Designing an effective outdoor Wi-Fi network, with 60GHz backhaul links

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Cambium Networks

Design Outdoor Public WIFI using CnWave 60Ghz

REQUIREMENTS

- Provide backhaul for Wi-Fi coverage

SOLUTION

- Deploy 60 GHz cnWave V5000, V3000, and V1000 with Point-to-Point, Point-to-Multipoint.

TOPICS

- Wi-Fi Network Design Fundamentals
- Traditional WIFI Outdoor Public WIFI Design Review
- CnWave 60Ghz Product Overview
- CnWave 60Ghz Link Design Demo
- Design Outdoor Public WIFI using CnWave 60Ghz

Wi-Fi Network Design Basics

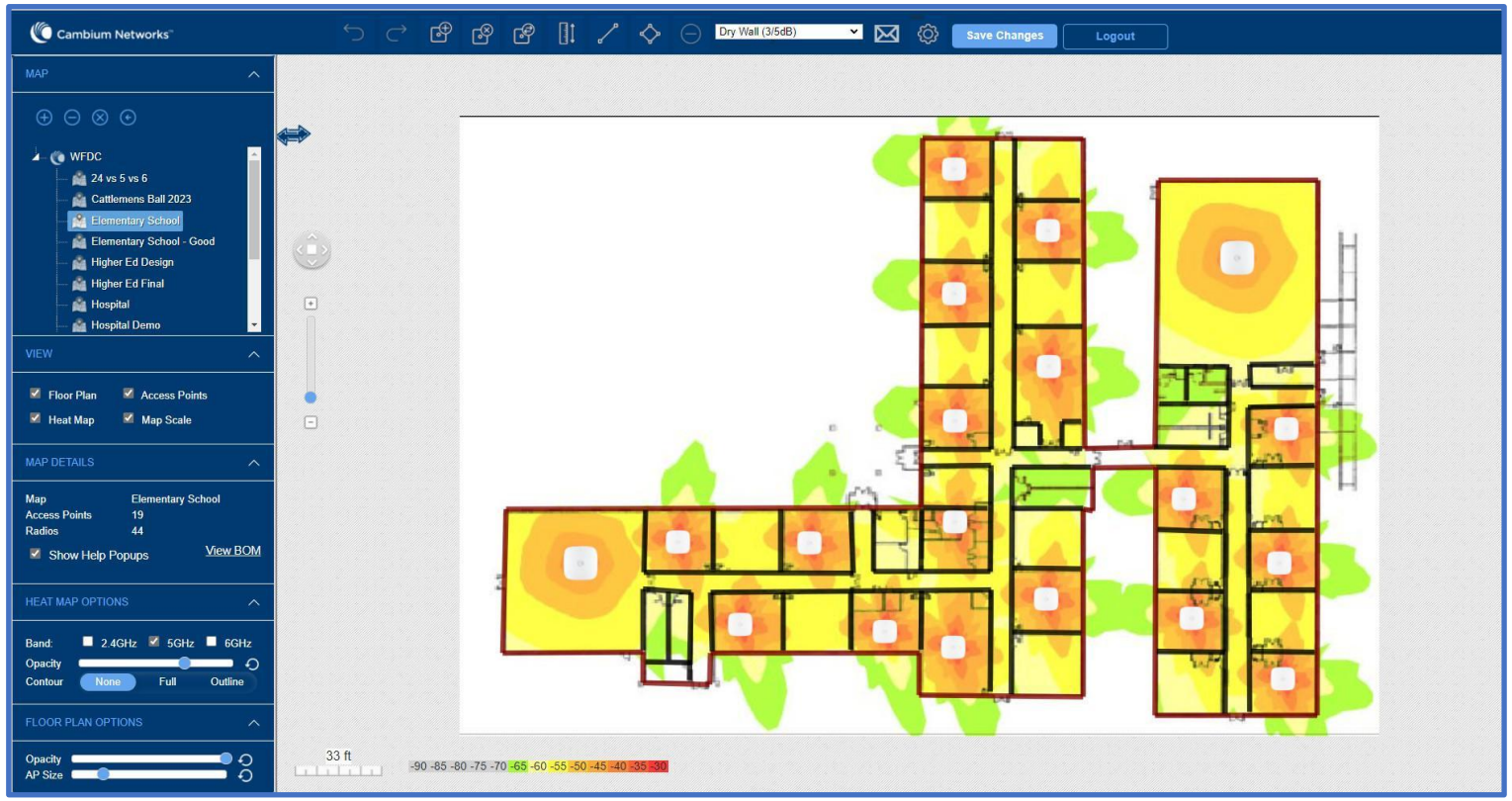
Introduction

- Site Surveys
- Design processes
- Design best practices
- Deployment best practices
- Optimization

Importance of a good WLAN design

Avoid the results of a poor network design!!!

- Insufficient coverage
- Insufficient capacity
- Lack of scalability
- Lack of required functionality
- Using wrong equipment
- Poor performance

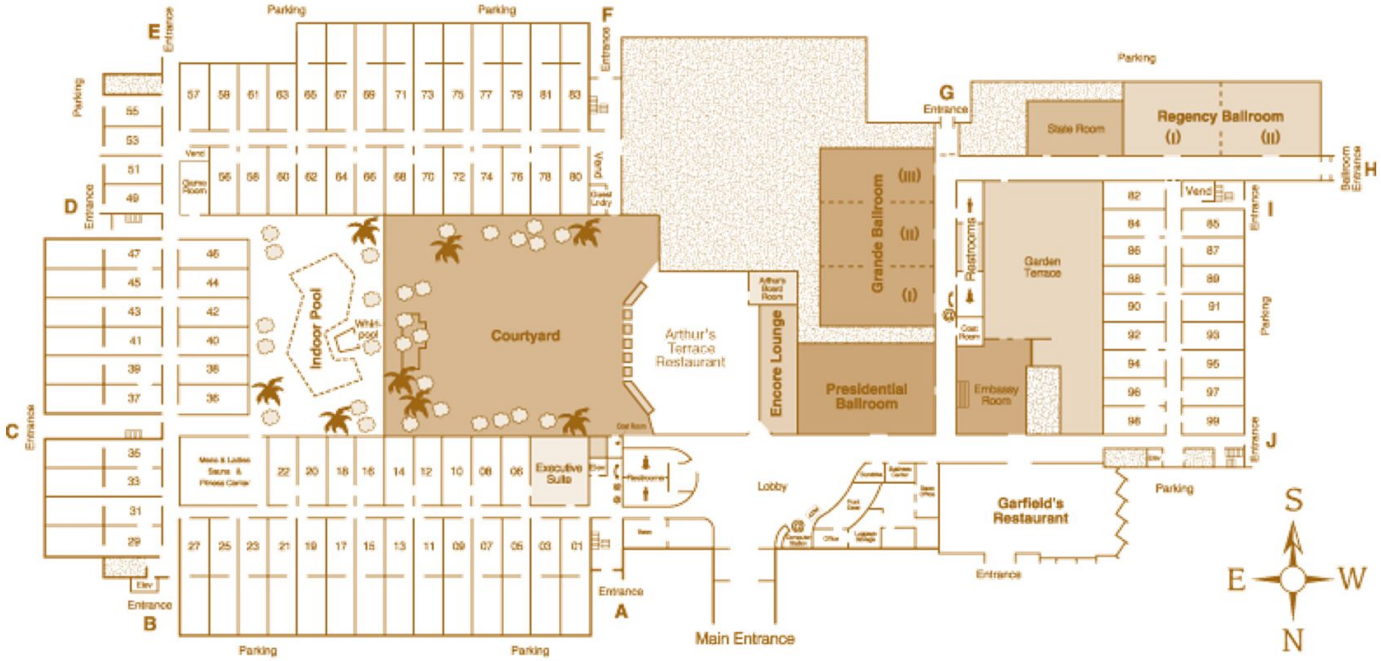


Cookie cutter designs

No two environments are exactly the same

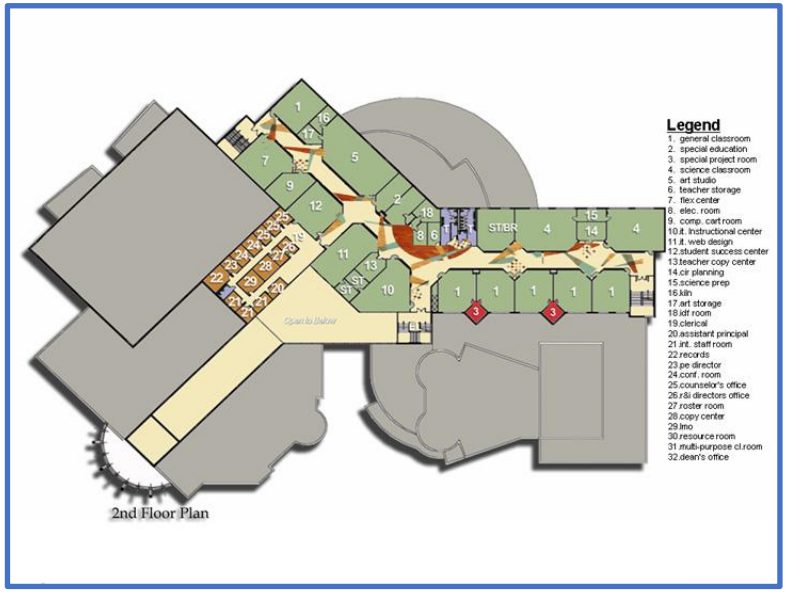
Taking shortcuts rises potential for:

- Missed interferers
- Too many devices or too few devices
- Poor performance



Design Process

- Defining
- Designing
- Implementing
- Optimizing
- Validating



Define phase

Requirements analysis and information gathering

- Existing WLAN
- Applications in use and future plans
- How many clients
- What types of clients
- VoIP
- Location services
- RF containment
- Ceiling height
- AP mount

Business requirements

Business requirements

- Internal business requirements
  - Business objective
  - Company policies
- User requirements
  - Goals or tasks users must perform
    - Network resource access, printing, VoIP, file transfers

Technical requirements - Environment

Environment

- Will affect network design
- Some building may have multiple different environments
  - Offices
  - Cubicle farms
  - Warehouse
  - Classroom
  - Hotel rooms
  - Many more!

