

The Cisco Live! logo, featuring the word "CISCO" in a dark blue, sans-serif font, followed by "Live!" in a dark blue, cursive script font.

CISCO *Live!*

The text "Let's go" in a large, dark blue, sans-serif font, positioned to the left of a bright white sunburst graphic that radiates across the right side of the image.

Let's go

#CiscoLiveAPJC



“Reconciliation”- Dustin Koa Art



“Reconciliation” – Dustin Koa Art





The bridge to possible

Wireless-First Enterprise

Cut the Cord and Build a Resilient Wireless Network!

Leigh Jewell
Technical Solutions Architect
BRKEWN-1703

CISCO *Live!*

#CiscoLiveAPJC

Cisco Webex App

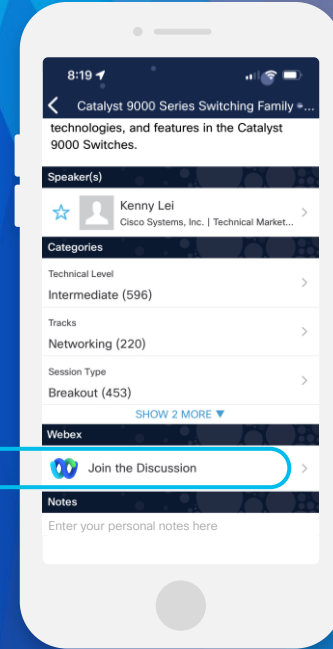
Questions?

Use Cisco Webex App to chat with the speaker after the session

How

- 1 Find this session in the Cisco Live Mobile App
- 2 Click “Join the Discussion”
- 3 Install the Webex App or go directly to the Webex space
- 4 Enter messages/questions in the Webex space

Webex spaces will be moderated by the speaker until December 22, 2023.

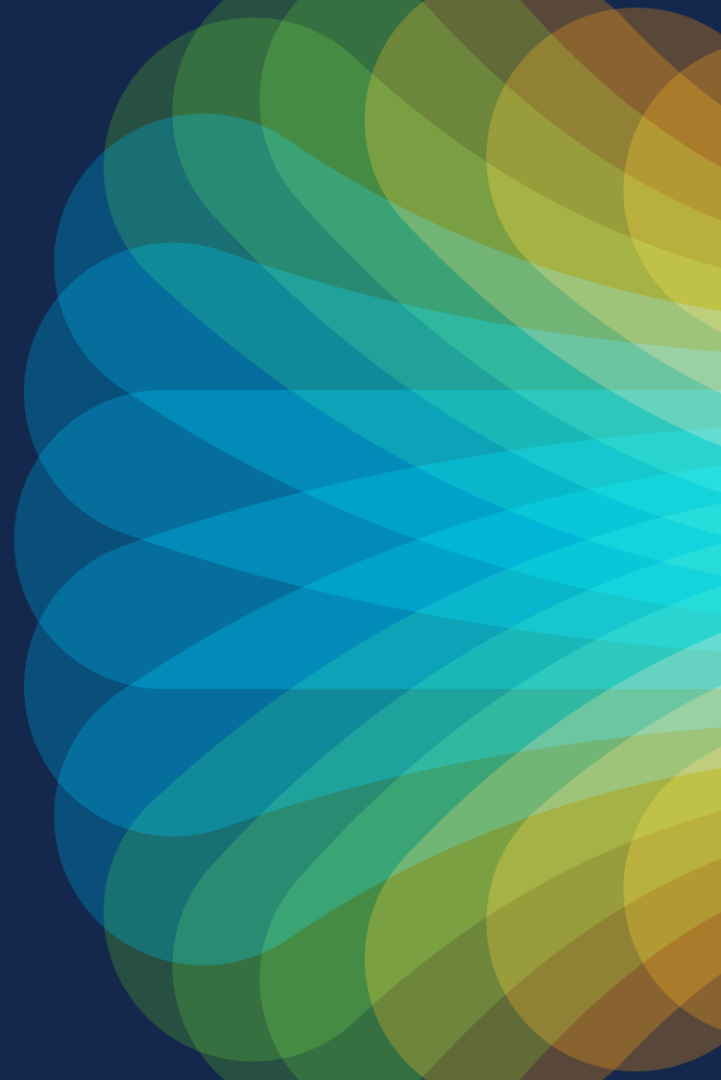


<https://ciscolive.ciscoevents.com/ciscolivebot/#BRKEWN-1703>

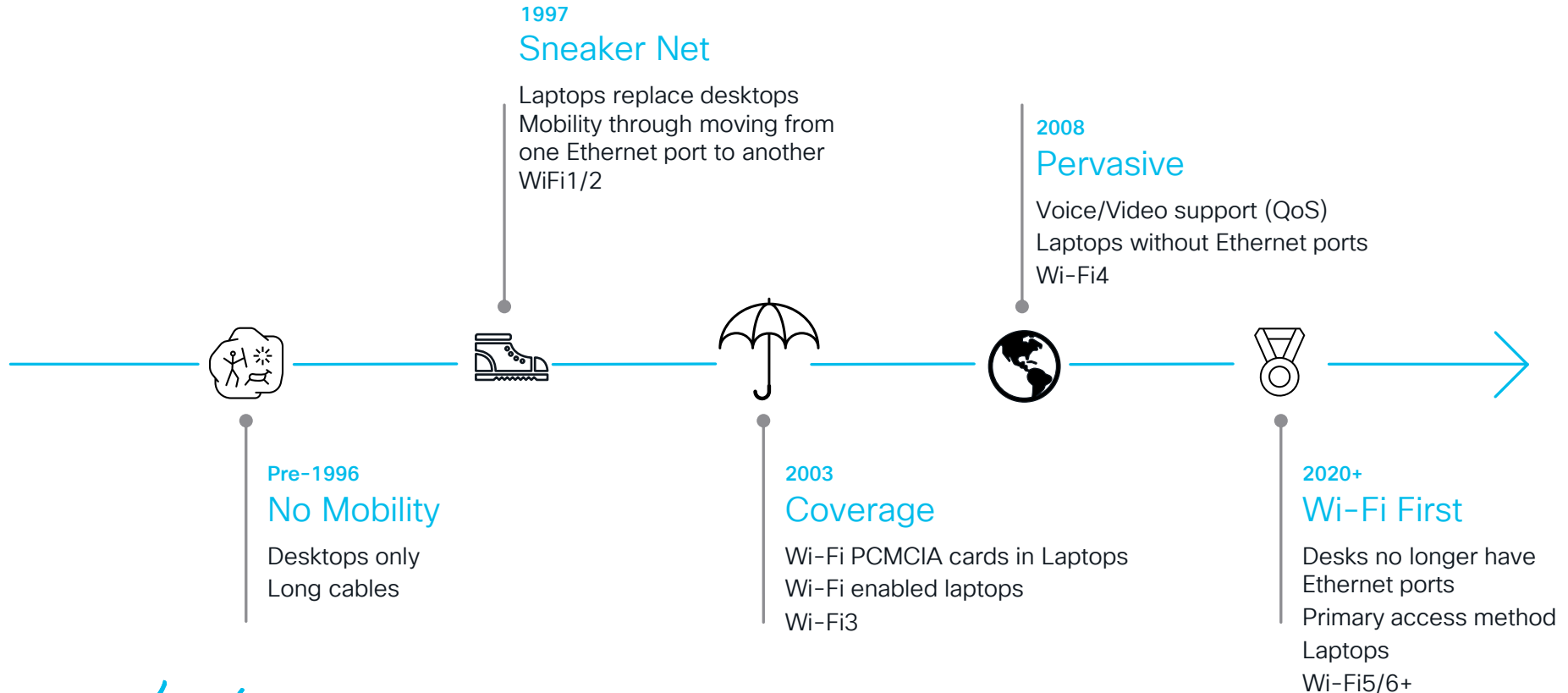
Agenda

- What is a Wireless-First network?
- Wireless-First Design
- Capacity planning
- Site survey and design
- Resiliency
- Sustainability
- Challenges and future trends
- Conclusion

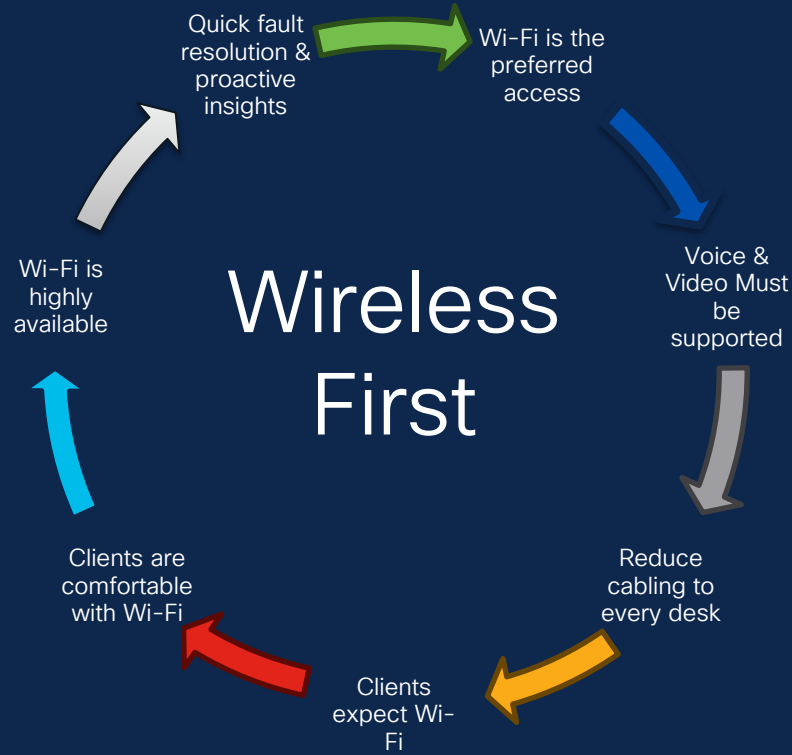
What is Wireless-First?



Mobility Evolution



Wireless First Strategy



Why Not Wireless Only?

Devices that can be powered with PoE should be

- Lower cost than high voltage outlets
- More control of devices with Ethernet connectivity
- Save precious RF bandwidth for those that need it
- Better for video conferencing

If it has a battery let it be free

- Wireless First supports battery operated mobile devices – mobiles, laptops
- These devices tend not to have Ethernet ports and its expected to use Wireless for connectivity



The Cutting of the Cord



Apple MacBook Air
released in 2008
never had an Ethernet
port



Apple MacBook
Pro Laptop
eliminated the
Ethernet port in
2012



Lenovo ThinkPad
X1 Carbon
moved to mini
Gigabit Ethernet
5th Gen 2017



Lenovo 2021 added
models without Ethernet
ports including the T
series



Hybrid Work – We've Changed How We Work

Hybrid work has changed how we work

Employees typically have better home Wi-Fi

Enterprises no longer require people to be on the corporate network or use VPN to work

Workplaces are looking at consolidating and condensing workspaces



Our Offices are Getting More Crowded



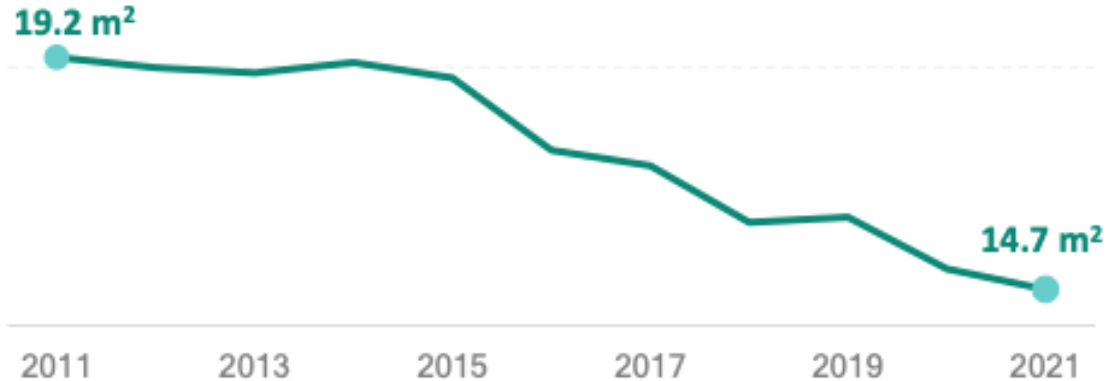
76 Entities
645 Tenancies
3,027,239 m² Controlled Area
2,422,416 m² Usable Office Area

14.8m² 44.3%

Occupational density remains consistent (increased 0.1m² from 2021).

Tenancies meeting the occupational density target (increased 0.7 per cent from 2021).

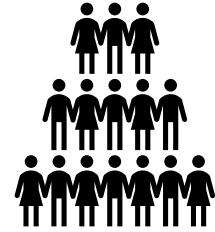
Chart 2.b National Occupational Density



Amount of office space per staff in Non-corporate Commonwealth entities has dropped by 23% (4.5m²) over the last 10 years

source: <https://www.finance.gov.au/government/property-and-construction/leased-office-accommodation/australian-government-office-occupancy-reports>

Perhaps its Worse Than We Think



Think your office is cramped? It could be much worse

“Sydney’s white-collar workforce has an average office density of 11.1sq m per person and Melbourne 12sq m, making them more densely crowded than the global average of 13.3sq m, according to the Benchmarking Cities and Real Estate report.”

source: <https://www.afr.com/property/commercial/think-your-office-is-cramped-it-could-be-much-worse-20210620-p582mx>

What's Wrong With this Picture?



70%
Bigger
screen
over
16
years

iPhone 15 Pro \$2,899
Storage 1TB



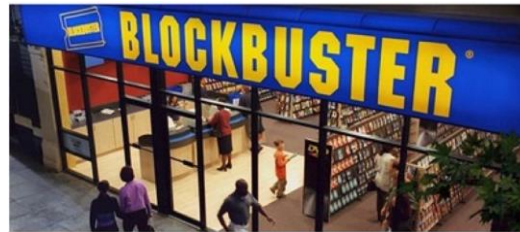
Mac Book Pro 14" \$2,699
Storage 512GB

Wireless First – So What

If you don't put wireless first then your infrastructure may not be able to support the devices and the applications, that need to run on them.



1889-2012



1985-2010



1937-2001

Why Wireless First?



Lowering

Cost

Horizontal cabling cost

Brownfield upgrades
challenges

Time to upgraded

Security policy

Increasing

Mobility

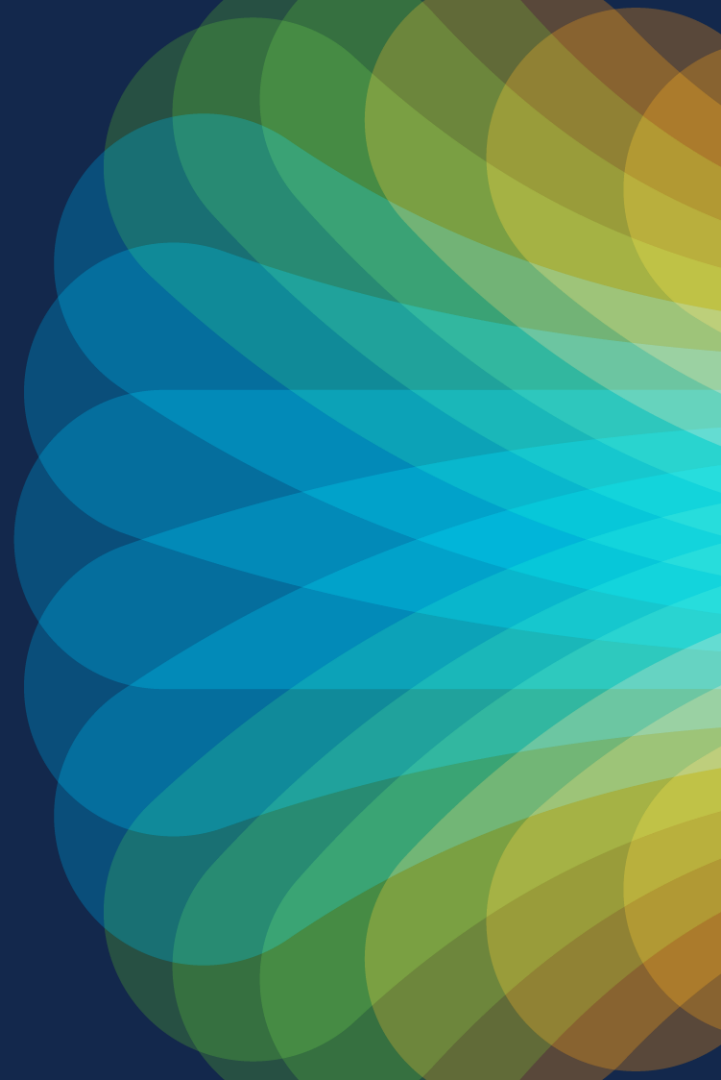
Hybrid work

VR/AR

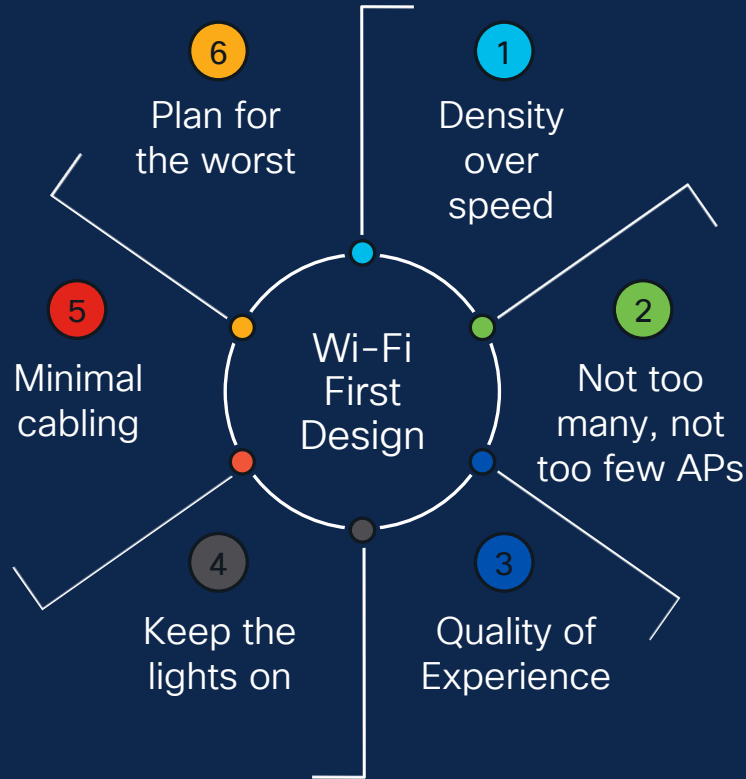
Removal of dedicated
workstations

Increase collaboration
workspace

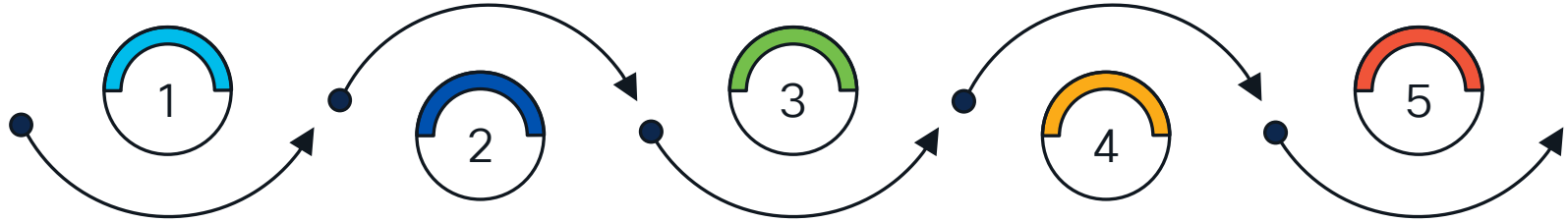
Wi-Fi First Design



Tenets of a Wireless First Design



Components of a Wireless First Design?



