There’s Nothing Wireless About Wireless!

Planning a Cabling Infrastructure to Support Wi-Fi Today and Tomorrow

Frank Straka

Panduit Corporation

Fun Fact

- Wired versus Wireless
  - 1 million square feet facility
  - 10 wireless devices per 1000 square feet
  - 10,000 wireless devices in facility
- Assuming 5 year battery life, staggered rollout
  - 2000 batteries fail per year
  - ~200 working days per year
  - 10 batteries to be replaced per day
  - 20 to 30 minutes to replace each battery (good luck finding them!)
  - 4 to 5 hours per day – about half of a person – to replace batteries!

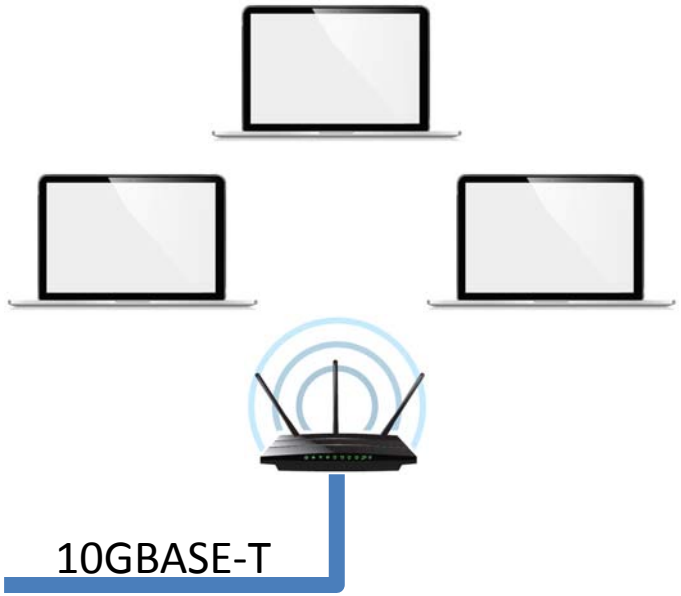
Agenda

- Wired versus Wireless
- Wi-Fi Today & Tomorrow
- Impact of 5G on Wi-Fi
- Wired Networks Impact on Wireless
- Wi-Fi Cabling Infrastructure Recommendations

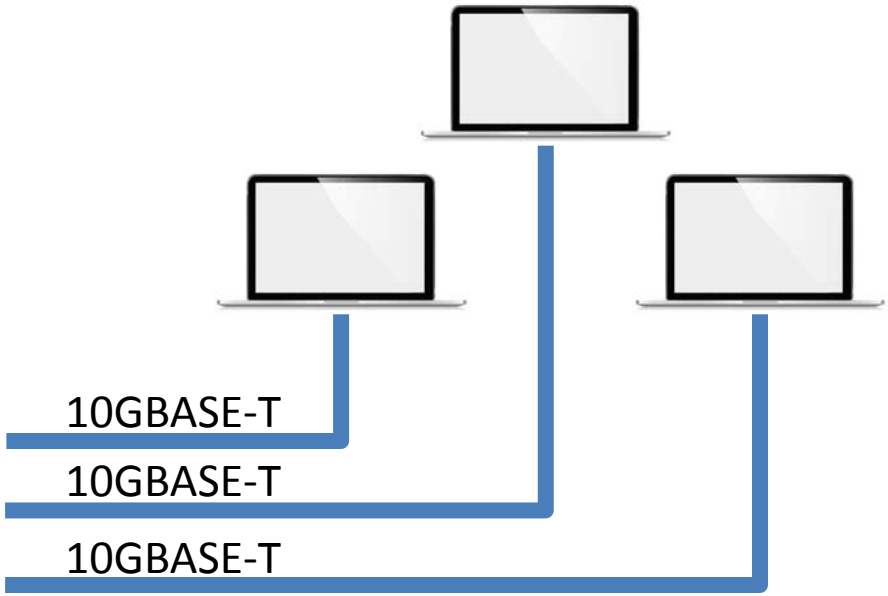
Overview and review of underlying application & cabling technologies.

