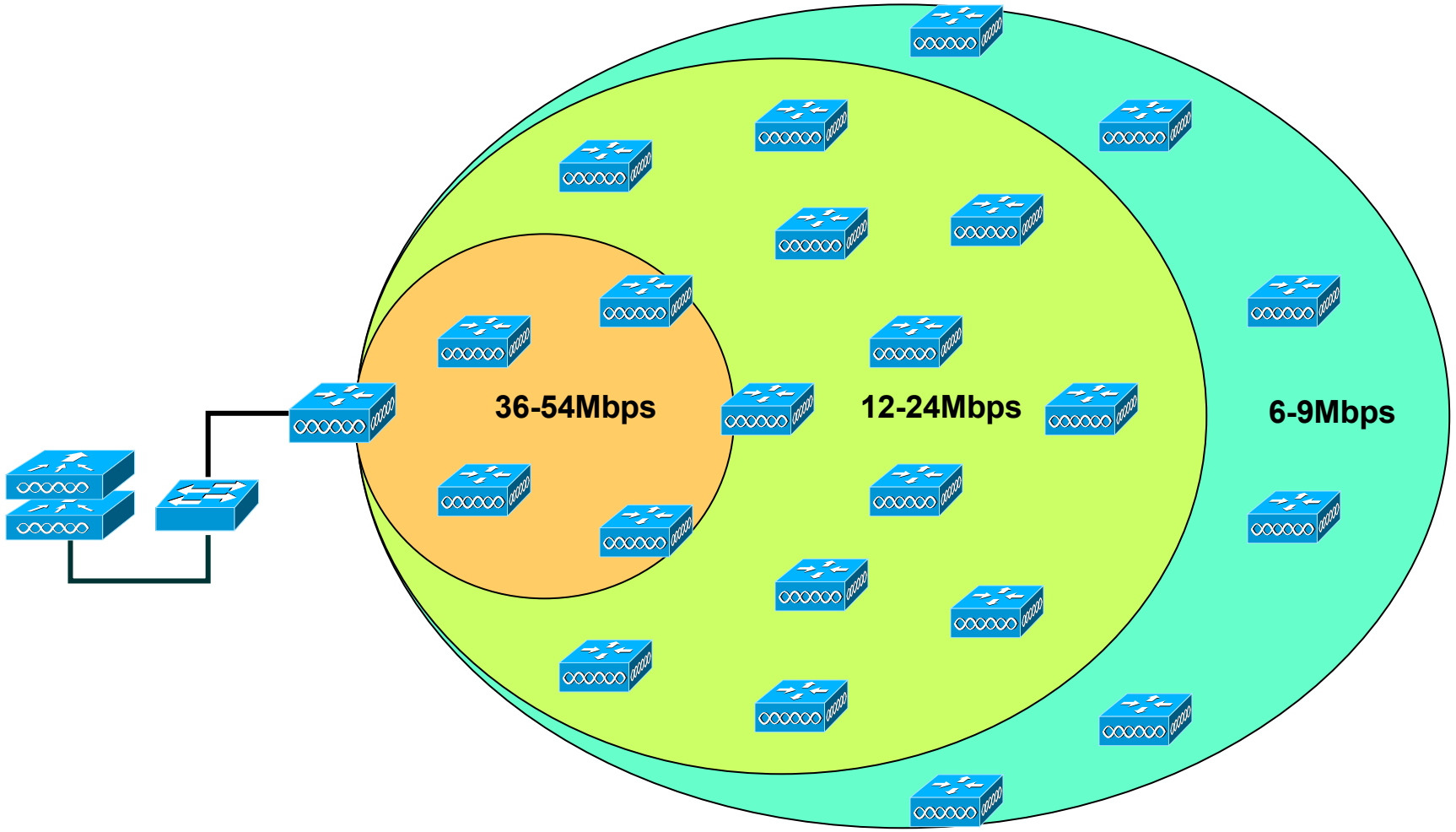
Data Rates

802.11b	1,2,5.5,11
802.11g	1,2,5.5,11,6,9,12,18,24,36,48,54
802.11a	6,9,12,18,24,36,48,54

