



IEEE 802.11n과 MESH

The Next Generation of Wireless Performance



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김준표

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Business Mobility Trends

Proliferation of Wi-Fi Devices

Businesses deploying wireless pervasively

Expect wireless performance close to wired for business applications

Over 1.1 billion Wi-Fi clients will ship within the next 3 years

IDC



Business mobility delivered with next generation wireless

Wi-Fi Challenges

Collaborative
Apps



High-Bandwidth
Applications



Support of
Mixed Client
Environments



Challenging RF
Environments



Business Ready Wireless Attributes

Throughput

The diversity and growth of mobile applications is driving the need for increased wireless bandwidth

Reliability

The introduction of real-time collaborative applications like voice and video requires low latency wireless connections

Predictability

The increase in interference demands more predictable coverage to reduce dead spots for consistent connectivity



802.11n solution

802.11n Cisco Next Generation Wireless Solution



Cisco Next Generation Wireless Solution

Overview

Aironet 1250 Series AP



First Wi-Fi Certified 802.11n Draft 2.0 Access Point

- Modular, field upgradeable
- Investment protection for future RF technologies

Catalyst Switches



Industry's Only 802.11n, Gigabit Power Over Ethernet Switch

- Will fully power AP1250 from a single GigE port
- Delivers full aggregation capacity for next generation throughput

Catalyst 6500 WiSM



Widest WLAN Controller Flexibility to Support Full 802.11n Capacity

- Support for 7 WiSMs per Catalyst 6509
- Scalable controller capacity up to 56Gbps

The Aironet 1250 Series Access Point

- Industry's first Wi-Fi Certified 802.11n draft 2.0 access point
- Modular platform
 - Field upgradeable radio modules/future technologies
- Higher speed WLAN technologies
 - Faster CPU to handle higher data throughput
 - Increased memory for expanded feature set
 - 10/100/1000 Ethernet port
- Available in Unified (LWAPP) and Standalone versions



New Antennas for Aironet 1250 Series

- Omnidirectional

Single enclosure with 3 antenna elements

2.4 GHz 3dBi (AIR-ANT2430V-R)

5 GHz 4 dBi (AIR-ANT5140V-R)



- Dipoles

New dipole without hinge (gray)

2.4 GHz 2.2 dBi (AIR-ANT2422DG-R)




5 GHz 3.5 dBi (AIR-ANT5135DG-R)

Also supports existing dipoles with hinge (black & white)



- Blue dot indicates 5 GHz

Aironet Access Point Portfolio Comparison

	AP 1130 	AP 1240 	AP 1250 
Modular Platform	No	No	Yes
Data Uplink (Mbps)	10/100	10/100	10/100/1000
Power Requirement	802.3af (11.1 W)	802.3af (12.95 W)	802.3af* 802.3at* (18 W)
Installation	Standard	Rugged	Rugged
Antennas	Internal	External	External
Wi-Fi 802.11n draft 2.0 Certified	No	No	Yes
DRAM	32 MB	32 MB	64 MB
Flash	16 MB	16 MB	32 MB

* Powers AP1250 with a single radio only, 802.3at is still a draft standard

Power

- Dual-band Aironet 1250 requires more than 15.4 Watts
802.3af is not sufficient power to deliver all features

Ethernet switch power options

- Cisco PoE switches enhanced to support higher power requirement of 1250

Catalyst 3750-E / 3560-E

24 port: 20 AP1250s

48 port: 40 AP1250s

Catalyst 4500 and 6500 families

Other power options

- AP1250 Power Injector (AIR-PWRINJ4)
- AP1250 Power Supply (AIR-PWR-SPLY1)
- 802.3af Ethernet switch (single radio only)

Not Supported

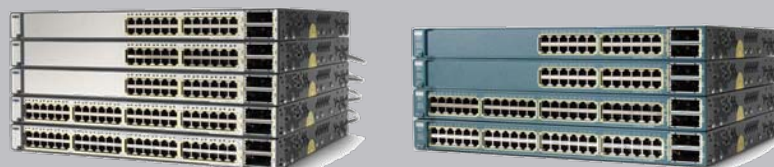
- Cisco PoE (6W), Cisco PoE (13W), Cisco mid-span (CMS), AIR-PWR-A, PWRINJ-FIB, PWRINJ3, AIR-PWRINJ1500

Only 11n Access Point to be Fully Powered by a Single Switch Port

Power



Catalyst Switches



The Classroom of the Future

Duke University

Cisco Aironet 1250 Series

Business Challenge

- Expand educational applications in the classroom
- Continue to attract new students through a reputation for innovation and progressiveness
- Wireless bandwidth to accommodate new applications

Deployment Overview

- Deployed in Epworth hall for improved coverage and throughput
- Mix of laptops – existing ABG and N
- Real-world throughput rates of 130mbps
- Deployment moving into the 1000s of access points – campus wide coverage over the coming months



Duke
UNIVERSITY

“The network must evolve to address our users' needs, and 802.11n is an obvious choice to support the growth in high-bandwidth applications.”

Kevin Miller
Associate Director
Communications Infrastructure
Duke University

Campus Wide Mobility

Concordia University of Montreal

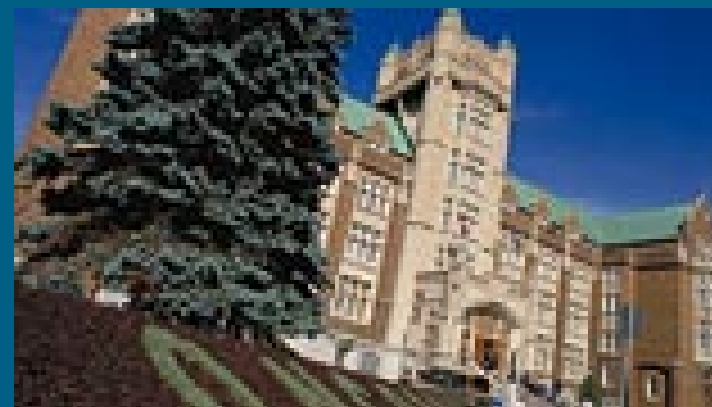
Cisco Aironet 1250 Series

Business Challenge

- Montreal, Canada University with 40,000 students
- Enable high density wireless access using 802.11n for bandwidth intensive applications
- Provide reliable coverage and greater performance for 802.11a/b/g clients with 802.11n MIMO technology
- Prepare campus for future 802.11n clients
- Deliver VoWLAN for dual-mode phones and Seamless Mobile Collaboration (SMC)

Deployment Overview

- Deploying 60+ 802.11n access points by Jan 1st 2008
- On-going migration of 300+ standalone access points to the Unified architecture and Cisco Aironet 1250 Series
- Modularity of Cisco's 802.11n solution future proofs the network



Concordia
UNIVERSITY



Cisco Next Generation Wireless Key Benefits

RF Leadership

- Industry's first enterprise draft 11n AP
- Enhanced reliability and predictability for existing 802.11a/b/g clients
- High throughput support for 802.11n draft 2.0 clients

Investment Protection

- Modularity provides investment protection
- Platform designed to support future advanced technologies
- Cisco Technology Migration Program

Interoperability

- Reference platform for the Wi-Fi Alliance 802.11n certification program
- Wi-Fi CERTIFIED 802.11n draft 2.0
- Intel Connect with Centrino certification
- Extensive testing in 802.11n plug fests

Unified Wireless + Wired

- Industry only end-to-end, unified wired and wireless solution
- Catalyst switches provide full power and aggregation capacity for next generation throughput
- Scalable controller capacity to 48Gbps

802.11n Technical Update



Wireless has Become Business Oxygen

- Business applications have gone mobile
- Wireless is evolving to meet needs for high performance, pervasive connectivity