WIRED VERSUS WIRELESS

Wired versus Wireless Channels

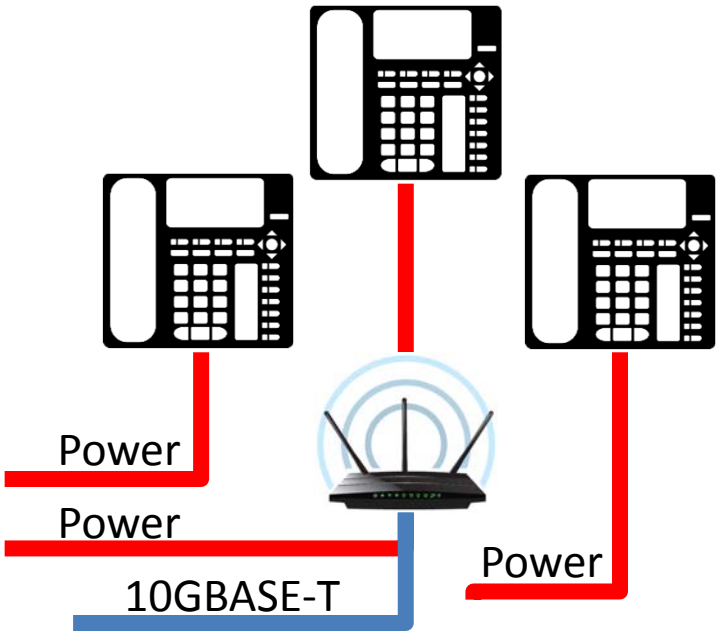


Shared bandwidth

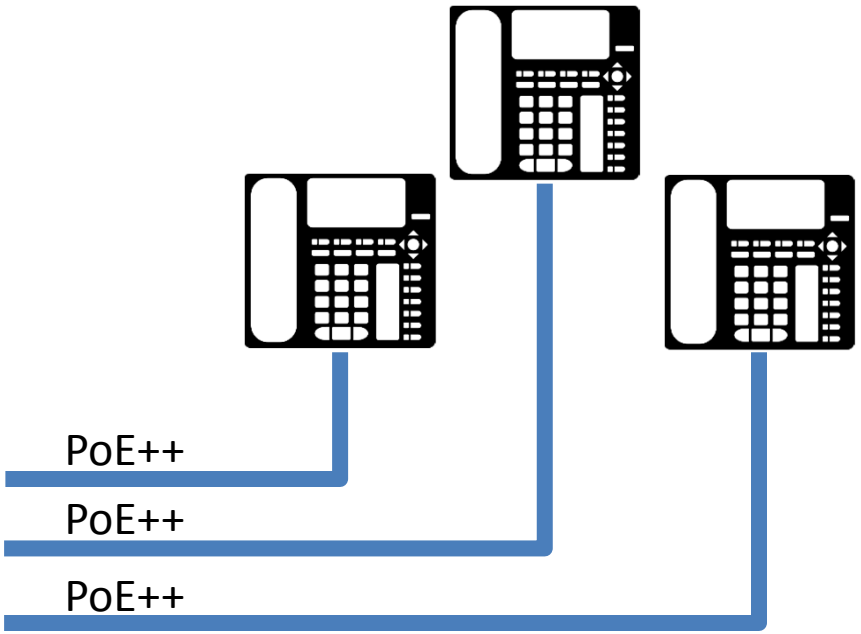


Dedicated bandwidth

Power Delivery Comparison



Still need power with wireless



Less cables run with PoE

Power Over Ethernet

Type	Standards	Maximum Current	Number of Energized Pairs	Power at Source	Power at Device	Maximum Data Rate	Standard Published	Cabling Recommendation
PoE	IEEE 802.3af (802.3at Type 1)	350 mA	2	15.4 W	13 W	1000BASE-T	2003	23AWG Category 6
PoE+	IEEE 802.3at Type 2	600 mA	2	30 W	25.5 W	1000BASE-T	2009	23AWG Category 6
PoE++ (4PPoE)	**IEEE 802.3bt Type 3 IEEE 802.3bt Type 4**	**600 mA 960 mA**	**4**	**60 W 99 W**	**51 W 71 W**	**10GBASE-T**	**APPROVED**	**Category 6A (assumes 23AWG)**

- New PoE standard 2X increase in pairs
- New PoE standard 50% increase in current
- New PoE standard 3X increase in power

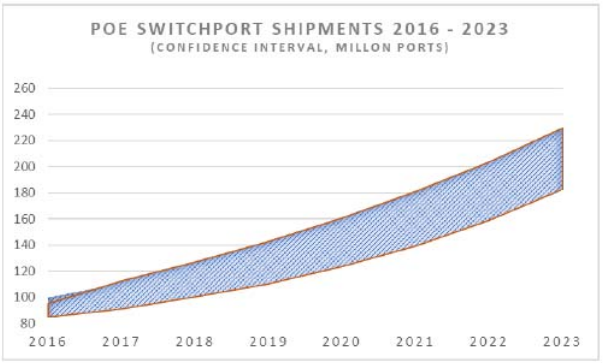
PoE Usage by Application Type

Main PoE applications worldwide, 2019

Application	Percentage of PoE ports	Number of PoE ports
CCTV cameras	18%	20 million
VoIP Phones	32%	36 million
Wireless Access Points	23%	26 million
Sensors	7%	7.9 million
Motors and actuators	4%	4.5 million
Others	15%	17 million
Included under others:		
- BACS	< 1%	~ 200 K
- A/V		~ 300 K
- Access control		~ 230 K
- Lighting		~ 250 K

Source: Grand View Research & BSRIA

- Estimation of 117 million PoE ports shipped in 2019
- Expect PoE ports to increase between 11% and 12.8% annually



Source: BSRIA based on several external sources

Source: *PoE applications global trends*, BSRIA, December 2019

Performance Risk at Speeds > 1Gig

Bundled Distance	Category	Channel Distance		
		1m – 30m	30m – 50m	50m – 100m
2.5GBASE-T	5e	Negligible	Low	Medium Low
	6	Negligible	Negligible	Low
	6A	None	None	None
5GBASE-T	5e	Low	Medium Low	Medium High
	6	Negligible	Low	Medium
	6A	None	None	None
10GBASE-T	5e	Not Recommended	Not Recommended	Not Recommended
	6	Low	Medium High	Not Recommended
	6A	None	None	None

