Cisco's WiFi Solution

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Agenda

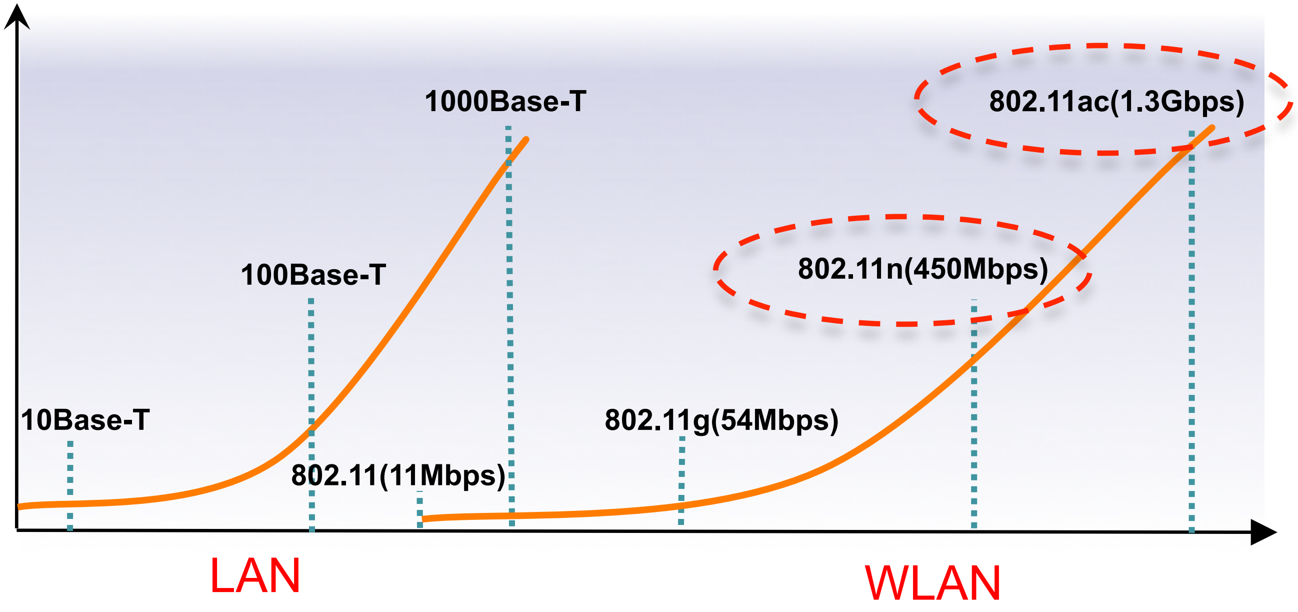
- Wireless Trends and Dynamics Roadmap / 20 Mins
- Cisco's Architecture Mobility Solution / 20 Mins
- Cisco's HDX Best Practices / 20 Mins
- Q&A

Sales & Partner Training
Worldwide Sales Enablement

“WiFi is OxyGen”

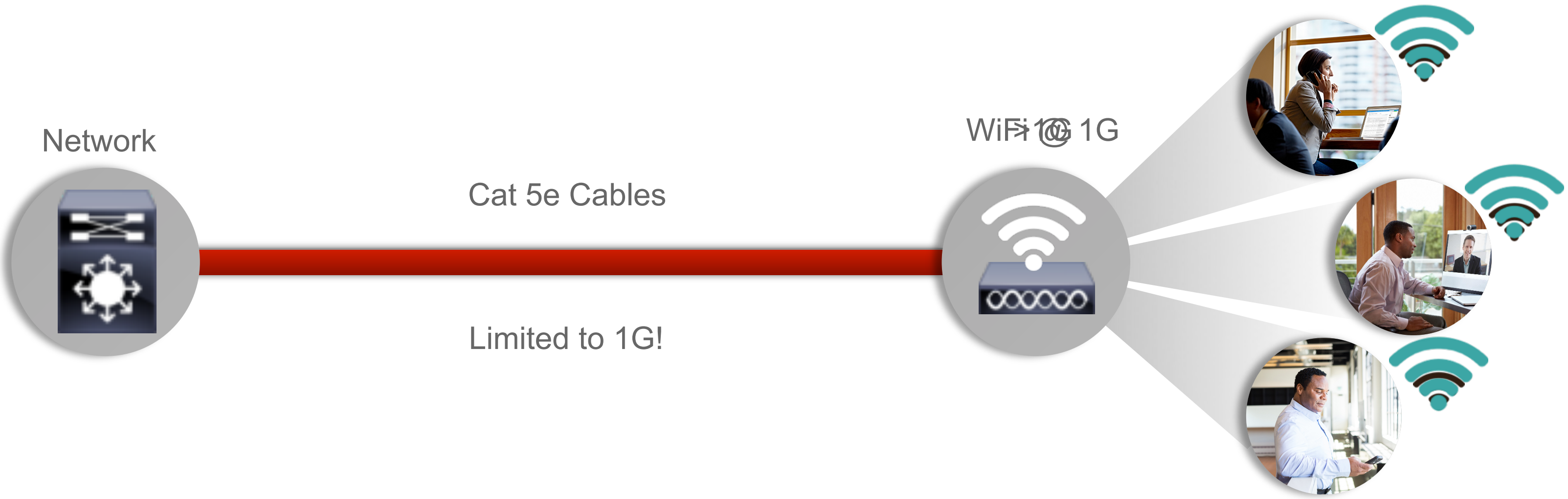
Access Networking Trends The Age of Gigabit Wi-Fi…

- **>50% of enterprise traffic will originate on Wi-Fi by 2017 (Cisco VNI)**
- **50% of all new Wi-Fi devices in 2014 will be 802.11ac capable (ABI Research)**
- **Wave 1 802.11ac has 5+ years of affectivity for Smartphones and Tablets**
- **Wave 1 802.11ac improves battery efficiency by 2X for Smartphones, Tablets, and Laptops**



Compiled from multiple sources: Gartner, ABI, IDC, VNI

The Problem - WiFi Bottleneck



Existing Gigabit infrastructure is insufficient to handle

RF Optimization’s share

Market needs an innovative technology to support > more clients

Consumer environment Yesterday and Today

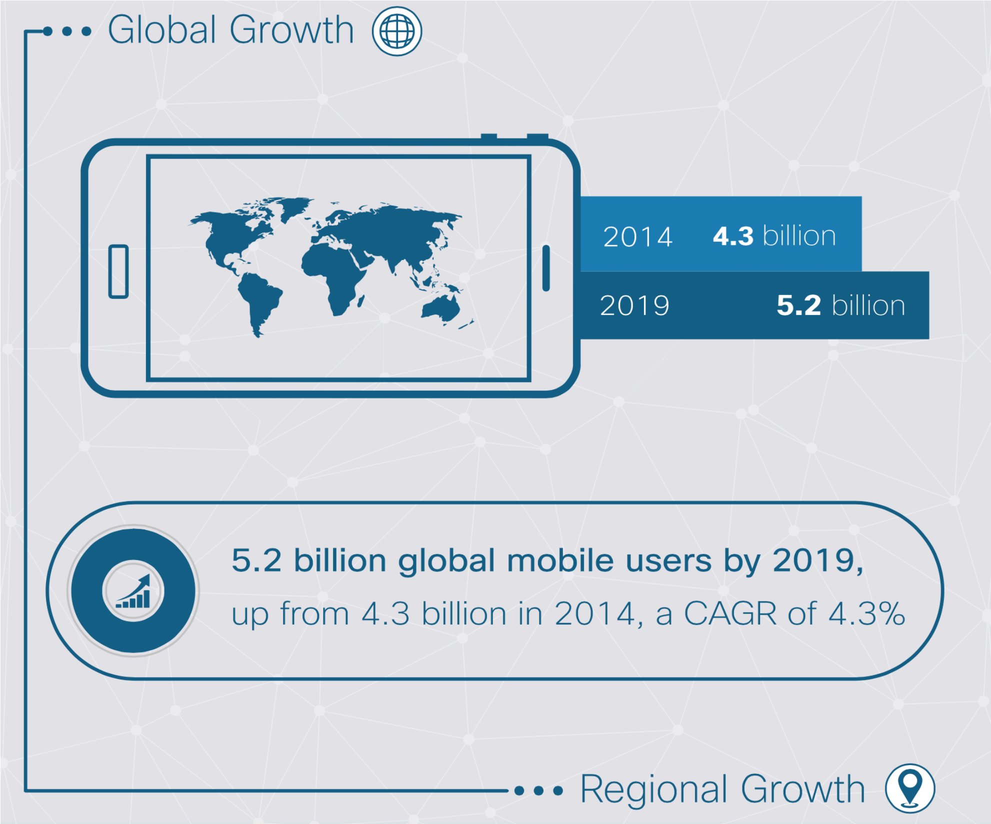
Mobile devices population

Mobile applications

Mobile data traffic

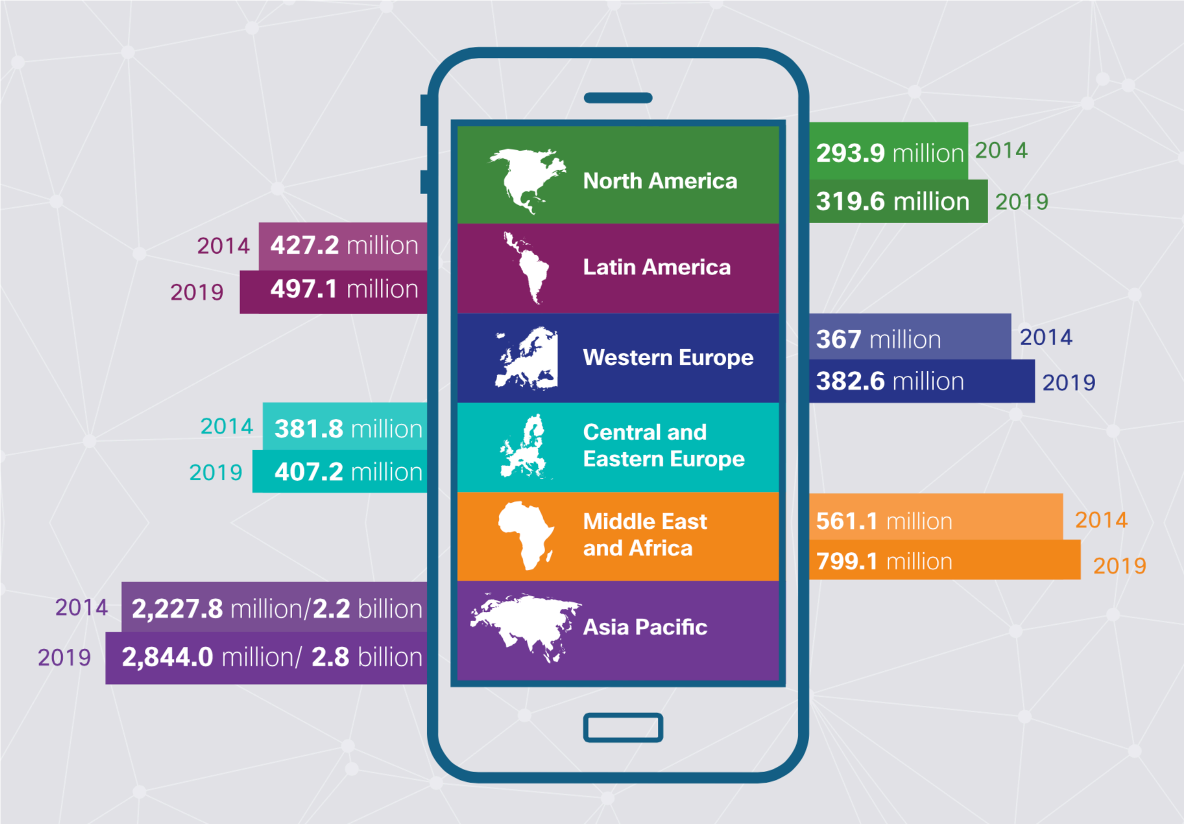
Broadband Wireless Access Networks

The Cisco® Visual Networking Index (VNI) Global Mobile Data Traffic Forecast



Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2014–2019 White Paper

The Cisco® Visual Networking Index (VNI) Global Mobile Data Traffic Forecast

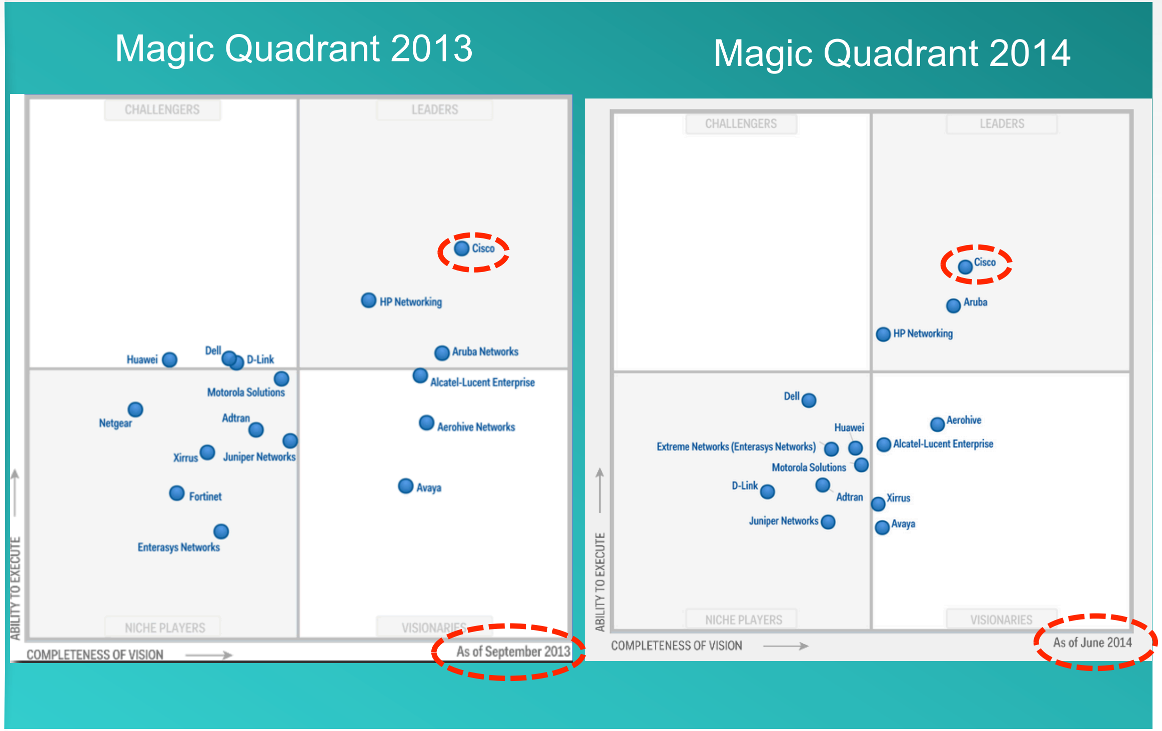


Magic Quadrant for the Wired and Wireless LAN Access Infrastructure

Gartner®

Magic Quadrant for the Wired and Wireless LAN Access Infrastructure 2013/2014

" Cisco Blogs" Cisco Positioned as A Leader in the Gartner Magic Quadrant for Wired and Wireless LAN Access Infrastructure– For the 3rd Time in a Row."