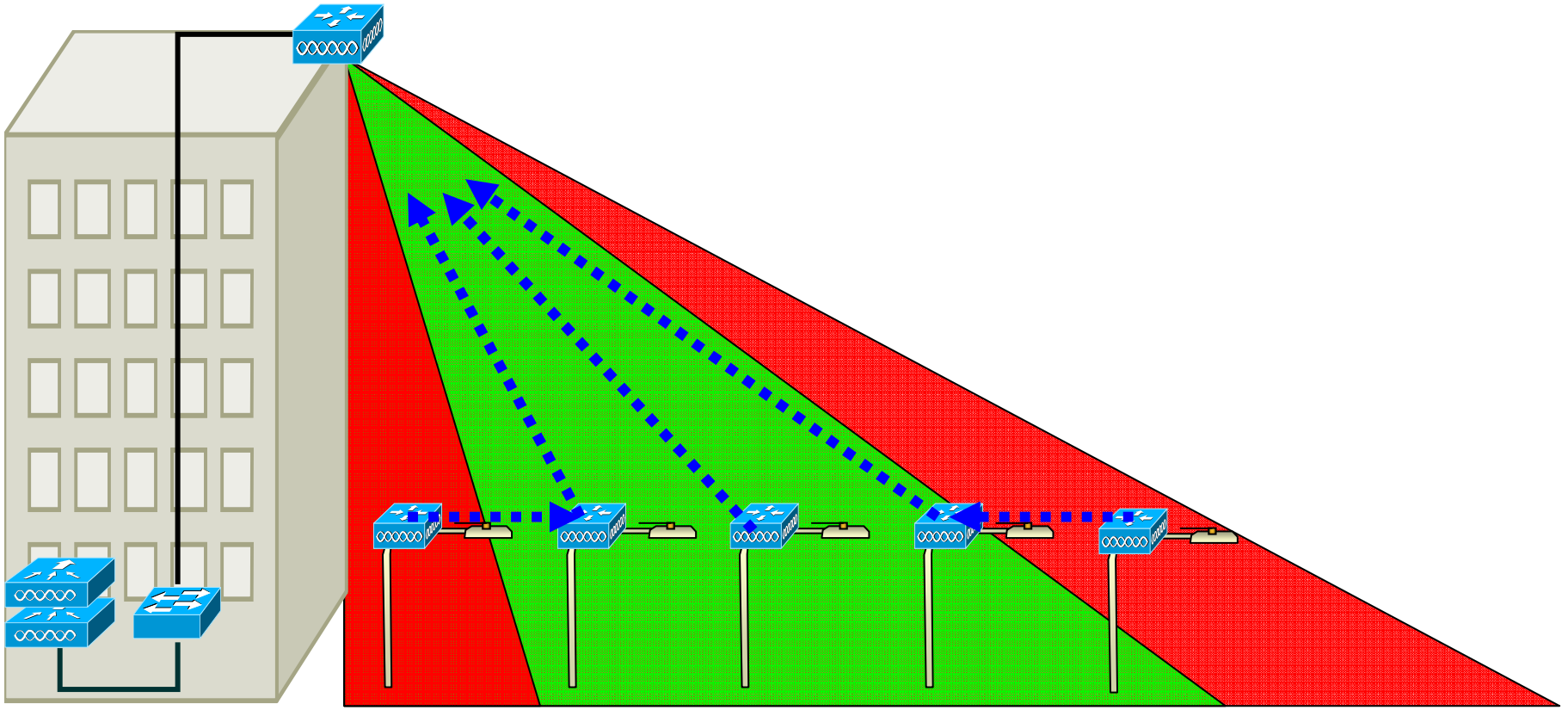


- **18 Mbps is the default fixed rate set for the backhaul**
- **We recommend to use 18 Mbps as the data rate for the backhaul**
- **Data rates for all the APs in a bridge group must match**

Why is 18Mbps the “Sweet Spot”