Capacity planning

- Total Throughput
- Device Throughput
- Number APs

Site Survey & Design

- Mounting APs
- Directional Antennas
- AP Placement

Resiliency

- Patching
- PoE
- Switching

Radio Settings

- Band Selection
- Minimum bitrate
- TX Power
- Channel Width
- DFS Channels

Quality of Experience

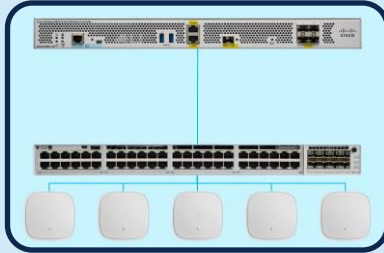
- Monitoring & assurance
- QoS
- Traffic Shaping
- Multicast
- Mobility

Wireless Deployment Options

Wireless Architectures

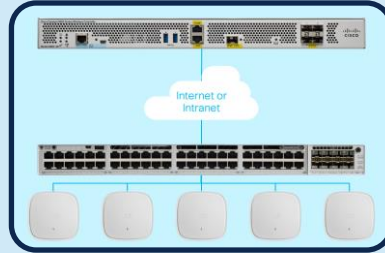
On-Prem

Cloud



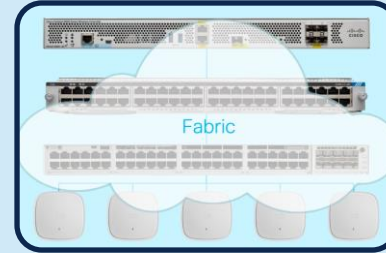
Centralised

- Distributed Network
- Highly Scalable
- Highly Available
- Advanced Solutions



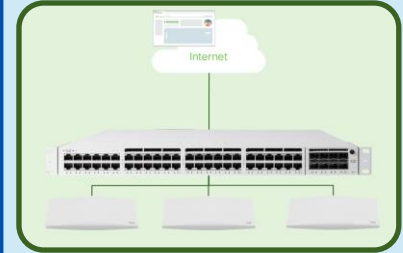
Flex Connect

- Distributed Network
- Centrally Hosted
- Highly Scalable



Software Defined Access

- Campus and Branch
- Intent Based Networking
- Highly Scalable
- Highly Available
- Consistent Wired/Wireless Policy
- Micro-segmentation



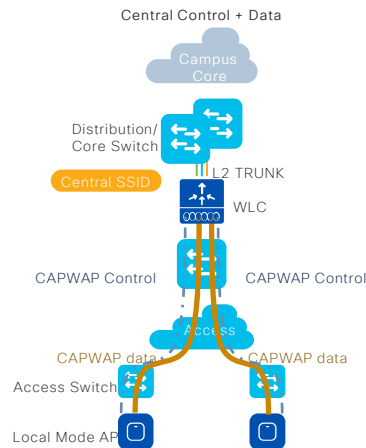
Cloud Managed

- Distributed Network
- Meraki Dashboard
- Highly Scalable
- Low IT Footprint
- Consistent Wired/Wireless Policy
- Micro-segmentation

Wireless Deployment Options

On-Prem Design

Centralized Design

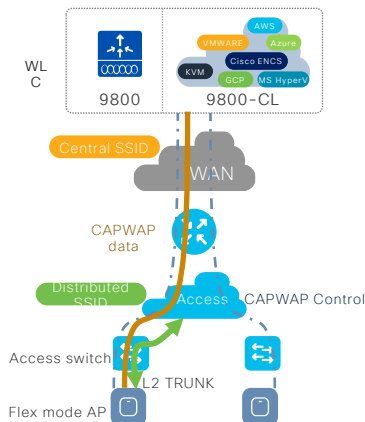


Local mode

- Mid to Large size Campus
- APs are in local mode
- Client traffic bridged at WLC in a L2 trunk
- Single point of entry into wired network
- Roaming is supported across all APs
- Latency < 20ms between AP and WLC

Distributed Design

Central Control | Distributed Data (802.1Q) or Centralized

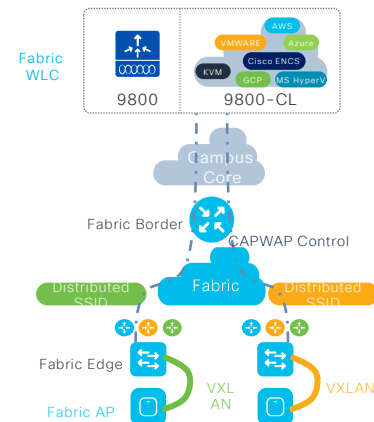


FlexConnect

- Distributed Enterprise design choice
- APs in Flex mode, across a WAN from WLC
- Per SSID: Client traffic is distributed at AP in L2 trunk or centralized via CAPWAP
- Roaming limited to APs in a Flex domain

SDA

Central Control | Distributed Data (802.1Q)
Cisco DNA Center and Cisco ISE

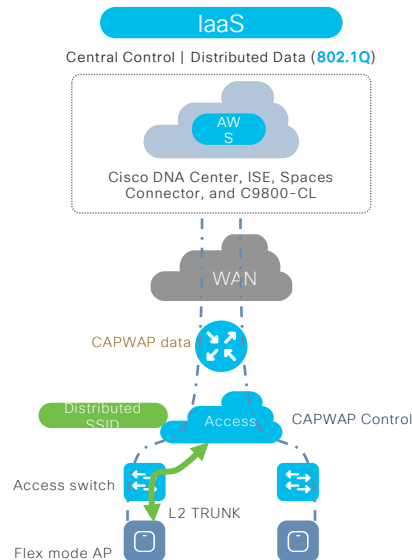


Software Defined Access (SDA)

- Mid to Large size Campus
- APs are in Fabric mode
- Traffic distributed at AP via VXLAN
- Roaming is supported across all APs
- Latency < 20ms between AP and WLC

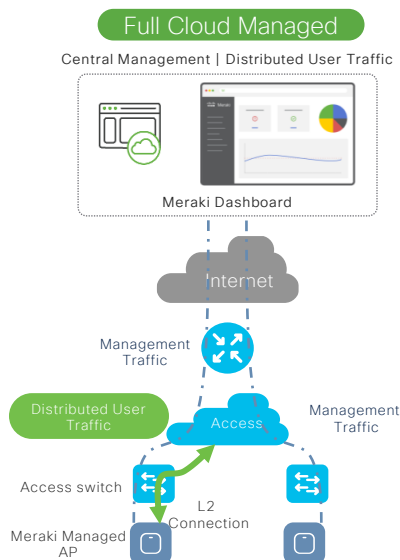
Wireless Deployment Options

Cloud Design



IaaS (Catalyst on Public Cloud)

- Distributed Enterprise design choice
- APs in Flex mode, across a WAN from WLC managed by Cisco DNA Center
- Per SSID: Client traffic is distributed at AP in L2 trunk
- Roaming limited to APs in a Flex domain

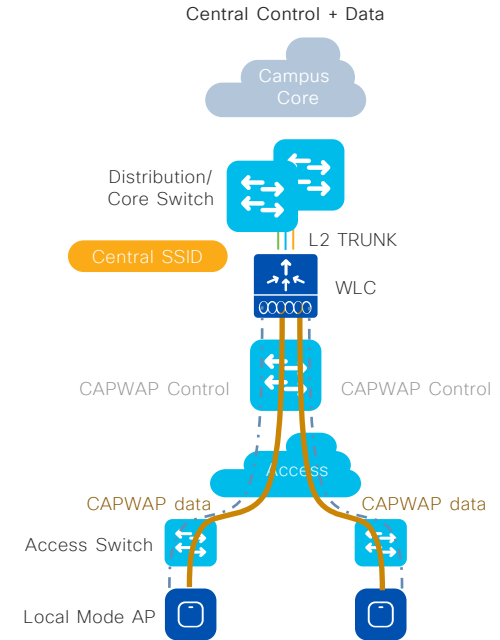


Full Cloud Managed

- Fully Cloud Managed Enterprise design choice
- APs fully managed by Meraki Dashboard with only Managed Traffic sent to Dashboard
- All customer user traffic is distributed at AP is sent to rest of user network and not sent to Dashboard
- Roaming limited to APs in a Dashboard Network

Why Central Mode Deployment?

- **Simple IP Addressing and mobility**
 - Wireless client traffic is switched at the WLC
 - Client IP addressing & VLAN(s) defined on the WLC
 - Client Layer 3 roaming without reassigning an address
- **Single point of connection to the wired network**
 - Easier to apply security & QoS policies for wireless users
- **Simplified Overlay Design**
 - Traffic is tunnelled (using CAPWAP Protocol) from AP to WLC
 - Can be deployed on top of any wired infrastructure



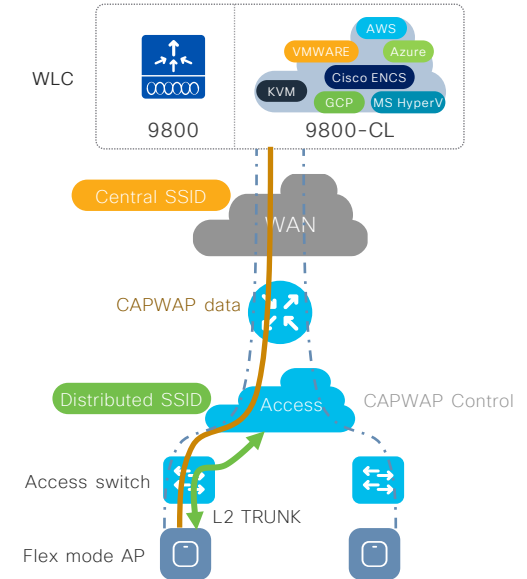
Examples -

- Enterprises
- Campus/Universities
- Hospitals

Why FlexConnect Mode Deployment?

- **Optimised Control and Data Planes**
 - Throughput does not rely on central WLC
- **WAN Failure Survivability in Branch Offices**
 - Flexconnect AP will go to “Standalone Mode” –
 - No impact on locally switched SSIDs
 - Disconnection of centrally switched SSIDs clients
 - Authenticates new clients with locally defined RADIUS server
- **Efficient AP Upgrade across WAN**
 - With the Smart Image Upgrade, software only sent to Master AP, reducing WAN bandwidth requirements

Central Control | Distributed Data (802.1Q) or Centralized

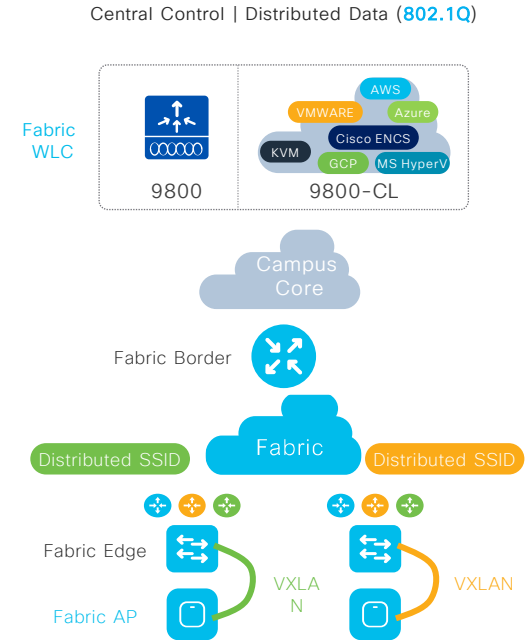


Examples -

- Branch Offices
- Small/Medium Stores/Retail

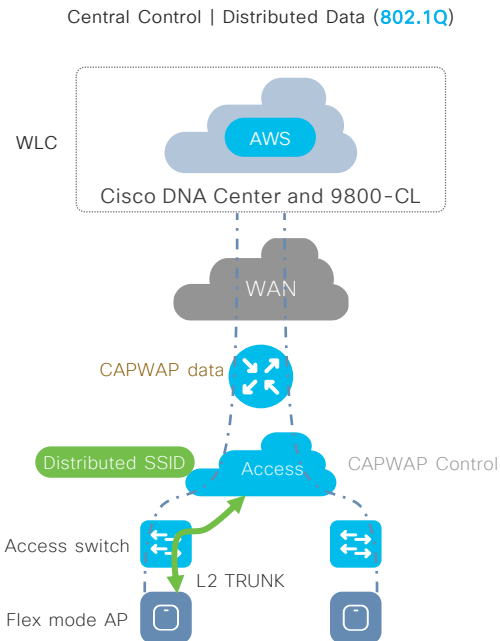
Why SD-Access Wireless Deployment?

- **Automation**
 - Unified Wired-Wireless automation for design and deployment
- **Simplifying Data, Control and Management Planes**
 - Control Plane centralized at WLC
 - Distributed data plane for Wireless (No restriction with Wireless Controller Data throughput)
 - Single touchpoint for management with Cisco DNA Center
- **Seamless Layer 2 roaming:**
 - Stretch client subnet without extending same VLAN everywhere
- **Segmentation**
 - Macro-Micro Segmentation for enhanced security (Common policies for Wired-Wireless)



Why IaaS (Public Cloud) Deployment?

- **Simplicity to Deploy and Reduced Operating Costs**
 - Reduce footprint inside datacenters by hosting Cisco DNA Center and Cisco Catalyst 9800-CL on Public Cloud
- **Optimised Control and Data Planes**
 - Throughput does not rely on central WLC
- **WAN Failure Survivability in Branch Offices**
 - Flexconnect AP will go to “Standalone Mode” –
 - No impact on locally switched SSIDs
 - Authenticates new clients with locally defined RADIUS server
- **Efficient AP Upgrade across WAN**
 - With the Smart Image Upgrade, software only sent to Master AP, reducing WAN bandwidth requirements



Why Full Cloud Managed Deployment?

- **Simplified Out of Band Management**

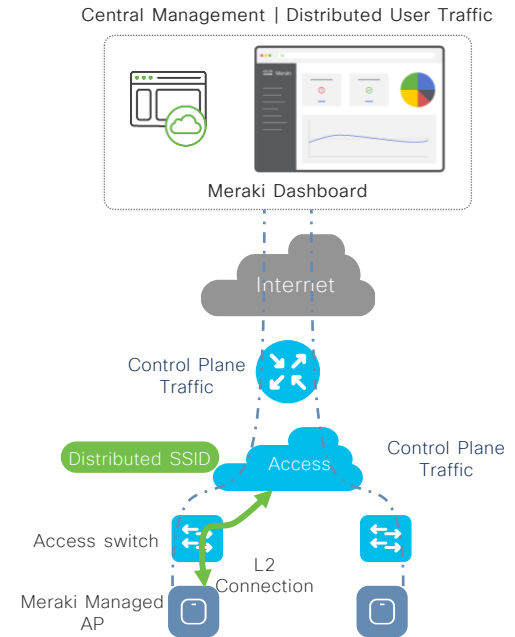
- Cloud-hosted Meraki Dashboard allows secure and simple management of all APs without the need for a WLC
- Easy plug-and-play deployment
- Only management data (e.g. configuration, statistics, monitoring, etc.) flows from Meraki devices to the Meraki cloud over a secure internet connection

- **Optimized Control and Data Planes**

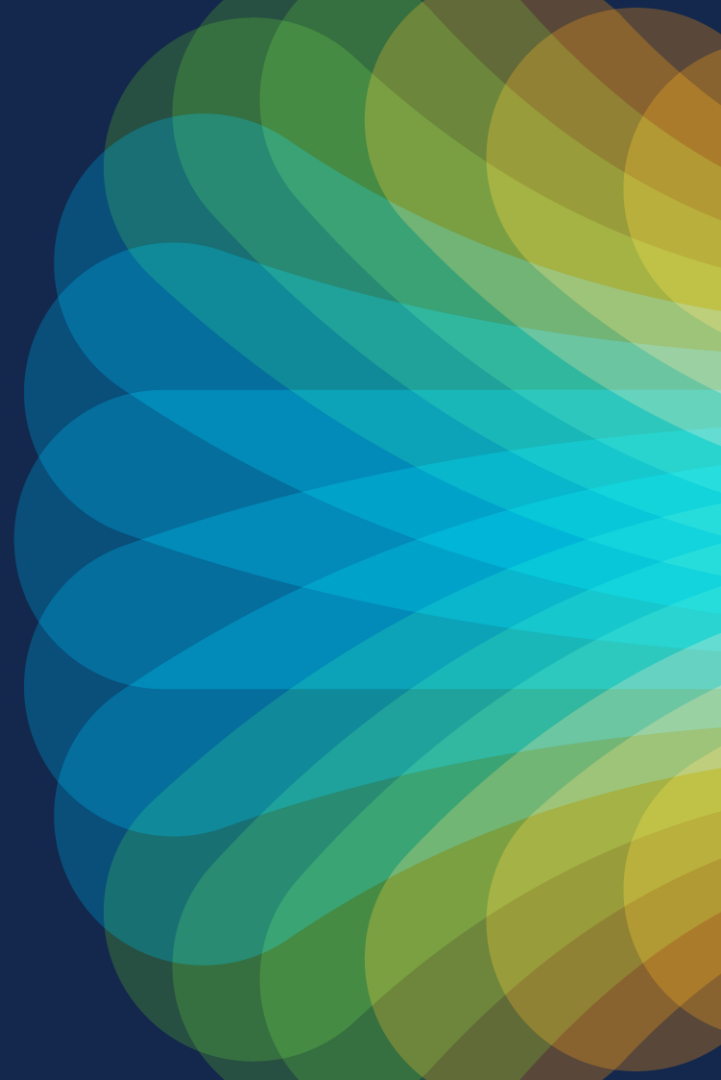
- Throughput is only limited by the AP and switchport connection
- User data (e.g. web browsing, internal applications) does not flow through the Meraki cloud, instead flowing directly to their destination on the LAN or across the WAN.