Low latency

Important for time sensitive applications

- Voice
- Video

	Latency maximum	Latency preference	Packet loss
Voice	Below 150ms in one direction	Below 50ms	Less than 1%
Video	5 seconds	Less than 2 seconds	2%

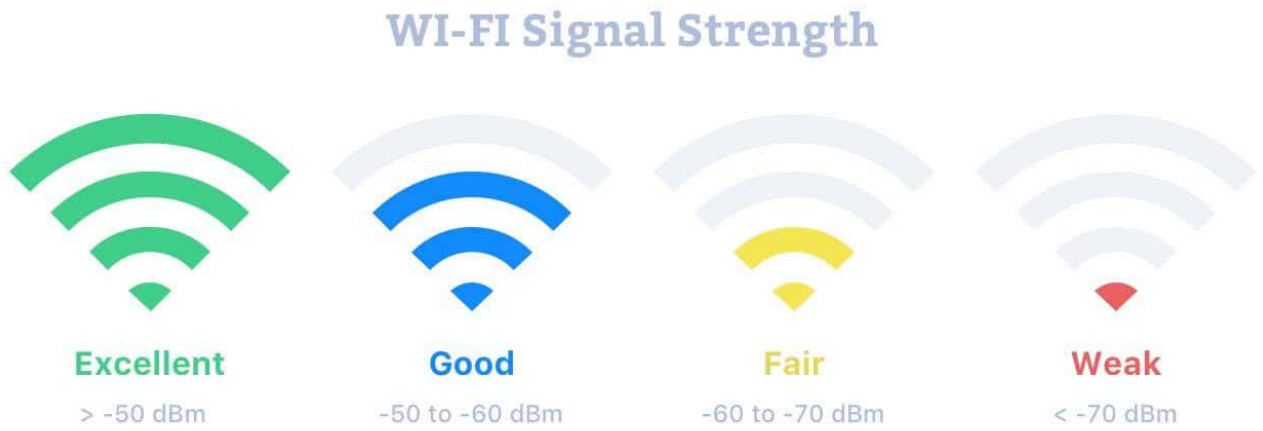
Other network devices/services have to be considered

- Routing
- Switching
- Applications
- Number of users
- Volume of data tx/rx
- Client devices
- Cabling
- QoS configurations

Signal strength

- Different client devices have different requirements
- Network Requirements have changed over time
- SNR

	Laptops	Tablets	Phones	IoT
RSSI level	-70	-62	-62	-60



Roaming

- Majority of roaming happens at layer 2
  - Laptops
  - Tablets
  - Mobile phone not acting as VoIP phones
  - Barcode scanners
  - Mobile healthcare devices
- Sometimes layer 3 roaming is required
  - VoIP phones*

802.11k – use of neighbor reports for faster client roaming

802.11r – provides fast, secure handoffs by caching authentication keys

*With roaming protocols enabled, VoIP phones can use layer 2 roaming

Data throughput

- Amount of useful data the network can transfer
- Typically measured in Mbps or Gbps
- Most apps have minimum requirements

Application Type	Bandwidth Consumption
General Browsing/Email	1Mb
Streaming Online Radio	.5Mb
VoIP Calls	.5Mb
Student	5 – 25Mb
Telecommuting	5 – 25Mb
File Downloading	10Mb
Social Media	1Mb
Video Streaming Std	3 - 4Mb
Video Streaming HD	5 - 8Mb
Video Streaming 4K	25Mb
Personal Video Call Std	1Mb
Personal Video Call HD	1.5Mb
HD Video Teleconferencing	6Mb
Game Console	3Mb
Online Multiplayer	4Mb

Voice and video

- Voice - latency is most important factor
- Throughput is also a concern
- Video – live streaming and stored files
  - Latency is important in both, but in different ways
  - Live video must have throughput and little latency
  - Stored videos files requires same but can buffer

Coverage requirements

- Physical or geographical areas that require access to wi-fi network
- Identify areas of coverage on floorplan
- Many different types of areas and environments
  - Indoors
  - Outdoors
  - Offices
  - Classrooms
- Building materials will affect coverage

Capacity requirements

- Design for capacity is different than design for coverage
- How many users will be in an area
- What applications will clients be using
- Client device type is also a factor
- IP address availability is often overlooked when considering capacity

Client devices

- Laptops
- Mobile phones
- Tablets
- IoT devices
- Wearables
- VoIP phones
- Scanners

Client Type	# of Antennas	Required signal
Laptops	1 – 4	-65
Tablets	1 – 2	-60
Mobile Phones	1 – 2	-60
Stationary Devices	1 – 4	-65
Cameras	1 – 2	-60
IoT Devices	1	-60
Barcode Scanners	1	-60
VOIP Phone	1	-60

Design constraints

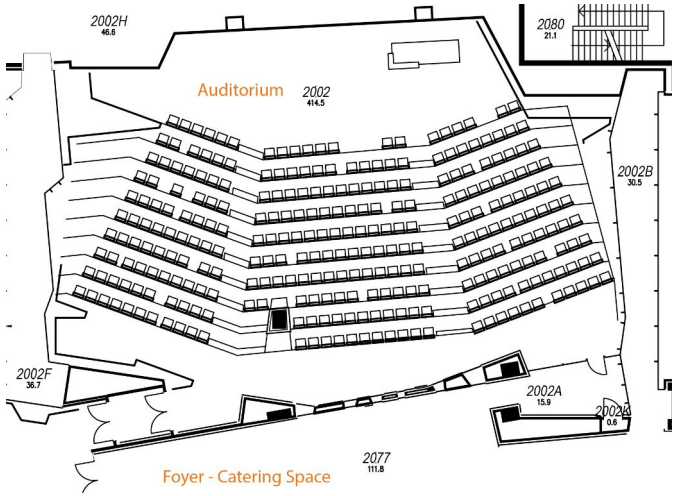
- Where are you not allowed to install an access point
- Discuss up front with customer

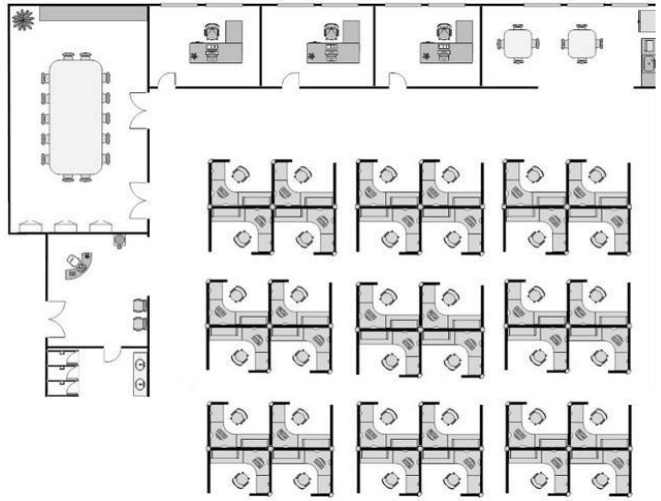
Wi-Fi Network Planning & Design

Coverage and Capacity

Planning Considerations

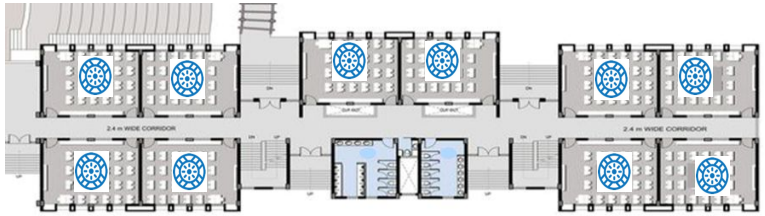
- ❑ Environment type
- ❑ Coverage areas
- ❑ Number of users/devices
- ❑ Device types
- ❑ Capacity requirements
- ❑ Number of clients per radio
- ❑ Number of radios
- ❑ Types of APs