Understanding RAP Coverage Areas

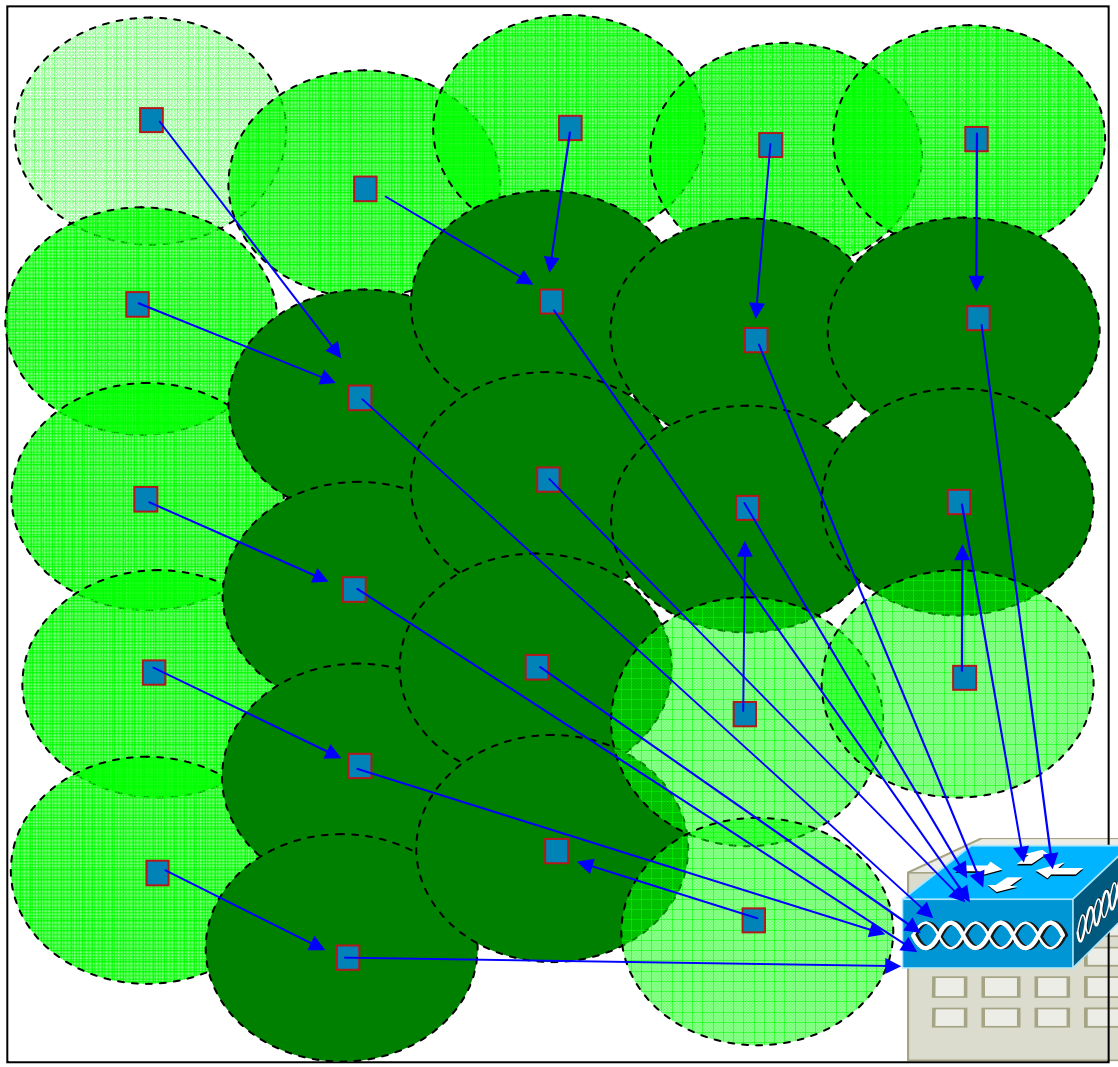


RF “Shadow” close to building; Poor SNR

18Mbps Coverage Area; SNR >20 dB

Beyond RF Coverage Area; Poor SNR

Applying RAP Coverage Areas to Designs

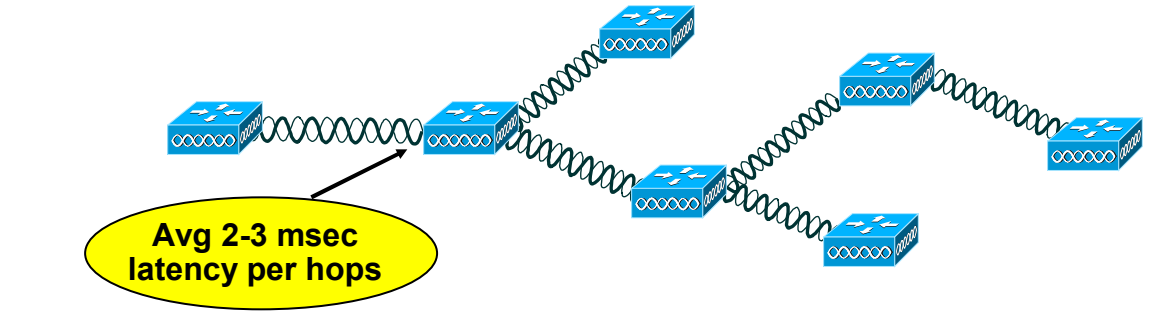