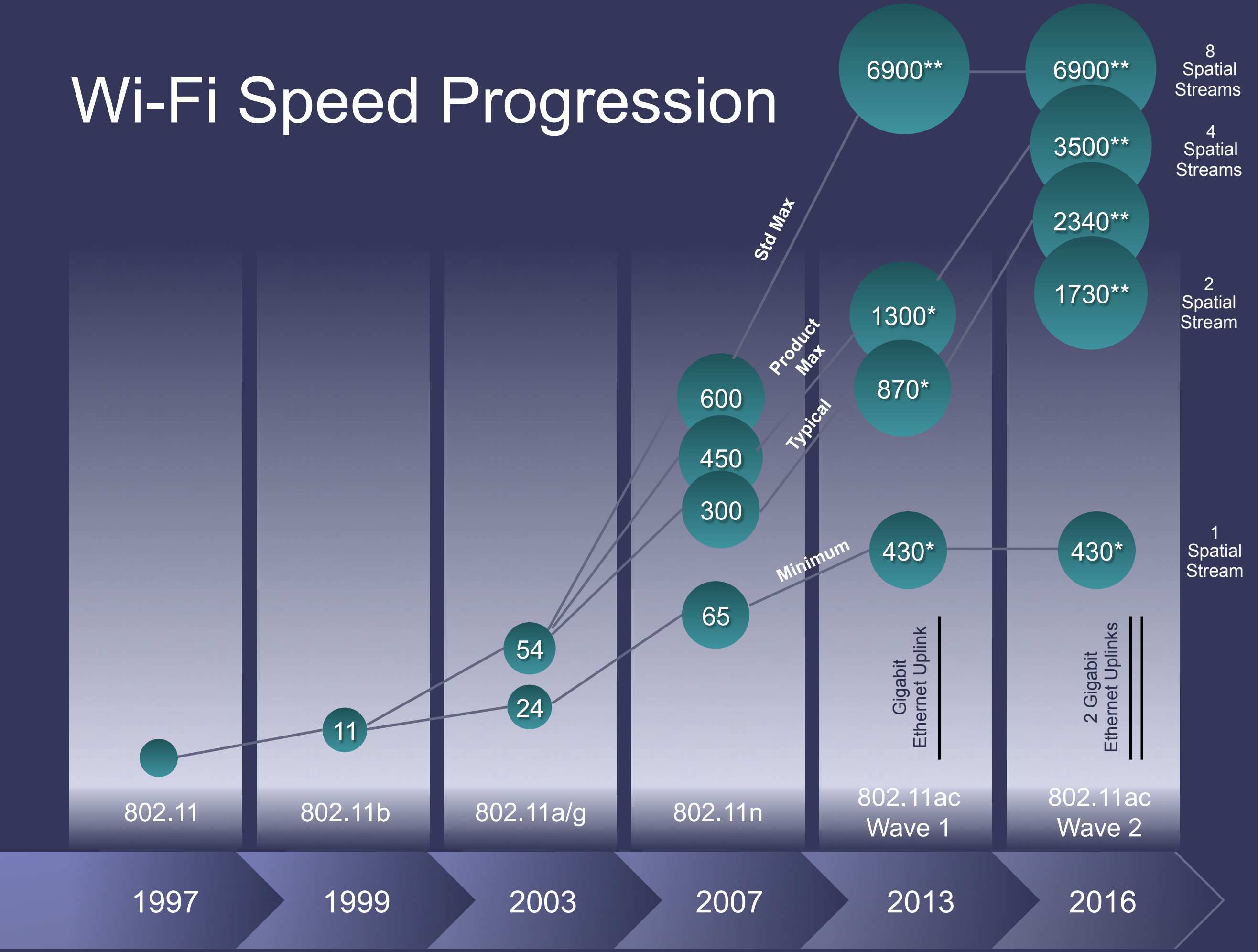


Technology Transitions Discussion

1. WiFi Technology Speed 802.11 / 802.11n(450Mbps),802.11ac Wave I(1.3Gbps) ,802,11ac Wave 2(1.7Gbps)

2. Campus Technology (Multi-Gig Ethernet) / NBASE-T(IEEE Standard) Speed 1G,2.5G,5G,10G

Wi-Fi Speed Progression



4SS	Desktops
3SS	Desktops / Laptops
2SS	Laptops / Tablets
1SS	Tablets / Smartphones

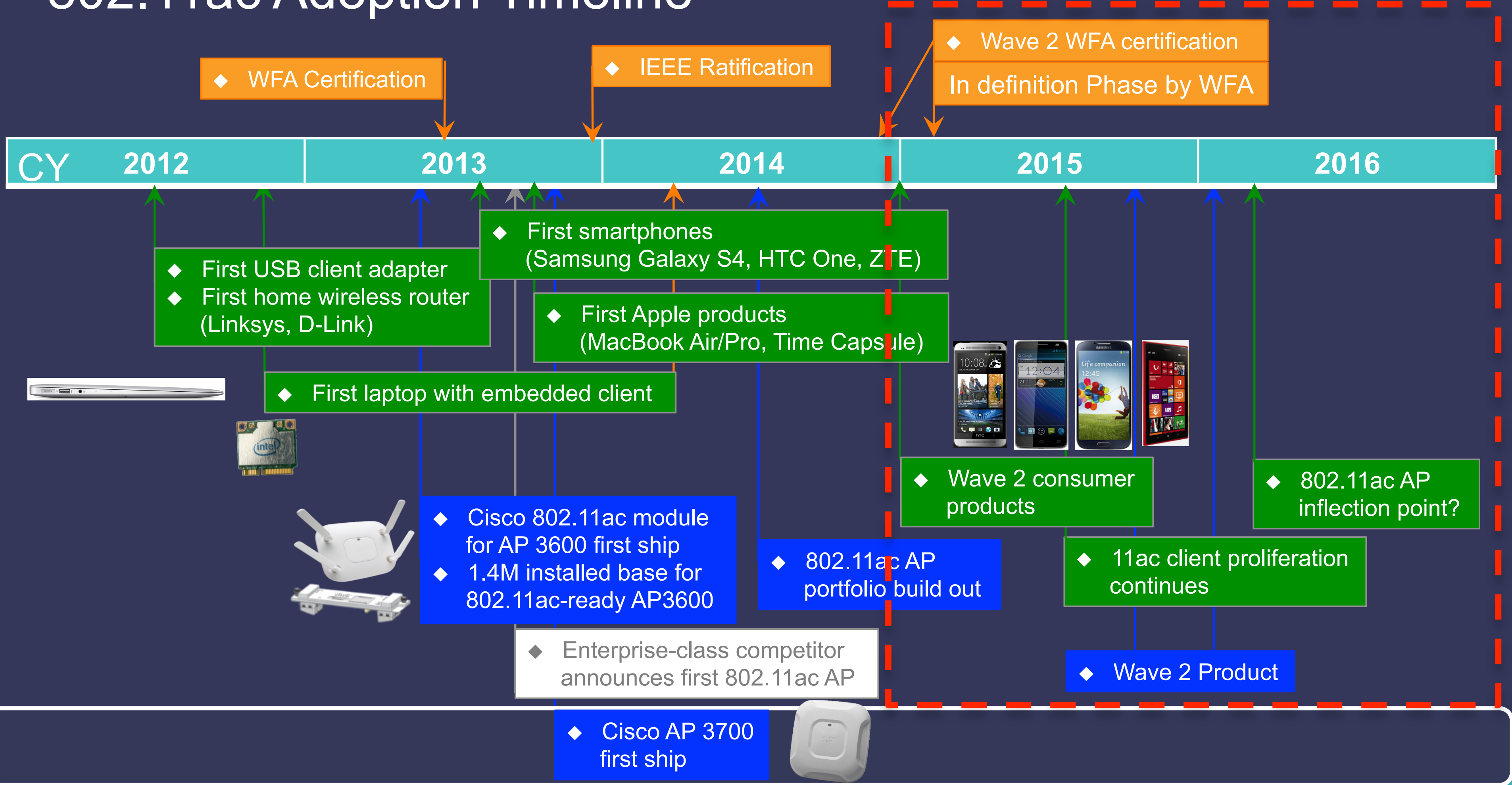
● = Connect Rates (Mbps)

SS = Spatial Streams

*Assuming 80 MHz channel is available and suitable

**Assuming 160 MHz channel is available and suitable

802.11ac Adoption Timeline



802.11 “Operating Mode” comparisons

802.11n	802.11ac Wave 1	802.11ac Wave 2
2.4 and 5.0 GHz band	5.0 GHz band only	5.0 GHz band only
3X3 or 4X4 MIMO	3X3 or 4X4 MIMO	4X4 MIMO
Single User MIMO (one to one)	Single User MIMO (one to one)	Multi User MIMO (one to many)
Fast Ethernet wired equivalent	Gigabit Wi-Fi wired equivalent	Multi-Gigabit Wi-Fi capable
Usually 20 MHz Channel Width	Usually 80 MHz Channel Width	Requires 160 MHz Channel Width
Single FE or GE uplink	Single GE uplink	Dual GE uplinks or mGig uplink
PoE for full operation	PoE+ for full 4X4 operation	PoE+ for full 4X4 operation
Support for AES128	Support for AES128	Support for AES256

Expected 802.11ac Client Throughput

802.11ac Performance Table

BW (MHz)	#Spat Strm	MCS (QAMr5/6)	PHY rate (Mbps)	MAC thruput (Mbps)*
80	1	64	290+	210
80	1	64	330	230
80	1	256	430	300
80	2	64	650	460
80	2	256	870	610
80	3	64	980	680
80	3	256	1300	910
80	4	256	1700	1200
80	8	256	3500	2400

Smartphones from 210 Mbps

Tablets from 460 Mbps

High End Laptops from 680 Mbps

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PoE for full operation	PoE+ for full 4X4 operation	PoE+ for full 4X4 operation
Support for AES128	Support for AES128	Support for AES256

How 802.11ac Wave 2 Works

BW (MHz)	# Spatial Streams	MCS (QAMr5/6)	PHY Rate (Mbps)	MAC Throughput (Mbps)*
80	3	256	1300	845
80	4	256	1733	1126
160	1	64	650	422
160	1	256	780	507
160	1	256	866	563
160	2	64	1300	845
160	2	256	1560	1014
160	2	256	1732	1126
160	3	64	1950	1268
160	3	256	2340	1521
160	3	256	2600	1690

* Based on 65% MAC utilization

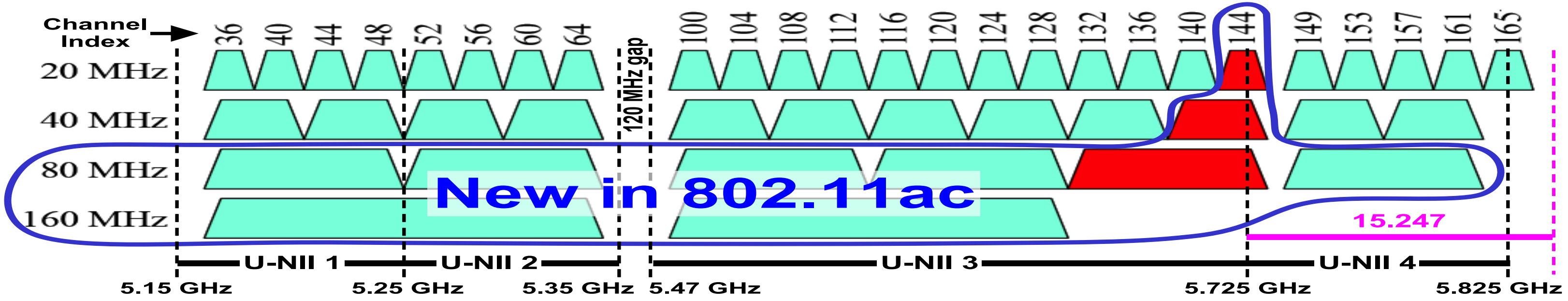
Potential throughput at 160-MHz channel widths:

Data rates introduced with 802.11ac Wave 2

- Multi-user MIMO (MU-MIMO)
- Wider RF channels

802.11ac Wave I

- Support for 802.11ac Explicit Beamforming at FCS
- Channel support
  - Full support DFS support
  - 5 - 80 MHz wide channels, with potential for a 6th pending FCC approval



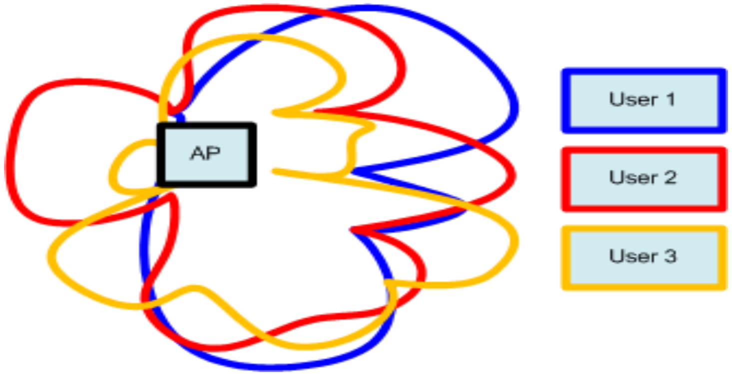
- Single GbE port on the AP3600
  - More than sufficient bandwidth from the full duplex GbE port on the AP3600

802.11ac Wave II

- Multi-User MIMO (MU-MIMO) – 802.11ac Spectrum Conservation - *Wave 2*

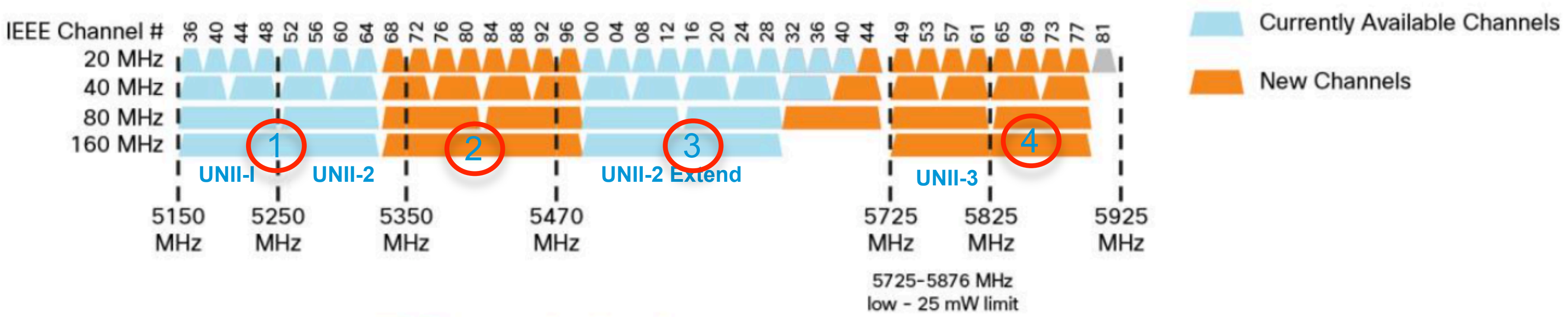
  Single User MIMO in 802.11n sends one frame to one receiver

  Multi-user MIMO in 802.11ac sends multiple frames to multiple



802.11ac Wave II (Continues…)

European: 5 GHz Channel Plan – Snapshot as of January 2015



- **EC MANDATE TO CEPT** on 5 GHz extension bands
  - TO STUDY AND IDENTIFY HARMONISED COMPATIBILITY AND SHARING CONDITIONS FOR
  - WIRELESS ACCESS SYSTEMS INCLUDING RADIO LOCAL AREA NETWORKS IN THE BANDS
  - 5350-5470MHZ AND 5725-5925 MHZ ('WAS/RLAN EXTENSION BANDS') FOR THE
  - PROVISION OF WIRELESS BROADBAND SERVICES
- World Radio Communications Conference 2015 Preparation (identify candidate Mobile Broadband bands)
- Additional unlicensed use of 5350-5470 MHz and 5725-5925 MHz would allow
  - Thirty six 20 MHz channels, Eighteen 40 MHz channels
  - Nine 80 MHz channels
  - Four 160 MHz channels

802.11ac Wave II (Continues…)

802.11ac Wave 2 Max Data Rate at 80 & 160 MHz

BW (MHz)	# Spatial Streams	Modulation Type	PHY Rate (Mbps)	MAC Thru-put (Mbps)*
80	1	64	325	189
80	1	256	390	215
80	1	256	433	280
80	2	64	650	423
80	2	256	780	507
80	2	256	867	564
80	3	64	975	634
80	3	256	1170	761
80	3	256	1300	845

BW (MHz)	# Spatial Streams	Modulation Type	PHY Rate (Mbps)	MAC Thru-put (Mbps)*
160	1	64	650	422
160	1	256	780	507
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160	2	256	1560	1014
160	2	256	1732	1126
160	3	64	1950	1268
160	3	256	2340	1521
160	3	256	2600	1690

- With 802.11ac Wave 2 we have the ability to exceed 1 Gbps of uplink traffic

1 actively serving 5 GHz radio operating at **160 MHz**

e.g. 2SS at 256 QAM = 1126 Mbps

e.g. 3SS at 256 QAM = 1521 Mbps

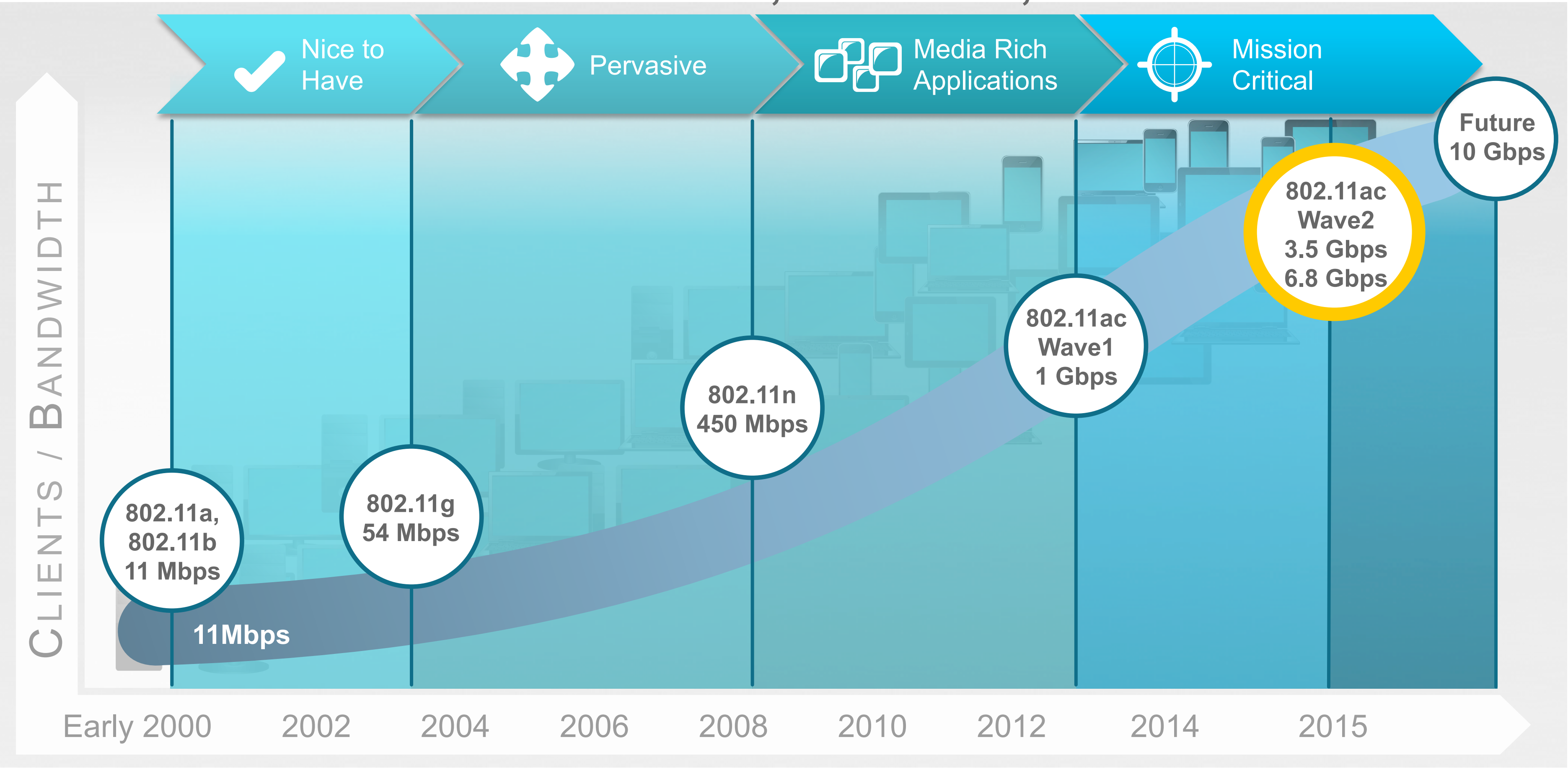
2 actively serving 5 GHz radio's at **80 MHz** wide

e.g. 3SS at 256 QAM = 780 Mbps x 2 = 1560 Mbps

e.g. 2SS at 256 QAM = 520 Mbps x 2 = 1040 Mbps

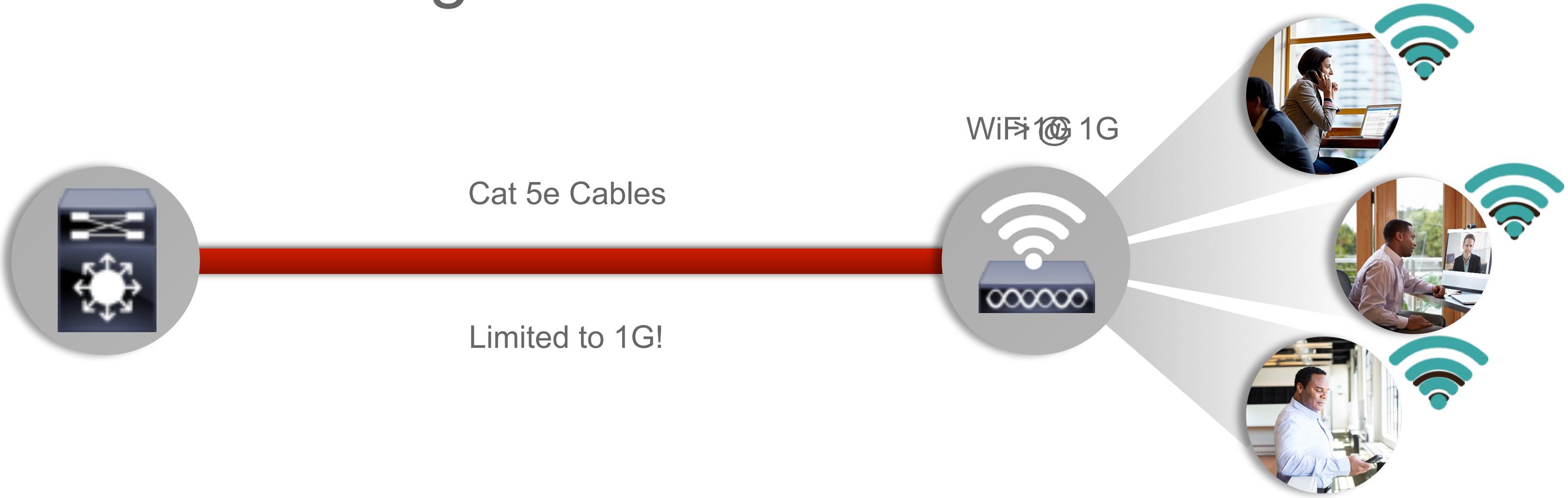
*Assumes 65% MAC efficiency

Wireless Standards – Past, Present, and Future



What's Multi-Gigabit(M-Gig)

The Problem - Gigabit Bottleneck



Existing Gigabit infrastructure is insufficient to handle .11ac growth beyond 1Gbps

Gigabit Ethernet has been around since 1999 and has now become the bottleneck

Market needs an innovative technology to support >1Gbps over existing cables

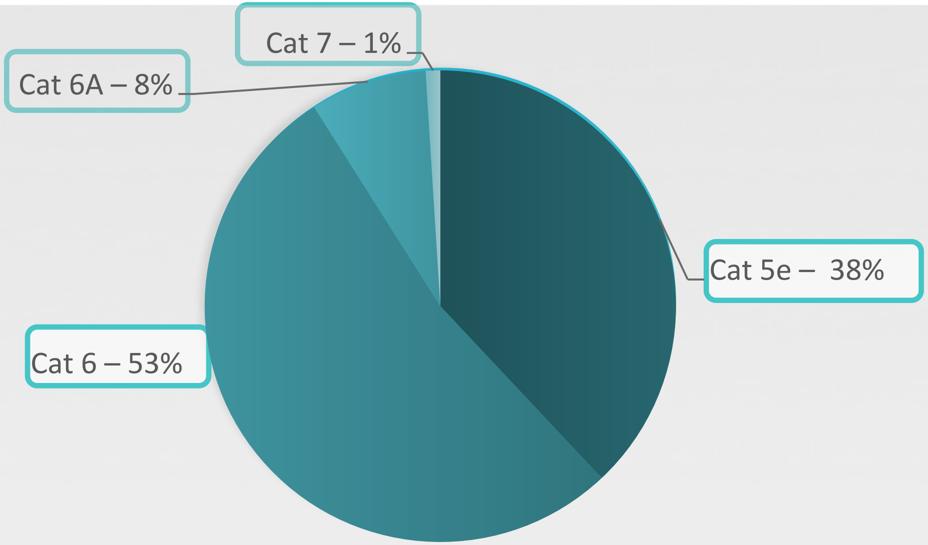
Why Not Use 10GBASE-T?