Point Applications

- Inventory Management
- Barcode Scanning



802.11
2Mbps

Mobile Data

- Email
- Web browsing



802.11b
11Mbps



Business Ready

- Voice, Video, Data



802.11ag
54Mbps



Next Gen Wireless

- Ubiquitous mobile computing



802.11n
300Mbps



Wi-Fi Device Proliferation

Technical Elements of 802.11n

MIMO

40Mhz Channels

Packet
Aggregation

Backward
Compatibility

MIMO

40Mhz
Channels

Packet
Aggregation

Backward
Compatibility

Aspects of 802.11n

MIMO

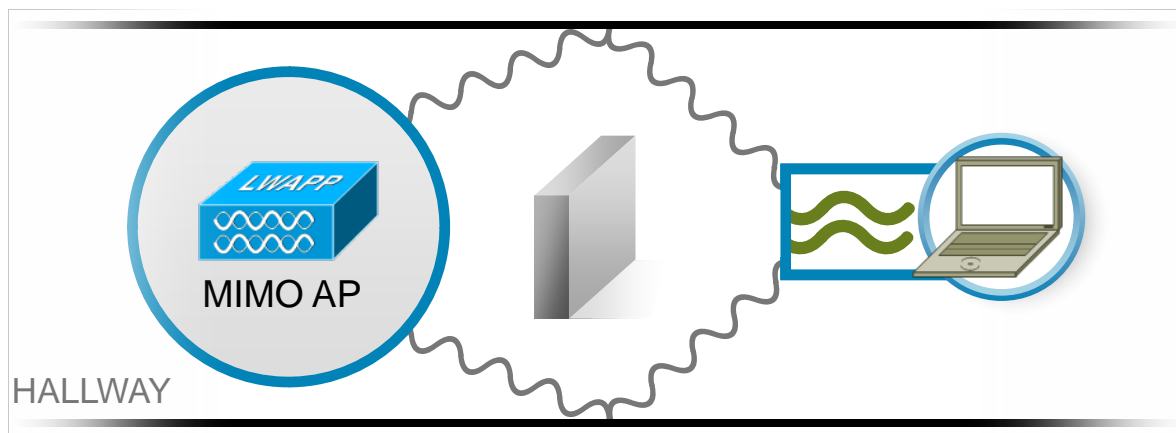
40Mhz Channels

Packet
Aggregation

Backward
Compatibility

MIMO (Multiple Input, Multiple Output)

With Beamforming Transmits in Phase, Increasing Signal Strength
Without Beamforming Transmits out of Phase



Performance

Performed by
Transmitter
(Talk Better)

Ensures Signal
Received in
Phase

Increases
Receive
Sensitivity

Works with
non-MIMO and
MIMO Clients

Beam Forming

Maximal Ratio Combining

Spatial Multiplexing

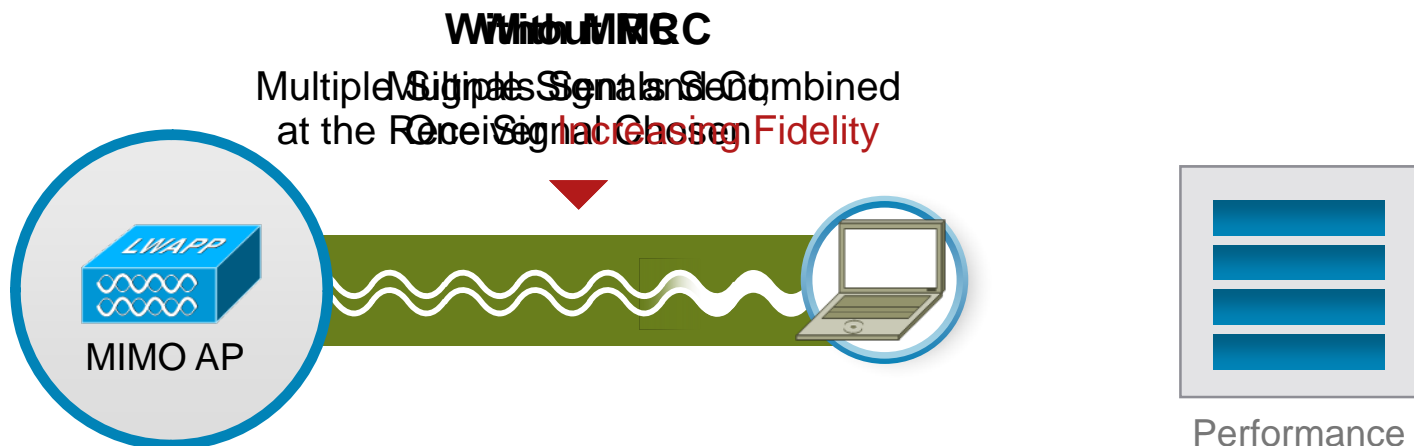
Aspects of 802.11n

40MHz Channels

Packet
Aggregation

Backward
Compatibility

MIMO (Multiple Input, Multiple Output)



Performed by
Receiver
(Hear Better)

Combines
Multiple Received
Signals

Increases
Receive
Sensitivity

Works with
non-MIMO and
MIMO Clients

Beam Forming

Maximal Ratio Combining

Spatial Multiplexing

Aspects of 802.11n

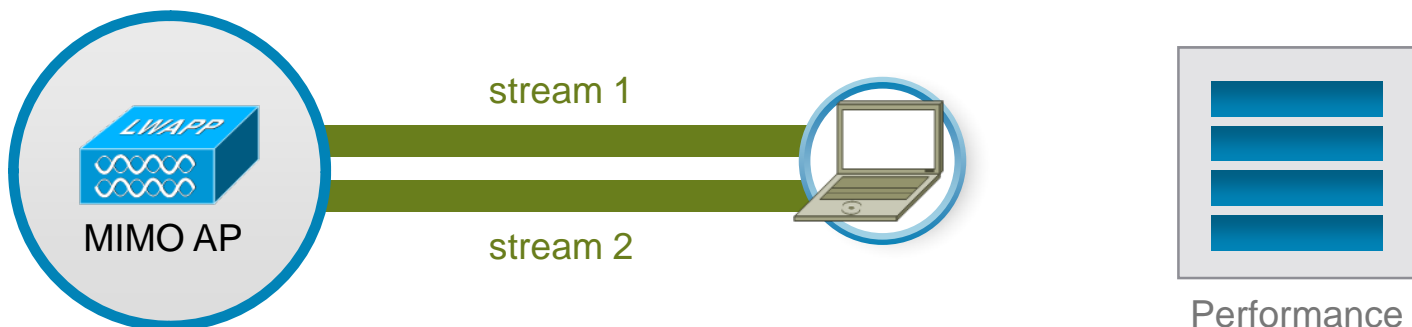
40Mhz Channels

Packet
Aggregation

Backward
Compatibility

MIMO (Multiple Input, Multiple Output)

Information Is Split and Transmitted on Multiple Streams



Transmitter and
Receiver
Participate

Concurrent
Transmission on
Same Channel

Increases
Bandwidth

Requires MIMO
Client

Beam Forming

Maximal Ratio Combining

Spatial Multiplexing

Aspects of 802.11n

MIMO

40Mhz Channels

Packet
Aggregation

Backward
Compatibility

40Mhz Channels

Moving from 2 to 4 Lanes



40-MHz = 2 aggregated 20-MHz channels—takes advantage of the reserved channel space through bonding to gain more than double the data rate of 2 20-MHz channels