1 hop to RAP

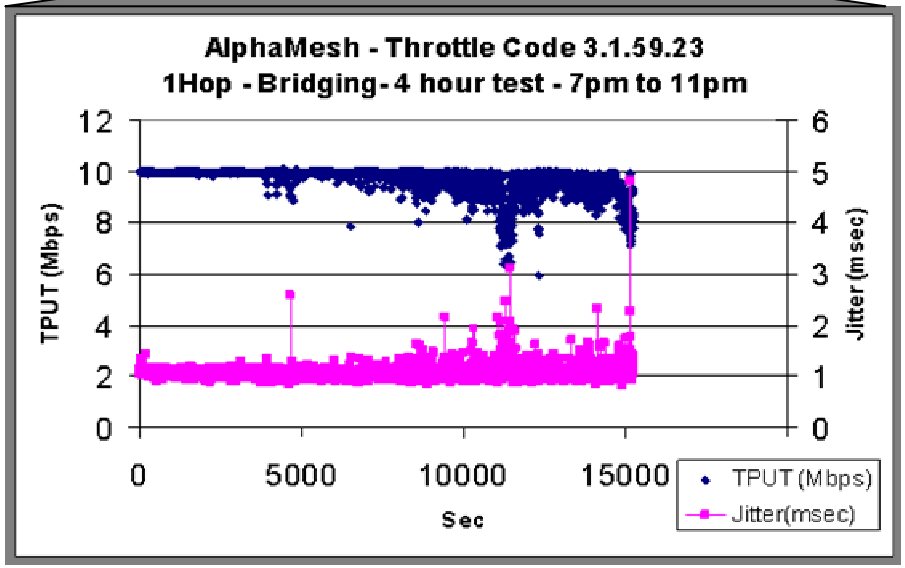
2 hops to RAP

2 hops to RAP

Typical Throughput and Latency



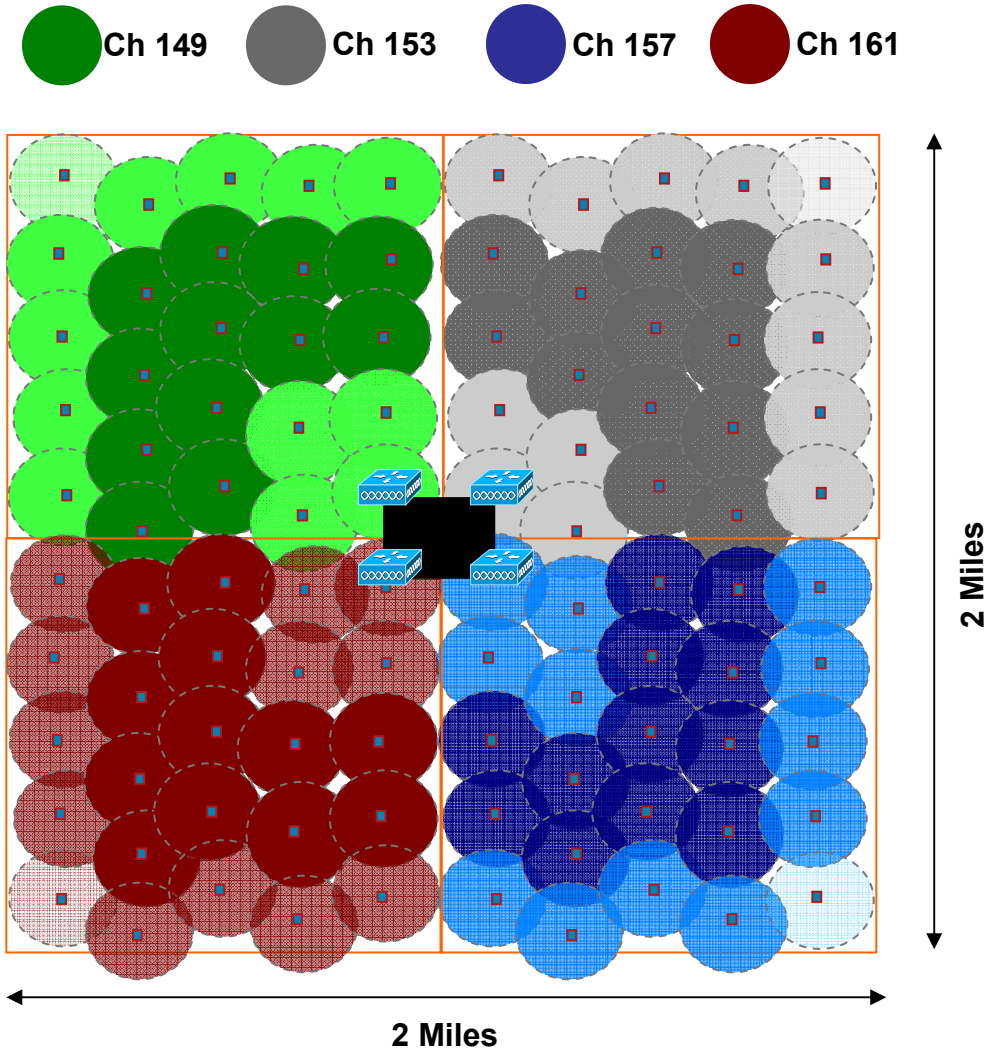
HOPS	One	Two	Three	Four
Throughput	~10Mbps	~5Mbps	~3Mbps	up to 1Mbps *