Cabling Comparison

TIA	Cat 5e	Cat 6	Cat 6A
Construction	UTP or STP	UTP or STP	UTP or STP
Specified Bandwidth	100 MHz	250 MHz	500 MHz
Cable Wire Gauge	23/24 AWG	23 AWG	23 AWG
PoE Support	Yes – no LP	Yes	Optimal
Diameter (Approx)	.210''	.240''	.250''
Gigabit Ethernet	100 m	100 m	100m
10GBASE-T Ethernet	Not Supported	Limited distances per TSB-155-A	100m
25/40GBASE-T	Not Supported	Not Supported	Not Supported
Approx. Relative Installed Cost	1 X	1.2 X	1.5X

Summary of Wired vs Wireless

Wireless uses shared bandwidth, wired is dedicated bandwidth

Compared to PoE, no cabling reduction with Wi-Fi when including power

Category 6A is recommended for next generation PoE

Category 6A is recommended for speeds above 1Gig

Understanding where Wi-Fi is today and where it is going

WI-FI TODAY AND TOMORROW

Wireless Standards Overview

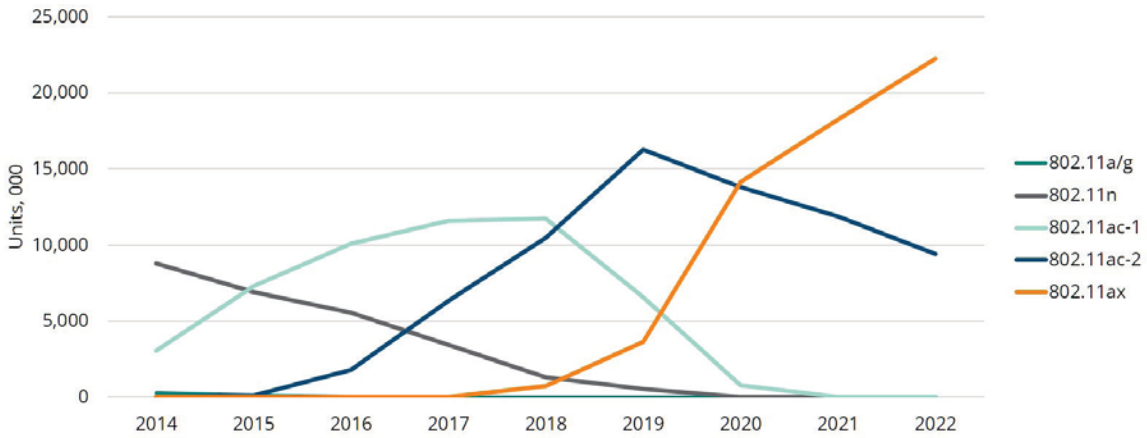
- New Wi-Fi terminology
  - 802.11n = Wi-Fi 4
  - 802.11ac = Wi-Fi 5
  - 802.11ax = Wi-Fi 6
  - 802.11be = Wi-Fi 7 (to be certified by the Wi-Fi Alliance)
- Observations
  - More devices per people than ever before
  - Wireless standards data rates increase faster than wired

Wireless Standard Comparison

Wi-Fi 7

Traditional Name	802.11n	802.11ac	802.11ax	802.11be
Wi-Fi Alliance Certification Mark	Wi Fi CERTIFIED	Wi Fi CERTIFIED	Wi Fi 6 CERTIFIED	TBD
Bands	2.5 or 5 GHz	5 GHz	2.4 and 5 GHz 6 GHz Compatible	2.4, 5, and 6 GHz
Data Rates (Max)	576 Mbps	6933 Mbps	9607.8 Mbps	> 10 Gbps
Spatial Streams	4	8 (unlikely > 4)	8	TBD
Beamforming	Yes	Yes	Yes	Yes
Cabling Reqs	Category 6	Category 6A	Category 6A	2x Category 6A
PoE Reqs (Full)	802.3af	802.3at	Yes	Yes
PoE Reqs (enhanced)	-	-	802.3bt	2x 802.3bt

Growth of Wi-Fi 6



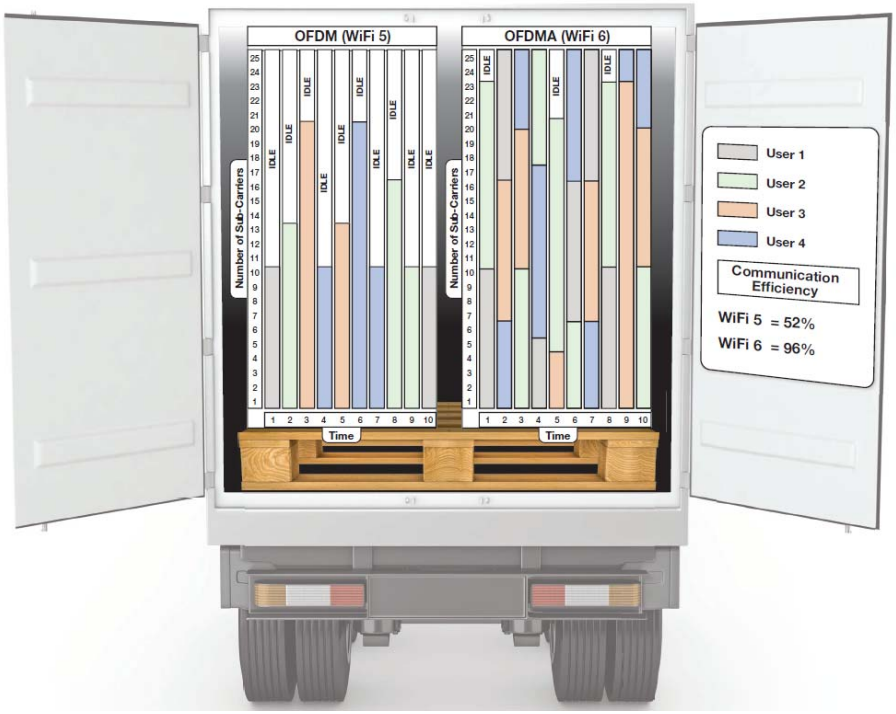
Source: 650 Group, 2017

- Wi-Fi 6 projected to be fastest growing Wi-Fi standard
- Wi-Fi 6 projected to be largest Wi-Fi standard