- **Meraki Cloud Connection Loss Survivability**

- Meraki Managed APs will never reboot if the following is met (otherwise reboots every 4 hours):
 - The configuration is safe – configuration that is not followed by a reboot for 30 minutes
 - 1 SSID is in bridge mode – wireless clients are bridged to the rest of the network
- Local Applications like RADIUS will still work if still reachable by APs



Capacity Planning



Goldilocks Principle of Wi-Fi APs

Not Too Many, Not too Few, Just Right



Too Few



Just Right



Too Many

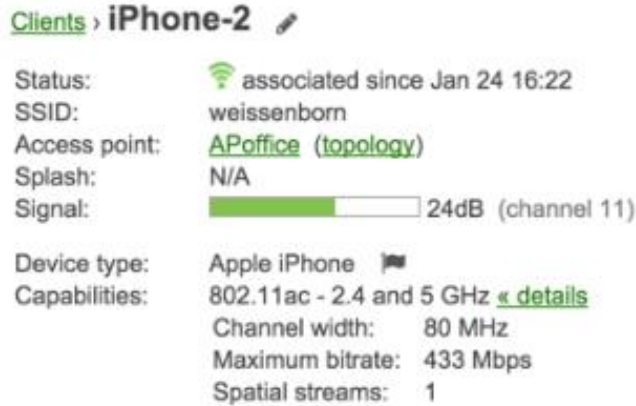
Estimate Throughput

Find your target application:

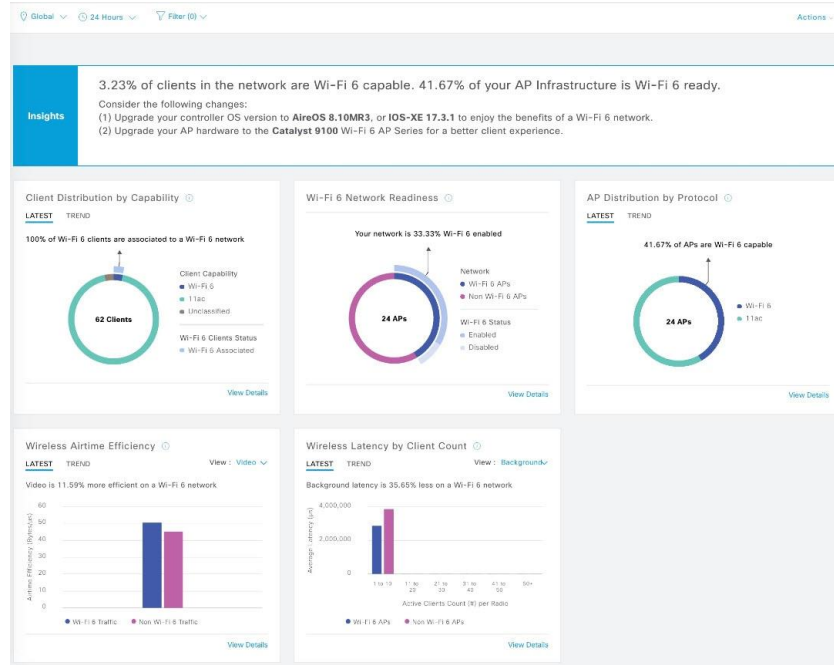
Application	Estimated Throughput
Video Conferencing	1.5Mbps
Streaming – Video	768Mbps
Streaming – Video HD	768– 8Mbps
Streaming – 4K	8 – 20Mbps
VR Training Headset	50Mbps

Understand Client Capabilities

Check the data sheet of the devices you will be supporting or use Meraki Dashboard and/or Catalyst Center Wi-Fi Readiness reports



Let's assume we have to support iPhone-2



Could we run 80Mhz?

802.11n and 802.11ac

MCS, SNR and RSSI

wirelessLAN
PROFESSIONALS

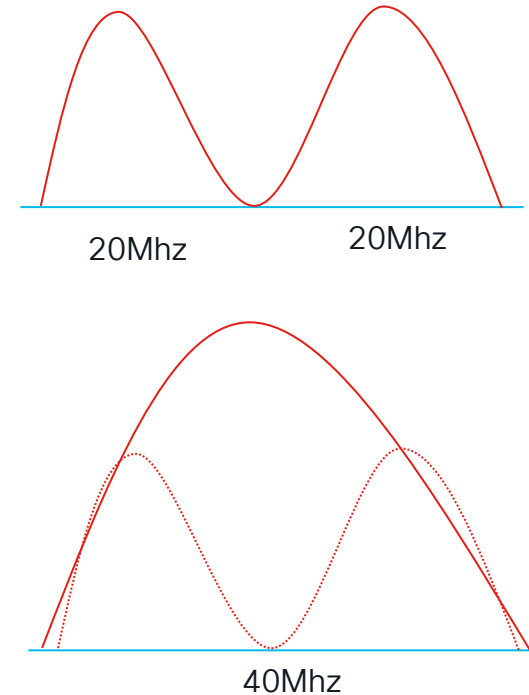
HT MCS	VHT MCS	Modulation	Coding	20MHz				40MHz				80MHz				160MHz	
				Data Rate		Min.	RSSI	Data Rate		Min.	RSSI	Data Rate		Min.	RSSI	Data Rate	
				800ns	400ns	SNR		800ns	400ns	SNR		800ns	400ns	SNR		800ns	400ns
1 Spatial Stream																	
0	0	BPSK	1/2	6.5	7.2	2	-82	13.5	15	5	-79	29.3	32.5	8	-76	58.5	65
1	1	QPSK	1/2	13	14.4	5	-79	27	30	8	-76	58.5	65	11	-73	117	130
2	2	QPSK	3/4	19.5	21.7	9	-77	40.5	45	12	-74	87.8	97.5	15	-71	175.5	195
3	3	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71	117	130	17	-68	234	260
4	4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67	175.5	195	21	-64	351	390
5	5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63	234	260	24	-60	468	520
6	6	64-QAM	3/4	58.5	65	20	-65	121.5	135	23	-62	263.3	292.5	26	-59	526.5	585
7	7	64-QAM	5/6	65	72.2	25	-64	135	150	28	-61	292.5	325	31	-58	585	650
8	8	256-QAM	3/4	78	86.7	29	-59	162	180	32	-56	351	390	35	-53	702	780
9	9	256-QAM	5/6			31	-57	180	200	34	-54	390	433.3	37	-51	780	866.7
2 Spatial Streams																	
8	0	BPSK	1/2	13	14.4	2	-82	27	30	5	-79	58.5	65	8	-76	117	130
9	1	QPSK	1/2	26	28.9	5	-79	54	60	8	-76	117	130	11	-73	234	260
10	2	QPSK	3/4	39	43.3	9	-77	81	90	12	-74	175.5	195	15	-71	351	390
11	3	16-QAM	1/2	52	57.8	11	-74	108	120	14	-71	234	260	17	-68	468	520
12	4	16-QAM	3/4	78	86.7	15	-70	162	180	18	-67	351	390	21	-64	702	780
13	5	64-QAM	2/3	104	115.6	18	-66	216	240	21	-63	468	520	24	-60	936	1040
14	6	64-QAM	3/4	117	130.3	20	-65	243	270	23	-62	526.5	585	26	-59	1053	1170
15	7	64-QAM	5/6	130	144.4	25	-64	270	300	28	-61	585	650	31	-58	1170	1300
8	8	256-QAM	3/4	156	173.3	29	-59	324	360	32	-56	702	780	35	-53	1404	1560
9	9	256-QAM	5/6			31	-57	360	400	34	-54	780	866.7	37	-51	1560	1733
3 Spatial Streams																	
16	0	BPSK	1/2	19.5	21.7	2	-82	40.5	45	5	-79	87.8	97.5	8	-76	175.5	195
17	1	QPSK	1/2	39	43.3	5	-79	81	90	8	-76	175.5	195	11	-73	351	390
18	2	QPSK	3/4	58.5	65	9	-77	121.5	135	12	-74	263.3	292.5	15	-71	526.5	585
19	3	16-QAM	1/2	78	86.7	11	-74	162	180	14	-71	351	390	17	-68	702	780
20	4	16-QAM	3/4	117	130	15	-70	243	270	18	-67	526.5	585	21	-64	1053	1170
21	5	64-QAM	2/3	156	173.3	18	-66	324	360	21	-63	702	780	24	-60	1404	1560
22	6	64-QAM	3/4	175.5	195	20	-65	364.5	405	23	-62			26	-59	1580	1755
23	7	64-QAM	5/6	195	216.7	25	-64	405	450	28	-61	877.5	975	31	-58	1755	1950
8	8	256-QAM	3/4	234	260	29	-59	486	540	32	-56	1053	1170	35	-53	2106	2340
9	9	256-QAM	5/6	260	288.9	31	-57	540	600	34	-54	1170	1300	37	-51		

MCS Table for 802.11n and 802.11ac

Ref: <https://wlanprofessionals.com/mcs-table-and-how-to-use-it/>

Channel Bonding

- First introduced in 802.11n
 - Allowed two 20Mhz channels to be bonded to increase bandwidth to client
 - 802.11ac increased this to 80Mhz and 160Mhz
- While channel bonding can provide higher data rates, it will also result in fewer channels available
- 20MHz channels to spread client usage provides better performance than having fewer 40MHz channels



Channel Bonding

- 2.4Ghz spectrum only has three non-overlapping 20Mhz channels
 - Channel bonding is not realistic
- 5Ghz spectrum has 22 x 20Mhz
- Channel bonding requires contiguous channels so:
 - 1 x 160Mhz
 - 5 x 80Mhz
 - 10 x 40Mhz

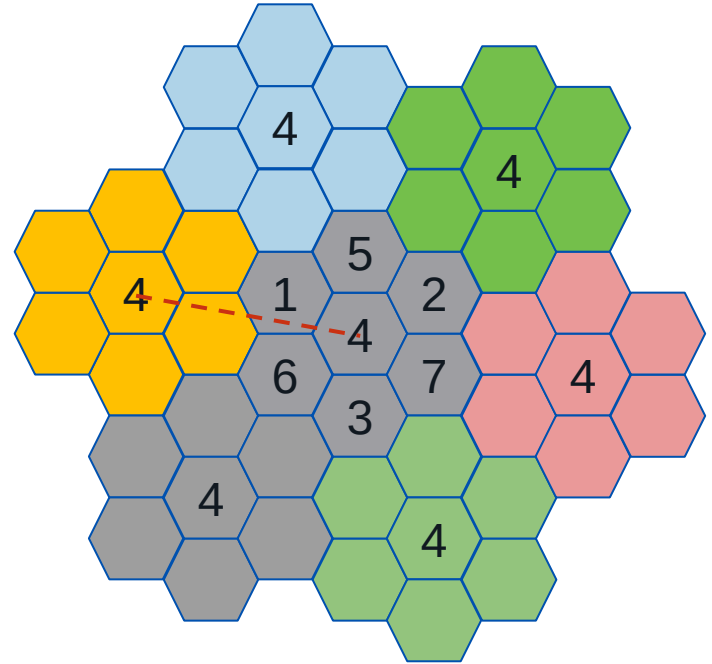
5Ghz Wi-Fi				802.11ac			n
Ch	F (MHz)	Range (MHz)	ACMA LIPD Class License 2015	160M	80M	40M	n
36	5180	5170-5190	Indoors 10mW EIRP / Mhz (61)	0	1		B
40	5200	5190-5210	Indoors 10mW EIRP / Mhz (61)	0	1	6	B
44	5220	5210-5230	Indoors 10mW EIRP / Mhz (61)	0	1	6 9	C
48	5240	5230-5250	Indoors 10mW EIRP / Mhz (61)	0	1	6 9 A	C M
52	5260	5250-5270	Indoors 10mW EIRP / Mhz + DFS (+TPC >100mW) (62)	0	2	6 9 A	D M
56	5280	5270-5290	Indoors 10mW EIRP / Mhz + DFS (+TPC >100mW) (62)	0	2	9 A	D N
60	5300	5290-5310	Indoors 10mW EIRP / Mhz + DFS (+TPC >100mW) (62)	0	2	A	E N
64	5320	5310-5330	Indoors 10mW EIRP / Mhz + DFS (+TPC >100mW) (62)	0	2		E
100	5500	5490-5510	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		3		F
104	5520	5510-5530	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		3	7	F O
108	5540	5530-5550	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		3	7	G O
112	5560	5550-5570	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		3	7	G P
116	5580	5570-5590	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		7		P
132	5660	5650-5670	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		4		H
136	5680	5670-5690	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		4		H Q
140	5700	5690-5710	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		4		I Q
144	5720	5710-5730	50mW EIRP / Mhz + DFS (+TPC >500mW) (63)		4		I
148	5745	5735-5755	Yes 4W EIRP (60)		5		J
153	5765	5755-5775	Yes 4W EIRP (60)		5	8	J R
157	5785	5775-5795	Yes 4W EIRP (60)		5	8	K R
161	5805	5795-5815	Yes 4W EIRP (60)		5	8	K S
165	5825	5815-5835	Yes 4W EIRP (60)		8		S

by goughlui.com

Ref: <https://archive.goughlui.com/wp-content/uploads/2018/05/5gwifi-channelselect.png>

Channel Bonding and Channel Planning

- Assume cell boundary is a hexagon
- Typical channel plan would require 7 non-overlapping channels
- 80Mhz only provides 5 bonded channels in 5Ghz
- Efficient channel plans for floors can only realistically use 40Mhz bonded channels or 20Mhz channels



80Mhz not recommended in a Wireless First design

Using 40Mhz

802.11n and 802.11ac

MCS, SNR and RSSI

wirelessLAN

HT MCS	VHT MCS	Modulation	Coding	20MHz				40MHz				80MHz				160MHz			
				Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI
				800ns	400ns			800ns	400ns			800ns	400ns			800ns	400ns		
1 Spatial Stream																			
0	0	BPSK	1/2	6.5	7.2	2	-82	13.5	15	5	-79	29.3	32.5	8	-76	58.5	65	11	-73
1	1	QPSK	1/2	13	14.4	5	-79	27	30	8	-76	58.5	65	11	-73	117	130	14	-70
2	2	QPSK	3/4	19.5	21.7	9	-77	40.5	45	12	-74	87.8	97.5	15	-71	175.5	195	18	-68
3	3	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71	117	130	17	-68	234	260	20	-65
4	4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67	175.5	195	21	-64	351	390	24	-61
5	5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63	234	260	24	-60	468	520	27	-57
6	6	64-QAM	3/4	58.5	65	20	-65	121.5	135	23	-62	263.3	292.5	26	-59	526.5	585	29	-56
7	7	64-QAM	5/6	65	72.2	25	-64	135	150	28	-61	292.5	325	31	-58	585	650	34	-55
8	8	256-QAM	3/4	78	86.7	29	-59	162	180	32	-56	351	390	35	-53	702	780	38	-50
9	9	256-QAM	5/6			31	-57	180	200	34	-54	390	433.3	37	-51	780	866.7	40	-48
2 Spatial Streams																			
8	0	BPSK	1/2	13	14.4	2	-82	27	30	5	-79	58.5	65	8	-76	117	130	11	-73
9	1	QPSK	1/2	26	28.9	5	-79	54	60	8	-76	117	130	11	-73	234	260	14	-70
10	2	QPSK	3/4	39	43.3	9	-77	81	90	12	-74	175.5	195	15	-71	351	390	18	-68
11	3	16-QAM	1/2	52	57.8	11	-74	108	120	14	-71	234	260	17	-68	468	520	20	-65
12	4	16-QAM	3/4	78	86.7	15	-70	162	180	18	-67	351	390	21	-64	702	780	24	-61
13	5	64-QAM	2/3	104	115.6	18	-66	216	240	21	-63	468	520	24	-60	936	1040	27	-57
14	6	64-QAM	3/4	117	130.3	20	-65	243	270	23	-62	526.5	585	26	-59	1053	1170	29	-56
15	7	64-QAM	5/6	130	144.4	25	-64	270	300	28	-61	585	650	31	-58	1170	1300	34	-55
8	8	256-QAM	3/4	156	173.3	29	-59	324	360	32	-56	702	780	35	-53	1404	1560	38	-50
9	9	256-QAM	5/6			31	-57	360	400	34	-54	780	866.7	37	-51	1560	1733	40	-48
3 Spatial Streams																			
16	0	BPSK	1/2	19.5	21.7	2	-82	40.5	45	5	-79	87.8	97.5	8	-76	175.5	195	11	-73
17	1	QPSK	1/2	39	43.3	5	-79	81	90	8	-76	175.5	195	11	-73	351	390	14	-70
18	2	QPSK	3/4	58.5	65	9	-77	121.5	135	12	-74	263.3	292.5	15	-71	526.5	585	18	-68
19	3	16-QAM	1/2	78	86.7	11	-74	162	180	14	-71	351	390	17	-68	702	780	20	-65
20	4	16-QAM	3/4	117	130	15	-70	243	270	18	-67	526.5	585	21	-64	1053	1170	24	-61
21	5	64-QAM	2/3	156	173.3	18	-66	324	360	21	-63	702	780	24	-60	1404	1560	27	-57
22	6	64-QAM	3/4	175.5	195	20	-65	364.5	405	23	-62			26	-59	1580	1755	29	-56
23	7	64-QAM	5/6	195	216.7	25	-64	405	450	28	-61	877.5	975	31	-58	1755	1950	34	-55
8	8	256-QAM	3/4	234	260	29	-59	486	540	32	-56	1053	1170	35	-53	2106	2340	38	-50
9	9	256-QAM	5/6	260	288.9	31	-57	540	600	34	-54	1170	1300	37	-51			40	-48

MCS Table for 802.11n and 802.11ac

Ref: <https://wlanprofessionals.com/mcs-table-and-how-to-use-it/>

40MHz				
Data Rate		Min. SNR	RSSI	
800ns	400ns			
1 Spatial Stream				
13.5	15	5	-79	
27	30	8	-76	
40.5	45	12	-74	
54	60	14	-71	
81	90	18	-67	
108	120	21	-63	
121.5	135	23	-62	
135	150	28	-61	
162	180	32	-56	
180	200	34	-54	
2 Spatial Streams				