Aspects of 802.11n

MIMO

40Mhz Channels

Packet
Aggregation

Backward
Compatibility

Packet Aggregation

Carpooling Is More Efficient Than Driving Alone



Without Packet Aggregation

802.11n
Overhead

Data
Unit
Packet

802.11n
Overhead

Data
Unit
Packet

802.11n
Overhead

Data
Unit
Packet

802.11n
Overhead

Data Unit

Packet

Packet

Packet

With Packet Aggregation

Aspects of 802.11n

MIMO

40Mhz Channels

Packet
Aggregation

Backward
Compatibility

Backward Compatibility

2.4GHz

5GHz

11n Operates
in Both
Frequencies

802.11ABG Clients Interoperate with 11n AND
Experience Performance Improvements

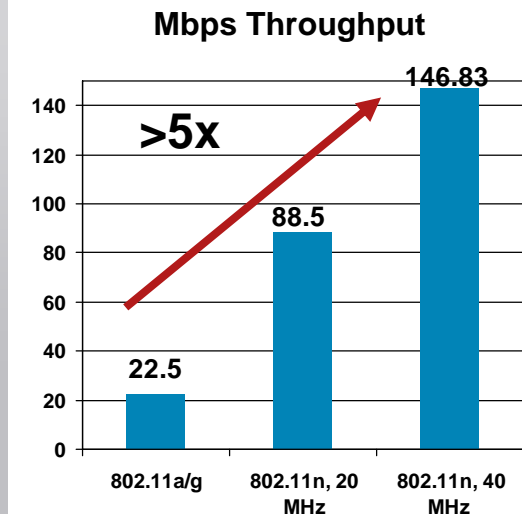
802.11n

It's About a Whole Lot More Than Speed

Throughput

5x more throughput

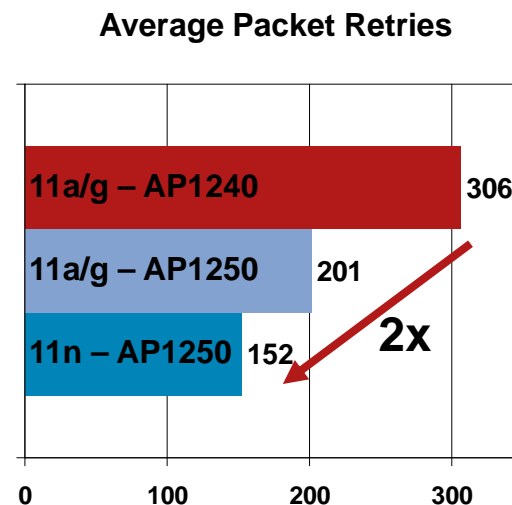
Enhanced file transfer and download speeds for large files



Reliability

2x more reliable

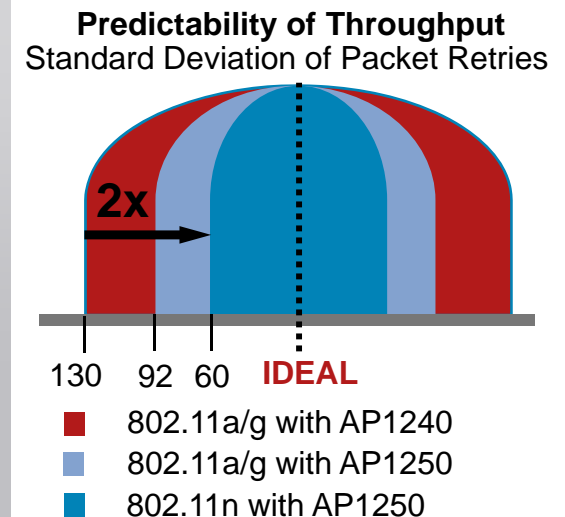
Lower latency for mobile unified communications



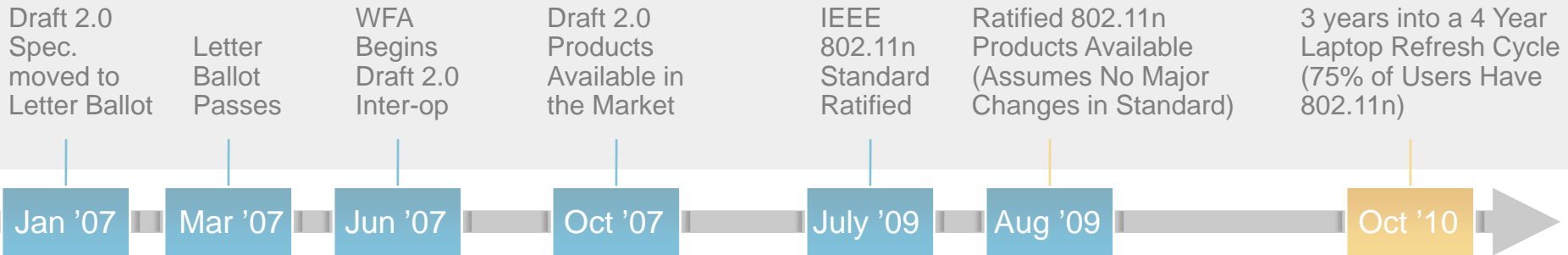
Predictability

2x more predictable

More consistent coverage and throughput for mobile applications



IEEE and the Wi-Fi Alliance

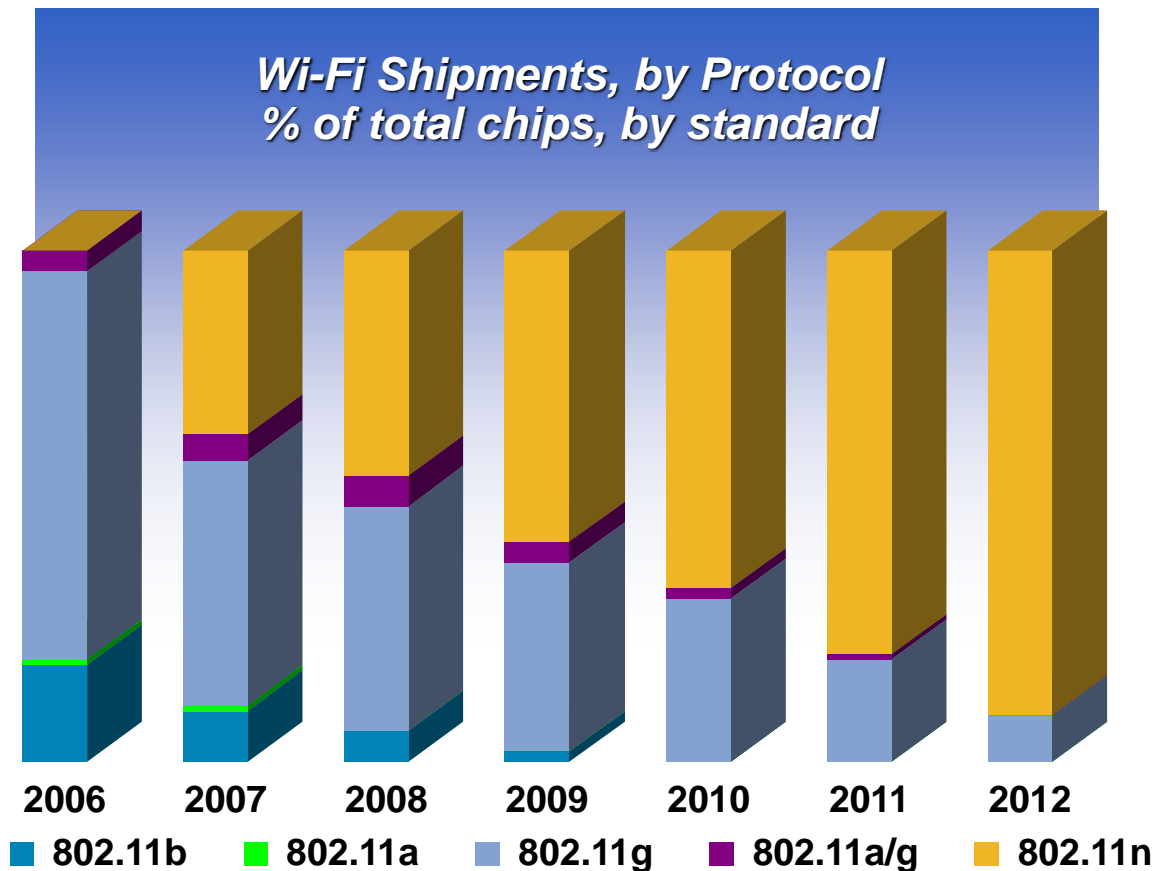


While changes to the standard are unlikely to require any hardware modifications to the existing Cisco AP, the platform is **modular** to ensure investment protection