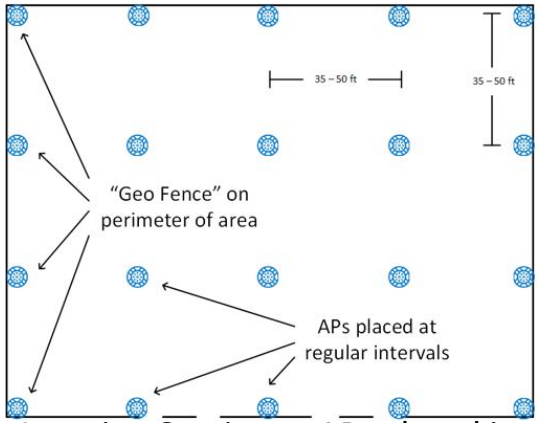


Wi-Fi Network Environments

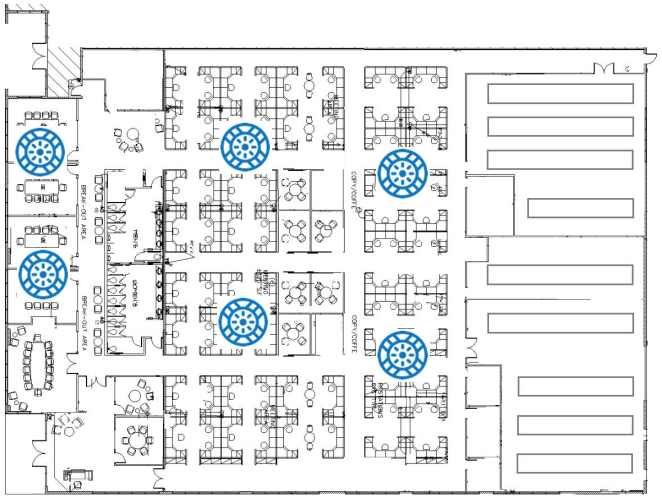
- Office
- Education
- Location Services
- Warehouse
- Outdoors



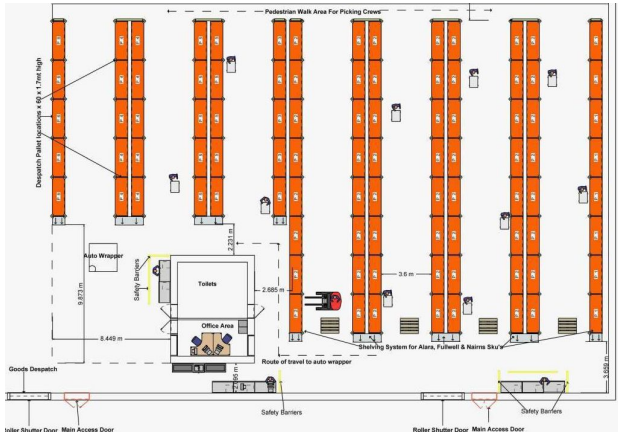
Education – High Density, High Usage



Location Services - APs placed in corners and along perimeter



Enterprise – High number of devices



Warehouse – Could vary from a few to many APs

Network Environments - Number of Clients

- Warehouse – very low number of clients
- Dorms / Hospitality – Low number of clients per radio
- Offices – Low to high number of clients per radio
- Classroom – Medium to high number of clients per radio
- Cafeteria / Auditorium – High number of clients per radio
- Convention Center / Stadium – Very high number of clients per radio

Type	Examples/Applications	Area/Person (sq ft / sq m)
Stadium/Arena	Sports, entertainment	5 – 10 / 0.5 - 1
Auditorium	Conferences, lectures, theater	10 – 15 / 1 – 1.5
Open Public Areas	Plazas, lobbies, show floors	10 – 100 / 1 - 10
Classroom	Education, training	20 – 30 / 2 - 3
Libraries	Study, research	50 – 100 / 5 - 10
Joint Use Retail	Stores, agencies, shops	75 – 150 / 7.5 - 15
Office – Open	Cubicles	80 – 100 / 8 - 10
Office – Closed	Enclosed offices	150 / 15
Hospital	Patient rooms, general areas	125 – 200 / 12.5 - 20
Dormitory	College, university, military	150 – 175 / 15 - 17.5
Light Industrial	Assembly, fab, packaging	150 – 400 / 15 - 40
Lodging	Hotel, resort	300 – 400 / 30 - 40
Warehouse	Distribution, storage	500+ / 50+

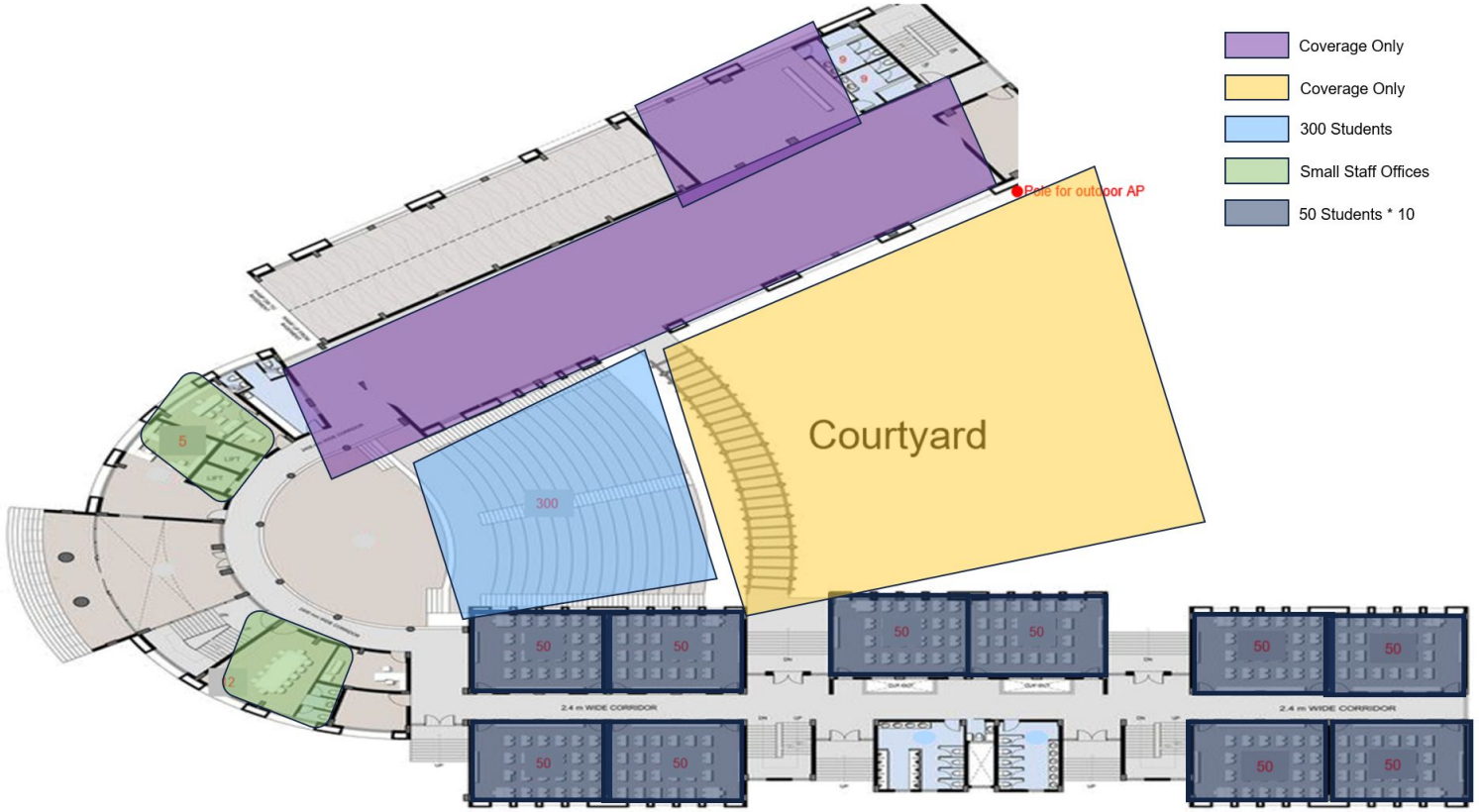
Client Types

Client Type	# of Antennas	Required signal
Laptops	1 – 4	-70
Tablets	1 – 2	-60
Mobile Phones	1 – 2	-60
Stationary Devices	1 – 4	-65
Cameras	1 – 2	-60
IoT Devices	1	-60
Barcode Scanners	1	-60
VOIP Phone	1	-60

- Low power devices require stronger RSSI (-60)
- Laptops / Desktop computers have bigger power sources and can use a weaker signal (-70)
- Design network signal strength to weakest client (in this case -60)