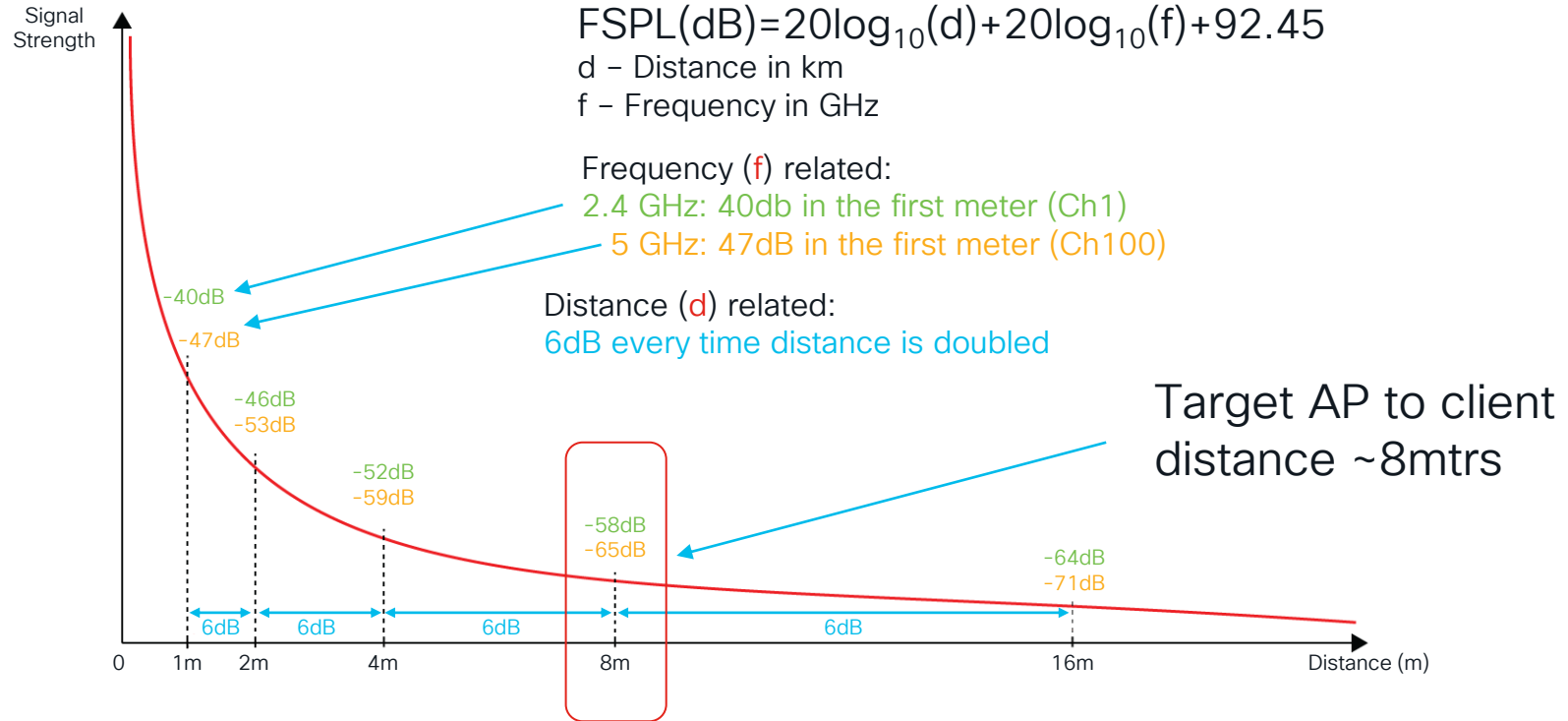
How to Calculate Path Loss

Receiver Signal Strength (RSSI) = Transmit Power (Tx) - Free Space Path Loss (FSPL)

Assume effective transmit power level = 14dBm (allow some headroom)
RSSI we want to achieve is -54dBm to get 200Mb data rate

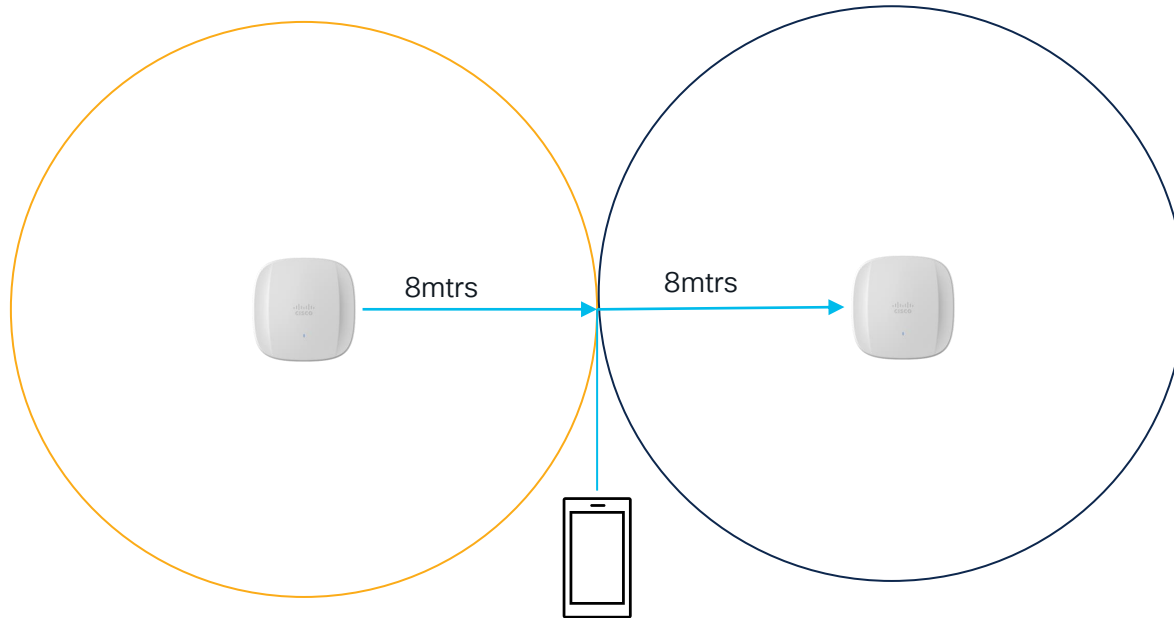
$$\begin{aligned} \text{Client Tx } 14\text{dBm} \text{ and RSSI} &= -54\text{dBm} \\ \text{FSPL} &= 14 - (-54) = 68\text{dBm} \end{aligned}$$

Free Space Path Loss Provides Distance



AP to AP Distance

Basic AP to AP distance calculates to 16mtrs or AP per 256m²



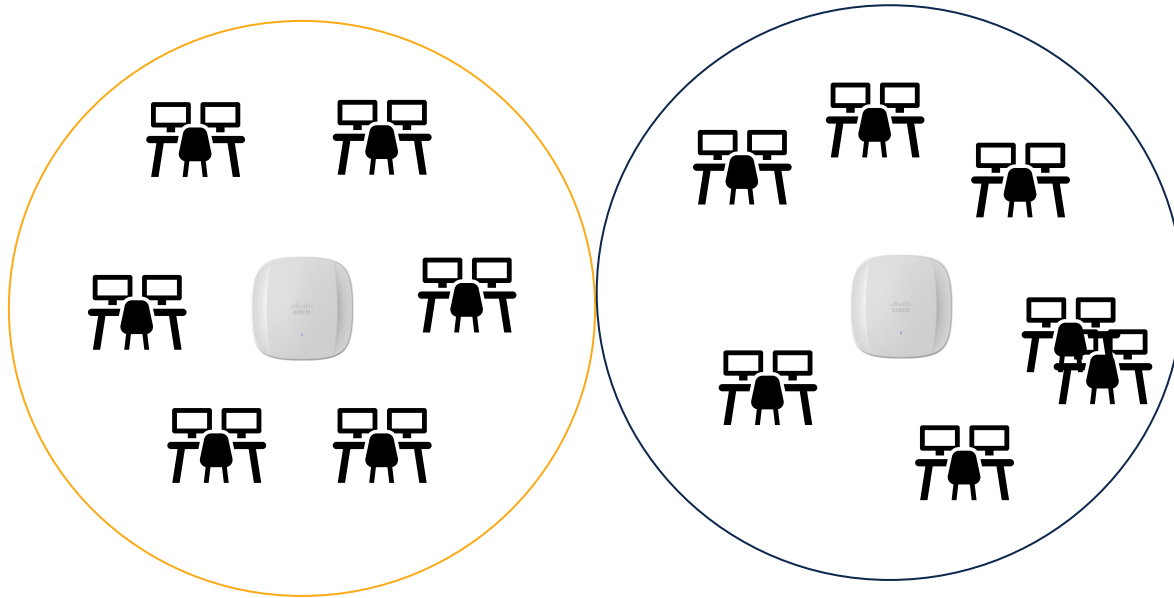
Roaming Makes Things Different

- iPhones/iPads are designed to roam at -70dBm
 - <https://support.apple.com/en-au/HT203068>
- Mac Book Pros are designed to roam at -75dBm
 - <https://support.apple.com/en-au/102002>
- Use 802.11k to help overcome sticky clients
 - iPhones and iPads support 802.11k
 - macOS Monterey supports 802.11k on Mac computers with Apple silicon.

Consider this threshold in view of the signal overlap between your wireless cells. macOS maintains a connection until the -75 dBm threshold, but 5 GHz cells are designed with a -67 dBm overlap. Those clients will remain connected to the current BSSID longer than you might expect.

Clients per AP

Basic AP to AP distance calculates to 16mtrs or one AP per 256m²



Client Wi-Fi Capabilities

Keeping your fleet of client devices current has a huge impact on your Wi-Fi throughput

	iPhone2	MacBook Air/iPhone11+	MacBook Pro
Streams	1	2	3
Data Rate	200	400	600
Simplex – 50%	100	200	300
Overhead – 30%	70	140	210
Clients per 250 sqm	18	18	18
Per user throughput	3.8Mbps	7.7Mbps	11.6Mbps
Application	Streaming Video	Streaming Video HD	Stream Video 4K

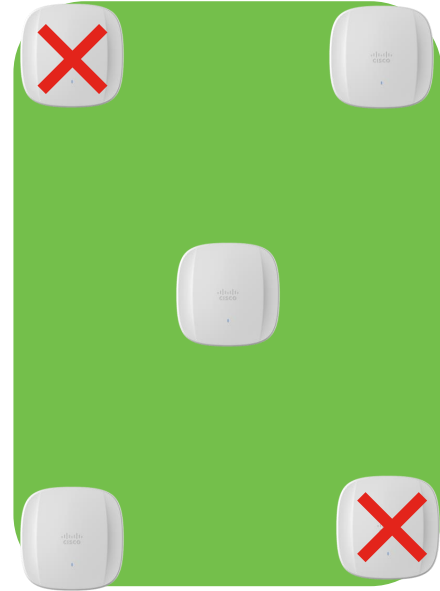
Disable 2.4Ghz Radios

- Going with a 5/6Ghz strategy
- Guest and IOT can remain on
- If you deployed for 5/6Ghz you will have too many 2.4Ghz radios

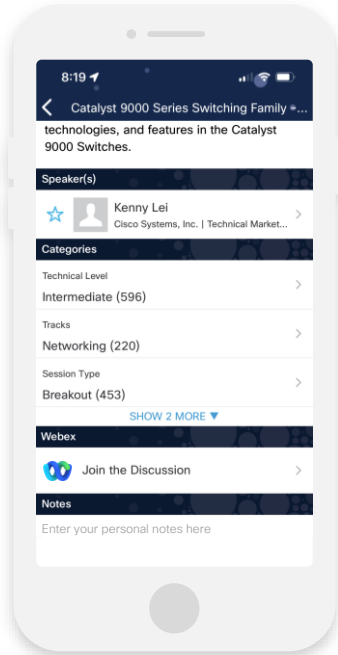
Turn them off (Meraki)

OR

Use Flexible Radio Assignment (FRA) - Catalyst

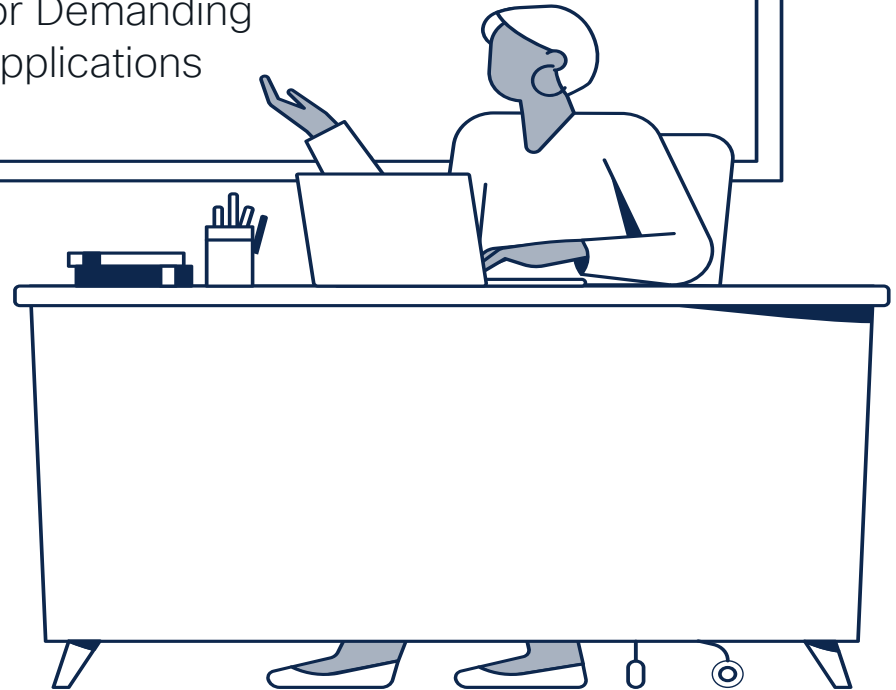


For More Information



BRKEWN-2926

A Client Perspective on
Wireless Network Design
for Demanding
Applications

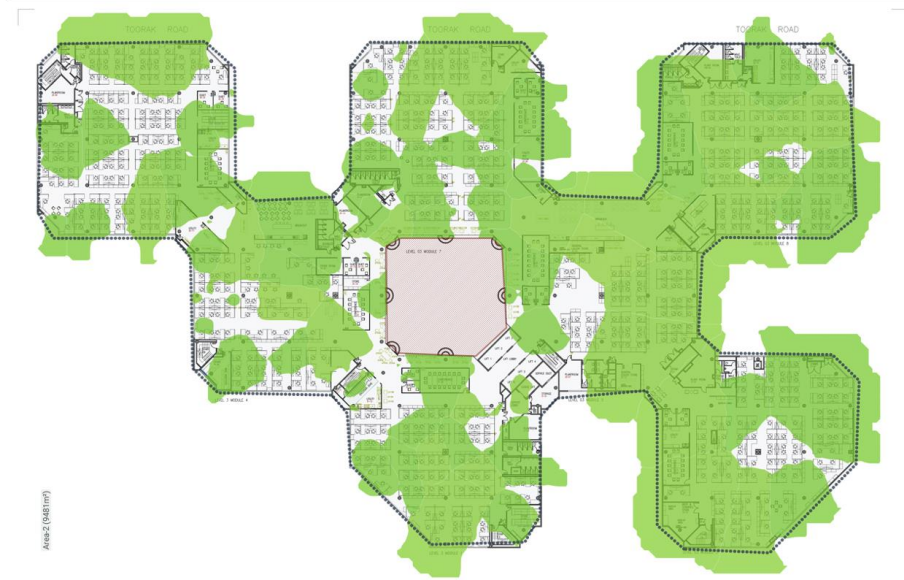


Site Survey & Design

Invest in Wireless First



What you think your Wi-Fi is



What the survey tells you it is

Ekahau Site Survey Tool

Wireless first essential to survey to ensure the we have coverage but also the required speed and redundancy

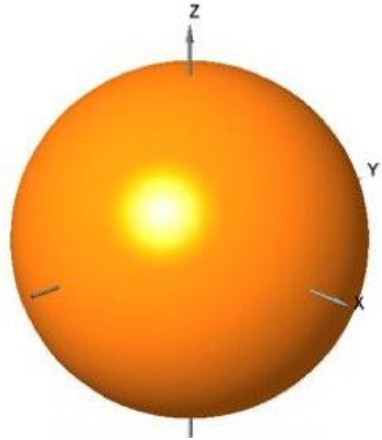


Hamina Site Survey Tool

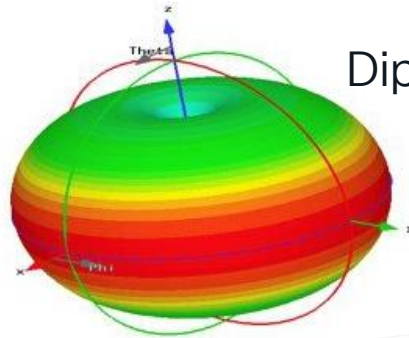
New Hamina app provides a client walk through feature.



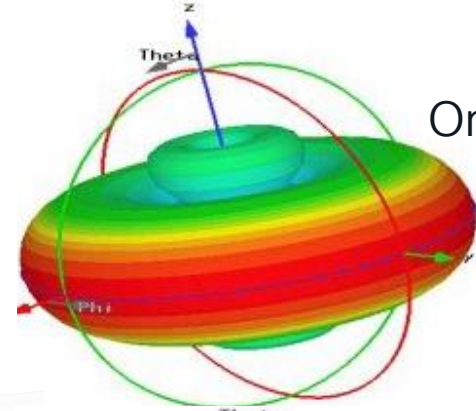
Control the RF



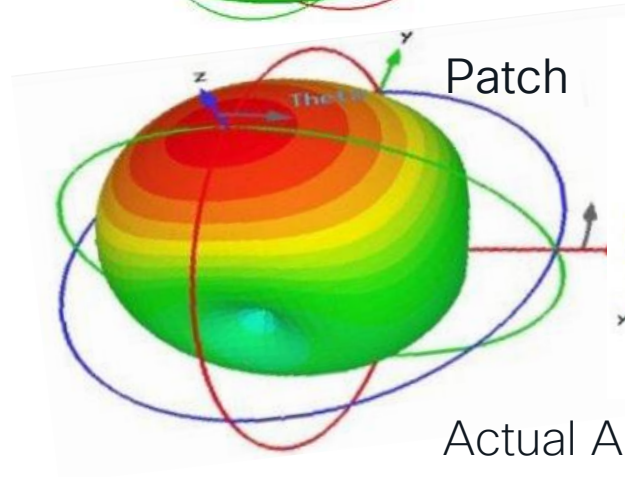
Theoretical Antenna



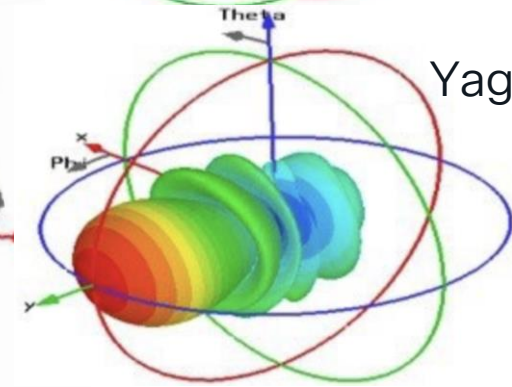
Dipole



Omni



Patch



Yagi

Actual Antennas

Antenna Selection

		Beamwidth	Use Case
	Dual-Band “Narrow” 8x8 Patch Antenna AP: 9130AXE Antenna: C-ANT9103	2.4/5GHz 75/70° Az 70/70° Elev	Augmentation and short-distance HD coverage (5m –10m to clients)
	Dual-Band “Wide” Patch Antenna AP: 3802E/P, 9120AXE/P, 9130AXE Antenna: AIR-ANT2566P4W-R	2.4/5GHz 105/125° Az 70/60° Elev	Augmentation and short-distance HD coverage (<10m to clients)
	Dual-Band “Narrow” Patch Antenna AP: 3802E/P, 9120AXE/P, 9130AXE Antenna: AIR-ANT2566D4M-N	2.4/5GHz 65/65° Az 65/65° Elev	Augmentation and short-distance HD coverage (5m –10m to clients)