Wi-Fi 6 Advantages over Wi-Fi 5

- End device data rates improved speed of up to 4x.
  - OFDMA, beamforming, and improved modulation
- Increased capacity
  - OFDMA, improved MIMO, and beamforming
- Improved performance in environments with many devices.
  - Beamforming and utilization of the 2.4 GHz band helps with IoT devices
- Increased battery life for end devices
  - Wi-Fi 6 employs a “target wake time” (TWT) feature where it tells the Wi-Fi radio when to sleep and wake up to receive its transmission.
  - This reduces power consumption with no impact on performance
- Reduced latency to under 1 ms.
  - Improved latency performance with the use of OFDMA

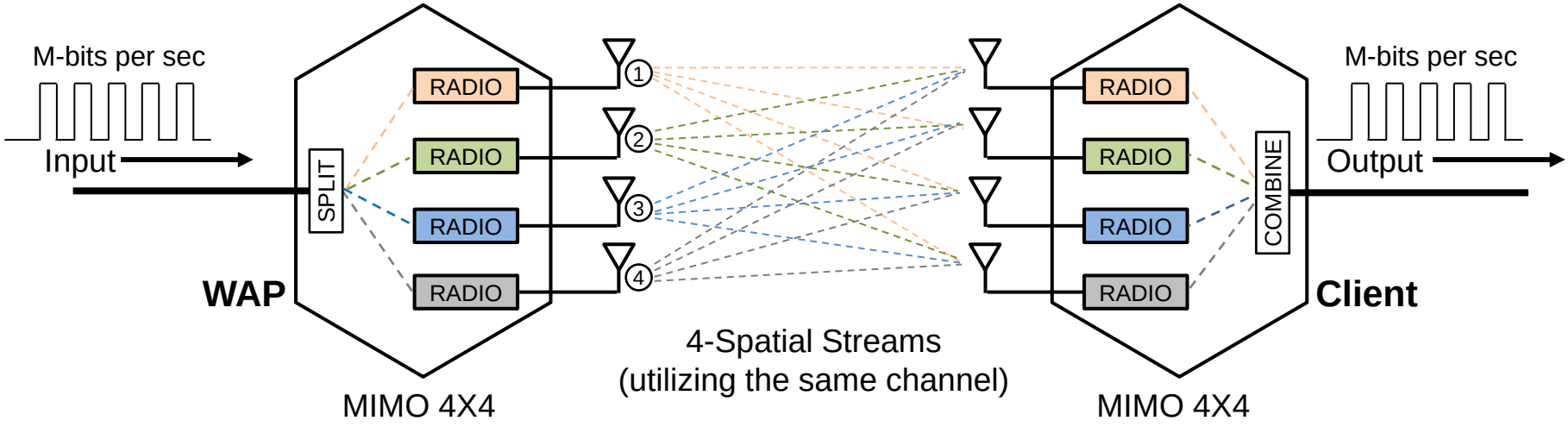
OFDM vs OFDMA



- Visualization showing how OFDMA more efficiently utilizes bandwidth
  - Users fill truck more efficiently
  - Utilizing 96% versus 52% of space
- Improves throughput while reducing latency

Spatial Streaming

- Increases the data rate by the number of streams utilized
- Each of the transmitted spatial streams are encoded independently so that each of the receiver radios can discern between the received spatial streams.



Note: Spatial Streaming available in 802.11n, 802.11ac, 802.11ax, and 802.11be

Beamforming

No beamforming

With beamforming

- Shaping of the radiation patterns towards client devices
  - Higher data rates
  - Longer reach
- Beams can encode multiple spatial streams (encoded signal that can be discriminated at receiver)
  - Wi-Fi 5 in practice uses up to 4
  - Wi-Fi 6 expected to use up to 8
- Enables increased density of access points
  - Reduces risk of contention

Wi-Fi 7 Expectations

- Worked on by IEEE 802.11be Task Force
  - Referred to as “extremely high throughput” (EHP)
- Expecting FCC to open bandwidth between 5.925 and 7.125 GHz
  - Wi-Fi 6 and 7 expected to use this additional bandwidth
- Expecting FCC to open 45 MHz unlicensed bandwidth in the 5.9 GHz range that will enable 160 MHz channels
- Improvements: Coordinated OFDMA, coordinated null stearing, and distributed MIMO to enhance beamforming
- 802.11be Task Force stated objective
  - **Two Category 6A cables per access point**
  - Supports the required data rates and to use a common cable type