UTP Cable	IEEE 10G Spec
CAT 5/5e	N/A
CAT 6	55 meters
CAT 6A	100 meters
CAT 7	100 meters

>75% of WW installed base is Cat 5e/6 up to 100 meters

10GBASE-T cannot work over vast majority of installed base

Global Install Base-T Outlets



Source: BSRIA data presented at IEEE 802.3 NGEABT SG Jan 2015

What About Pulling A Second Cable?

Infrastructure upgrade involves

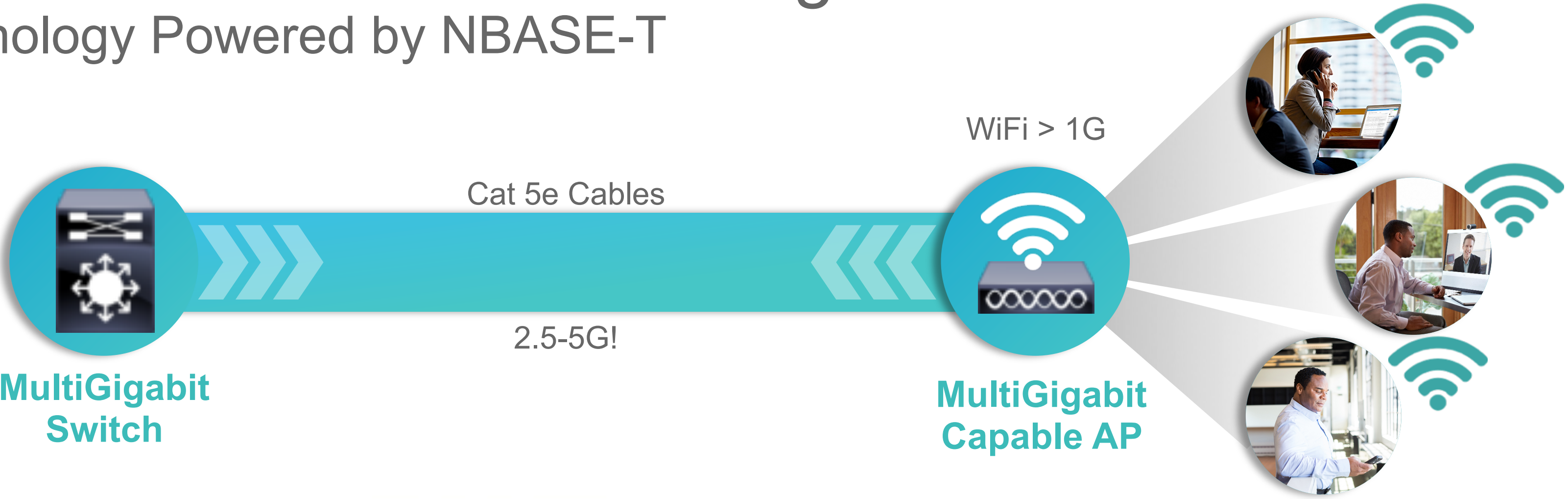
- New cable runs, including labor: average **$300 per cable**
- Link Aggregation issues

Case Study
Enterprise Campus
1,000 Access Points

Total Cable Upgrade
COST: $300k!!!

The Solution – Cisco MultiGigabit

Technology Powered by NBASE-T



Cisco MultiGigabit with NBASE-T™

Is a game-changing innovation allowing enterprise networks to evolve beyond 1G	Enables 2.5 and 5 Gbps up to 100m on legacy cables	Supports all PoE standards up to 60W

Delivers up to 5X Speeds in Enterprise without replacing Cabling Infrastructure

Cisco's Architecture for Cisco Mobility Solution

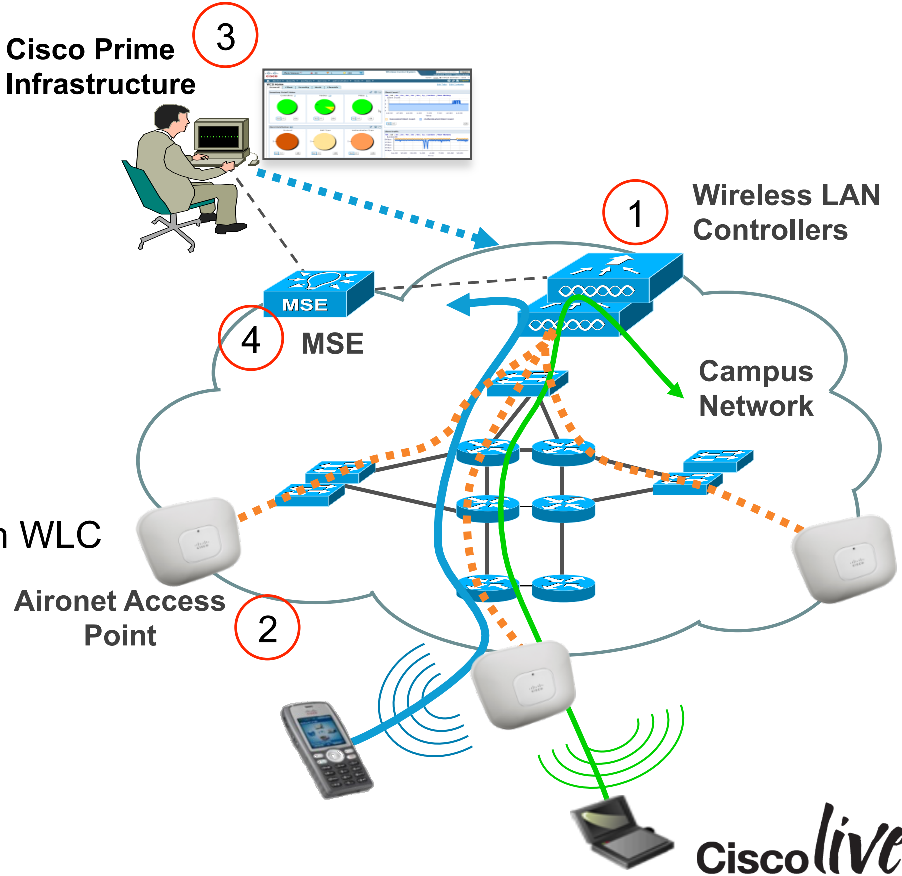
Deploying the Cisco Unified Wireless Architecture

- Local Profiling and Policy Classification
- High Availability (AP and Client SSO)
- RF Optimization - AP Groups / RF Groups / HDX
- Application Visibility Control
- IPv6 Deployment with Controllers
- Branch Office Designs

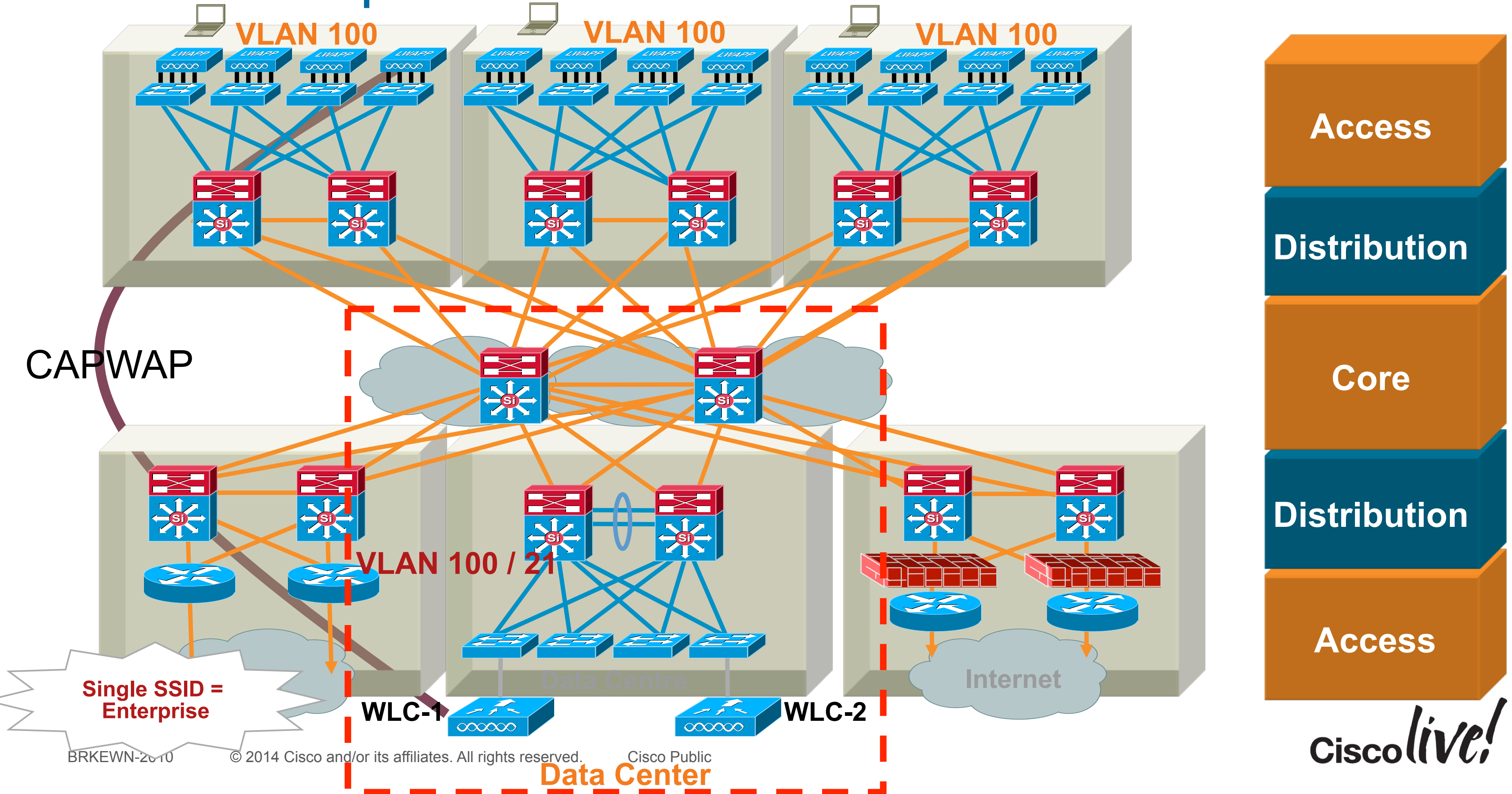
Cisco Unified Wireless Principles

- Components
  - 1. Wireless LAN controllers
  - 2. Aironet access points
  - 3. Management (Prime Infrastructure)
  - 4. Mobility Service Engine (MSE)

- Principles
  - AP must have CAPWAP connectivity with WLC
  - Configuration downloaded to AP by WLC
  - All Wi-Fi traffic is forwarded to the WLC



AP in Campus



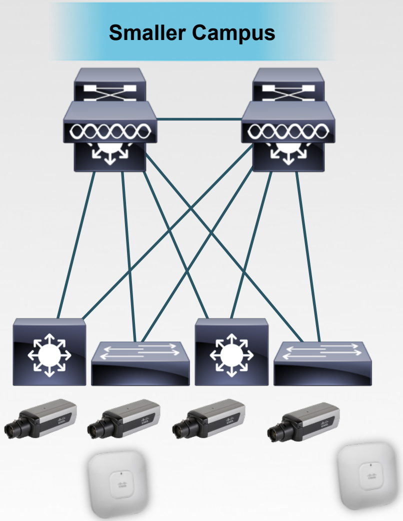
VLAN 100
VLAN 100
VLAN 100
LWAPP
CAPWAP
VLAN 100 / 21
Single SSID = Enterprise
WLC-1
WLC-2
Data Centre
Internet
Data Center
Access
Distribution
Core
Distribution
Access

Campus Profiles

Campus Design Difference Is Scale

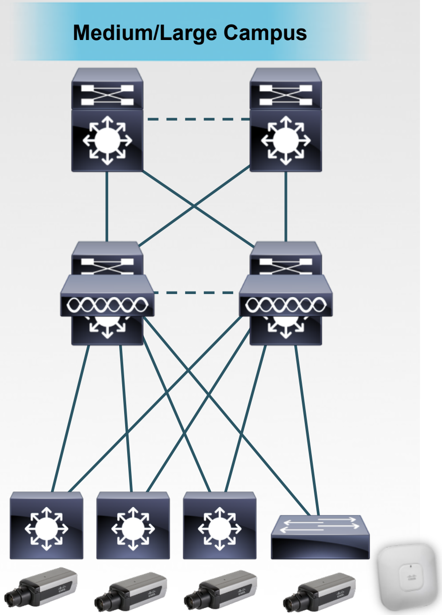
Two-Tier Model

- Common to smaller campus environments
- Full functionality and all services
- Integrated or appliance-based services
- VSS and MEC for max performance and availability



Three-Tier Model

- Scales to arbitrary size (1000s of endpoints)
- Consistent services and functionality with two-tier model
- Distributed or centralized services

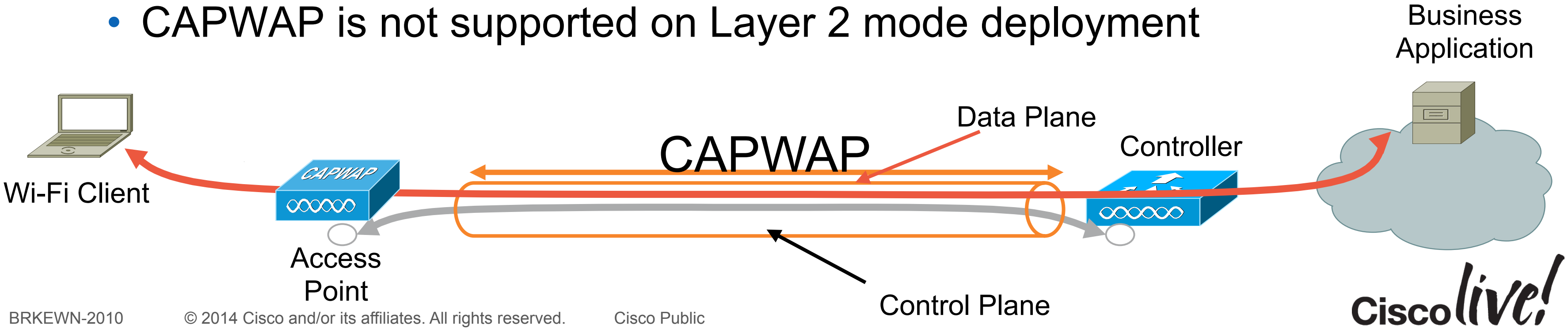


Performance, Scale, and Availability

Centralized Wireless LAN Architecture

What Is CAPWAP?