The Client Drives the Migration

- Enterprise-class 802.11n clients widely available

Laptop refresh cycle at 20% - 30% per year



11n



11n



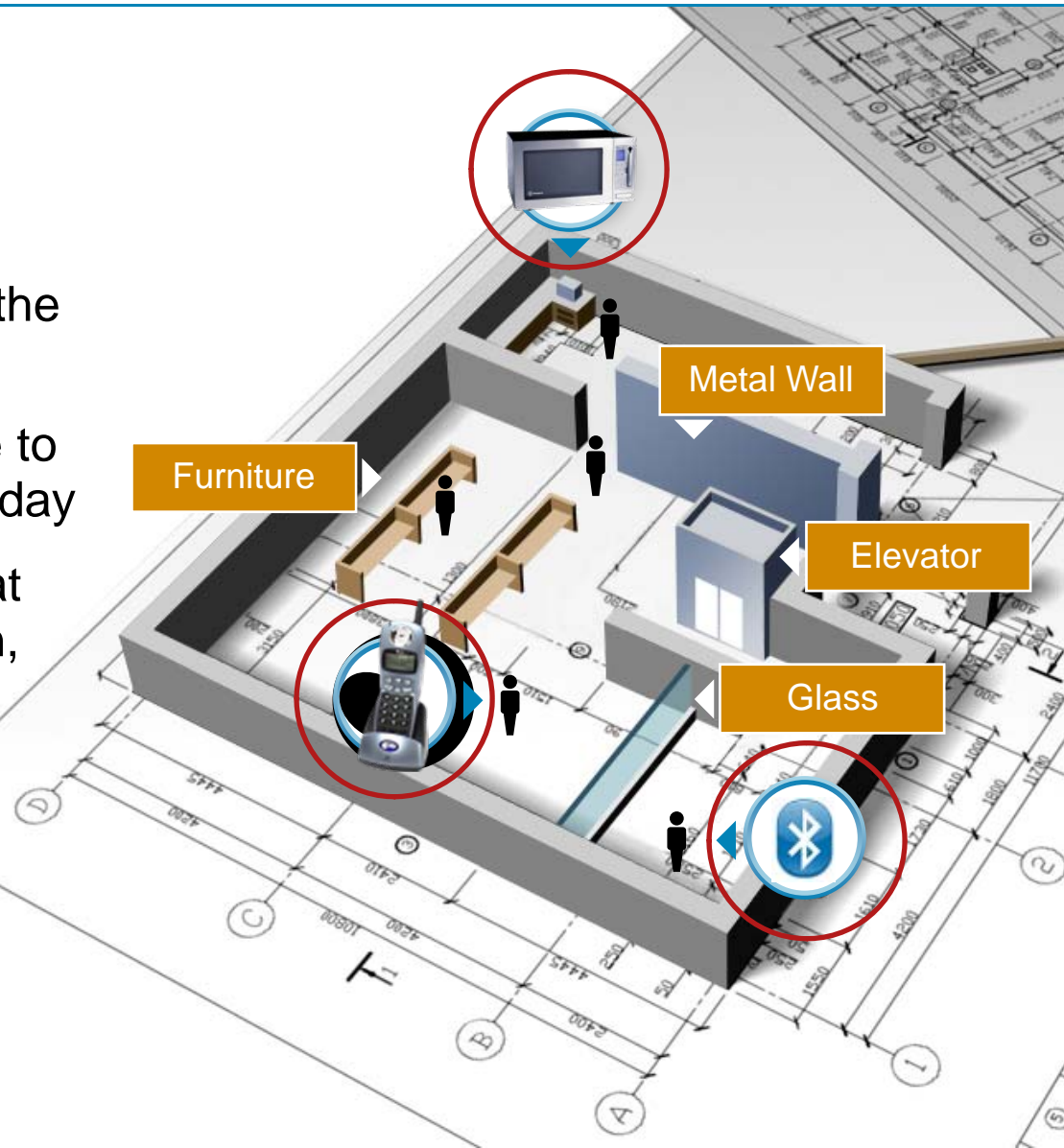
11n

802.11n Design and Deployment



Site Survey Prepares for 802.11n

- Recommended to optimize 11n deployment
- Survey reveals effects of building characteristics on the wireless spectrum
- Measure RF variations due to human activity and time of day
- Survey with client types that you plan to implement (11n, 11abg, VoIP, location tags)
- Spectrum intelligence to detect interference



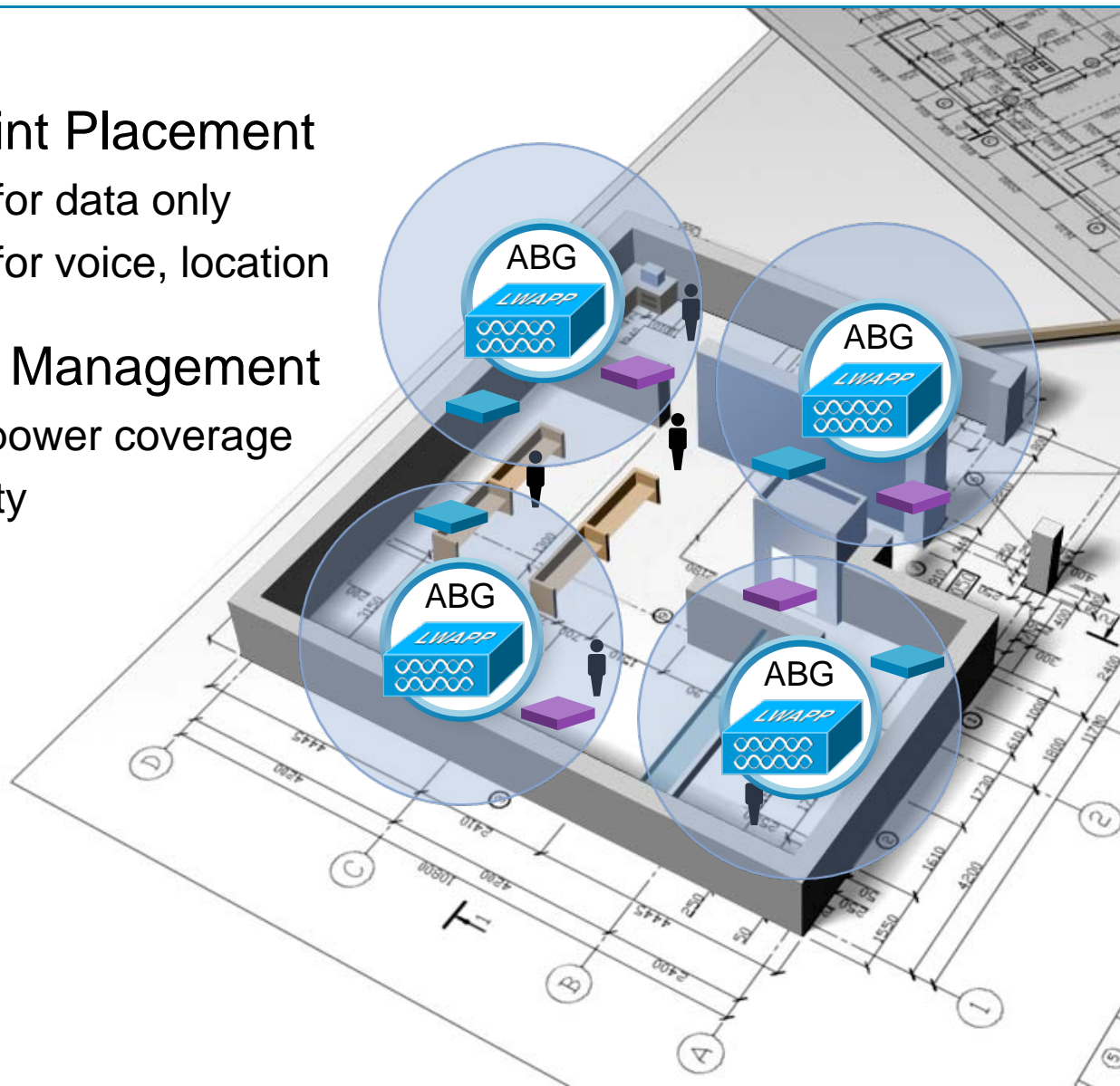
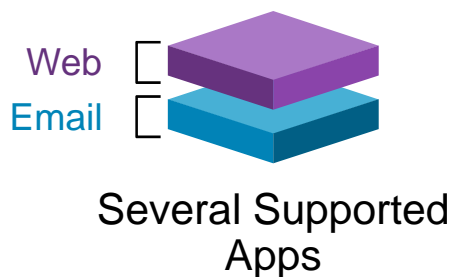
Access Point Placement