Catalyst 9166D1 Wi-Fi 6E Directional AP

Low Power Indoor

- Indoor Only
- Integrated Antenna Required
- Can use up to 1200 MHz
- Wired Power

Standard Power

- Indoor or Outdoor
- Integrated or External Antenna
- UNII-5 and UNII-7 Only
- Requires AFC

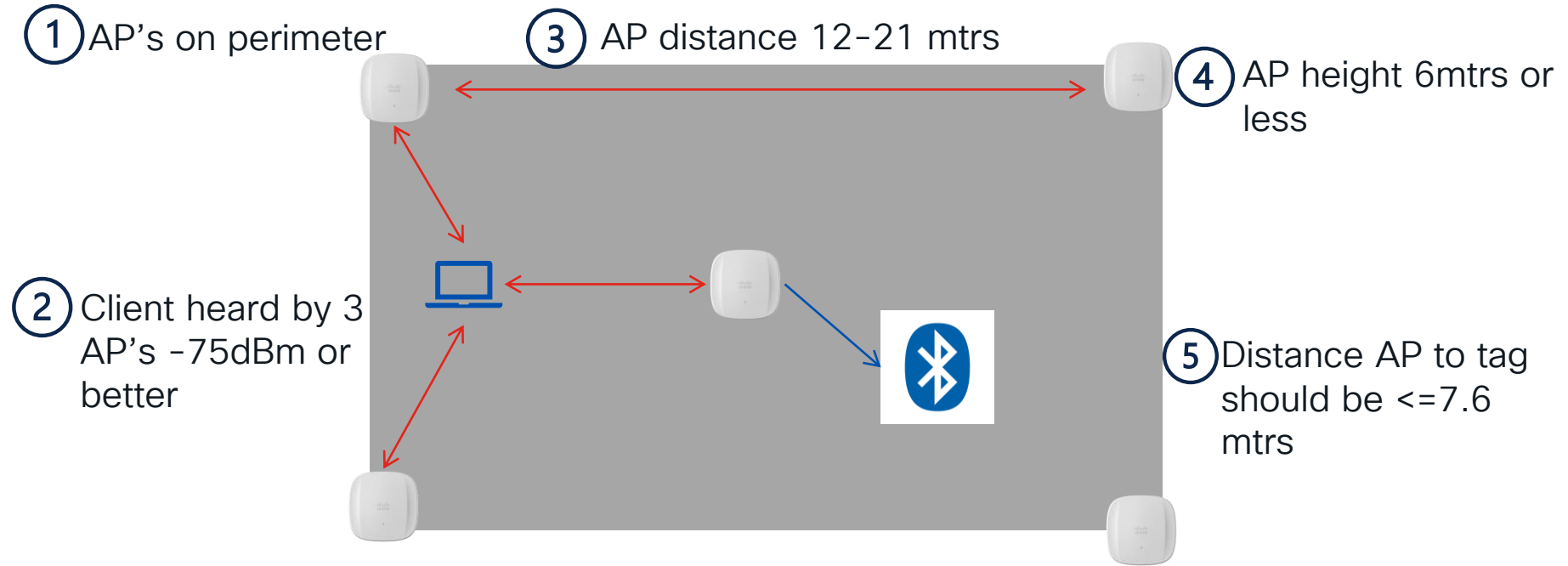


Best Practices for AP Mounting

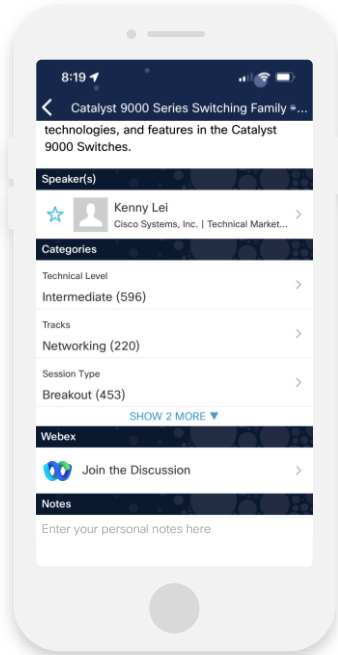


- Mount **horizontally**
- Mount **below** obstructions
- Minimum 1mtr **away from obstructions**
- 3mtr minimum distance **between APs**
- Only **one type of antenna** per AP
- Keep to around **2-4 metres high**
- Use **indoor APs** for indoor coverage
 - Most likely won't have indoor channels and power tables UNII1/2

Real Time Location with W-Fi or BLE



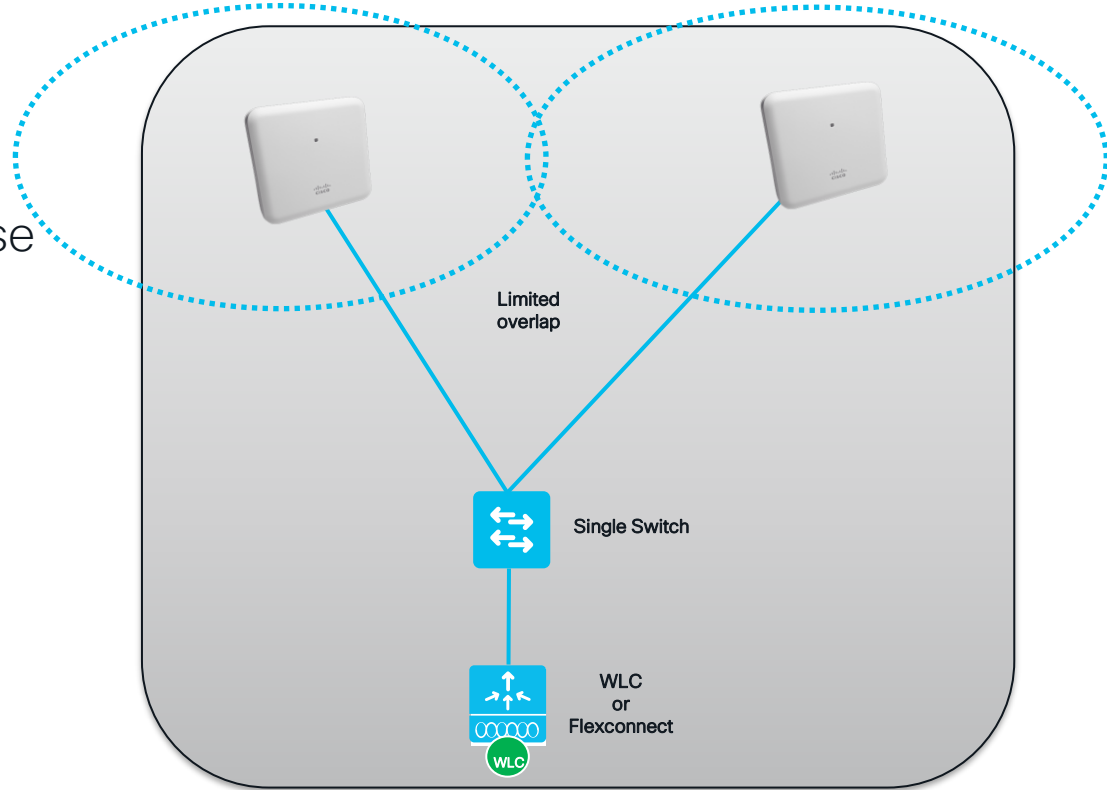
For More Information



Resiliency

Legacy - Wireless as a Secondary Network

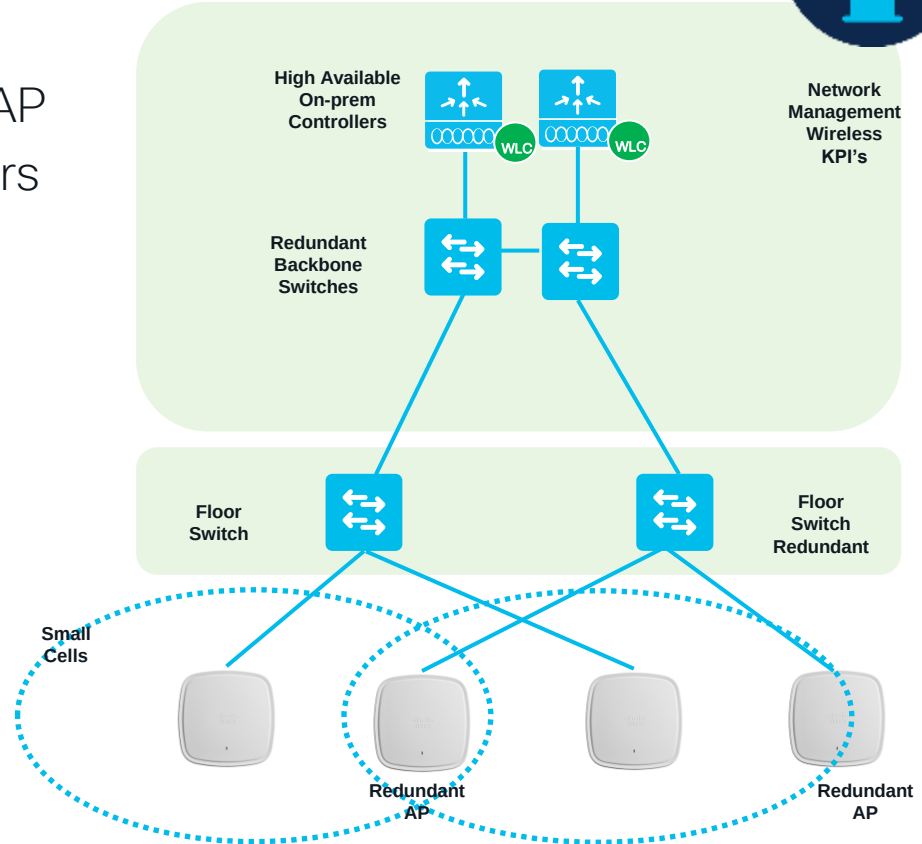
- Ethernet primary access
- Wireless supplementary use
- Non business critical
- Monitoring priority P3
- No resiliency
- Coverage only
- No Quality of Experience
- Static channels & power



Future - Wireless First Network



- No single points of failure to the AP
- Stateful, highly available controllers
- Small cells sizes
- High density design
- multi-Gigabit Ethernet to edge
- Quality of Experience
- Wireless KPI & metrics
- Location services
- Dynamic power & channels



Wireless First Switching Architecture

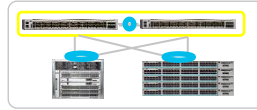
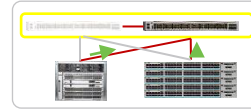


Wireless First Needs Switching Resiliency



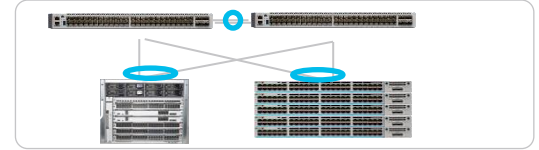
Platform Resiliency

- **Redundant Switches and Supervisors** for Standalone and Modular Switches with Non-Stop Forwarding and Routing (NSF/NSR)
- **Redundant Fan & Power Supply** in case of any hardware failure



Design Resiliency

- **StackWise Virtual:** Redundant System for high availability, simplified design and configuration
- **GIR:** No downtime when device removed for maintenance



Operational Resiliency

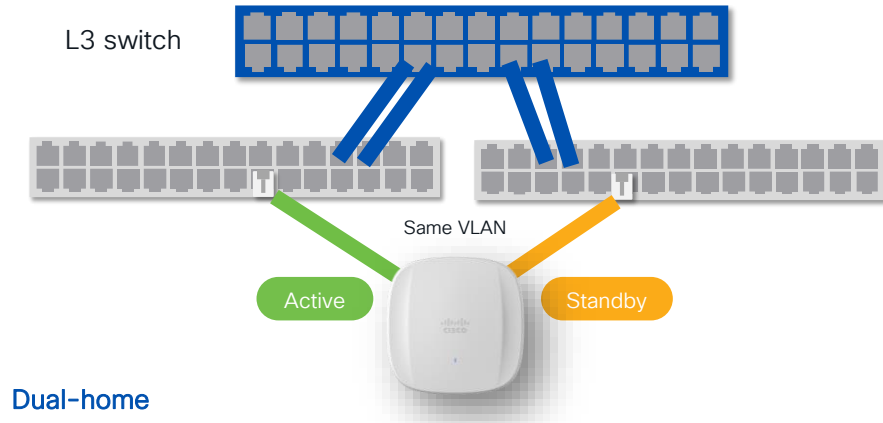
- **ISSU:** Upgrade software with minimal to no traffic loss
- **xFSU :** Upgrade or Reload the Catalyst 9300 with very minimal traffic loss
- **Hot Patching:** No downtime for bug fixes (no reboot)

Keep the Lights On

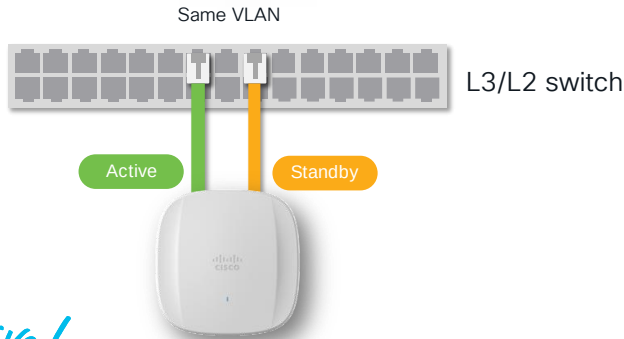


- **StackPower** “zero-footprint” power redundancy
- **Fast PoE** restores power to connected devices within 30 seconds
- **Perpetual PoE** maintains power to connected devices during reload
- **PoE Port Priority** loss of a power-supply will ensure APs have priority over other devices

Catalyst AP C9136 to Switch connection

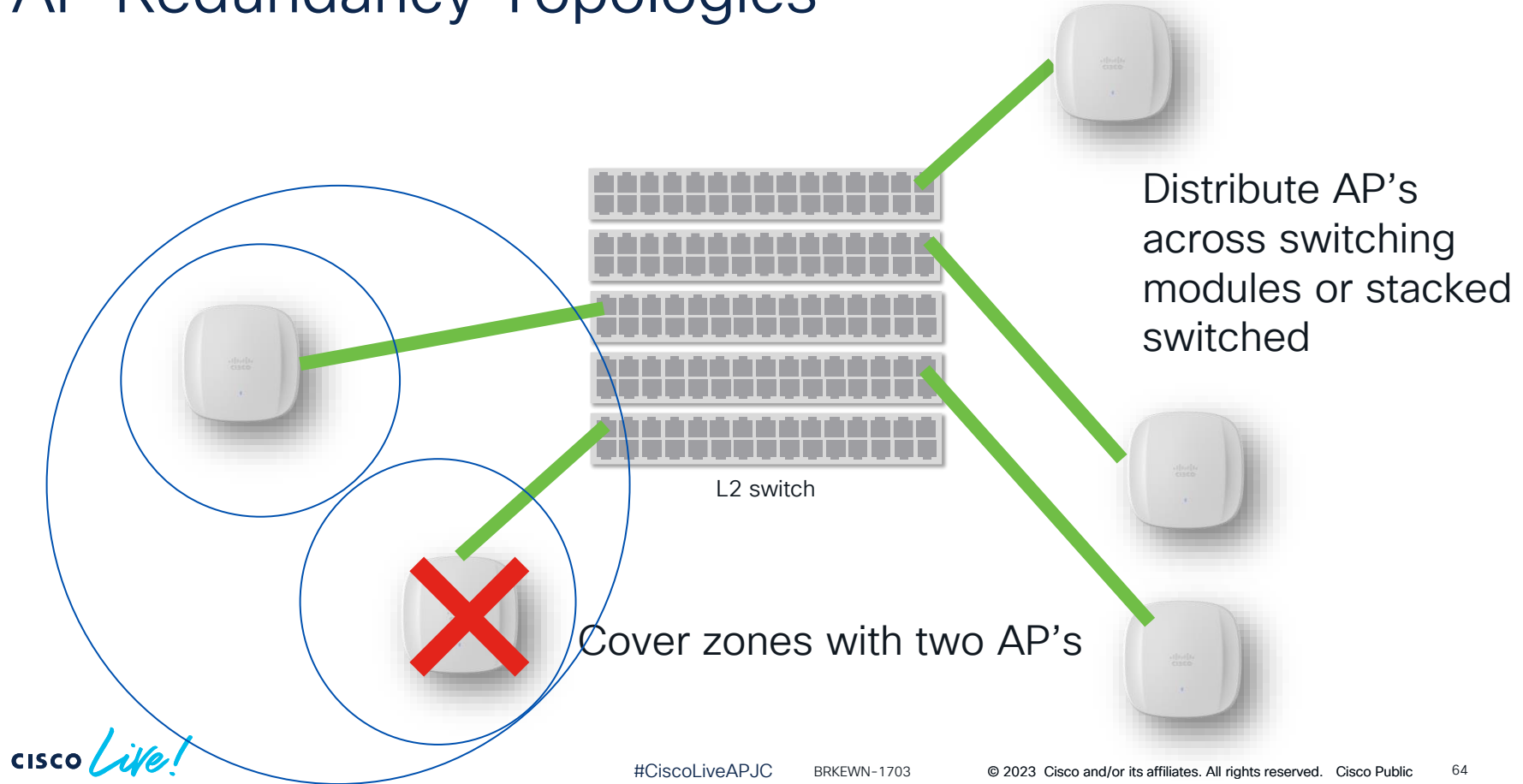


Single-home



- Dual-home to two different switches
 - Recommend to connect to switches in different IDF, whenever possible
- Single-home to one logical switch (Stack Wise, vPC, Multi-layer switch, etc.)
 - Recommend to connect to two different members of the stack or line-cards
- In both scenario, the switchports must be configured in the same VLAN