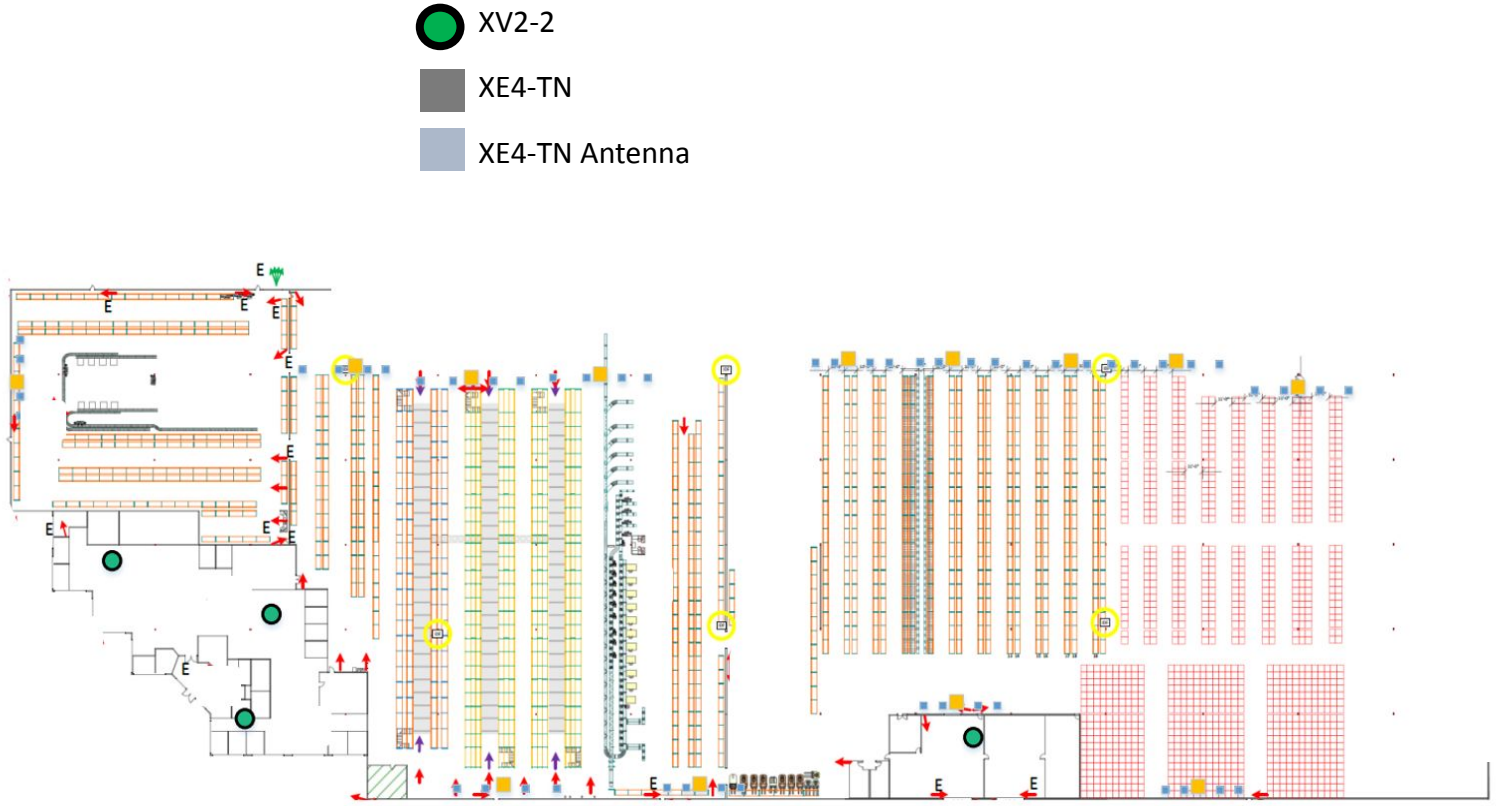
Coverage – Common Areas

- Physical or geographical areas that require Wi-Fi access
- Best displayed on floor plan or map of facility / area
  - Common areas
    - Workspace Areas
    - Hallways
    - Lunch/break rooms
    - Restrooms
    - Stairwells
    - Elevators
    - Hotel rooms / Dormitories
    - Lobbies
    - Storage Areas



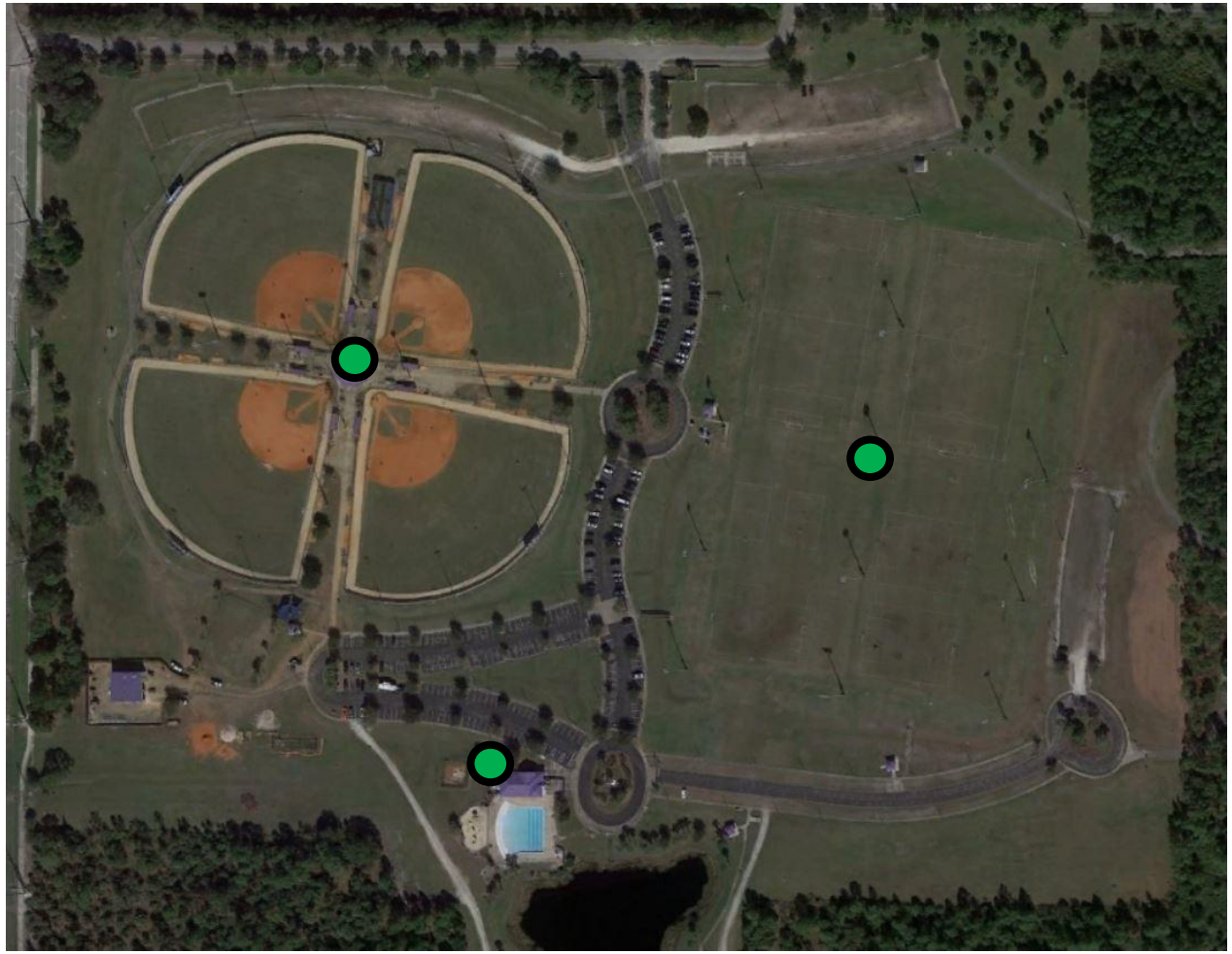
Coverage – Industrial Areas / Warehouses

- Industrial areas / Warehouses
  - Building materials
  - Square footage
  - Ceiling heights
  - Shelves / pallet racking
  - Materials on shelfs
  - Height of AP placement
  - Multi-floor structures
  - Wiring and power limitations
  - Facility access



Coverage – Outdoors

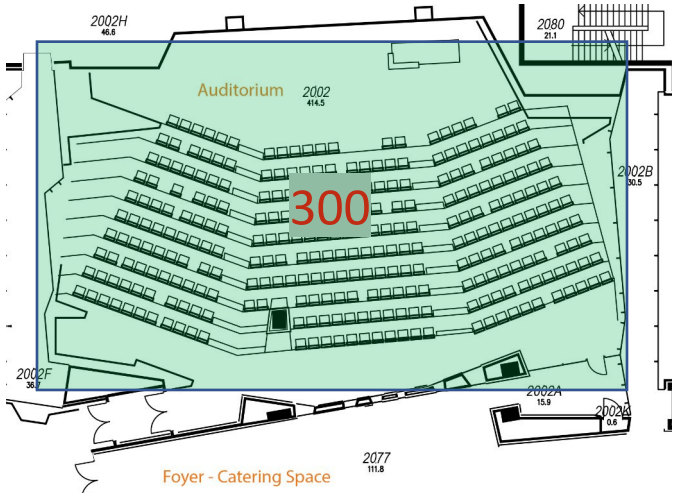
- Outdoors
  - Few obstacles
  - Free Space Path Loss

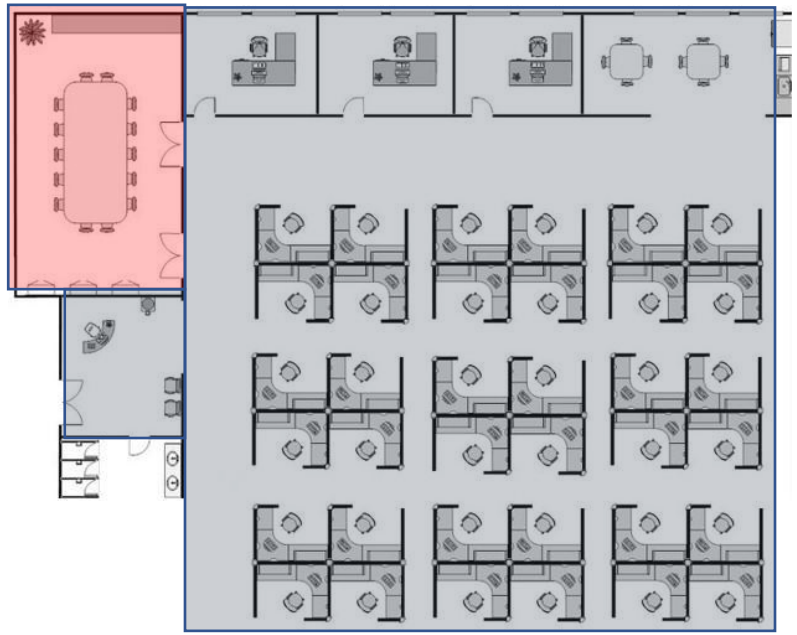


XV2-2T0

Coverage Area / Number of Users / Devices

- Network must accommodate different environments
- Not all areas will have similar requirements
- Identify how many devices will be in each coverage area