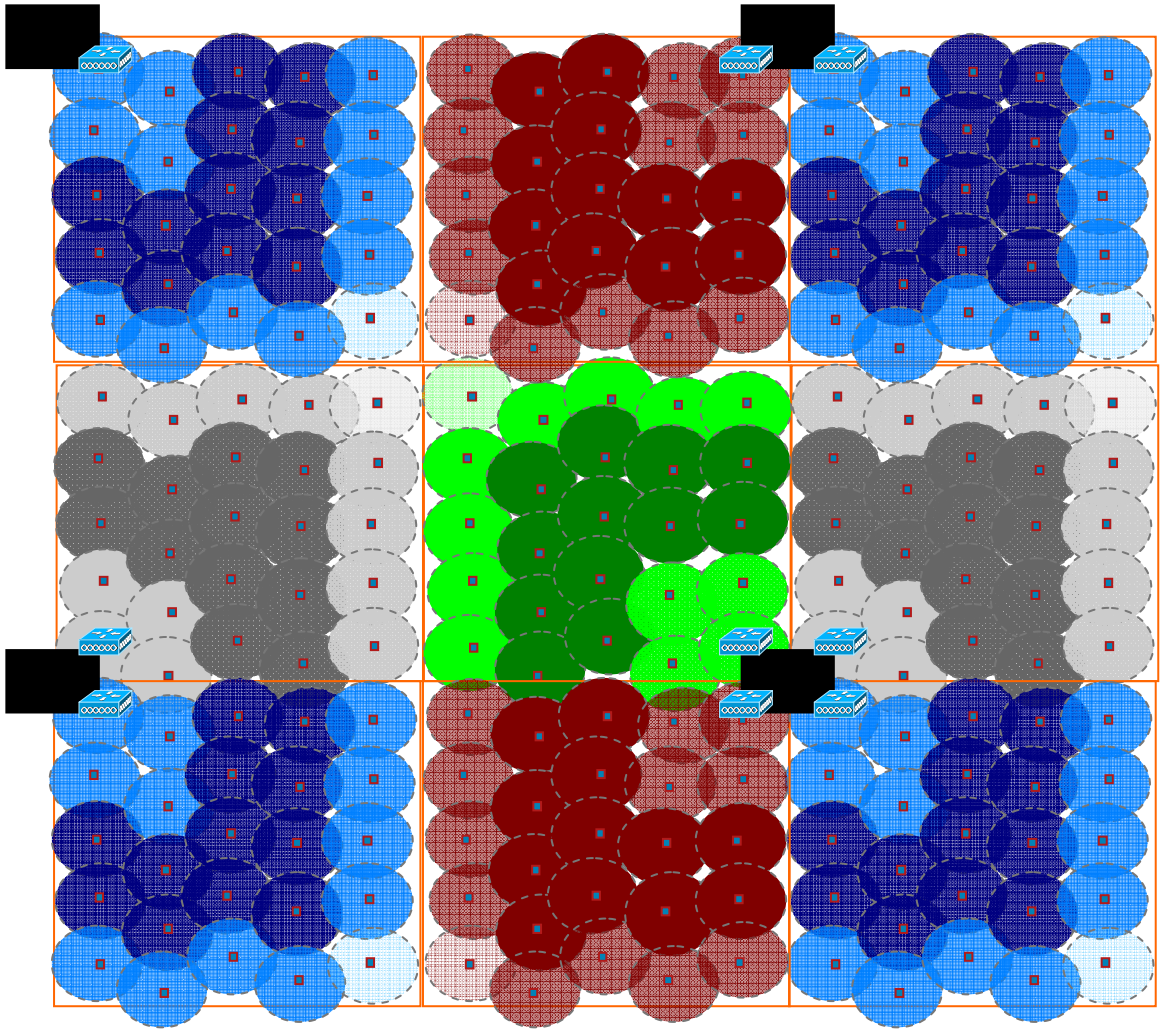
* more data to be collected

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