AP Redundancy Topologies

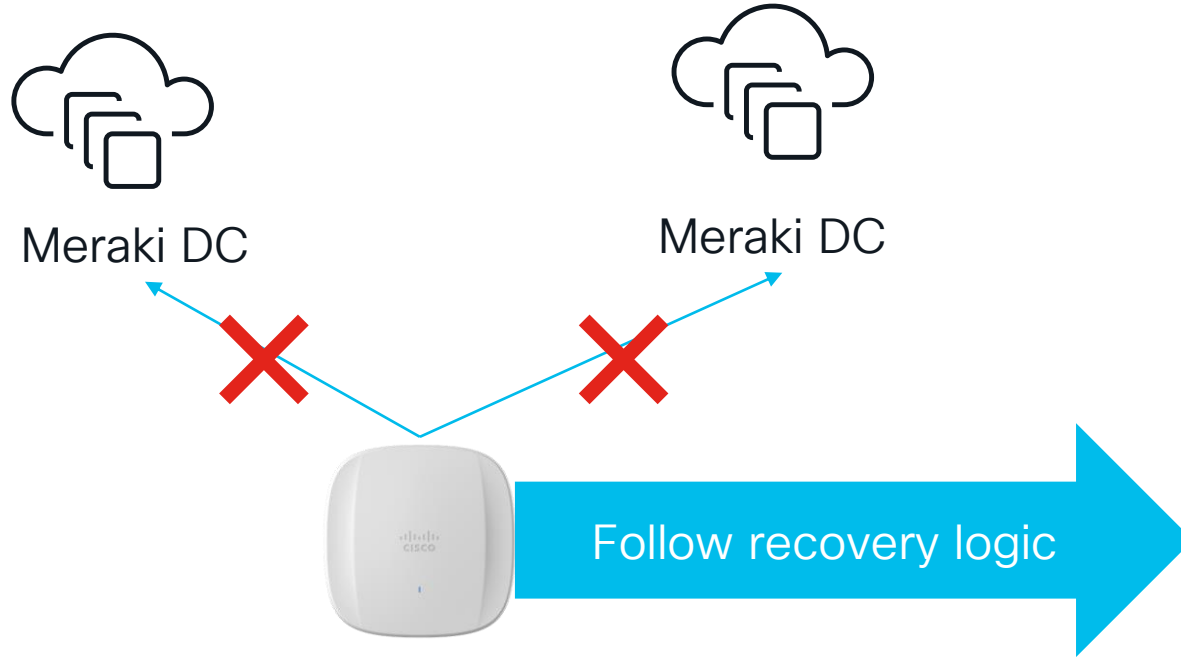


High Availability | SSO vs N+1

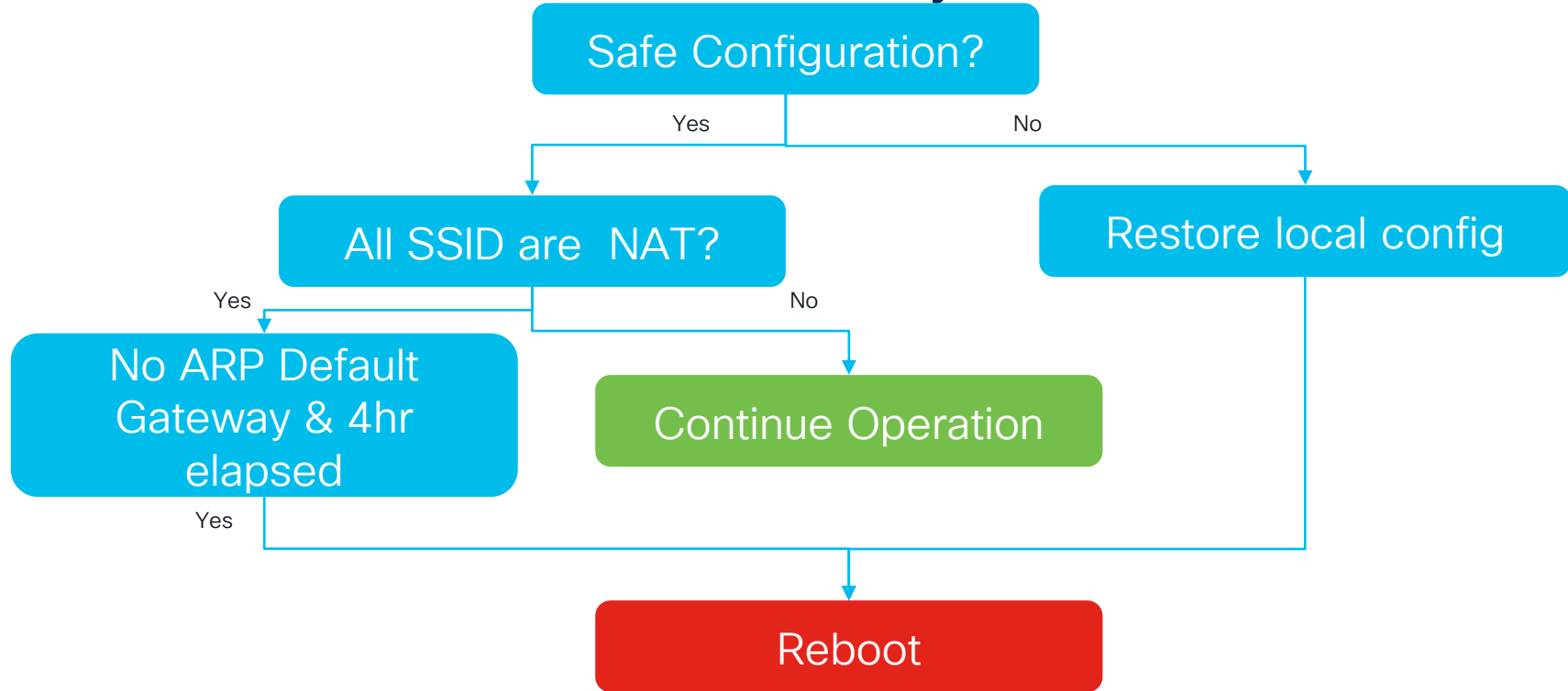
Functionality	SSO	N+1
Failover time	Sub second for device failure and <8sec for default gateway failure	45-60seconds for rediscovery and join of secondary controller
Config sync	Automatic configuration client state synchronised	N.A
Detection Mechanism	Keep alive timers between Active/Standby 100-1,000msec and retry count 5-10	Based on various timers including heartbeat and discovery request timers
Layer2/3 topology	Only Layer-2 between Active/Standby supported	Layer3 supported between primary and secondary controllers

Cloud Redundancy

Cloud Redundancy

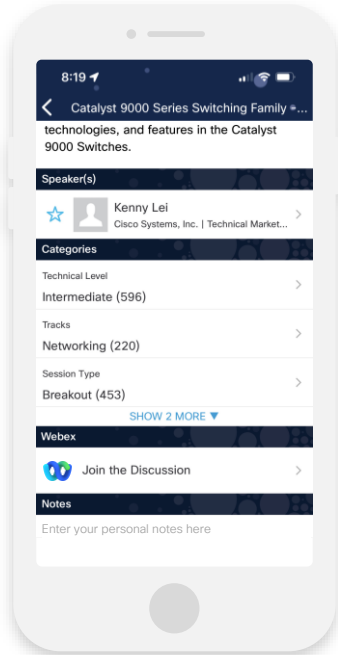


Meraki Dashboard Recovery Workflow



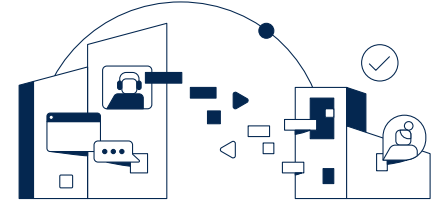
Safe configuration is the last configuration the device received from the cloud that was not followed by a reboot within 30 minutes.

For More Information



Non-Wireless Resiliency

Don't Forget RADIUS, DHCP & DNS



- RADIUS Load Balancing
 - Session persistence is important
 - Network Device IP load balancing works well
 - Accounting is important too for licensing release
- DHCP
 - Configure lease time to prevent exhaustion
 - Split scope redundancy can work well and is easy to configure
- DNS
 - Consider anycast for DNS

Don't Forget Sustainability

Wireless-First Sustainability

84 of the 187 ASX200 companies had net-zero targets for scope 1 and 2 emissions

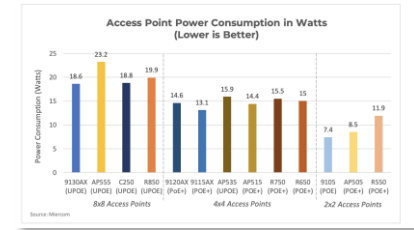


Wireless-First Needs to be sustainable

Calculating AP energy savings

If you want calculate AP energy savings, you need to consider three different tiers/modes of operations for the APs when it comes to energy consumption:

- **AP is fully operational/full power** > Catalyst Wi-Fi 6 and 6E APs have the highest power efficiency in the market* thanks to the Cisco hardware and software innovation
- **AP Power Save mode** > Power save mode optimizations (e.g. radio off) can save an additional 20% in energy cost vs. regular idle mode
- **AP shut down** > Automating the power off/on of the Access Points during off-peak hours, you can maximize your energy savings



AP Power Save Mode

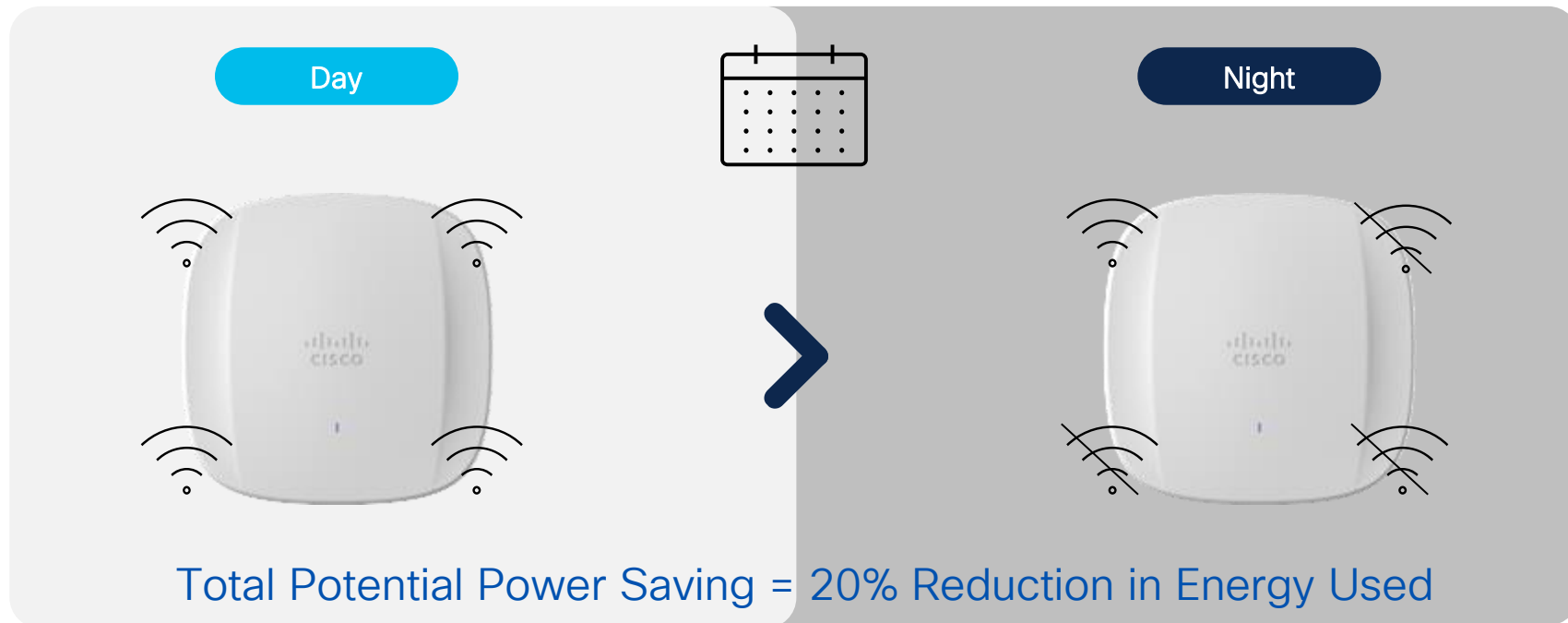


MAX savings

(*) Miercom report: <https://miercom.com/pdf/reports/DR201007K.pdf>

AP Power Save Mode

AP power save mode allows administrators to schedule periods of time where APs should, for example, turn off radios to save power



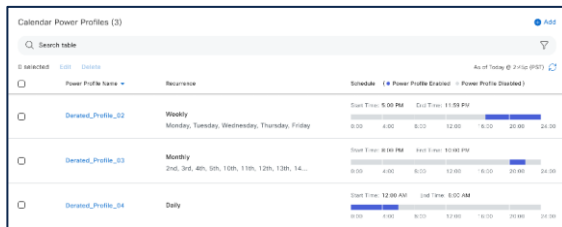
AP Power Optimizations Feature Suite

Save Power, reallocate power, and visibility into saving

AP Power Save Mode

Lower AP Power Usage

- Create a calendar profile for off-peak hours.
- Create a power profile to lower the power consumption budget during off-peak hours.
- Power Profile: Shut AP Radio or lower spatial Stream, lower port speed, disable USB port.



IOS-XE 17.8

Supported only on Catalyst APs: 9115, 9120, 9130, 9136, 9166, 9164, 9162

AP Power Distribution

Control over how power is used

- Reallocate extra AP Power to different radios while operating on PoE+ (30W).
- Example: Disable 2.4 GHz radio -> use extra power for 6 GHz radio.
- Power Profiles: Control the speed of the radio, e.g., from 4x4 to 1x1 spatial stream

Sequence	Interface	Interface ID	Parameter	Parameter Value
0	Ethernet	GigabitEthernet0	Speed	5000 Mbps
1	Radio	6 GHz	State	Disabled
2	USB	USB 0	State	Disabled

IOS-XE 17.10

AP Power Savings Insight

Power, Money, and Emissions Savings on Cisco Catalyst Center*

- Cisco Catalyst Center PoE dashboard integration.
- Power Savings, Money Savings, Emissions Reductions.
- Visibility into trends and insights.
- Both site level and AP level view.



(*) Catalyst Center Automation and Assurance PoE Visibility is in release 2.3.6, Visibility of \$ and CO2 is later in the roadmap

Save Energy with AP Power Save

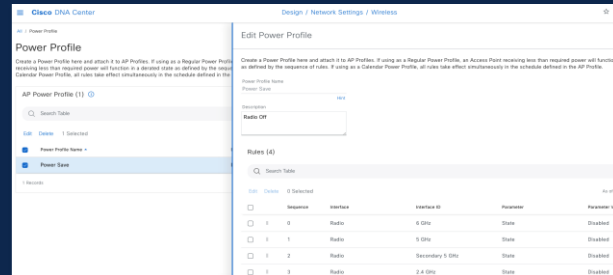
We estimate that using Power Save on 2,000 APs (1.5 W) for 10 hours a day (10pm to 8am), could save:

- 10,950 kWh energy/\$4,051 per year
- Over 5 years \$20,257
- 8.43t CO₂ emissions per year

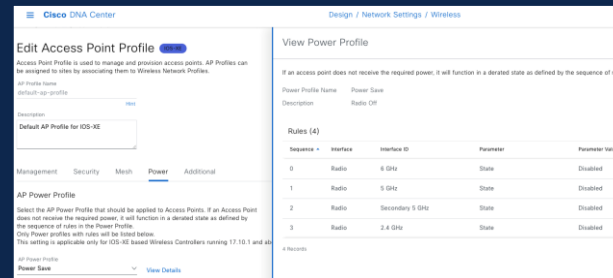
42.15t CO₂ over 5 years

*Based on internal analysis. Actual estimate that varies depending on the location where the devices are operated. Location in the example: Sydney, assumed energy price: 37c/kWh

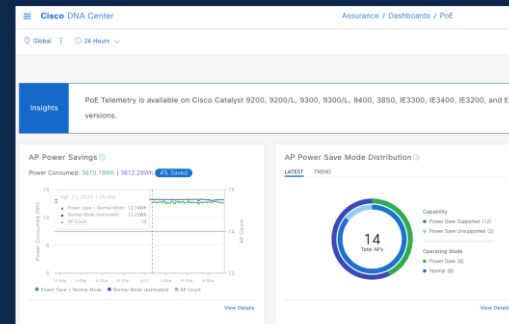
Design



Act



Report



Powering off/on: Switch Port Scheduling

Meraki MS Switches

Port schedules

Local time zone: America - Los Angeles (You can set this on [General](#))

Energy Savings used by [1 port](#)

Templates: 8 to 5 daily 8 to 5 on weekdays only weekdays only always on always off

Day	Status	During	Time display
Monday	enabled	8:00 - 17:00	24 Hour AM/PM
Tuesday	enabled	8:00 - 17:00	24 Hour AM/PM
Wednesday	enabled	8:00 - 17:00	24 Hour AM/PM
Thursday	enabled	8:00 - 17:00	24 Hour AM/PM
Friday	enabled	8:00 - 17:00	24 Hour AM/PM
Saturday	enabled	8:00 - 17:00	24 Hour AM/PM
Sunday	enabled	8:00 - 17:00	24 Hour AM/PM

[Add a new port schedule](#)

Energy Saving Port Schedules
Create port schedules to turn off POE power to access points during off peak hours

Save Energy with Meraki Switch Port Schedules

- We estimate that powering off 2,000 PoE devices (10W) for 10 hours a day, could save:
- 73,000 kWh energy year/\$27,010
- Over 5 years \$135,050
- 56.2t CO₂ emissions per year
- 281t CO₂ emissions over 5 years.