Summary of Wi-Fi Today & Tomorrow

Wi-Fi 6 is expected to be the largest and fastest growing Wi-Fi standard

Wi-Fi 6 offers increased speeds, capacity, & battery life, reduced latency

Wi-Fi 6 can offer improved access point densities

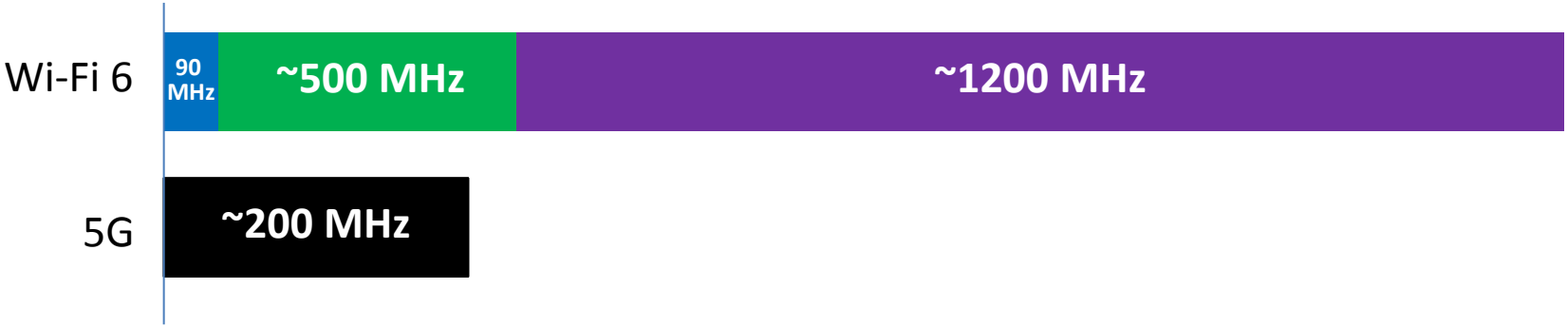
Wi-Fi 7 will be even better and require (2) Category 6A per access point

Will 5G impact Wi-Fi?

IMPACT OF 5G ON WI-FI

5G vs Wi-Fi: Bandwidth

BLUE = 2.4 GHz region, GREEN = 5 GHz region, PURPLE = 6 GHz region, **BLACK** = 5G region



- Significantly more bandwidth available with Wi-Fi
- 1790 MHz vs 200 MHz
- WiFi and 5G will co-exist, be complementary, and handoff to each other

Note: WiFi utilizes shared unlicensed spectrum while each cellular service provider utilizes their own licensed spectrum

5G vs Wi-Fi: Capacity

- Key differentiator between 2 is capacity
  - Capacity measurement in data rate density ($Mb/s/m^2$)
  - Wi-Fi 6 estimate is 400 $Mb/s/m^2$
  - 5G estimate is 10 $Mb/s/m^2$
- Wi-Fi will still be preferred in areas with high user or device density
  - Stadium, office, or home with many networked devices
- Difference in capacity
  - Larger bandwidth
  - Shorter reach & ability to really target devices with beamforming

5G vs Wi-Fi: Indoor Networks

- Indoor DAS expected to be active utilizing structured cabling
  - Expect cabling to be structured cabling
  - Indoor small cells
  - 5G radio units
  - Core network connection
  - Duplicated for each carrier that is supported
- Wi-Fi networks are universal for devices
- **Expect amount of network traffic offloaded from 5G to Wi-Fi to INCREASE**
- Expect both to coexist for foreseeable future

Summary of Impact of 5G on Wi-Fi

Wi-Fi has more bandwidth available than 5G

Wi-Fi has more capacity than 5G & is less expensive to deploy indoors

Expect amount of traffic offloaded to Wi-Fi to increase

Expect 5G and Wi-Fi to coexist for the foreseeable future

The best of both worlds.

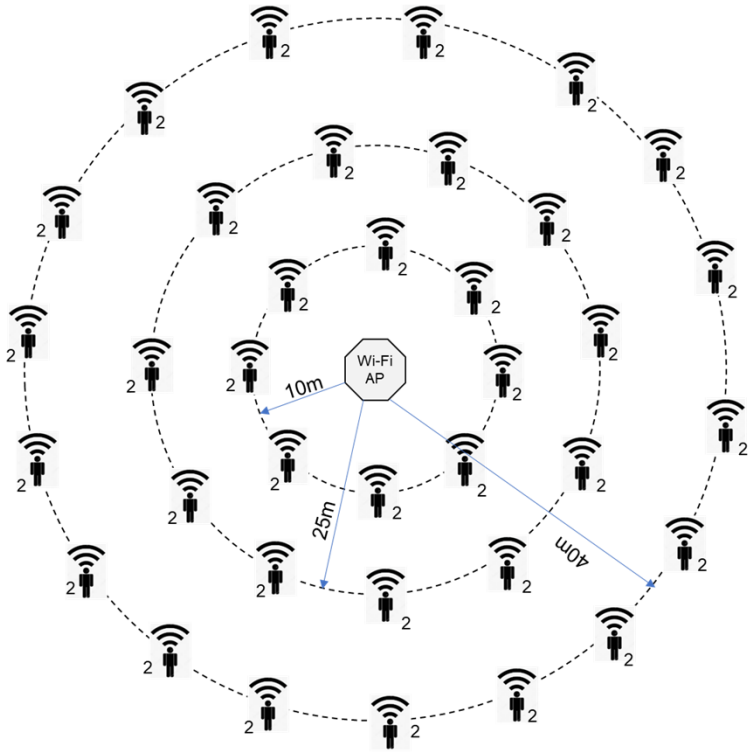
WIRED NETWORKS IMPACT ON WIRELESS

Wired and Wireless Working Together

- Some environments are conducive to having devices on both wired and wireless networks
- Think of an office
  - Mobile phone on wireless
  - Employees with laptops can dock laptop at desk to put on wired
  - Employees with desktops are hard wired as well
- Does this convey specific advantages?