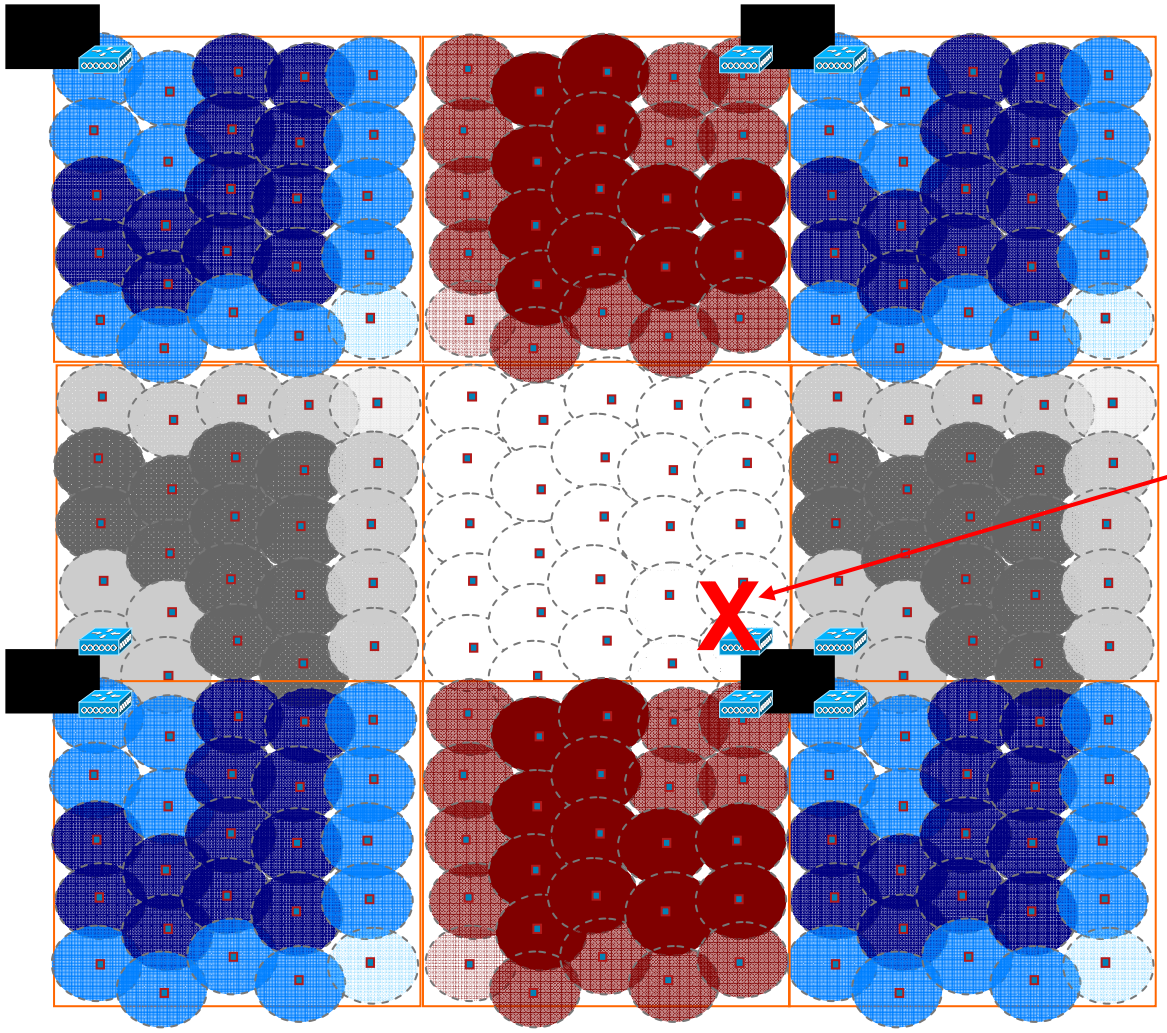


Mesh is in "Maintain State" and passing traffic…

…wiring closet switch port is 'disabled'