	Environment	Notes
	Office Area	40 users with 5 devices each
	Conference Room	15 people w/ 4 devices each
	Auditorium	300 people w/ 4 devices each

Bandwidth Requirements

Determine throughput rates required for each application

- If possible – test application and validate actual bandwidth requirements
- Application bandwidth requirement charts are available for reference

Oversubscription

- Takes into account that not all devices will be using the network at the same time, nor will the devices that are connected have heavy activity all at the same time

Take Rate

- How many clients in an area are actually using the network

Aggregate throughput

- Total site bandwidth requirement =

  number of connected devices * individual bandwidth requirement / oversubscription ratio

Environment	Oversubscription Rate	Take Rate %
Office	5:1	100
Apartments	20:1	50
Student Housing	5-10:1	50
Education	5:1	100
High Density	15:1	10 – 50

Application Bandwidth Requirements*

Activity	Download Speed (Mbps)		Activity	Download Speed (Mbps)
General Browsing/Email	1		Personal Video Call Std	1
Streaming Online Radio	0.5		Personal Video Call HD	1.5
VoIP Calls	0.5		HD Video Teleconferencing	6
Student	5 – 25		Game Console	3
Telecommuting	5 – 25		Online Multiplayer	4
File Downloading	10		File Transfer	100
Social Media	1			
Video Streaming Std	3 - 4			
Video Streaming HD	5 - 8			
Video Streaming 4K	25			

* FCC Broadband Speed Guide (www.fcc.gov/consumers/guides/broadband-speed-guide)

Bandwidth Requirements - Example

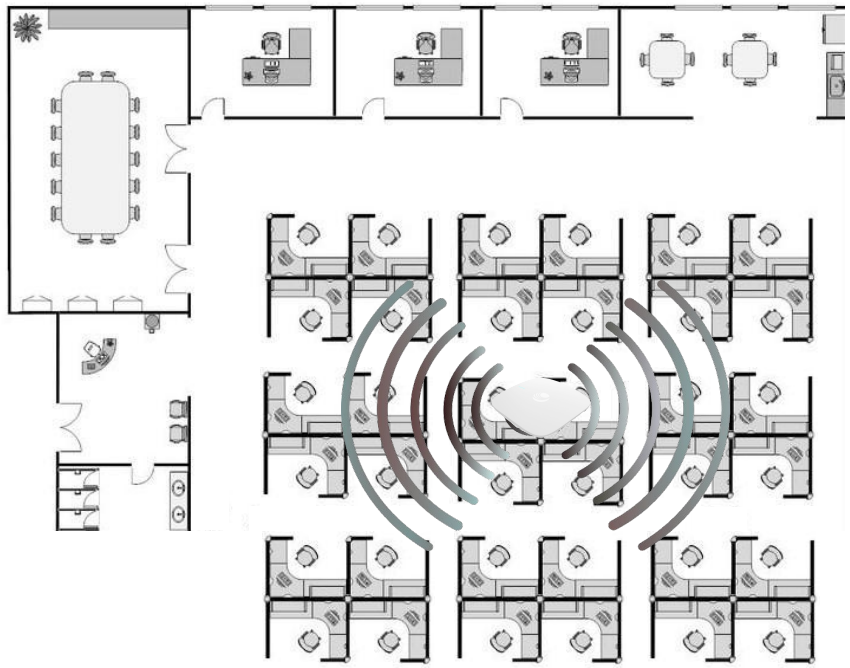
Application	Bandwidth Requirement (Mbps)
Email	1
Zoom calls	5.5
MS Office	5
Other network traffic	1
Future growth	10%
Bandwidth requirement	14

Conference room

15 Clients * 4 devices each * 14Mbps each * .20

60 * 14 / 5:1 = 168Mbps

168Mbps Aggregate bandwidth



Office area

40 Clients * 5 devices each * 14Mbps each * .20

200 * 14 / 5:1 = 560Mbps

560Mbps Aggregate bandwidth

$$\text{Aggregate bandwidth} = \frac{\text{number of connected devices} * \text{individual bandwidth requirement}}{\text{oversubscription ratio}}$$

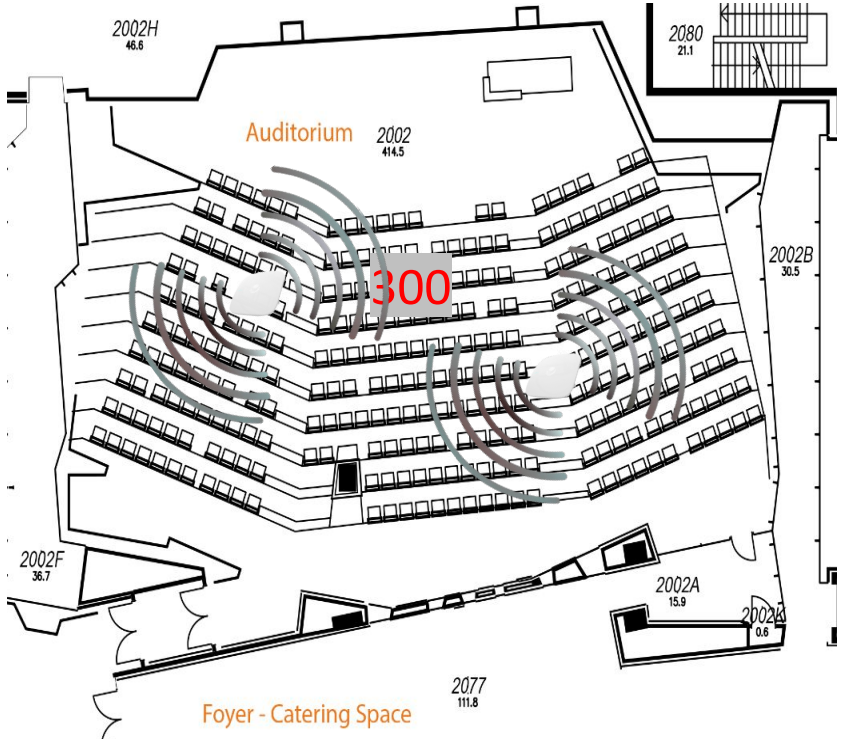
Bandwidth Requirements - Example

Application	Bandwidth Requirement (Mbps)
Email	1
File Downloading	10
MS Office	5
Other network traffic	1
Future growth	10%
Bandwidth requirement	20

Aggregate bandwidth

$$\frac{\text{number of connected devices} * \text{individual bandwidth requirement}}{\text{oversubscription ratio}}$$

Auditorium Network



Auditorium classroom

300 Clients * 4 devices each * 20Mbps each * .20

1200 * 20 / 5:1 = 4,800Mbps

4,800Mbps Aggregate bandwidth

Number of Clients Per Radio

Public Wi-Fi, High Density – Best effort			
XV3, XE3, XE5	Low	Medium	High
Bandwidth in Mbps	20	20–50	50+
Clients per 5GHz 4x4 radio	100	75	1-50
Clients per 6GHz 4x4 radio			

Enterprise			
XV3, XE3, XE5	Low	Medium	High
Bandwidth in Mbps	1–30	30–60	60+
Clients per 5GHz 4x4 radio	40+	25-40	1-25
Clients per 6GHz 4x4 radio			

High Capacity				
XV3, XE3, XE5	Low	Medium	High	High-Capacity Transfers
Bandwidth in Mbps	1 – 40	40 – 75	75-100	100
Clients per 5GHz 4x4 radio	25+	15-25	10-15	5-10
Clients per 6GHz 4x4 radio				

- General guidelines only, so many other factors to consider

- Bandwidth requirements
- Environmental factors
- # of antennas on ap
- # of antennas on client

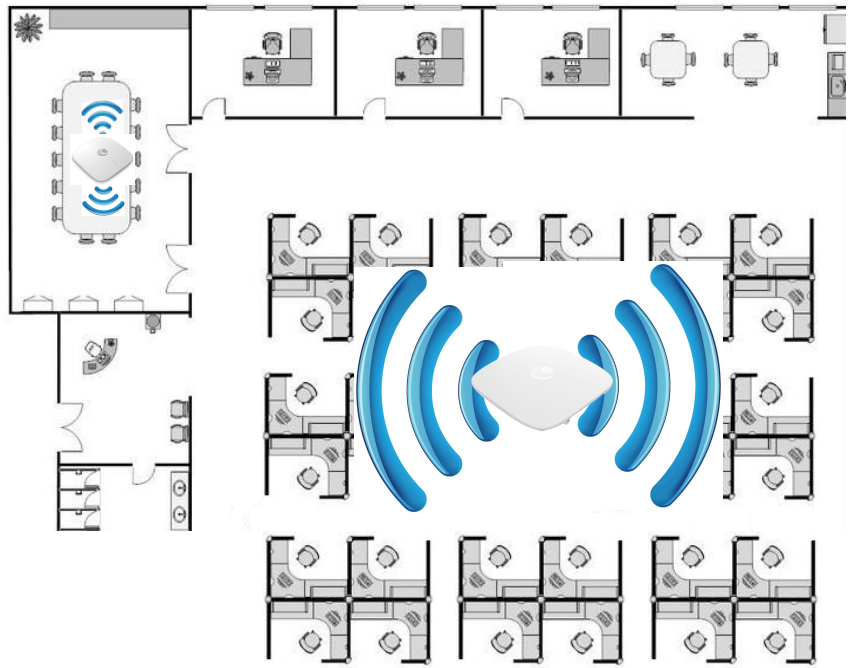
Number of Clients Per Radio

Design for performance

	Enterprise		
XV3, XE3, XE5	Low	Medium	High
Bandwidth in Mbps	1–25	25–60	60+
Clients per 5GHz 4x4 radio	40+	25-40	1-25
Clients per 6GHz 4x4 radio			