ABG Access Point Placement

- 1 per 5,000 sq feet for data only
- 1 per 3,000 sq feet for voice, location

Radio Resource Management

- Adaptive channel / power coverage
- Operational simplicity

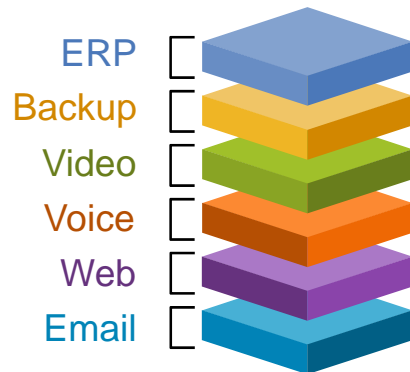


Access Point Placement

1 for 1 replacement

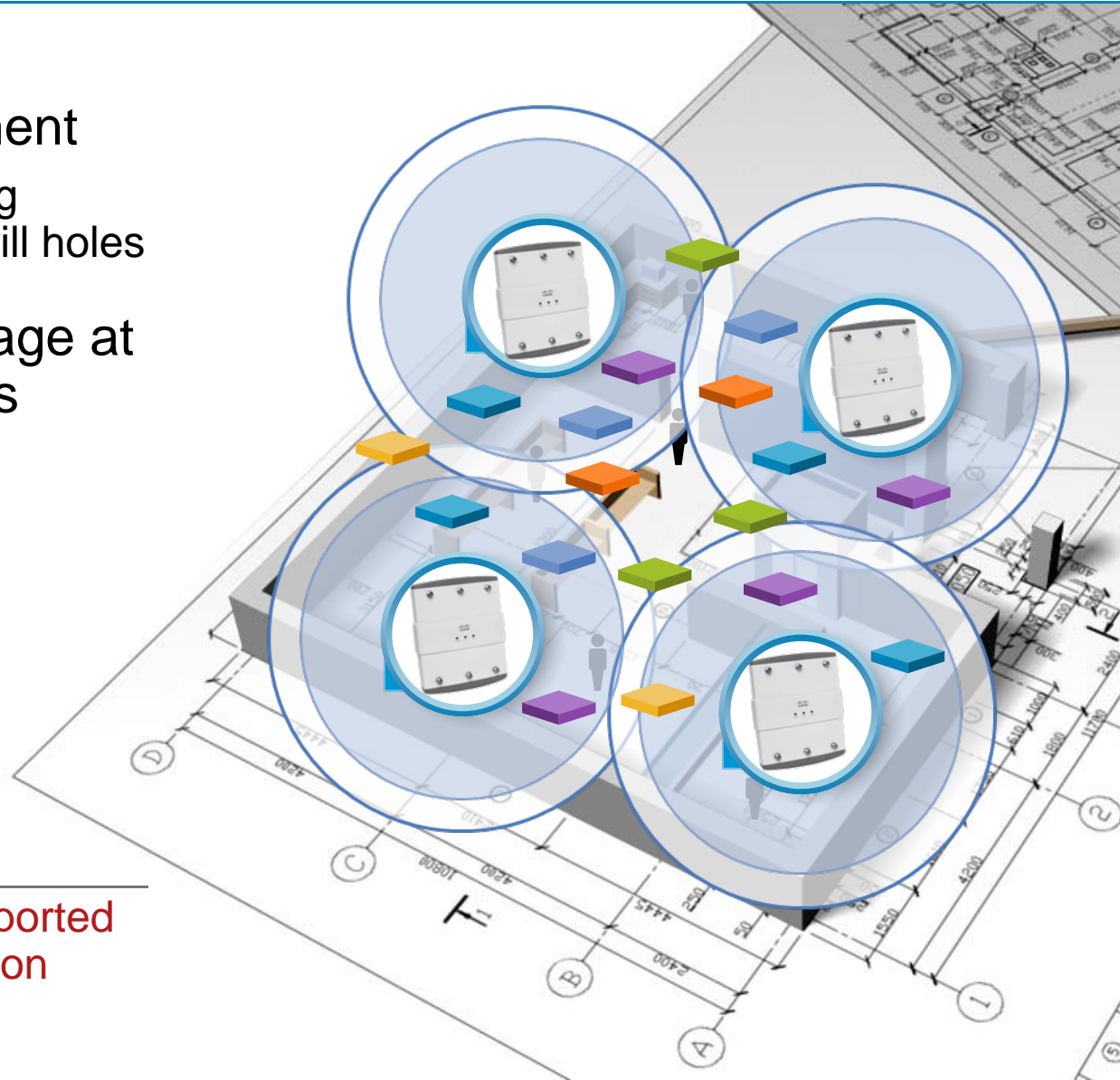
1250 reuses existing
Cisco AP bracket drill holes

Improved coverage at
higher data rates



Supported Apps

**More Applications Supported
at Any Given Location**



Effective Frequency Use—5GHz and 2.4GHz

Create a 5GHz Strategy

- 5GHz Recommended for 802.11n

More available spectrum—greater number of channels

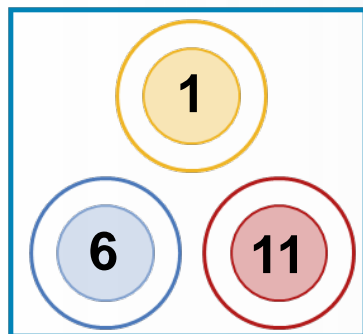
Benefits from 40MHz channels, although 20MHz still works well

Many 11n devices only support 40MHz in 5GHz, although Cisco supports 40MHz in both 2.4GHz and 5GHz

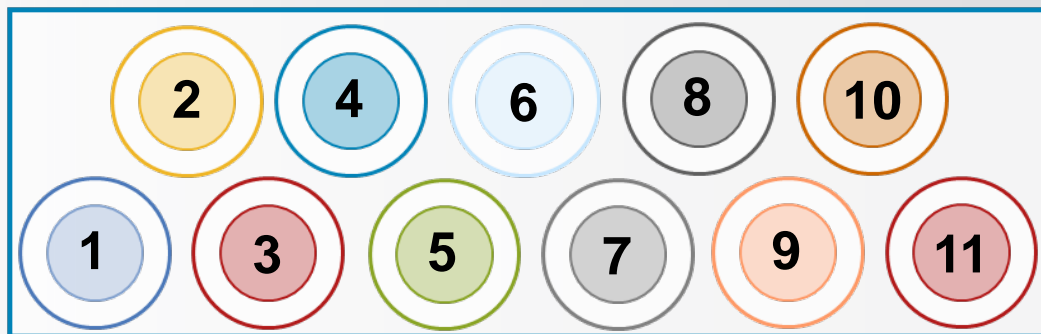
- 2.4GHz still benefits from MIMO and packet aggregation

Ideal for legacy apps (handhelds, scanners, med. applications)

2.4GHz 20MHz Channels



5GHz 40MHz Channels



5GHz Dynamic Frequency Selection

When Radar Is Present

APs Shift
Channels—
Results in Lower
Available Channels
and Loss of UNI 2
and UNI 2e Bands



Radar

Available 40MHz Channels	No DFS Support	DFS Support
	4	11

← 5 GHz Frequency →

UNI 1

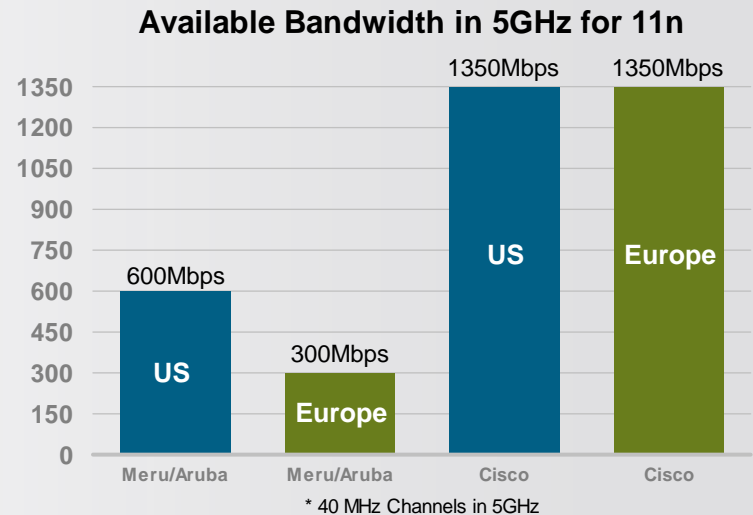
UNI 2

UNI 2 Ext.