- CAPWAP: Control and Provisioning of Wireless Access Points is used between APs and WLAN controller and based on LWAPP
- CAPWAP carries control and data traffic between the two
  - Control plane is DTLS encrypted
  - Data plane is DTLS encrypted (optional)
- LWAPP-enabled access points can discover and join a CAPWAP controller, and conversion to a CAPWAP controller is seamless
- CAPWAP is not supported on Layer 2 mode deployment



Wireless Comparison Unified WLAN vs Autonomous Deployments

	Unified WLAN	Non Unified WLAN
Requirement	**Description**	**Autonomous Solution**
Layer 2 Fast Secure Roaming	Seamless client roaming within subnets across access points and virtual LANs (VLANs)	Add a wireless domain services (WDS) device (access point or switch module) to facilitate roaming
Layer 3 Fast Secure Roaming	Seamless client roaming between subnets across access points and VLANs	Not available in an autonomous access point. Requires a centralized solution to facilitate roaming
Upgrade Costs	Time to deploy additional management capabilities and push new images to access points	Deploy a centralized management station or use management scripts
Intrusion Detection System (IDS)	Ability to detect access point impersonation, attacks, and unauthorized access	Use a WDS-based IDS or add an overlay WLAN solution
Location Services	Visualization into received-signal-strength-indication (RSSI) information changes and location of Wi-Fi devices	Use a site survey solution or an overlay WLAN
Dynamic RF	Immediate, dynamic adaptation to RF environment	Use systems-level application appliance or a Simple Network Management Protocol (SNMP); RF information is available for manual review and action

Wireless Comparison Unified WLAN vs Autonomous Deployments

	Unified WLAN	Non Unified WLAN
Requirement	**Description**	**Autonomous Solution**
Load Balancing	Auto-balance client loads between adjacent access points	Individual access points advertise load, but load is not automatically spread between access points
Guest Networking	Ability to provide customers, vendors, and partners with controlled access to the WLAN while keeping the network secure	Implement specialized trunk VLANs into each access point and propagate them across the enterprise
Voice Over WLAN	Cost-effective, real-time voice services using the existing wireless infrastructure	Implement access point-based Call Admission Control (CAC); control is on a per-access point basis and not coordinated across multiple access points
Management	Cost-effective, simplified WLAN management and deployment	Implement scripts or SNMP solution to configure WLAN management and individually configure each access point

Cisco's HDX Best Practices

Best Practices For High Performance Mobile Infrastructure

RF Planning

Engineer the WLAN for data, voice, video, location, and client density

802.11ac : -65 to -67 RSSI
10 – 20% cell overlap
1 AP / 2500 sq ft

RF Optimization

Optimize Gigabit Wi-Fi as primary connectivity – Gig Ethernet as fallback

Cisco CleanAir
Clientlink
RRM

High Availability

Replicate the High Availability of the LAN on the WLAN

LAN SSO – Edge, Core, Disti
WLAN SSO – Client, AP, Controller

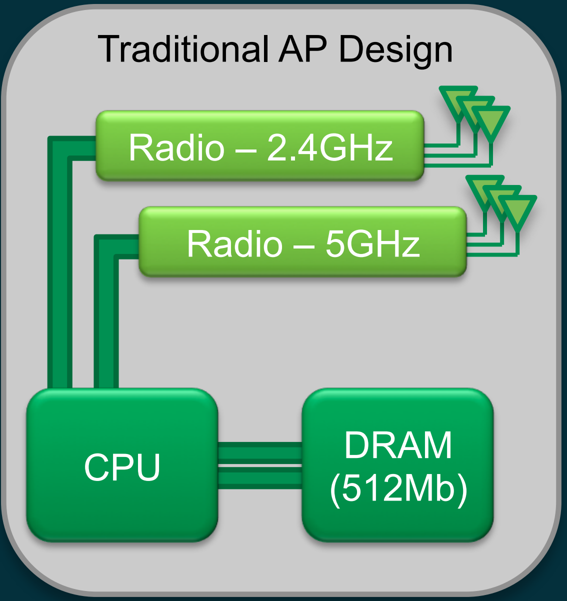
Application Visibility & Control

Prioritize mission critical business applications over personal applications

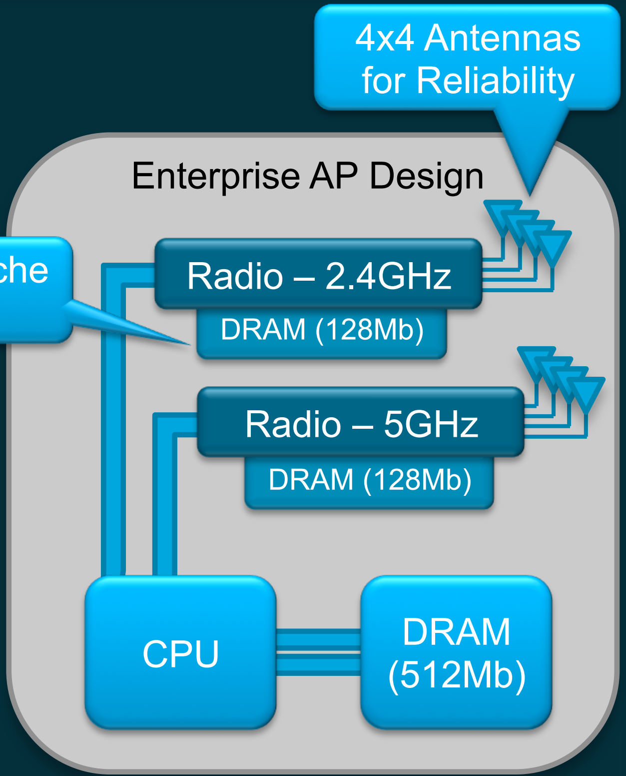
Cisco AVC– Identify, Prioritize, Control Apps across LAN, WLAN

Multi-Client Performance Performance

Performance

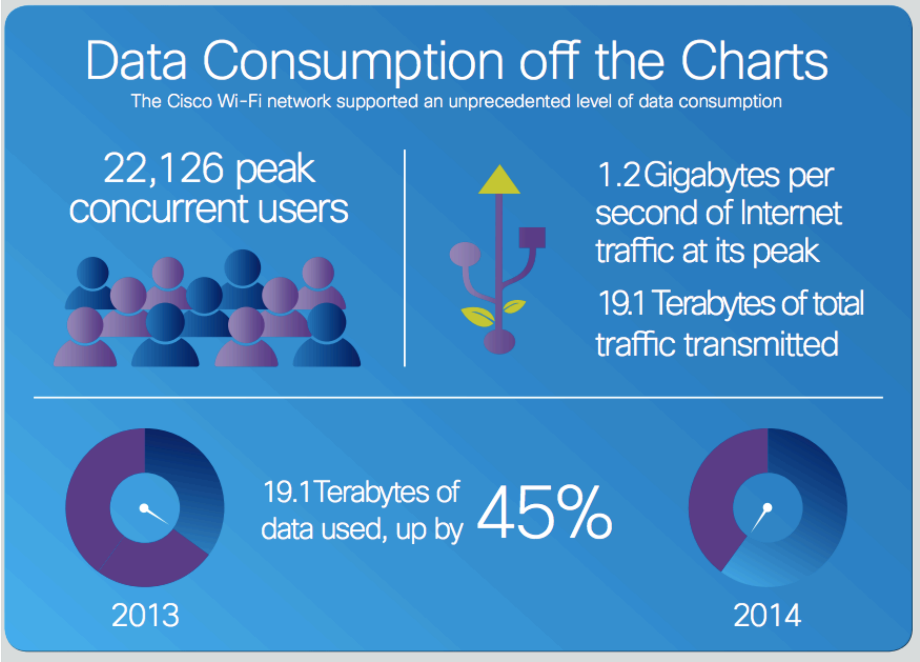


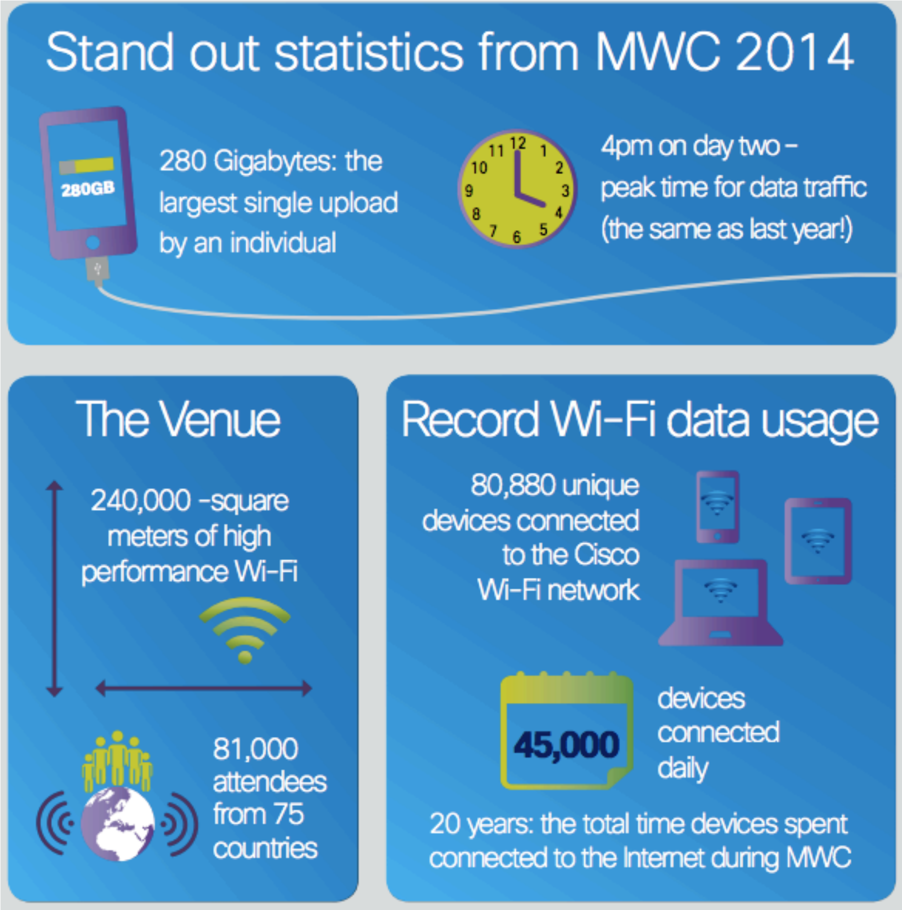
- With 802.11ac, the total bandwidth available to clients is increased to 1.3Gbps, but this is still a shared medium technology.
- An efficient packet scheduler designed for the needs of 802.11ac is needed to keep up with client counts of 60+ per radio.
- Cisco's AP3700 provides on-radio caching technology which leverages additional RAM for per-client queuing techniques.



Cisco 802.11ac with HDX at Mobile World Congress 2014
Barcelona, Spain

850 x AP 3700 + WLC 8500





Why High Density Wi-Fi?

- Wireless has become the preferred access technology -- and in many cases the only practical one
- The need for high density started with stadiums and auditoriums – but has reached every network
- The explosion of smart devices and increasing connection counts per seat are everywhere
- Application demands are increasing
- Even with advances - wireless is still a shared half-duplex medium and requires efficient use to succeed.

What are Some Typical Challenges?

- Interference from other WiFi networks in the venue
- Interference from non-WiFi systems operating in the same band
- Co-channel interference: Many APs in the venue, but effectively no more capacity
- Clients operating at low data rates (ex. 802.11b) pull down the performance of the network
- Clients mistakenly choose a 2.4 GHz radio (louder signal) instead of 5 GHz (less load)
- Sticky Clients: Clients mistakenly stay on the same AP, even when person has moved from one end of the venue to another
- Limitations on mounting assets. Hard to put APs where you want them
- Probe storms: 2.4 GHz clients probe on all 11 overlapping channels (3 Channel Non-Overlap)
- Ad Hoc Viruses: Clients forming bogus ad hoc networks such as “Free Public WiFi”

HD Wi-Fi -- Best Practices

Solid RF Design

- Constrain RF
  - Directional Antennas, Down-Tilt
- Good RF Layout/Design:
  - Channels, Tx Power
- Eliminate Interference
  - Rogues and Non-Wi-Fi Interference

Basic Tuning

- Minimize SSIDs
- Disable Low Data Rates
  - Helps with Sticky Clients, Improves capacity
- Band Steering
  - Push dual-band clients to 5 GHz
- RF Profiles

Advanced

- Rx-SOP Tuning
  - Greatly improves capacity by reducing co-channel impact
  - Also reduces sticky clients
- Optimized Multicast Video

Are you already seeing pressure?