40 clients per radio

Conference room
60 Client devices * 14Mbps each * .20
168Mbps Aggregate bandwidth



Conference room
40 Clients, 14Mbps
40 clients per radio

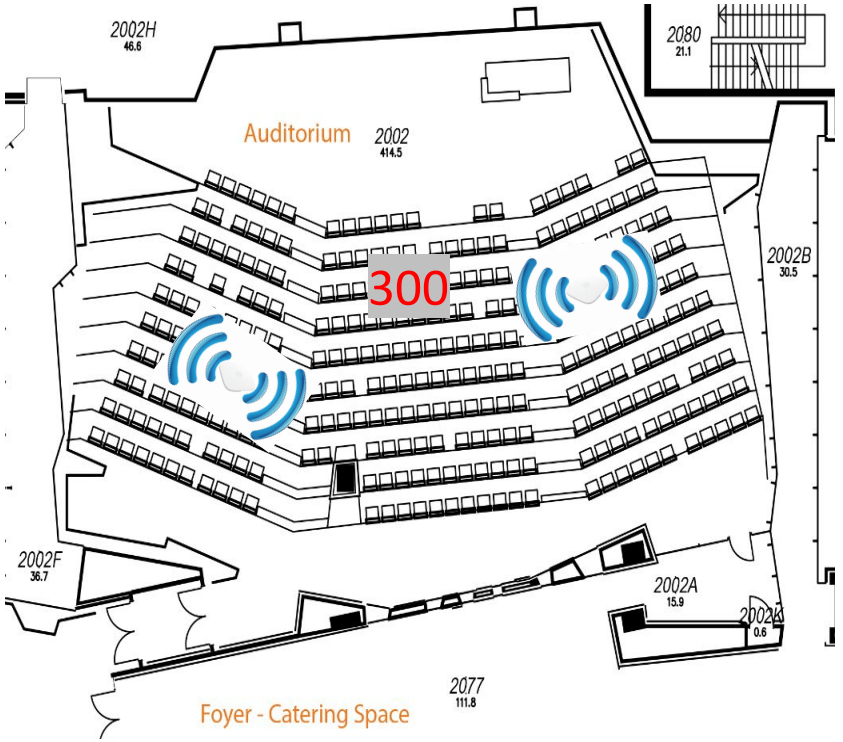
Number of Clients Per Radio

Design for high-density and capacity

High Density			
XV3, XE3, XE5	Low	Medium	High
Bandwidth in Mbps	1–40	40–75	75-100
Clients per 5GHz 4x4 radio	25-50	15-25	10-15
Clients per 6GHz 4x4 radio			

40 clients per radio

Auditorium Network



Auditorium classroom
300 clients, 20Mbps
40 clients per radio

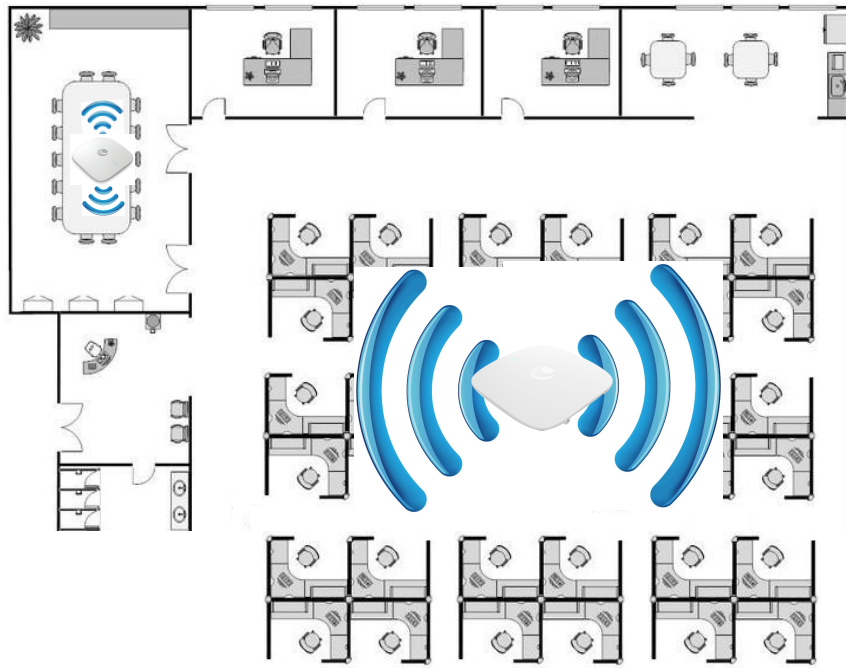
Number of radios

Enterprise			
XV3, XE3, XE5	Low	Medium	High
Mbps	1–25	25–60	60+
Clients per 5GHz 4x4 radio	40+	25-40	1-25
Clients per 6GHz 4x4 radio			

40 clients/
40 clients per radio
=
1 - 5/6Ghz radios*

1 – 2 radios required in office
1 radio in conference room

Office Network



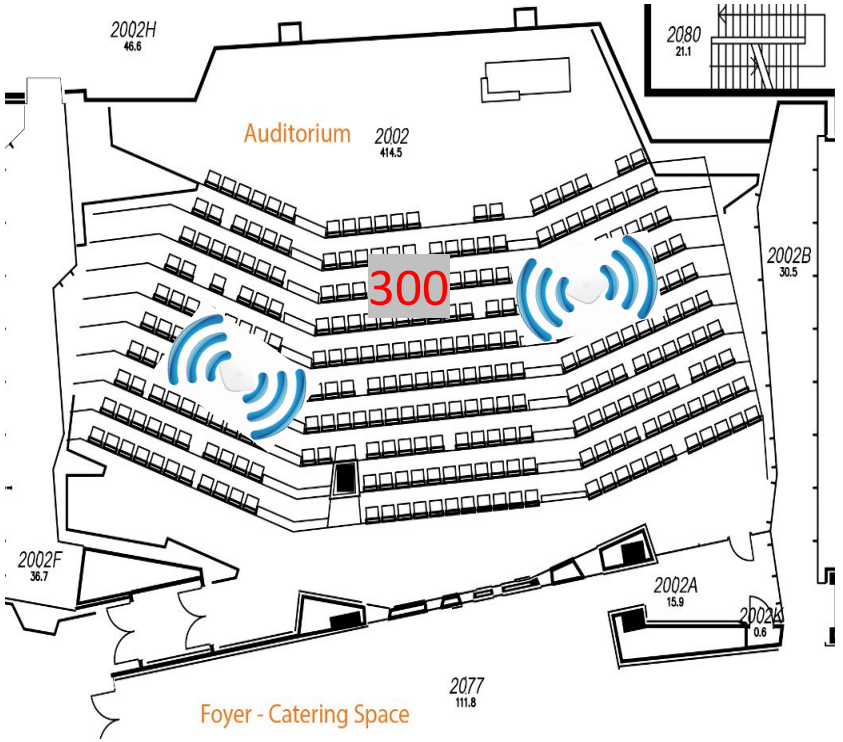
40 Clients / 14Mbps each
580Mbps aggregate bandwidth

Number of radios

High Density			
XV3, XE3, XE5	Low	Medium	High
Mbps	1–40	40–75	75-100
Clients per 5GHz 4x4 radio	25-50	15-25	10-15
Clients per 6GHz 4x4 radio			

300 students /
40 students per radio
=
8 - 5/6Ghz radios

Auditorium Network



300 Clients / 20Mbps
1,500Mbps aggregate bandwidth

AP Selection Considerations

- Indoor / Outdoor
- Environment type (Warehouse, Office, Classroom, Cafeteria, etc.)
- Antenna type (Internal / External)
- Radio type
- Bandwidth requirements

- Radio options
  - 2-radio access point
  - 3-radio access point
  - 5-radio access point

Which AP models where?

- XV3-8 / XE3-4
- Ceiling/wall/tripod mount up to 15ft
- Or under seats
- Demo podiums

XE3-4TN

- Outdoor coverage areas
- Over 15 ft ceilings or catwalks

XE5-8

- Ceiling/wall/tripod mount up to 15ft
- Auditoriums up to 500 devices
- Hallways, lobbies, common areas