Wi-Fi 6 Analysis

- 72 clients (36 people)
  - # of clients < 10m = 16
  - # of clients < 25m = 22
  - # of clients < 40m = 34
- Theoretical to practical ratio of 8
  - Assuming performance is 8X worse
- Reviewing performance at outer edge (40m)
- Performance Criteria
  - (Actual BW available) / (Required BW)
  - Want Performance Criteria > 1

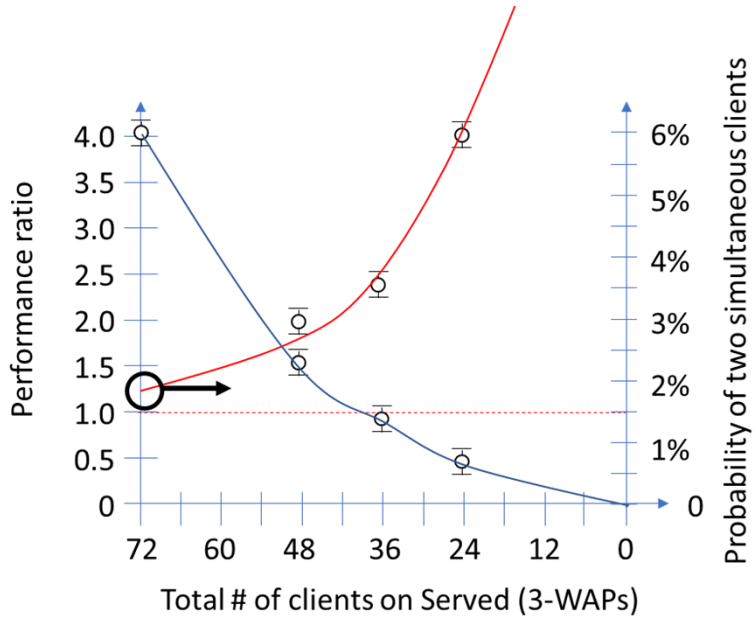


User Profiles

User Type	Down Stream User Profile	Example Users
High-end	Mean DR = 5Mbps Burst DR = 500 Mbps (for 5s) occurring every 2 minutes	Engineer, 4K video streaming, Hospital Imaging File Transfers
Middle	Mean DR = 1Mbps Burst DR = 250 Mbps (for 5s) occurring every 5 minutes	Engineer, 720p video, office worker with extensive network drive usage
Low-end	Mean DR = 0.1Mbps Burst DR = 100 Mbps (for 5s) occurring every 10 minutes	Office employee with primarily email, minimal network drive usage, some web browsing

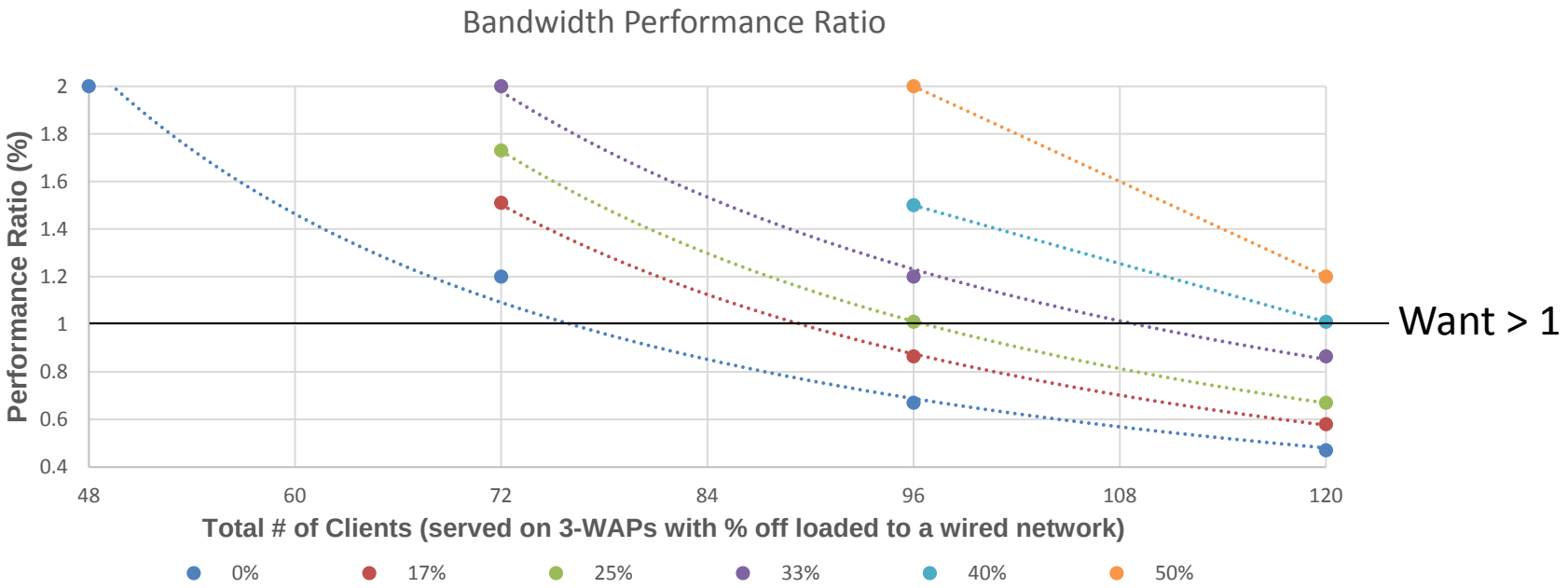
Test Cases

- Looked at variety of scenarios
- Number of clients split between 3 wireless access points and a wired network
- One scenario shown on right
  - Putting 1/3 of clients on access point improves performance by 60%
- Examined further amounts of clients and numbers to offload to the wired network