How do you know?

- Most IT's are reporting an increase in devices per user (2-4 average)
- January 2012 - Education communities reported as much as a 25% increase in devices following Christmas Break
- Each MAC/radio requires resources–
  - DHCP pool exhaustion/utilization – first sign of pressure
  - Channel Utilization – Logical Airtime availability
  - Increase in transient Rogue devices
  - Adhoc Rogues – My-Fi

Any device operating in your spectrum is using your bandwidth authorized or not

Step 1: Migrate to 802.11n to Enhance Legacy Network Performance

Challenge:

Scaling tablets and mobile devices accessing bandwidth intensive applications across the WLAN

Advantage:

802.11n optimizes high bandwidth in the same spectrum

- 7x higher throughput for Voice, Video, Data Applications
- More reliable and predictable coverage

Backwards compatibility with 802.11a/b/g clients

Primary 802.11n Components

Multiple Input Multiple Output (MIMO)

- Maximal Ratio Combining
- Beam forming
- Spatial multiplexing

40 MHz Channels

- Two adjacent 20 MHz channels are combined to create a single 40 MHz channel

Improved MAC Efficiency

- Packet aggregation
- Block Acknowledgements

All major devices entering the market are 802.11n today

Step 2: Configure for High Density Wireless Deployments

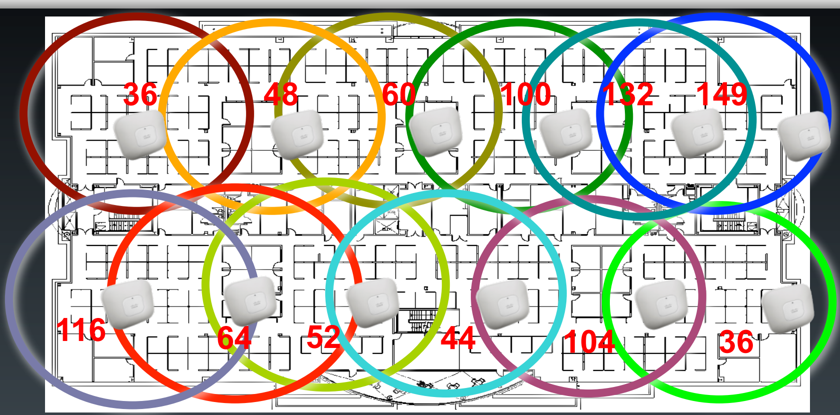
Challenge:

Proper WLAN configuration to support Wi-Fi enabled devices in concentrated areas

Advantage:

These RF design best practices help fine tune the network in advance to accommodate high density areas

a. Assess Application Bandwidth Requirements
b. Understand Wireless Protocol Selection
c. Determine Required Number of AP Channels
d. Optimize the Installation
e. Understand what is using your spectrum and why

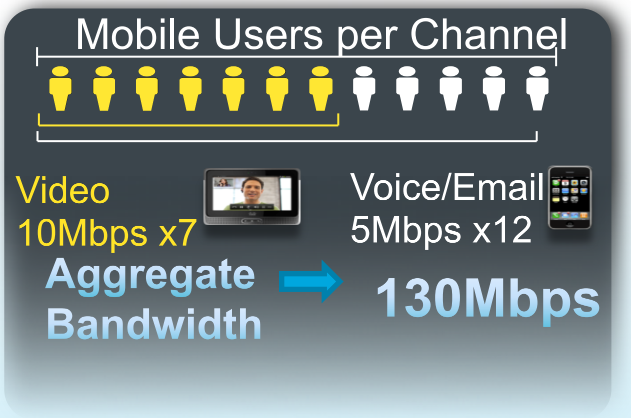


Efficient RF Design Improves Coverage for Mobile Devices in Concentrated Areas

Step 2a: Assess Application Bandwidth Requirements and Supported Protocols

- Determine the bandwidth required for each user of the target application
  - Determine the minimum acceptable throughput applications require
  - Design for the highest bandwidth requirement
- Multiply this number by the number of connections/seats that you need to support
- This is the aggregate bandwidth you will require in your space

Protocol	Throughput (Mbps)
802.11b	7.2
802.11b/g mix	13
802.11g/a	25
802.11n HT20 SS	35
802.11n HT40	160



Step 2b: Access Application Bandwidth requirements and protocols?

Often, less than you'd think…

- Its most likely that you won't be supporting just one application
- Design for the highest bandwidth demand that you intend to support
  - What you need - the minimum acceptable throughput that the application will require
  - It is advisable to measure this yourself
  - Multiply this number by the number of connections/seats that you need to support
- This is the aggregate bandwidth you will require in your space

Application – by use case	Throughput – Nominal
Web - Casual	500 Kbps
Web - Instructional	1 Mbps
Audio - Casual	100 Kbps
Audio - instructional	1 Mbps
Video - Casual	1 Mbps
Video - Instructional	2-4 Mbps
Printing	1 Mbps
File Sharing - Casual	1 Mbps
File Sharing - Instructional	2-8 Mbps
Online Testing	2-4 Mbps
Device Backups	10-50 Mbps

Step 2c: Determine the Required Number of AP Channels

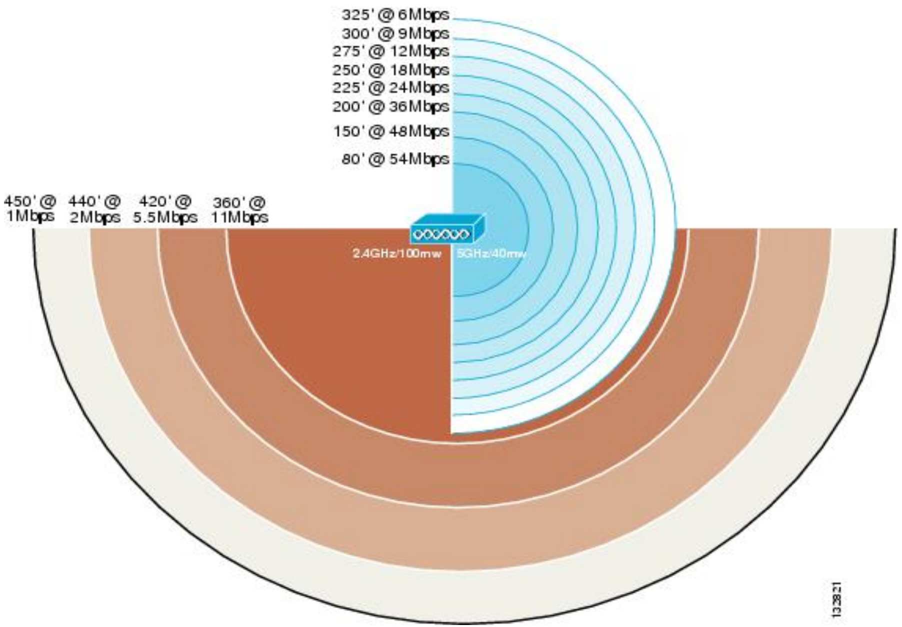
Technology	Data Rate (Mbps)	Aggregate Throughput (Mbps)	Example User Count	Average per User Throughput
802.11b	11	7.2	10	720Kbps
802.11b	11	7.2	20	360Kbps
802.11b	11	7.2	30	240Kbps
802.11b/g	54	13	10	1.3Mbps
802.11b/g	54	13	20	650Kbps
802.11b/g	54	13	30	430Kbps
802.11a/g	54	25	10	2.5Mbps
802.11a	54	25	20	1.25Mbps
802.11a	54	25	30	833Kbps
802.11n MCS7	72 (400 nS GI)	35	10	3.5 Mbps
802.11n MCS7	72 (400 nS GI)	35	20	1.75 Mbps
802.11n MCS7	72 (400 nS GI)	35	30	1.16 Mbps

Maximize AP Channel Usage to Increase Bandwidth Efficiency

Step 2d: 2.4 GHz Channel Efficiency

- Range versus rate is something that we are generally working to maximize in a coverage design - However
- In High Density Design, the reverse is actually true – we want to minimize the propagation of a cell
- For 2.4 GHz you can use 1-6-11 once every 10K ft^2 in open space
- Minimizing the cell size is a function of limiting the propagation, there are 3 ways to do this–
  1. Limiting supported rates
  2. Managing the power of the radio's (AP and Client)
  3. Using the right antenna's
- Properly applied, this will maximize channel re-use in a small space

Step 2e: Cell Size – by protocol / speed

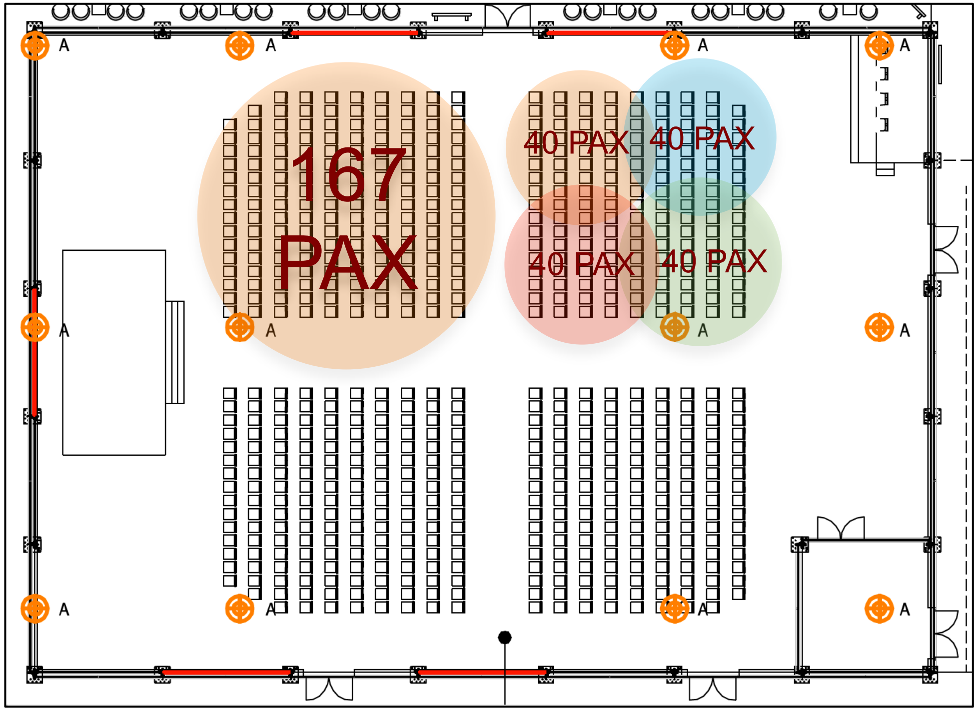


Assuming 10% PER

Speed	Required SNR	AP Sensitivity
1	0	-91
2	3	-91
5.5	6	-91
6	2	-87
11	9	-88
12	6	-86
24	11	-85
36	13	-85
48	17	-78
54	19	-77

Channel Utilization – is the aggregate of every radio on the channel that can be heard

Bigger Cells, More Users



Sample Auditorium

Sample HD Design

- Dense open space: 560 square meter - 500 seats
- Where to put 2.4GHz Ap's? Open space = 10,000 ft/2 for single channel reuse
- Need to reduce cell size:
  - Lower power level/increase data rates
  - Use bodies to absorb RF ?
  - Use specific antenna types (patch, yagi)?
- RF survey can provide some information, but difficult to do when you most need it: when auditorium is full
- Difficulty of access during the semester since these are very busy facilities
- Facilities were not built to accommodate wireless
- Costs must be contained
  - Public Higher Ed, no major budget for these retrofits
  - Can't afford expensive coring and pathway installs

Sample Antenna Placement Options

- Cisco HD design discusses high gain directional antennas
  - Patch or Yagi style
    - Downtilt adjust for focusing beam
    - Useful in auditoriums with high ceilings
    - Provides narrow coverage lobe for smaller cells
- Could Locate APs/Antennas on walls, close to floor:
  - Typically the easiest installation in terms of cabling and access
- However - Wall mounted may have issues with coverage in large auditorium
  - Need to turn power down to low levels to get channel re-use
  - **Reduced power may result in poor coverage in center of room**

Sample 2.4 GHz Antenna Placement Options

- Locate APs/antennas under seat ?
  - Requires cabling access, typically need to install conduit
  - Can place antennas in center of room for improved coverage
  - Uses bodies to help absorb RF power and reduce effective cell size
- On the floor, pointing up ?
  - Requires enclosure to protect equipment
- Under the desk, pointing down ?
  - Need to route cables and make it all unobtrusive
- Locate APs/antennas under floor ?