XV2-2T / XH2-240

- Outdoor coverage areas
- Light/phone pole or outside wall mount

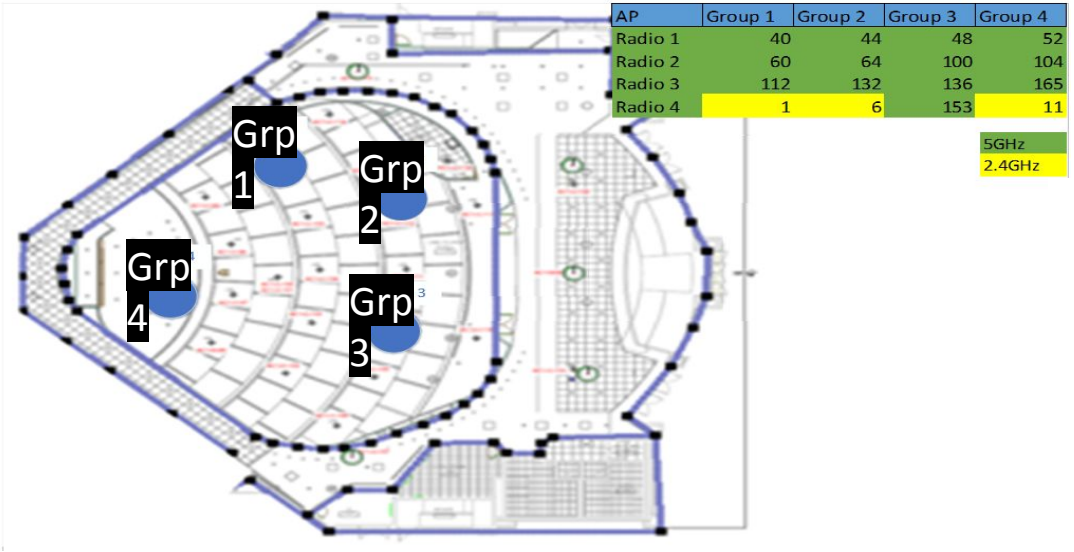
Wi-Fi Network Optimization

Channel Planning Best Practices

- Careful channel planning is a big factor of ANY Wi-Fi design, especially a high-density network design
- Auto-Channel or Channel assignments to avoid ACI & CCI
- Channel reuse patterns may be necessary
- Disabling 2.4GHz radios may be necessary if more than 3 APs are located near each other
- Create as much channel separation as possible (minimum 3 channels, ex. 36 and 48)
- 40Mhz Channels are typical in most environments
- Channel bonding is typically not recommended in high density to minimize co-channel interference and because channel re-use becomes critical

Channel Planning with Channel Groupings

- Channel Plan Groups are used to simplify the process of manually channel planning a wi-fi network where auto-channel is not recommended
- 2 – 5 radios (depending on the AP model), each with a channel assignment
- Channels are selected to create as much separation possible
- 2.4GHz channels should be assigned manually after the 5GHz & 6GHz groups have been assigned



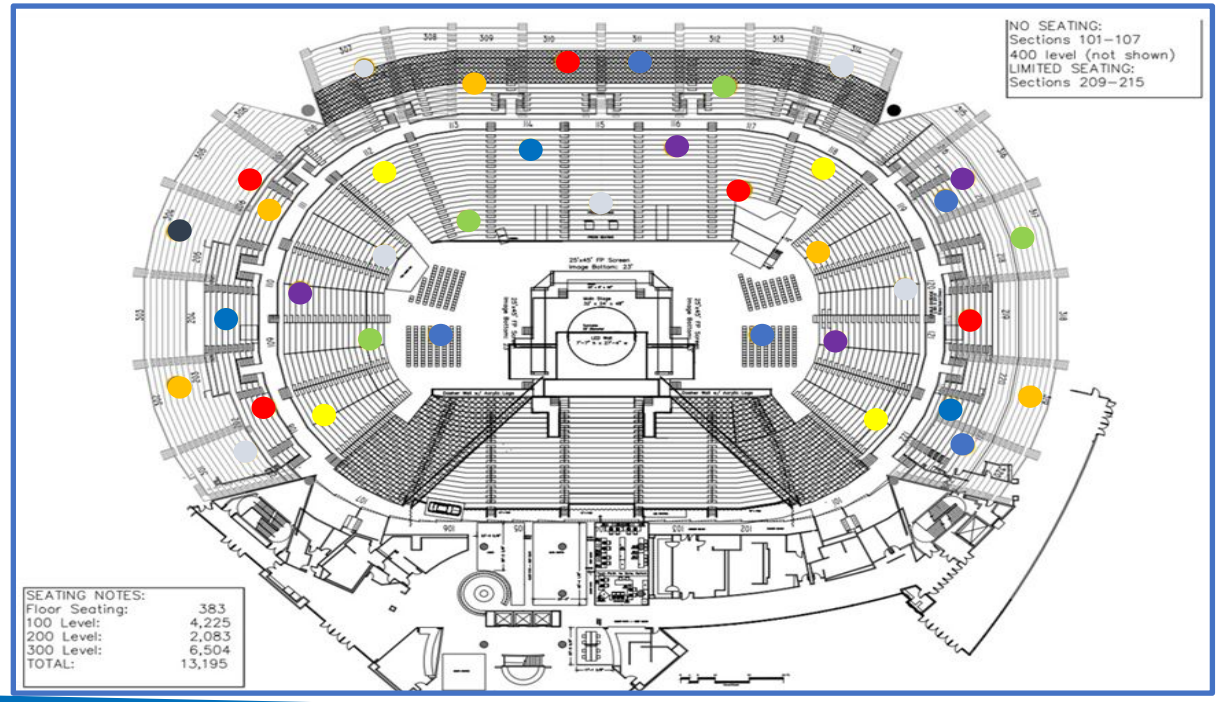
AP	Group 1	Group 2	Group 3	Group 4
Radio 1	40	44	48	52
Radio 2	60	64	100	104
Radio 3	112	132	136	165
Radio 4	1	6	153	11

5GHz
2.4GHz

XV3-8 Channel Plan Groups

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Radio 1 (2.4Ghz)	1	6	11	1	6	11	1	6
Radio 2 (5GHz)	112	116	132	136	140	149	153	157
Radio 3 (5GHz)	40	44	48	52	56	60	64	36

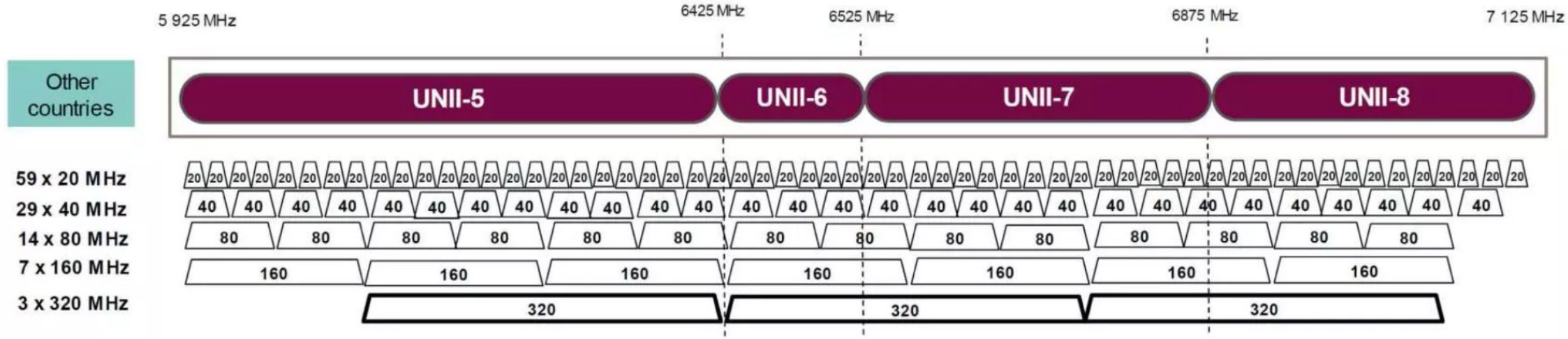
Color coded to identify on map easier



6GHz Channel Availability*

6GHz Channels

Country	Start	Stop	Channel Start	Channel Stop	# of Channels
AT, AU, BA, BE, BG, CH, CY, DZ, DE, DK, EE, ES, FI, FR, GB, GR, HK, HR, HU, IE, IS, IT, JO, KR, LI, LT, LU, LV, MT, NL, NZ, PL, PT, QA, RO, SE, SI, SK, TR, ZA	5955	6425	1	97	25
BR, CA, US	5955	7125	1	233	59



*All Countries

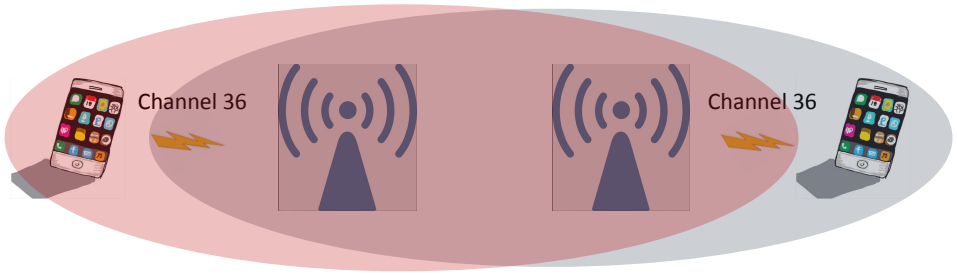
Power Settings Best Practices

- Critical to the performance of the network
  - Too high – roaming/sticky clients, CCI
  - Too low – poor device performance, coverage area
- Cambium APs are defaulted to “Auto”. This is the highest power allowed for that radio

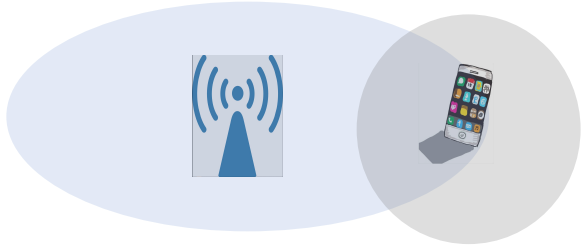
Environment	2.4GHz	5GHz	6GHz
Classrooms	Small (4-9dBm)	Medium (10-16dBm)	Medium (10-16dBm)
Hallways	Medium (10-16dBm)	Large (17-24dBm)	Large (17-24dBm)
Enterprise	Small (4-9dBm)	Medium (10-16dBm)	Medium (10-16dBm)
Outdoor	Max (25-30dBm)	Max (25-30dBm)	Max (25-30dBm)
Auditorium with APs in line of sight Based on # of APs and height of AP. The lower the AP is deployed, the lower the power setting will be.	Preferably Off. Otherwise, 9	Medium (10-16dBm)	Medium (10-16dBm)