Number of clients = 72

Improved Future Proofing with Dual Wired and Wireless Networks



Summary of Wired Networks Impact on Wireless

Many environments can support both wired and wireless networks

Off loading to wired networks can improve a wireless network by >25%

Wired networks better future proof a wireless network

A robust wired network will compliment a wireless network

Planning for day one, day two, and day three.

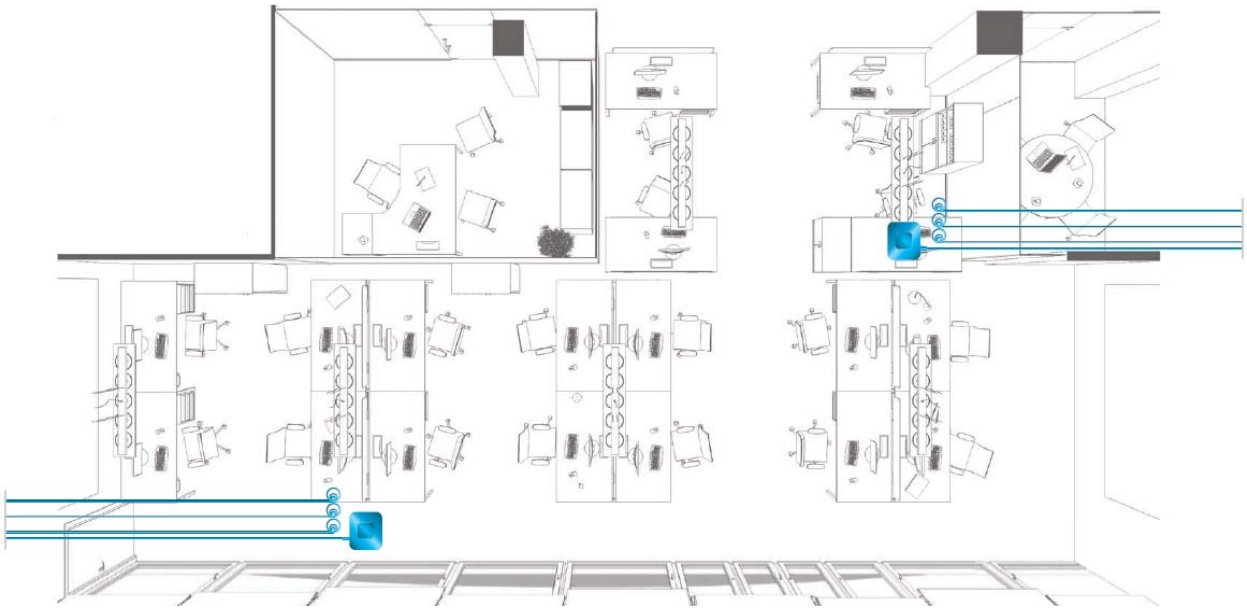
WI-FI CABLING INFRASTRUCTURE RECOMMENDATIONS

Wi-Fi Cabling Recommendations

- Design a cable plant for Wi-Fi 6 and beyond
  - Cable plant can accommodate present and future data rates & PoE
  - Cable plant is future proofed to maximize ROI from your investment
- Observations
  - Wi-Fi 6 of today will have data access needs up to almost 10 Gbps
  - Wi-Fi 6 and beyond have ability to allow increased densities of access points
  - Future Wi-Fi technologies like Wi-Fi 7 are projected to exceed 10 Gbps
- Recommendation of **four** Category 6A cables per access point today to support ***increased density*** and ***speeds beyond 10Gbps***