  If concrete is thin enough, isn’t filled with rebar or stress cables, and access is available

  1. Can provide good RF power absorption, leading to smaller cell size
  2. Makes it possible to locate antennas near center of room
  3. Avoids cables and conduits inside the auditorium, reducing trip hazards

Sample 2.4GHz AP Placement

- Located 2.4 GHz APs/antennas under the concrete floor.
  - RF survey showed that using patch antenna and low power level could produce smaller cell size than under seat location inside room
  - Testing showed that a good signal could be seen in the room
- Made it possible to provide five 2.4 GHz channels
  - This meets the design goal of channel re-use
  - Provides adequate coverage and capacity
  - Sufficient in room channel isolation

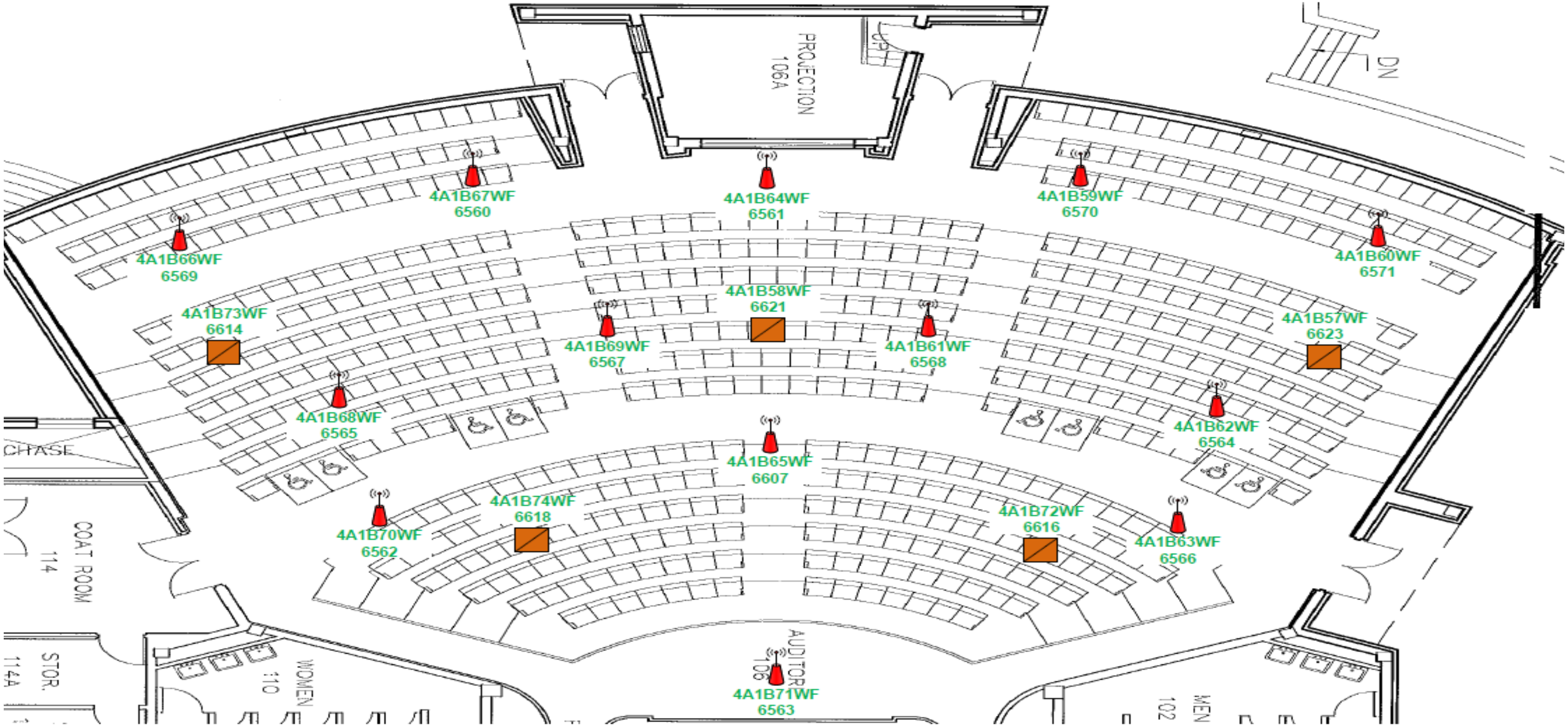
BUT – PER IS INCREASED WITH HIGHER DENSITY RF PATH

Sample 5GHz Antenna Placement

- Put 5GHz APs on ceiling
- Ease of access and cabling
- Provide multiple APs, one per channel
- Set power level high to encourage 5GHz use
- General campus uptake: 25 percent on 5GHz
- BUR 106 uptake: 50 percent on 5GHz

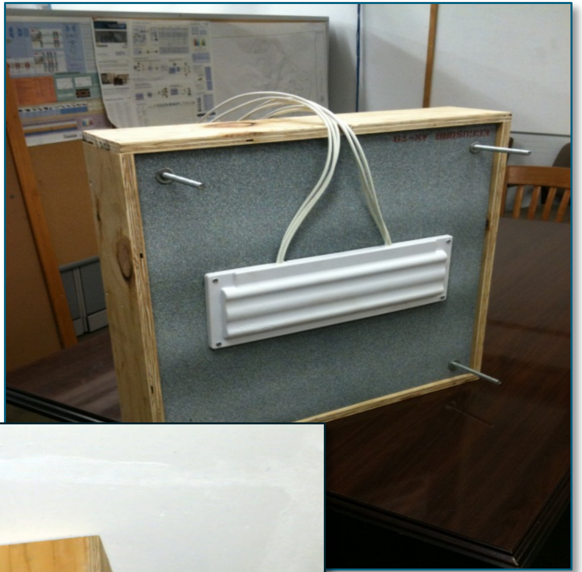
Sample Auditorium at Class Time

Sample AP Layout



Underfloor RF and Backlobe

- Antenna radiation pattern is 360 degree
- Front to back ratio (FTB) is measure of reduction in RF energy in opposite direction of antenna coverage (“backlobe”)
- However the antenna backlobes are being exposed to open space below the auditorium floor, no bodies and few walls to absorb energy
- How to reduce co-channel interference on backlobe?
- Answer: RF absorbing foam



RF Absorbing Foam

- Emerson and Cuming Microwave Products
- ECCOSORB AN 4.49 inch thickness

  “used in reducing crosstalk between adjacent antennas, shrouding antennas to improve the antenna patterns and undesired backlobes”

http://www.eccosorb.com/products-eccosorb-an.htm

Sample Ceiling APs

- 5GHz APs mounted on ceiling using Internal Omni antenna:

2.4GHz Configuration

- Removed 802.11b rates for entire campus in May, 2011
- 802.11g:
  - 12 Mbps set to mandatory on campus controllers
  - 18-54 Mbps set to supported
- No modification of 802.11n speeds:
  - MCS 0-23 all supported
- Manually configured power levels:
  - PL4 on four APs, PL3 on one AP

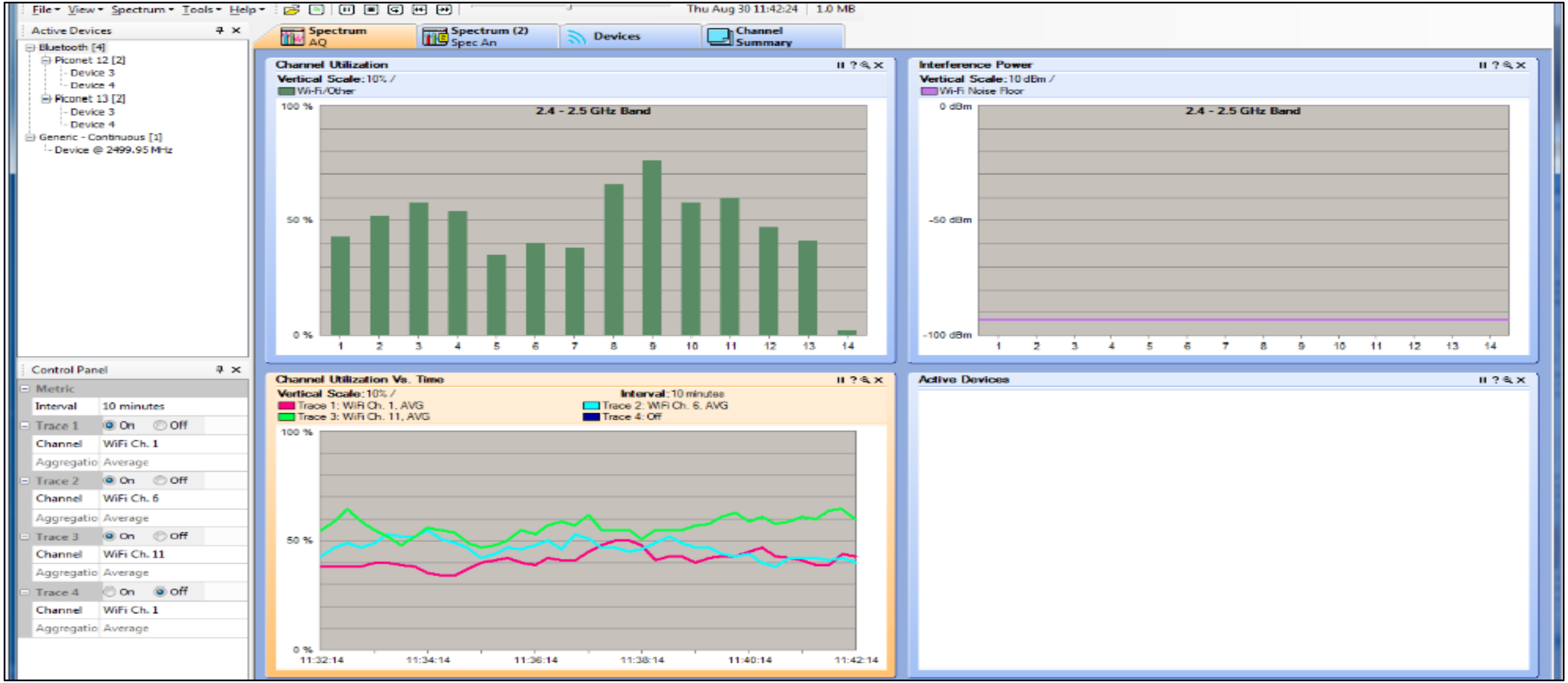
5GHz Configuration

- 802.11a Speeds:
  - disabled 6 and 9 Mbps.
  - Supported: 12, 18, 34, 48, 54
  - Mandatory: 24
- No modification of 802.11n speeds:
  - MCS 0-23 all supported
- Enabled “Extended UNII-2 channels”
  - Supports 21 channels to assist with Dynamic Frequency Selection issues

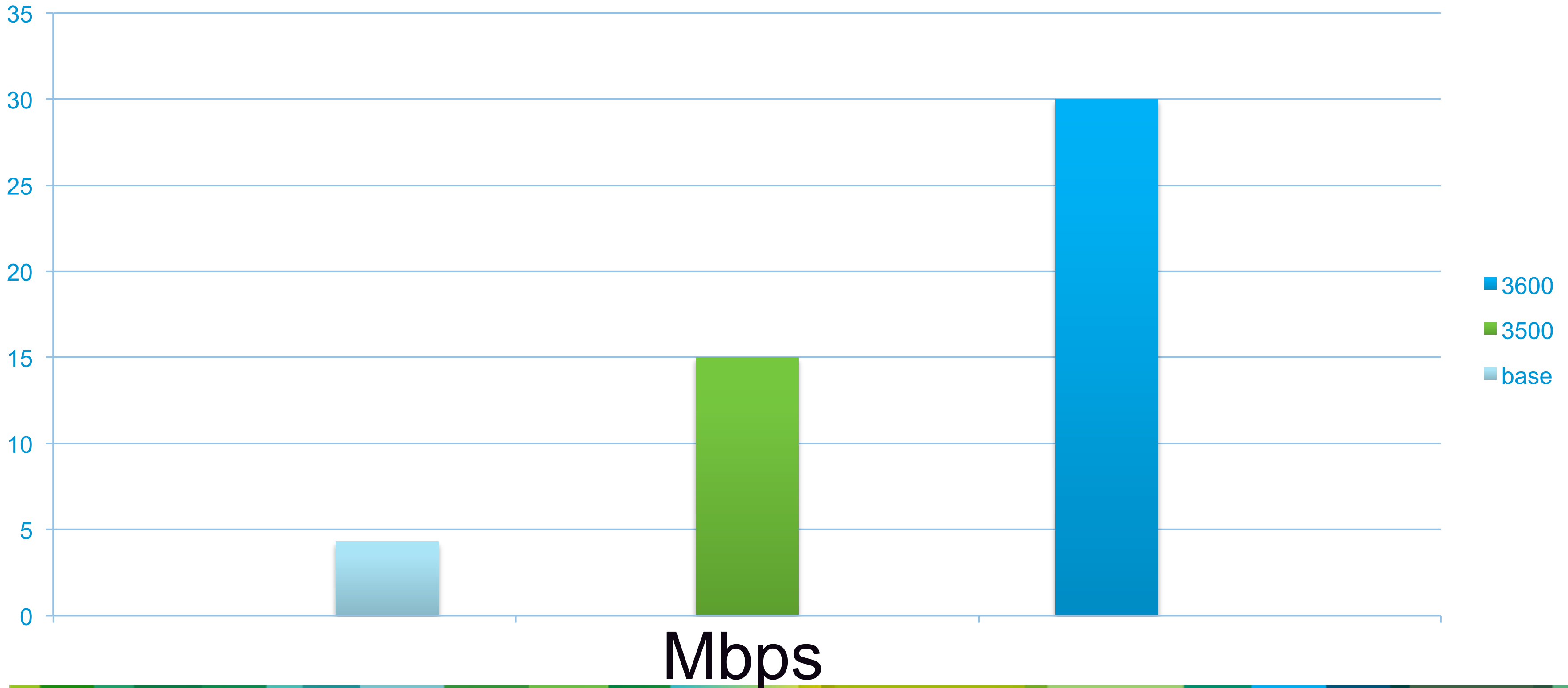
Global Configuration

- Client BandSelect enabled
- Client Load Balancing enabled
- ClientLink enabled by default
- CleanAir enabled for reports
  - Not using CleanAir for RRM
  - CleanAir provides information on interferers