UNI 3

DFS and Available Bandwidth

- Full DFS support is required for complete use of channels in 5GHz
- Limited DFS support directly impacts available bandwidth
- Limited bandwidth restricts application support and negates investment in 11n



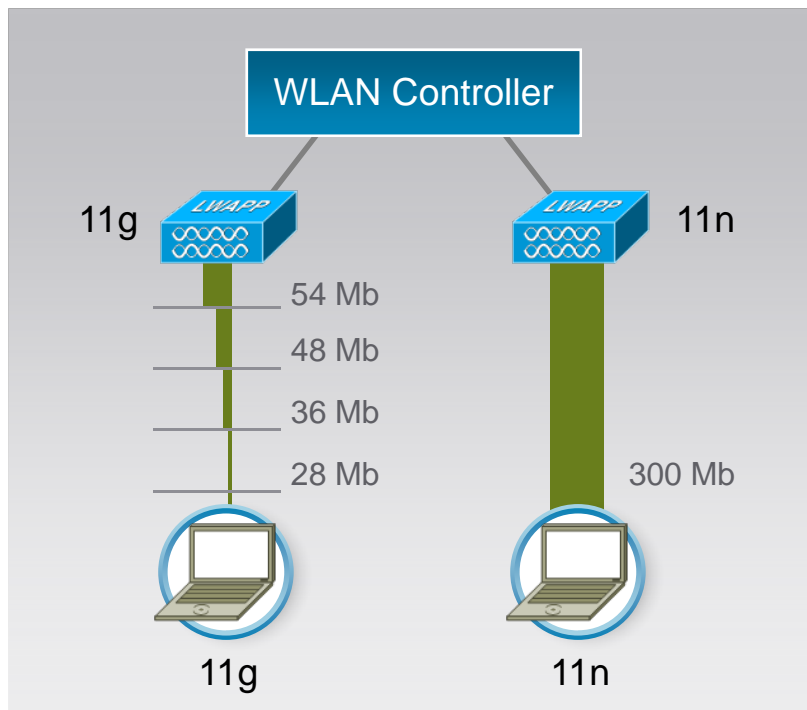
Available Channels per Region		Theoretical	Cisco	Meru/Aruba
United States	11n 5GHz 20MHz	24	21	8
	11n 5GHz 40MHz	11	9	4
Europe	11n 5GHz 20MHz	19	19	4
	11n 5GHz 40MHz	9	9	2

Backward Compatibility & Co-Existence

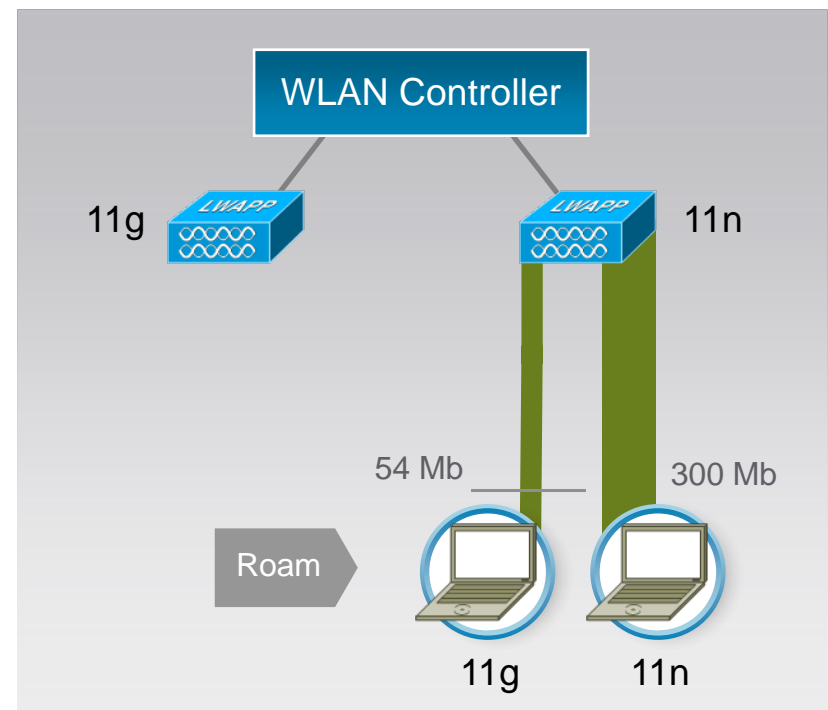
- Co-existence of ABG/N APs
- Benefits of 11n accrue to ABG clients