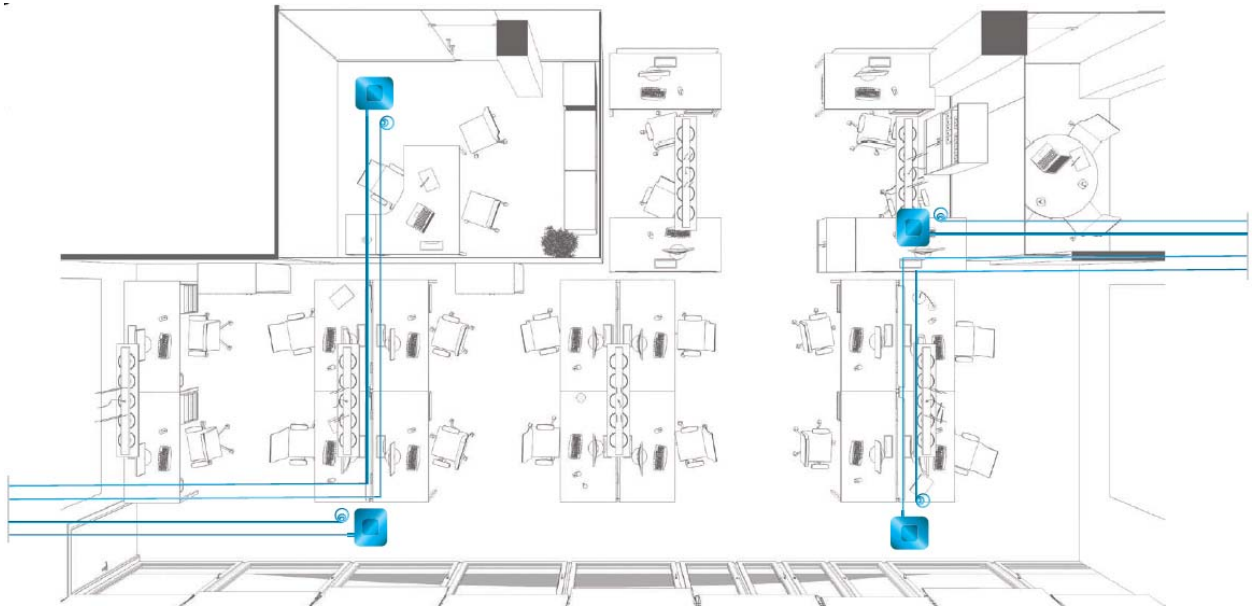
Day 1: Wi-Fi 5 or 6

- 2 access points
- 4 Cat 6A cables installed per access point
- 1 Cat 6A cable used per access point
- 1 out of 4 installed cables used



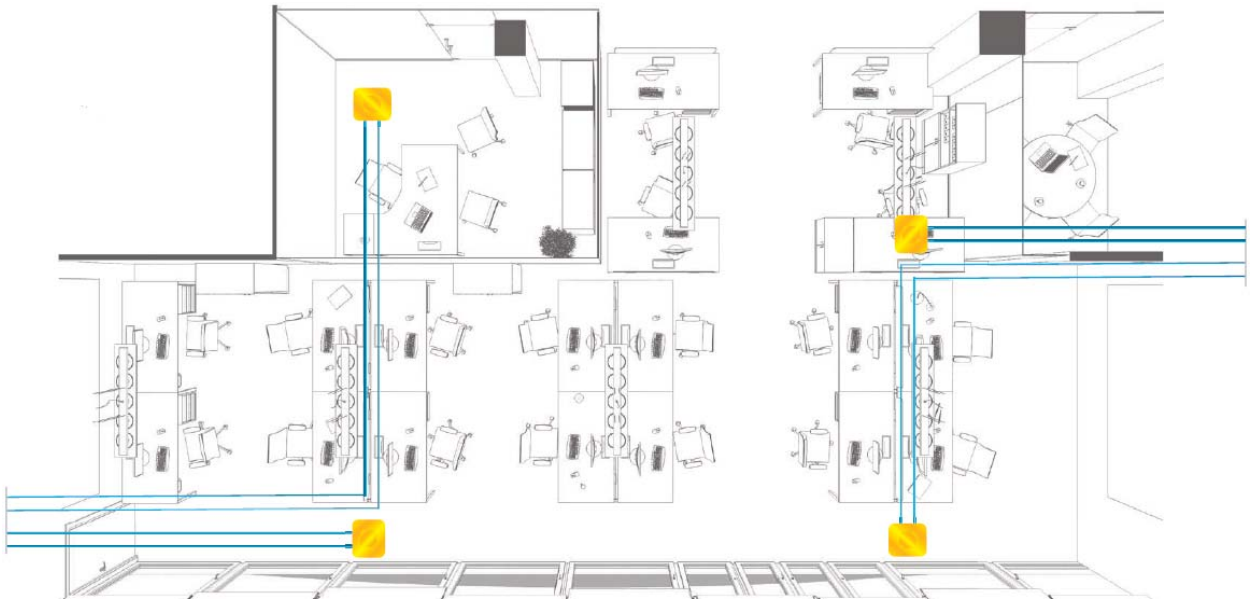
Day 2: Increase Density with Wi-Fi 6

- 4 access points
- 2 Cat 6A cables installed per access point
- 1 Cat 6A cable used per access point
- 2 out of 4 installed cables used



Day 3: Wi-Fi 7 and Beyond

- 4 access points
- 2 Cat 6A cables installed per access point
- 2 Cat 6A cables used per access point
- 4 out of 4 installed cables used



Cost Today versus Future

Option	Description	Initial Cost	Upgrade Cost	Total Cost
1	4 cables today	$200	$0	$200
2	2 cables today, 2 cables on day 2	$100	$1000	$1100
3	1 cable today, 1 cable on day 2, 2 cables on day 3	$50	$1500	$1550

- Lowest cost to install all cables today
- Simplified upgrading
- Best investment

Summary of Wi-Fi Cabling Recommendations

Day 1: Run 4 cables to each access point and use one of them

Day 2: Increase density using 2 of the 4 cables

Day 3: Use Wi-Fi 7 with 4 of the 4 cables initially deployed

Running 4 cables today provides the lowest cost & simplest upgrading

Wrap Up

- Wired connections offer a higher bandwidth and power over a single connection
- New Wi-Fi standards offer significant improvements in speed, latency, and battery life
- Wi-Fi will coexist with 5G and usage of Wi-Fi will increase
- A joint wired and wireless network optimizes and future proofs a wireless network
- Recommend installing (4) Cat 6A cables per access point

Questions?