*Based on internal analysis. Actual estimate that varies depending on the location where the devices are operated. Location in the example: Sydney, assumed energy price: 0.37/kWh

Discover



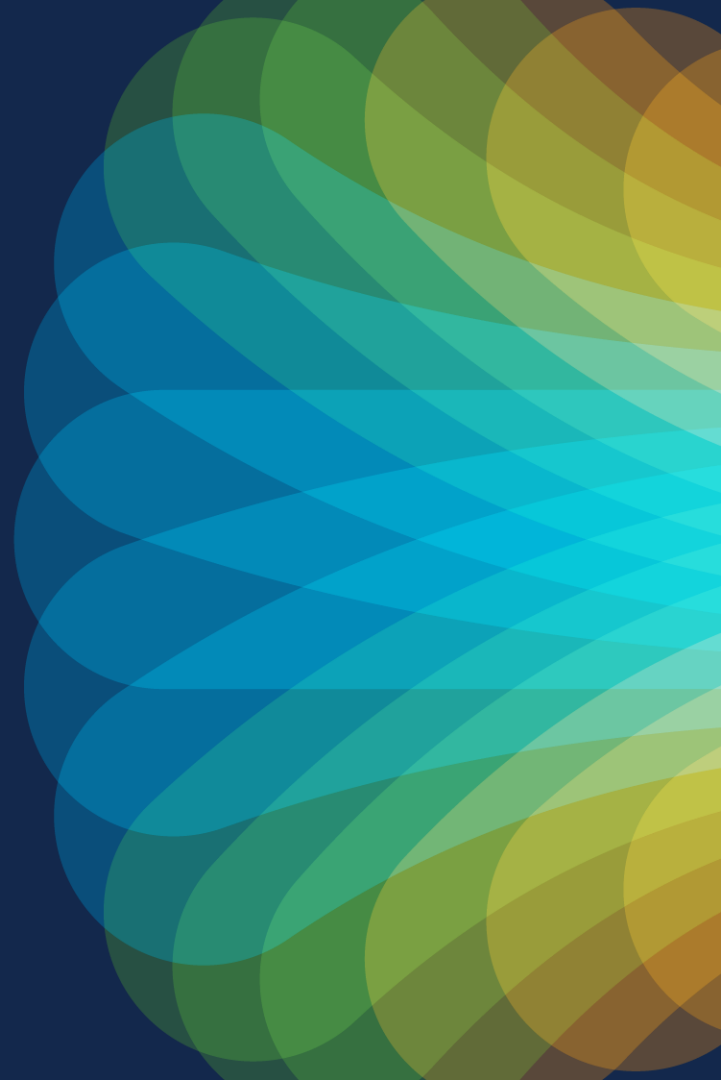
Act



Report



Radio Settings



Building Resiliency into Your Wi-Fi

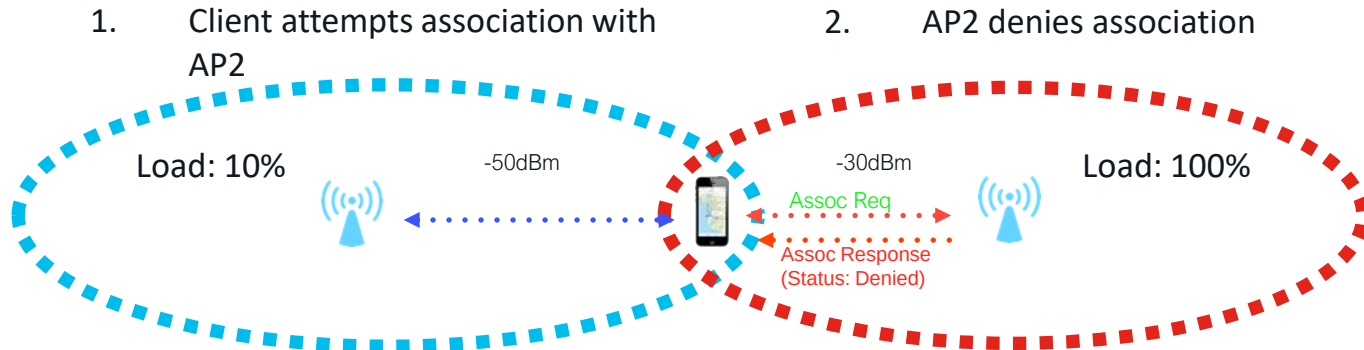


Requirement	Features On-Prem	Features Cloud
RF Resiliency	RRM & AI-RRM, Dynamic Channel Assignment, Transmit Power Coordination, Coverage Hole Detection, RX-SOP	Auto-RF & AI-RRM, Auto Power Reduction, Auto Channel Selection, RX-SOP
Interference mitigation	ED-RRM, Spectrum Analyser, CleanAir/Pro Excluding DFS Channels	Spectrum Analyser, AirMarshall, Exclude DFS Channels

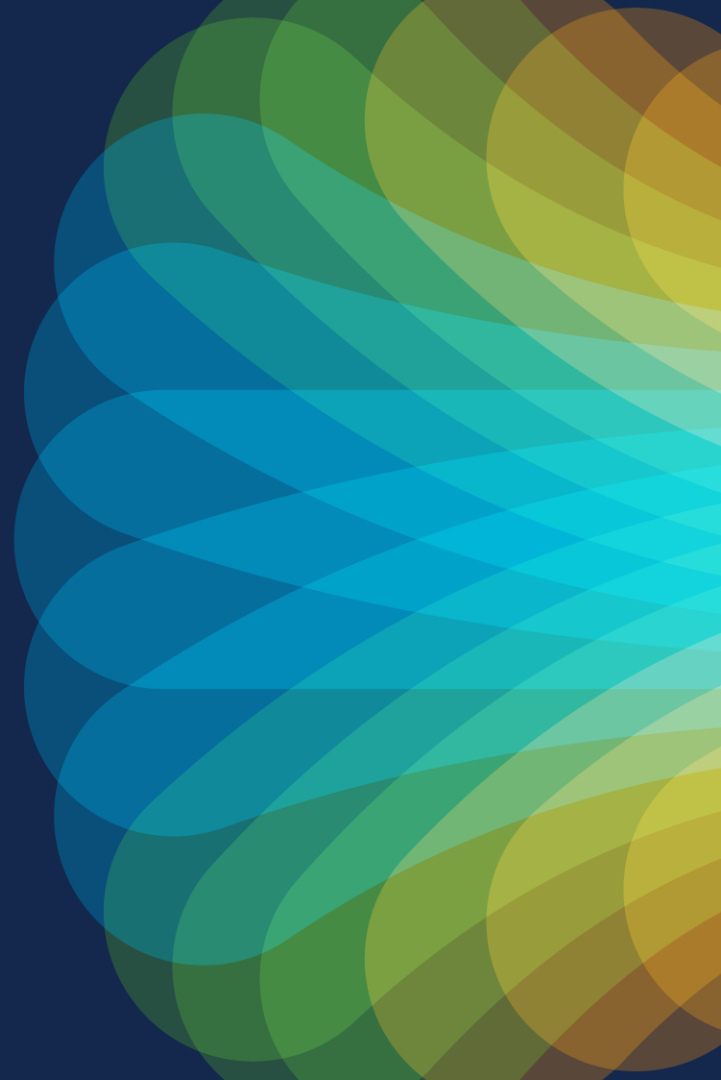


Be Careful of Load Balancing

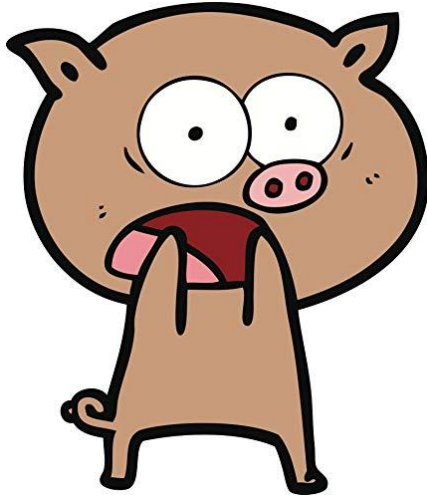
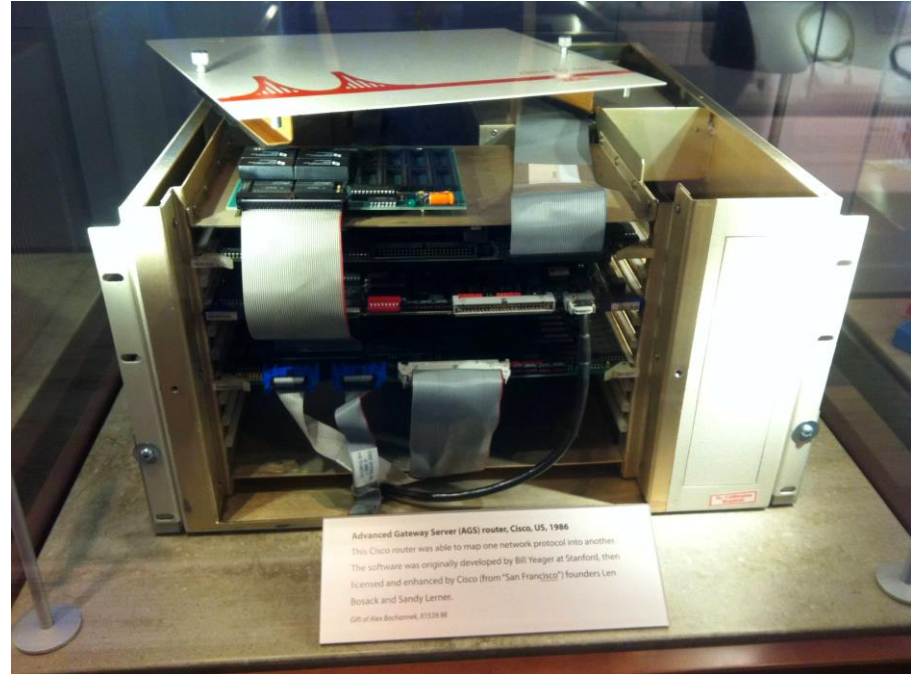
- Band steering and load balancing can create a poor UX
- Design your network so you don't need it
- Use more client friendly protocols such as 802.11v/k



Quality of Experience



That network device no one wants to touch!!



Advanced Gateway Server (AGS) router, Cisco, US, 1986
This Cisco router was able to map one network protocol into another.
The software was originally developed by Bill Yeager at Stanford, then
licensed and enhanced by Cisco (from "San Francisco") founders Len
Boruck and Sandy Lerner.
Gift of Alex Bachmann, 01/28/88

Hand built vs assembly line



Intent-Based Network in Action

Business Goal = Corporate Wireless in North Sydney Level 22

Cisco DNA Center

Des

Network Profiles / Wireless

Edit Network Profile

Following tasks must be completed before creating a Wireless Network Profile.

1. Define SSIDs & RF Profiles under Network Settings & Wireless [Wireless](#)
2. Define Templates in Template Editor (optional) [Template Editor](#)
3. Define Model Configs (Optional) [Model Config](#)

Profile Name: **NSD5-Level22**

Site: [1 sites](#)

Profile Type: **wlan**

SSIDs AP Zones Model Configs Templates Advanced Settings

SSID

corporate

Fabric

☐ Yes ☒ No

TRAFFIC SWITCHING

☒ Interface ☐ VLAN Group

Interface Name*

management

Do you need Anchor for this SSID?

☐ Yes ☒ No

Flex Connect Local Switching

☒

Local To VLAN*

20



Search Hierarchy

- Global (1)
 - 250 Victoria Square Adelaide 5000
 - 9800 Training
 - ACT
 - Australia
 - Ekahau Import
 - Melbourne
 - NSW
 - AWS
 - North Sydney
 - ☒ Level22
 - PI migration
 - SA
 - WA
 - Xavier College

Intent-Based Network in Action

Network Result = Assign new AP to site and DNAC will configure the appropriate business goal.

The screenshot shows the Cisco DNA Center 'Inventory' page. On the left is a search hierarchy tree with categories like Global, Unassigned Devices, and various sites. The main area displays a table of 9 devices. The device 'nsd5-9120-ap1' is selected, and a context menu is open over it, showing options like Inventory, Software Image, Provision, Telemetry, Device Replacement, Others, and Compliance. The 'Provision' option is highlighted, and a sub-menu is visible with options: Assign Device to Site, Provision Device, LAN Automation, LAN Automation Status, Learn Device Config, Configure WLC HA, Configure WLC Mobility, and Manage LED Flash Status.

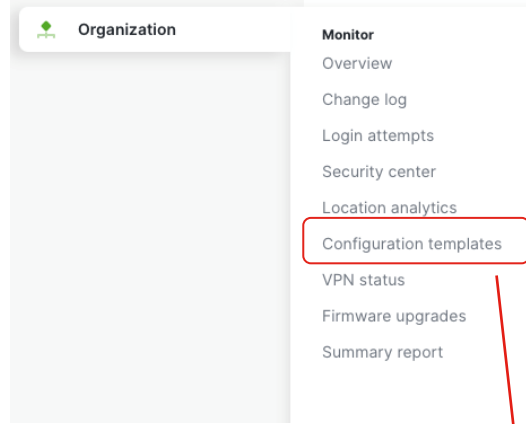
Device Name	Device Family	Reachability	EoX Sta
northsydney-sensor1	Wireless Sensor	Unreachable	Not
nsd5-3800-ap1			Not
nsd5-4800-ap1			Not
nsd5-9120-ap1			Not
nsd5-9120-ap2			Not
nsd5-9130-ap1			Not
nsd5-9130-ap2			Not
std1-sensor1			Not
syd-9800-1.cbr.ciscolabs.com			0 a

The screenshot shows the Cisco DNA Center 'Provisioning' page for device 'nsd5-9130-ap1'. It features a progress bar with three steps: 1. Assign Site, 2. Configuration, and 3. Summary. The 'Device Details' section on the right lists the following information:

- Device Name: nsd5-9130-ap1
- Serial Number: KWC25080RK
- Mac Address: 48:8b:0a:3a:d2:e0
- Device Location: Global/NSW/North Sydney/Level22

At the bottom right, there are 'Cancel' and 'Deploy' buttons.

Meraki Dashboard Templates



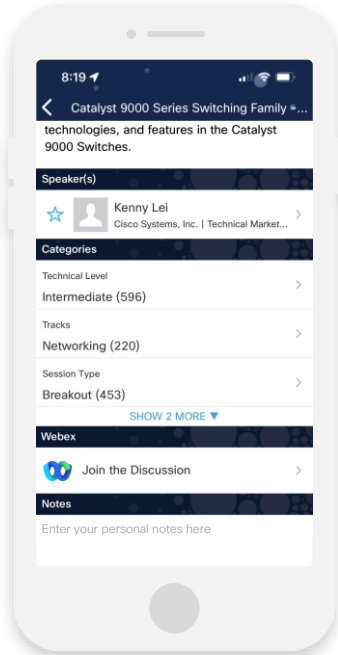
Create intent with templates and apply to networks for consistency.

A screenshot of the Meraki Dashboard's 'Configuration templates' page. The page has a green header with the Cisco Meraki logo and a search bar. The left sidebar shows 'Global Overview' and 'Organization LJEWEEL Network'. The main content area is titled 'Configuration templates' and includes a 'Create a new template' button, a 'Delete' button, a 'Combine' dropdown, and a 'Split' button. Below these buttons is a table with the following data:

#	Name	# of bound networks	Network type
1	Corporate Wi-Fi First	1	Combined

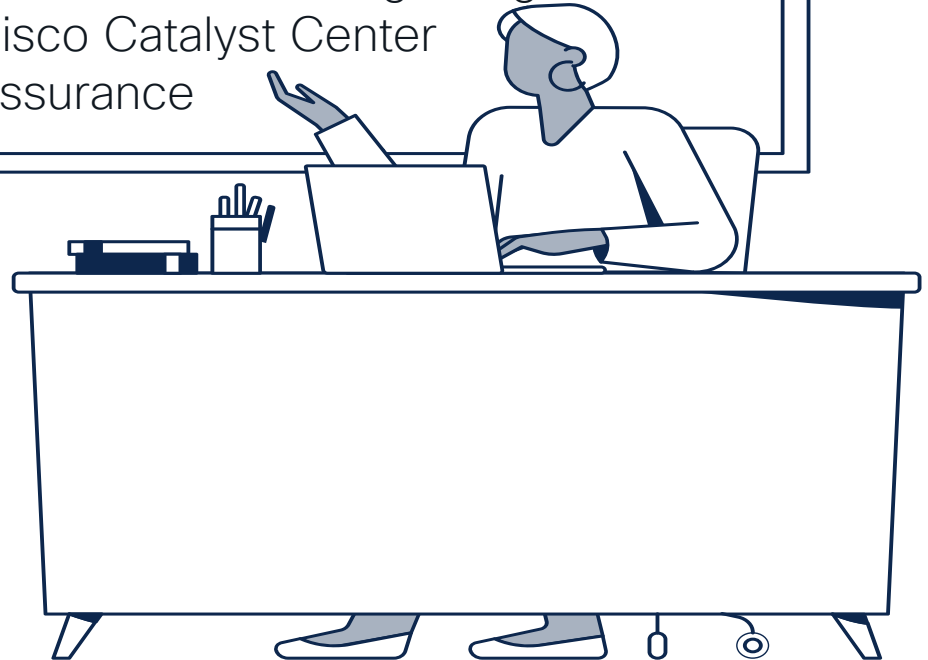
At the bottom of the table, it says '1 total'. A red arrow points from the 'Configuration templates' option in the left sidebar to the 'Create a new template' button.

For More Information



BRKEWN-1267

Wireless Network Insights
and Troubleshooting using
Cisco Catalyst Center
Assurance

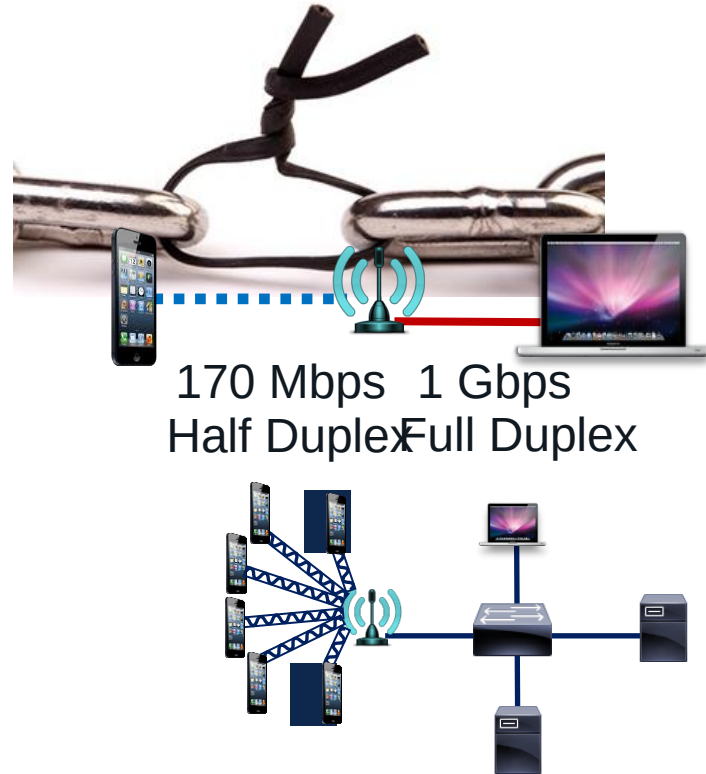


Wireless QoS



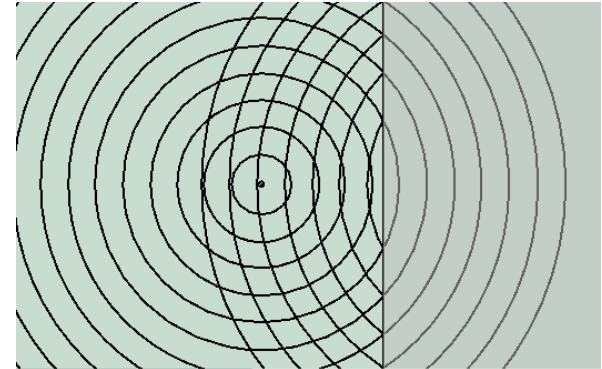
Why Wireless QoS For Real Time Applications

- QoS is like a chain
 - It's only as strong as its weakest link
- The WLAN is one of the weakest links in enterprise QoS designs for three primary reasons:
 - 1) Typical downshift in speed (and throughput)
 - 2) Shift from full-duplex to half-duplex media
 - 3) Shift from a dedicated media to a shared media
- WLAN QoS policies need to control both jitter and packet loss