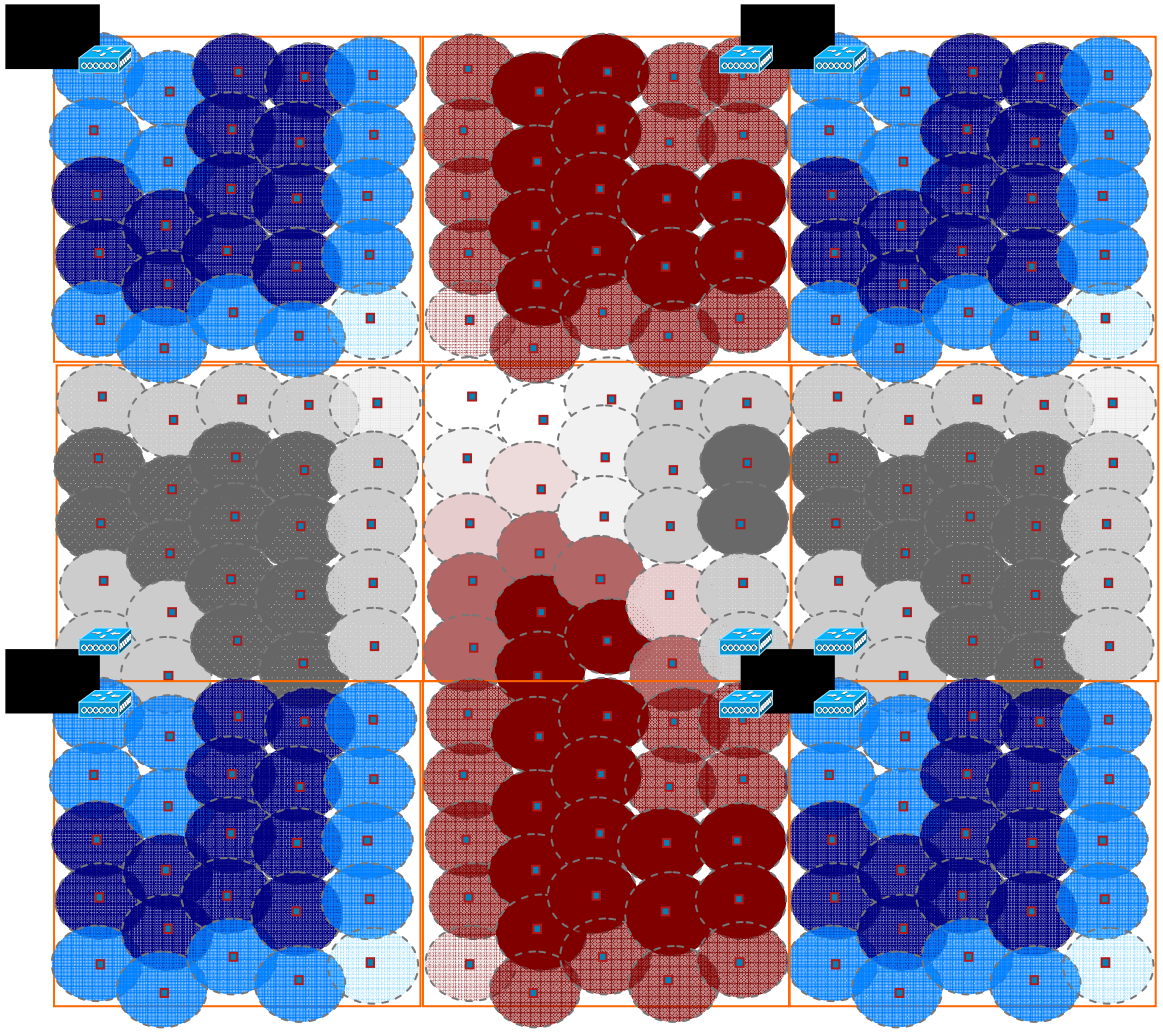
(True story)

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