MIMO benefits ABG clients on the AP receive side from MRC

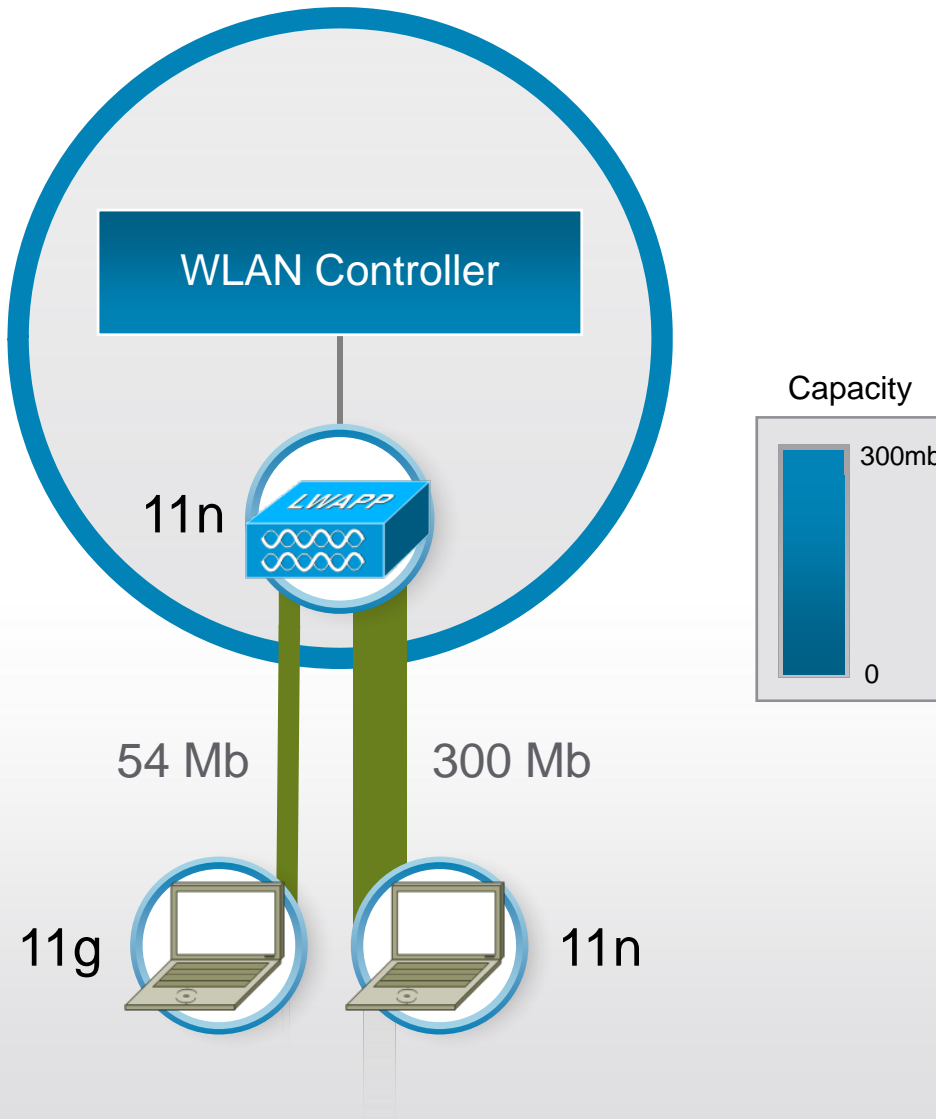
Co-Existence at Controller Level



Backwards Compatibility

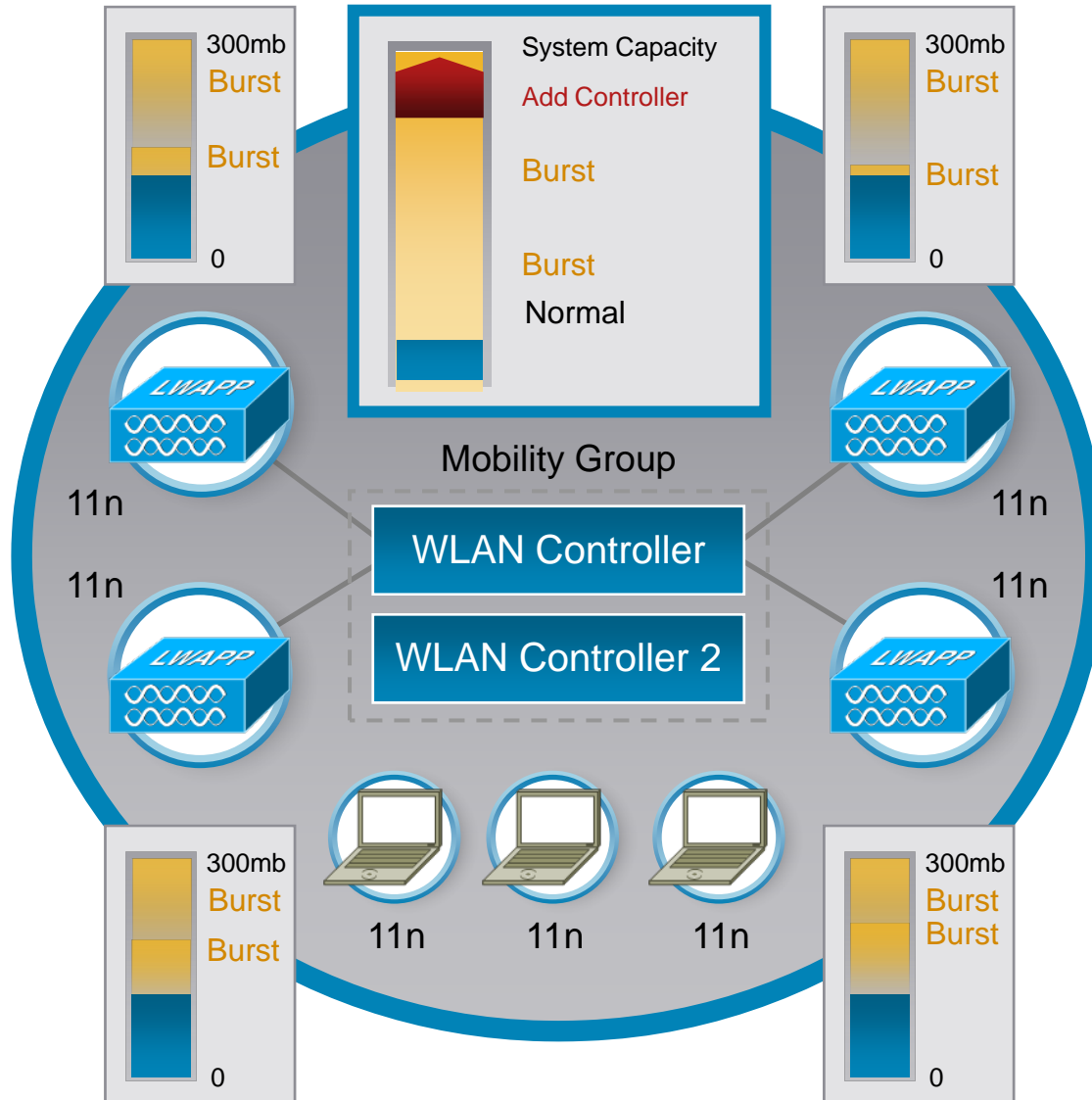


Mixed Mode Performance



- 3 Modes of operation supported
 - Legacy
 - Green Field
 - Mixed
- Mixed mode experiences slight performance impact due to ABG clients
- 11n clients still transmit at full performance
- PHY and MAC for 11n provides co-existence and protection for ABG clients

Network Capacity and Scalability



- Plan for system level capacity, not per AP capacity
- Additional controller increases capacity and improves availability
- Typical Ethernet network oversubscription is 20:1
- With 1250 APs at full capacity, Cisco WLAN controllers reach 12:1

Power Considerations

Cisco Offers Flexible Power Options

Aironet 1250



**Full 802.11n
requires more than
standard 802.3af
Power over Ethernet**

Standard 802.3af PoE

- Supports standard PoE with single radio module only
- Ideal for 5GHz or 2.4GHz only deployments

Cisco Enhanced PoE

- Industry only single port PoE solution
- Catalyst switch family – 3750, 3560, 4500, 6500
- Full 11n performance

Power Injector

- Maintains existing switch infrastructure
- Delivers full 18 watts power

Local AC Power

- Power from any local power outlet

Power over Ethernet: An Industry View

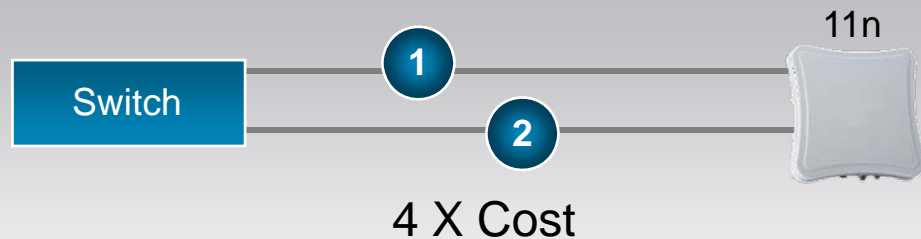
Cisco Single Port PoE

- Deployment simplicity
- Select Catalyst 3750, 3650, 4500, 6500s
- Lowest TCO



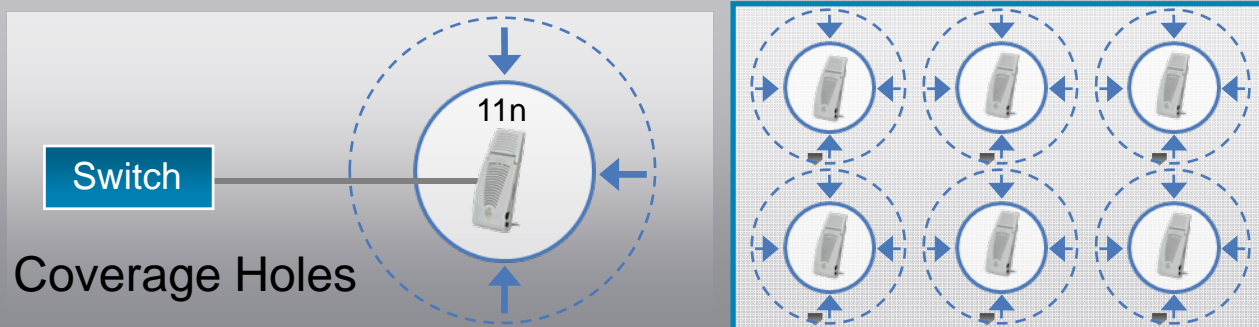
Dual-802.3af Port

- Requires additional cable drop
- Consumes two switch ports



Standard 802.3af

- Performance reduction
- Reduction of coverage
- Requires more APs



802.11n Intel and Cisco Partnership



Play Video

Cisco MESH Solutions



Building the Mobile Business



Cisco Unified Wireless Network



Client

- CCX Program—90% of laptops Cisco compatible
- Secure Services Client (CSCC)