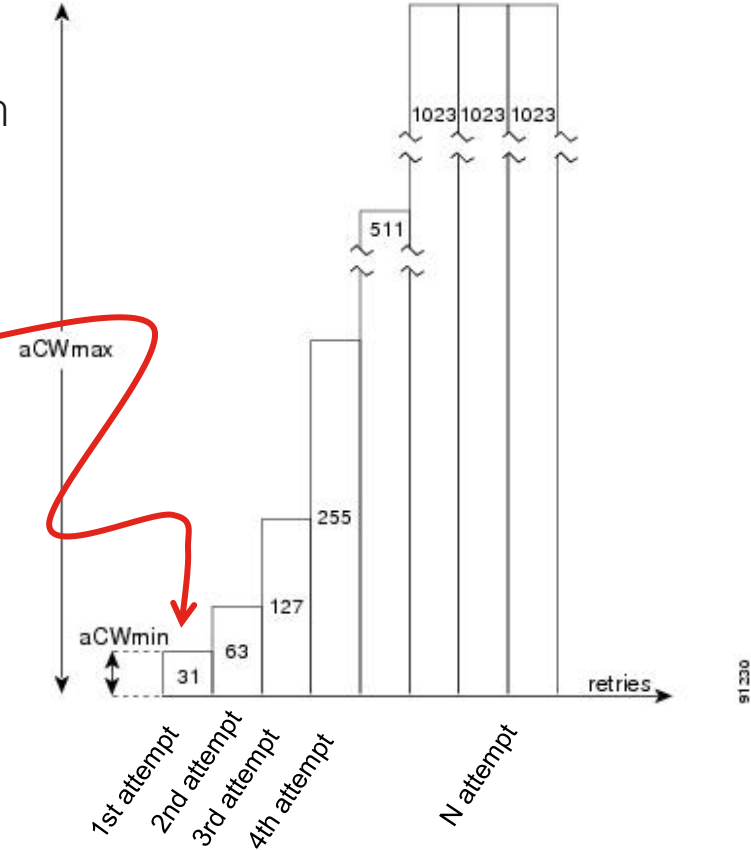
Carrier Sense Multiple Access / Collision Avoidance

- Wired Hubs use CSMA/CD (collision detection)
 - A transmitting station will first listen to the medium to see if it is idle before sending its frame. When it seems idle, it sends the frame.
 - After sending, it listens to see if a collision occurred (the wired link is a closed system)
- 802.11 networks use CSMA/CA (collision avoidance)
 - Wireless networks have no way to detect that a collision even occurred!
 - CSMA/CA accepts collisions will occur but has a system for dealing with them once they do.
 - In 802.11, all transmitted frames MUST be acknowledged by the receiving station



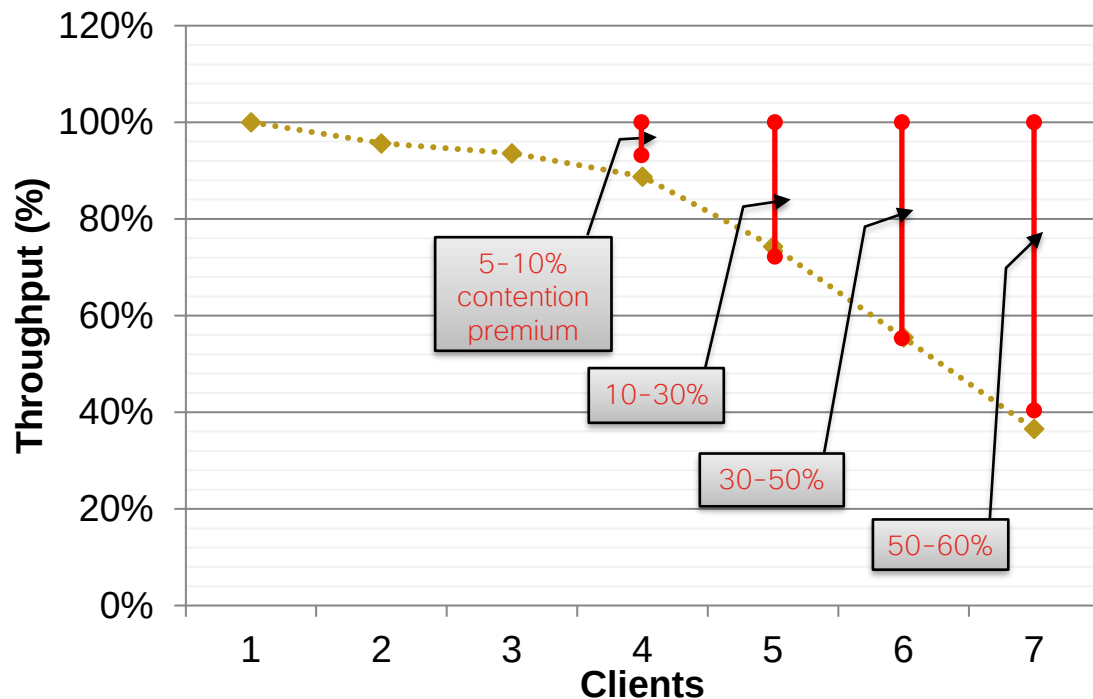
The Impact of Retries

- How do you know the transmission got through okay? The receiving station must send an acknowledgment.
- If the first attempt didn't work (no ACK received), double the previous CW size and pick a new random number.
- Keep doing this until the CW reaches a maximum size of 1023 slot times.
- How many times should the station keep trying?
- In Cisco APs, the maximum number of attempts is 64 before the frame is discarded.



The Contention Breaking Point (802.11ac)

(source: IEEE 802.11-15/0351r2)

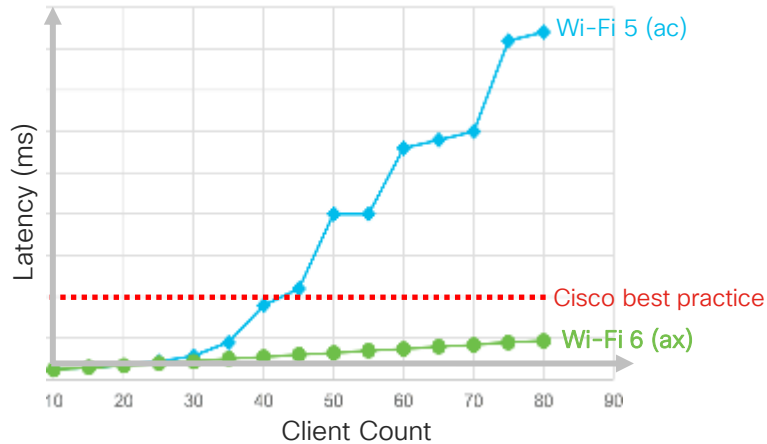


As more clients associate and transmit, WLAN contention increases for all clients. Retries and back off windows increase and each station spends more and more time in the “waiting and listening” state, thus driving down per-station performance

Wi-Fi 6/6E, provide determinism at scale

Enabling high-quality voice, video, and data services cost-effectively

Linear Voice delay



Source: Cisco sponsored research

Consistent Data throughput



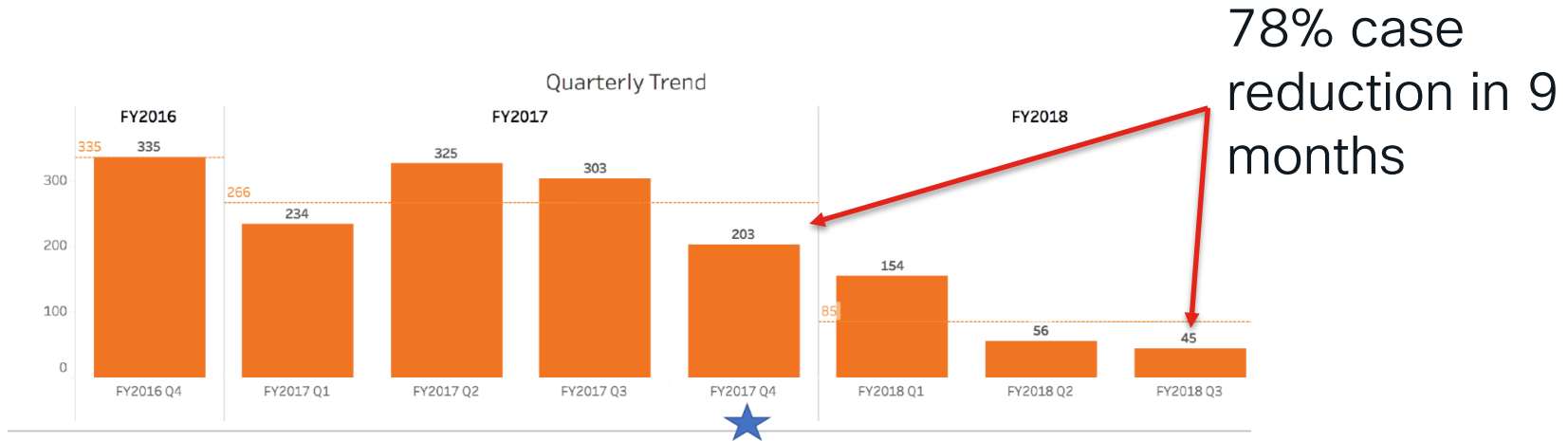
Source: Cisco sponsored research



Wi-Fi 6 is now capable of delivering SLAs

Case Study: Wireless First

Impact of Wireless First Design – No 2.4Ghz



Wireless First Design can have a dramatic influence

Cisco IT Case Study – London Office

What we did:

- Bedfont lakes Building 5 – **Wireless Only**
- Over 1,800 employees
- AP count increased 20%
- Wired ports disconnected
- Desk phones moved to wireless

What we learnt:

- Phone authentication on wireless is tricky
- Updating client drivers essential
- Wireless KPI's are needed
- Build wireless for worst case densities
- Understand how to do high density



Wireless Only Considerations

Saving's Opportunity

- Floor port: Eliminated
- Cable run: Eliminated
- Switchport: Eliminated
- Distribution frame: Reduced
- Switch real-estate: Reduced
- Rack real-estate: Reduced
- Power + Cooling: Reduced
- UPS: Reduced
- Fire suppression: Reduced
- Comms room real-estate: Reduced



Investment Required:

- Wireless Infrastructure (AP's + WLC)
- Wireless Monitoring: Investment required
- Wireless IP Phones: Investment required
- Increased initial support
- New Floor + Network design:
- Training: Wireless troubleshooting
- Invest in Digital Ceiling strategy
- Wireless printers/security cameras
- Rigorous Wireless certification testing on most popular devices
- Multi-fleet visit



Challenges and Future Trends



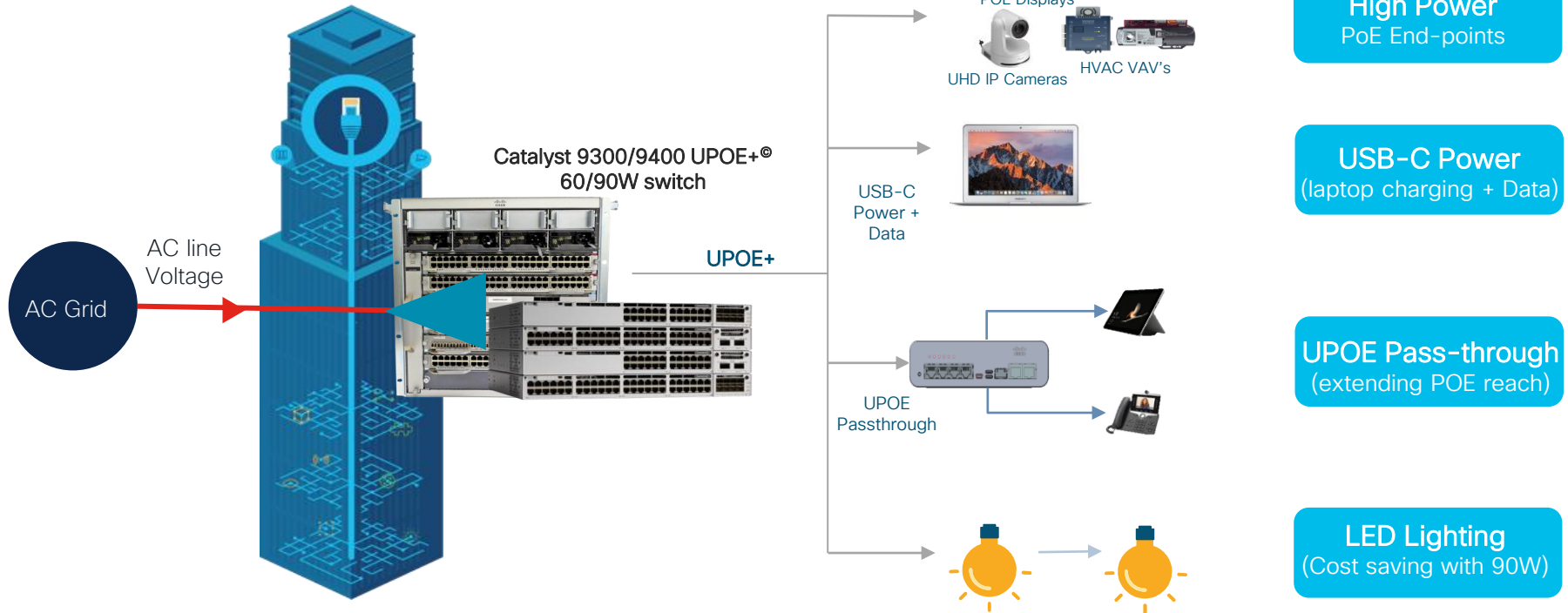
Challenges for Wireless First

- Just use 5G instead of Wi-Fi
- We run out of RF
- Many devices stay on Ethernet
- Wireless First usage without the investment



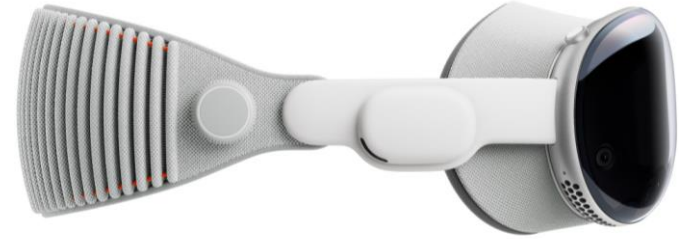
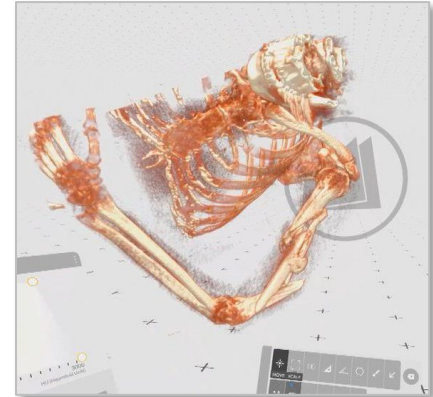
Don't Bank on Saving With Reduced Cabling

Make way for Low Voltage Smart Buildings



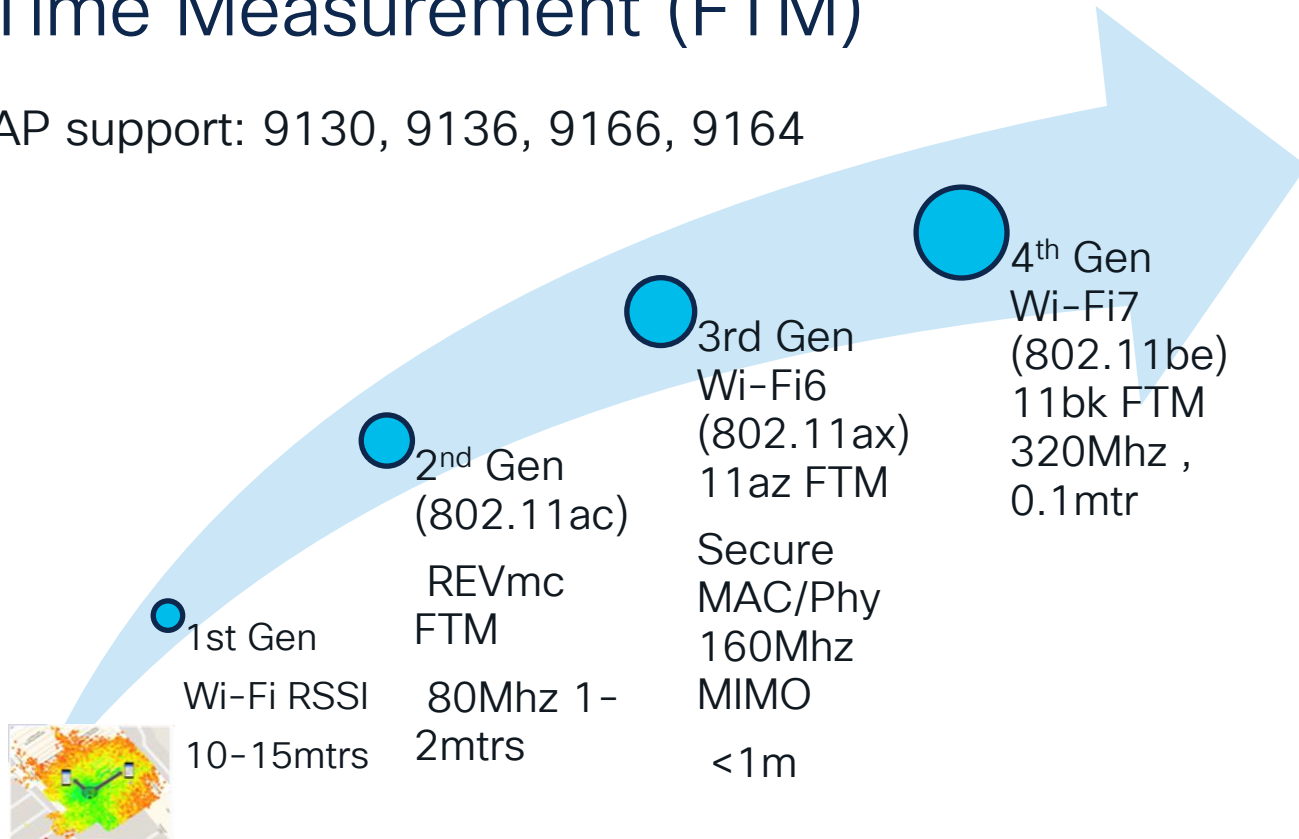
Future Trends

- Wi-Fi7
- ACMA and 6Ghz
- VR for training
- AR apps
- FTM enhancements



Fine Time Measurement (FTM)

Current AP support: 9130, 9136, 9166, 9164



Last Words on Wi-Fi First

- Consider the investment you need to make
- IT Ops may resist moving to Wi-Fi First
- Don't make Wi-Fi First a race to the bottom



Your Journey Continues

Code	Description	Date/Time
BRKEWN-2024	Architecting Next Generation Wireless Network with Catalyst Wi-Fi 6E Access Points	Wed 4:00 pm
BRKEWN-2926	Cisco Wi-Fi: how to tune your design and configurations for your most demanding clients and applications	Thu 9:00 am
BRKEWN-1267	Wireless Network Insights and Troubleshooting using Cisco Catalyst Center Assurance	Thu 4:00 pm
BRKEWN-2846	High Availability Design with Cisco Catalyst 9800 Wireless Controllers	Thu 4:00 pm
BRKEWN-2087	High Density Wi-Fi Design, Deployment, and Optimization	Thu 11:00 am

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Wednesday	11:15am – 7:00pm
Thursday	9:30am – 4:00pm
Friday	10:30am – 1:30pm

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The bridge to possible

Thank you

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The background features a vibrant, multi-colored abstract design. On the left, there are horizontal, wavy bands of color in shades of red, orange, yellow, and green. On the right, a bright white light source emits a series of colorful rays in shades of blue, green, and yellow, creating a sunburst effect.

cisco *Live!*

Let's go

#CiscoLiveAPJC