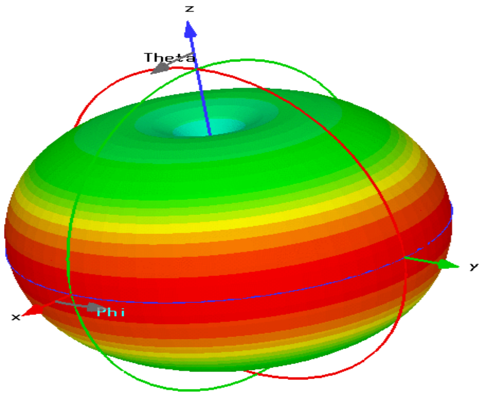
Spectrum Expert



Tuning Improvements

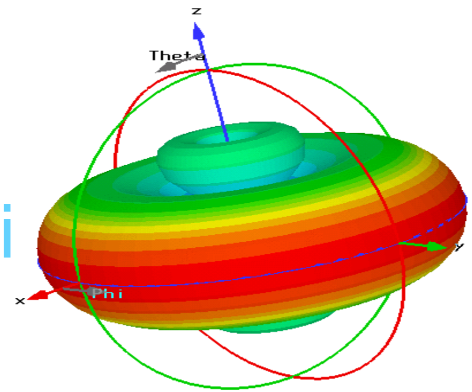


Antenna Radiation Patterns

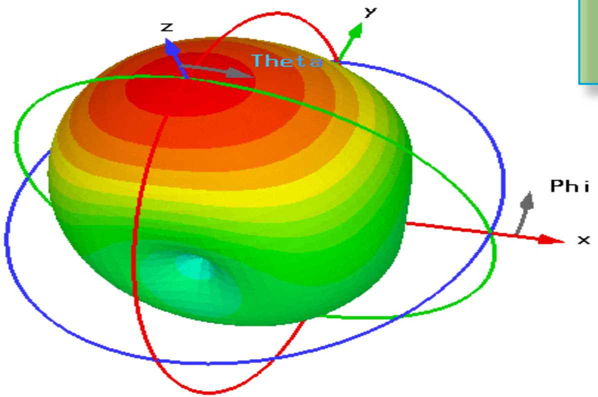


Dipole

Omni

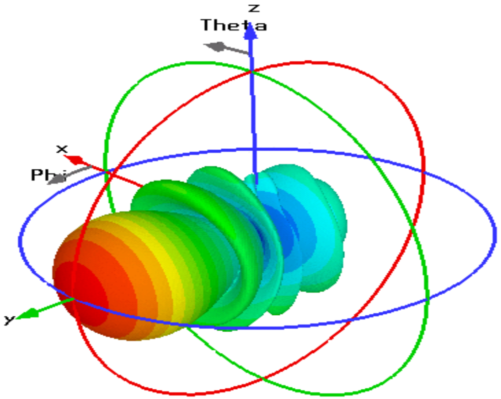


Antenna Choice Plays a Critical Part in Design for Proper Coverage



Patch

Yagi



Expanded WLAN Controller Portfolio

Large Campus and Service Provider

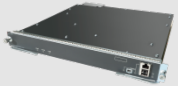
5508

- 12 to 500 APs
- 7000 clients
- 8 Gbps

5760

- 25 to 1000 APs
- 12,000 clients
- 60 Gbps

WISM2



- 300 to 1000 APs
- 15,000 clients
- 20 Gbps

NEW 5520

- 10-1500 APs
- 20,000 clients
- 20 Gbps

8510

- 100 to 6000 APs
- 64,000 clients
- 10 Gbps

NEW 8540

- 100 to 6000 APs
- 64,000 clients
- 40 Gbps

Small Campus and Branch (Controller on Premise)

2500

- 5 to 75 APs
- 1000 clients
- 1 Gbps

Catalyst 3650

- 1-50 APs per switch/stack Directly connected APs
- 1000 clients per stack
- 40 Gbps per switch

Catalyst 3850

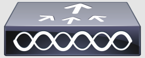
- 1-100 APs per stack Directly connected APs
- 2000 clients per stack
- 40 Gbps per switch

Catalyst 4500-E SUP

- 1-100 APs per SUP Indirectly connected APs
- 2000 clients per stack
- 40 Gbps per switch

Branch (Controller in DC)

Virtual WLC (NEW KVM)



- 5 to 200 APs
- 6000 clients
- 500 Mbps

Flex 7500

- 300 to 6000 APs
- 64,000 clients
- 1 Gbps

Sales & Partner Training
Worldwide Sales Enablement

Cisco Aironet 700W Access Point Series

- Target for Multi Dwelling Unit (MDU) Deployments seeking a high-performance in-room Wireless + Wired Access Device:
  - Hospitality
  - Higher Education for dorm-rooms
  - K-12 for dorm-rooms or other similar deployments
  - Health care (long-term care facilities or similar deployments)
- Designed for ease of mounting to numerous global wall junction standards. Specially designed brackets: default bracket included in the box (zero cost) or an optional bracket to cover local Ethernet ports.
- Sleek design in a small form factor: 15 x 10 x 3 cm (6 x 4 x 1.5 in)
- Robust enterprise-class design and RF performance
- Simultaneous Dual Radio, Dual Band with Integrated Antennas
- 4x GigE Ethernet Ports, 1x uplink GigE port
- Powered over Ethernet (PoE) or with AC Adapter
- PoE out port up to 803.af Class 0 (depending on powering options)

Cisco Aironet 700W Series

Wi-Fi Standards	802.11a/b/g/n
Max Data Rate	300 Mbps per radio
Radio Design MIMO: Spatial Streams	Dual-Radio, 2x2:2
Local Ethernet Ports	4 x GE
Powering Capability	1 x GE port PoE out
Port-based VLANs	(Future)
Autonomous	(Future)
Data Uplink (Mbps)	10/100/1000

Cisco Aironet Indoor Access Points Portfolio

Industry's Best 802.11ac Series Access Points

Current 11ac AP Portfolio

Enterprise Class

1700

- 802.11ac W1
- 870 Mbps PHY
- 3x3:2SS
- CleanAir Express
- Tx Beam Forming
- 2 GbE Ports

Mission Critical

2700

- 802.11ac W1,
- 1.3 Gbps PHY
- 3x4:3SS
- HDX: High Density Experience
- CleanAir 80 MHz
- ClientLink 3.0
- 2 GbE Ports

Best in Class

3700

- 802.11ac W1, 1.3 Gbps PHY
- 4x4:3SS
- HDX: High Density Experience
- CleanAir 80 MHz
- ClientLink 3.0
- StadiumVision
- Modularity: Security, 3G Small Cell or Wave 2 802.11ac

Enterprise → Mission Critical → Best In Class

Cisco Aironet Indoor Access Points Portfolio

Industry's Best 802.11ac Series Access Points

Enterprise Class 1700

- 802.11ac W1
- 870 Mbps PHY
- 3x3:2SS
- CleanAir Express
- Tx Beam Forming
- 2 GbE Ports

New

Enterprise Class 1850

- 802.11ac W2
- 2.0 Gbps PHY
- 4x4:4SS
- Spectrum Analysis*
- Tx Beam Forming
- 2 GbE Ports, USB 2.0

Mission Critical 2700

- 802.11ac W1,
- 1.3 Gbps PHY
- 3x4:3SS
- HDX: High Density Experience
- CleanAir 80 MHz
- ClientLink 3.0
- 2 GbE Ports

Best in Class 3700

- 802.11ac W1, 1.3 Gbps PHY
- 4x4:3SS
- HDX: High Density Experience
- CleanAir 80 MHz
- ClientLink 3.0
- StadiumVision
- Modularity: Security, 3G Small Cell or Wave 2 802.11ac

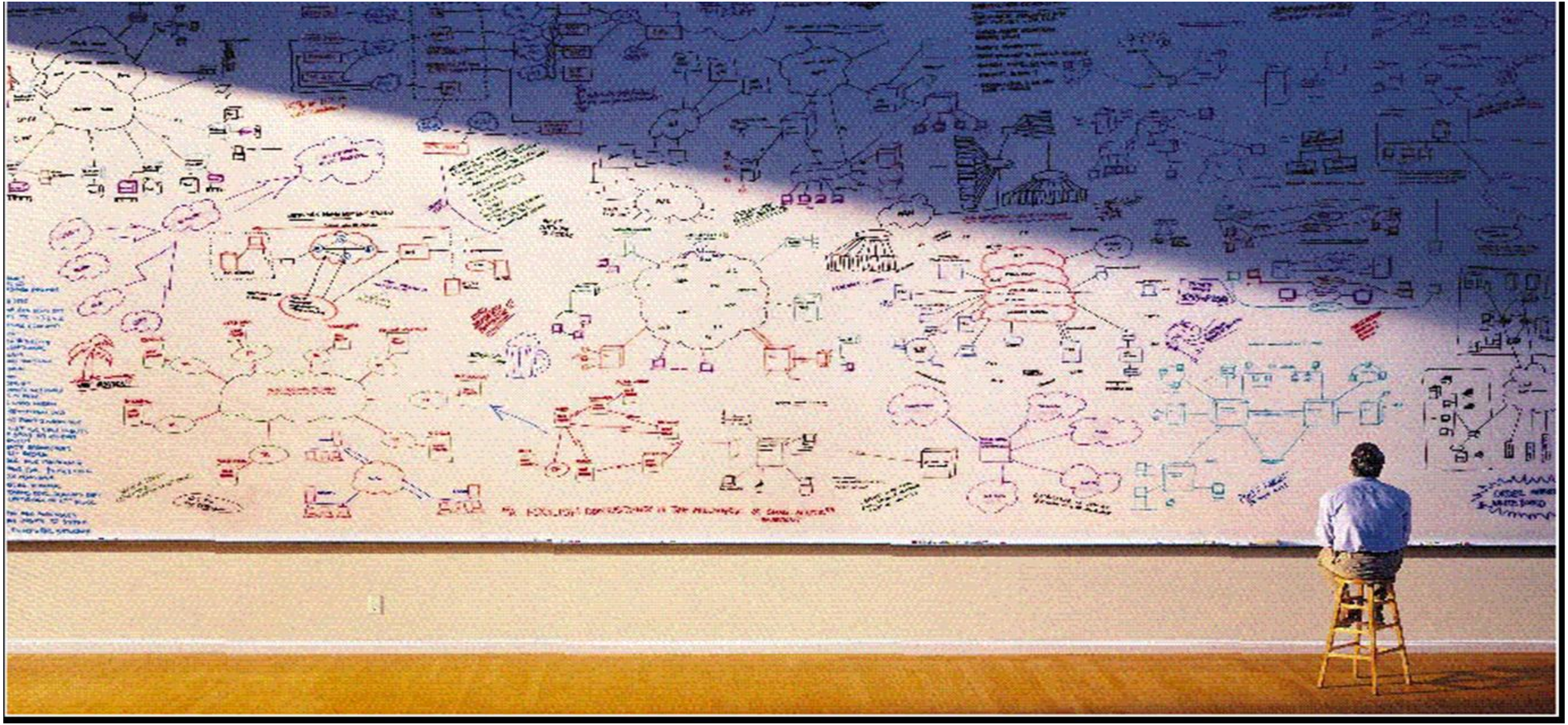
Enterprise → Mission Critical → Best In Class

* Planning

Cisco Aironet 802.11ac Access Point Comparison

Indoor AP Access Points	Enterprise			
	AP-1700	AP-1850	AP-2700	AP-3700
Max PHY Data Rate (5GHz)	870 Mbps	1.7 Gbps	1.3 Gbps	1.3 Gbps
RF Design (MU-MIMO)	3x3:2, Dual SU-MIMO	4x4:4, SU-MIMO 4x4:3, MU-MIMO	3x4:3, Dual SU-MIMO	4x4:3, Dual SU-MIMO
Performance/Coverage/Investment Protection	◆◆	◆◆◆	◆◆◆	◆◆◆◆
Max No. of Clients per AP	400	400	400	400
RRM	✔	✔	✔	✔
High Density Experience			✔	✔
CleanAir	CleanAir Express	Spectrum Analysis*	✔	✔
Beam Forming	Tx BF	Tx BF	ClientLink 3.0	ClientLink 3.0
BandSelect	✔	✔	✔	✔
VideoStream	✔	✔	✔	✔
Rogue AP Detection	✔	✔	✔	✔
Adaptive wIPS	✔	✔	✔	✔
External Antenna Option		✔	✔	✔
Ethernet Ports	2 x GbE	2 x GbE	2 x GbE	1 x GbE
LAG Support	n/a	✔	n/a	n/a
USB		2.0		
Module Options				Security, 3G Small Cell, High Accuracy Location

Q & A



Thank you.

Gigabit Wi-Fi - 802.11ac

- 802.11ac is the transformational technology for the Gigabit Wi-Fi Edge
- Cisco is the Leader of 802.11ac amendment for the 802.11 standard
- Industry's only future proof modular (3) radio platform
- Supports 802.11b/g/n, 802.11a/n, and 802.11ac
- Support for Wave 1 and Wave 2 modules

2 Mbps
802.11

11 Mbps
802.11b
1999

54 Mbps
24 Mbps
802.11ag
2003

600 Mbps
450 Mbps
300Mbps
65 Mbps
802.11n
2007

6900 Mbps
8SS @ 160

1300 Mbps
3SS@80
870 Mbps
2SS@80
430 Mbps
1SS @ 80

Now

AP3700, AP2700, AP1700
and
Wave 1 Module

≤GbE

802.11ac **Wave 1**
2013

6900 Mbps
8SS @160
3500 Mbps
4SS @ 160
2340 Mbps
3SS @ 160
1730 Mbps
2SS @ 160
430 Mbps
1SS @ 80

AP1850

802.11ac **Wave 2**
2HCY15 (Target)