Device

Access Points

- Indoor and Outdoor
- Modular, 802.11a/b/g/n



Access

Unified Network

Wireless LAN Controllers and Management

- Centralized management
- Flexible, scalable (1000s of APs)
- Radio resource management



Unified Wired and Wireless Network
Control and Visibility

Wired Network Services

- Unified **Security and Management** services
- Mobile Unified Communications



Service and Performance

Mobility Services



Security



Guest Access



Spectrum Intelligence



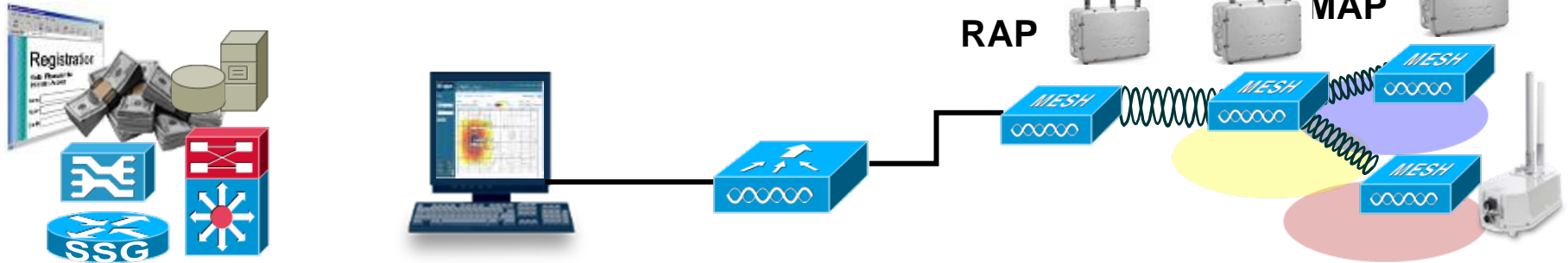
Voice



Location

Mobile Applications

Outdoor Wireless Mesh Solution Components



Back Office Systems

- Bandwidth Monitoring and Management
- Policy Definitions
- Subscriber Database Management
- Billing and OSS Systems

Wireless Control System (WCS)

- Wireless Mesh Management System enables network-wide policy configuration and device management\
- SNMPv3, Syslog, IPSec, AAA, etc

Wireless LAN Controller

- Handles RF algorithms and optimization
- Seamless L3 Mobility
- Security and Mobility control
- Image Management

Root Access Point

- Serves as "Root" AP to the wired network
- Typically located on roof-tops or towers
- Connects up to 35 Mesh APs using 802.11a

Mesh Access Point

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

**Reliable
Hardware**

Industry Proven Devices at Every Layer

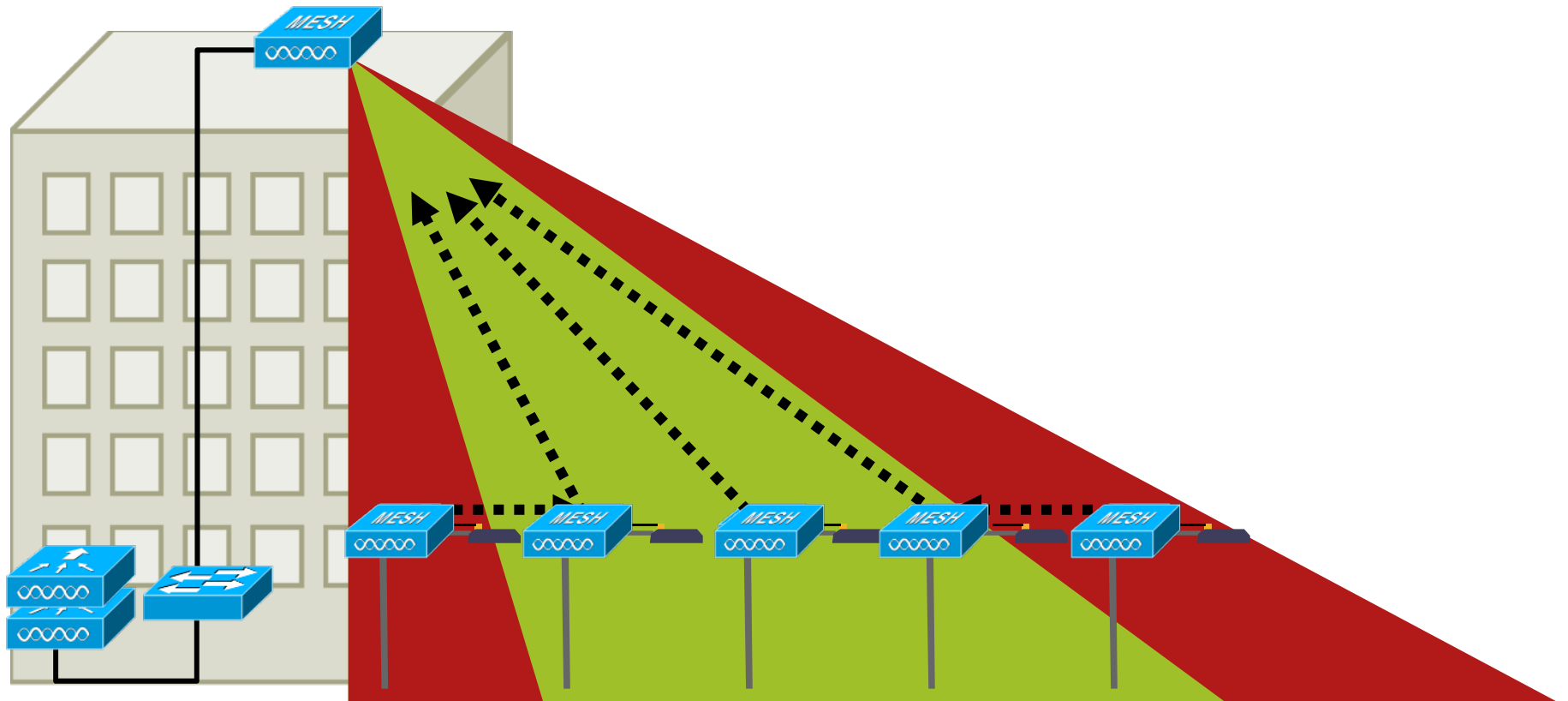
Installation—RAP Is All About **Location**

Mount Your Root AP on a Roof Top or Tower That Has a Good View of the Coverage Area

Ideally, You Should See Your RAP Site from the Streetlight or Coverage Area Looking Up



Understanding RAP Coverage Areas



RF "Shadow" Close to Building; Poor SNR

Beyond RF Coverage Area; Poor SNR

RAP with a Directional Antenna(~17dBi) buys you distance with solid performance

SNR Deployment Practices

- AP1510 Backhaul Data Rate LinkSNR Requirements

- Data RATE , MinSNR + Fade Margin = Required LinkSNR (good Link)

- 18Mbps 9dB + FM = 18dB

- 24Mbps 13dB + FM = 22dB

- 36Mbps 17dB + FM = 26dB

- 48Mbps 21dB + FM = 30dB

- 54Mbps 24dB + FM = 33dB

- Typical Fade Margin is ~9-10dB.

- We do not recommend going above 24Mbps as the SNR requirements will not make distances practical.

- 18 & 24 Mbps of data rate require similar SNRs to decode

- Since 24Mbps offers more throughput, it makes sense to use 24Mbps

Mesh Roles—Mesh Access Point “MAP”



Antennas Installed on the Top of Pole