Power Settings – Too High

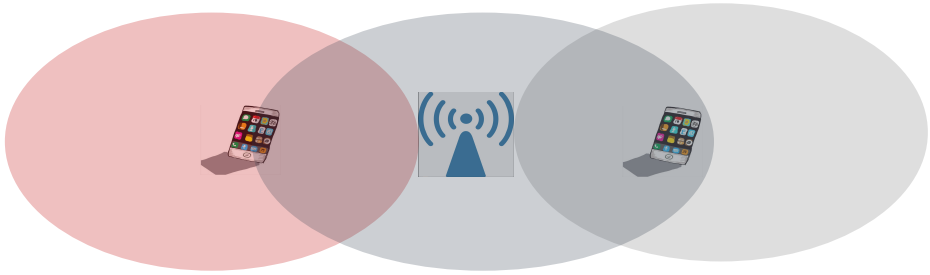
- High CCI
- Hidden nodes
- Asymmetric power – Power from AP exceeds power from client device
- Data corruption from smaller device due to distance from AP - common result is invalid password message
- Very large coverage areas
- Sticky clients and odd roaming behavior



Co-Channel Interference



Asymmetric power



Hidden Nodes

Optimization

Automatic channel selection when booting up

- AP scans surrounding RF environment and selects the cleanest channel available
  - For best results, do this during the day, when network is being used. False readings occur when run off production hours because all channels look clean.
  - Unlikely customer will agree to this due to down time during production hours affecting clients.

    Therefore, when auto channel is performed during off-peak hours it is not taking into account interferers and attenuation from people throughout the building.
  - Will work for 90% of our customers

Optimization

Auto-RF Dynamic Tx Power

- AP scans surrounding RF environment and gathers variety of RF statistics
    - AP will choose proper channel and transmit power for each radio

Auto-RF Features

- Dynamic channel – radios choose best channel at bootup and subsequently if channel/rf conditions change
- Auto power – assists radios in determining proper transmit power to deal with coverage gaps and reduce RF interference

Optimization

Automatic channel selection when booting up

- Trust but verify!
- Run report to verify –
  - cnMaestro - Monitor & Manage > Site > Report > Devices >Type – Enterprise Wi-Fi
  - XMS-Cloud – My Network > Access Points > Export > All Radio Configurations

When NOT to use Automatic channel selection and use a manual channel plan

- Complex designs require manual channel plans and power/RX settings
  - High-Density environments
  - Dense AP deployments
  - High capacity

60 GHz cnWave™

Product Overview

60 GHz Frequency Range

What is the 60 GHz Band?

- 12 GHz range (57.24 to 70.2 GHz)
- Divided into 6 channels
- Each channel has Bandwidth of 2.16 GHz

Channel	Center (GHz)	Min. (GHz)	Max. (GHz)
1	58.32	57.24	59.40
2	60.48	59.40	61.56
3	62.64	61.56	63.72
4	64.80	63.72	65.88
5	66.96	65.88	68.04
6	69.12	68.04	70.20

Unlicensed Spectrum Allocated Countries

Region	Frequency channels
USA	1,2,3,4,5,6
EU/AUS/NZ	1,2,3,4
Japan	1,2,3,4
South Korea	1,2,3

60 GHz Pros and Cons

Pros

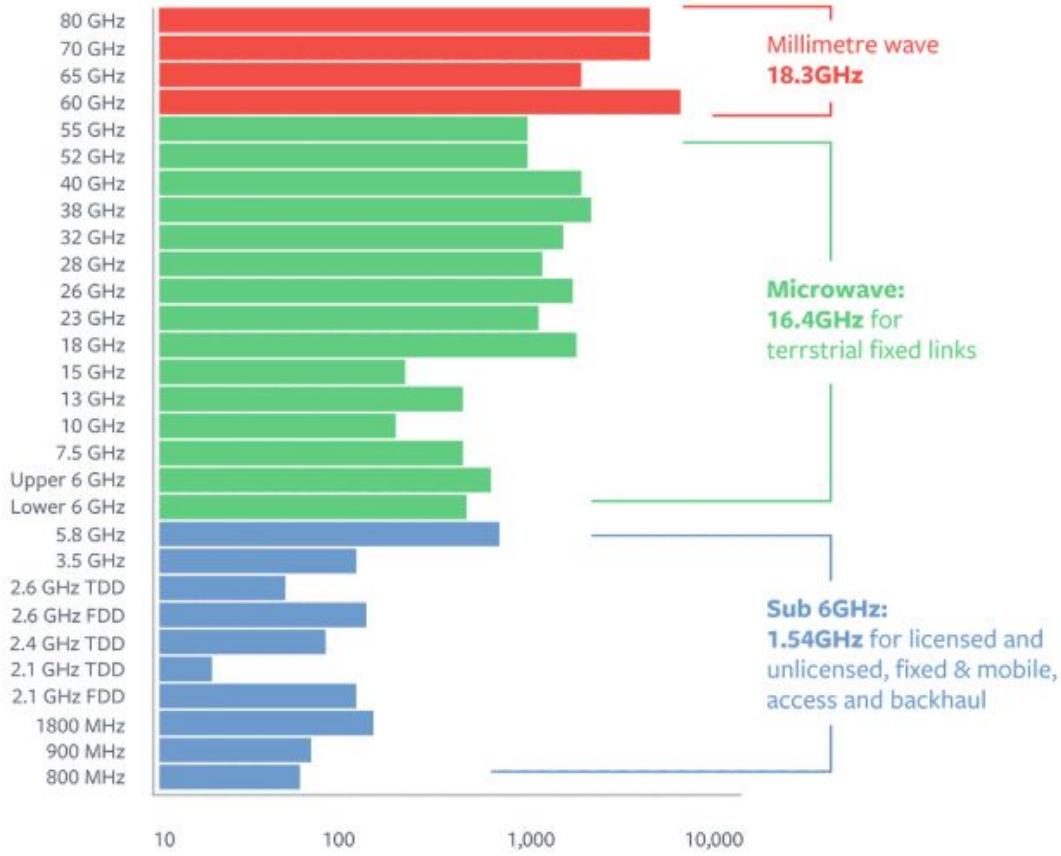
- 60 GHz spectrum is either unlicensed or lightly licensed
- Wide spectrum available
- Very small wavelength, thus smaller radio with a higher antenna gain
- Obeys quasi optic properties
  - (No dispersion or no penetration only reflection)
- High-frequency re-use is possible

Cons

- LOS required at 60 GHz
- Reduced range due to high O2 absorption
  - The typical range is limited up to 500 meters with beamforming
  - Typical 1.5 – 2 km require a high-gain directional antenna
  - Uses multi-hops to extend the range of 60 GHz

Advantages of 60 GHz

802.11ay-based 60 GHz solution transforms fixed wireless access from a broadband option of last resort into a competitive alternative to fiber and cable-based solutions.



Unlicensed
Light licensed

Link licenced (PTP)
Area licensed (PMP)

Area licensed
Unlicensed

More Spectrum, Wide Channel Bandwidth → **Multi Gigabits High Speed**

Oxygen Absorption + Beam forming → **Security + Frequency Reuse**

Advert of 802.11ay (TDMA, TDD Sync) → **High Density Deployment**

Source: "Frequency Band Review for Fixed Wireless Service" for Ofcom, Nov 2011, http://goo.gl/7S26p

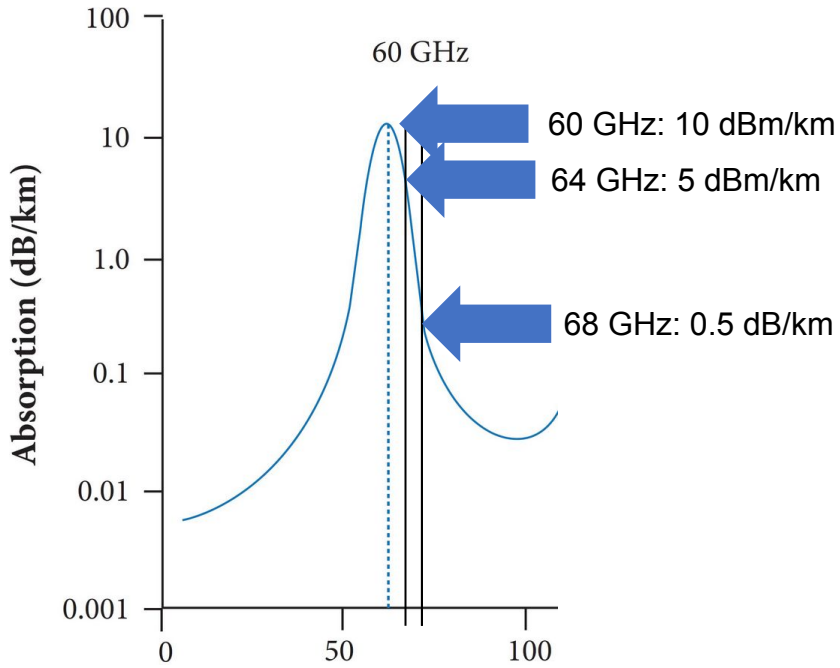
60 GHz Propagation

The 60 GHz Propagation is determined by link budget and signal fade rate. There are two main factors why a 60 GHz links require Line of Sight only:

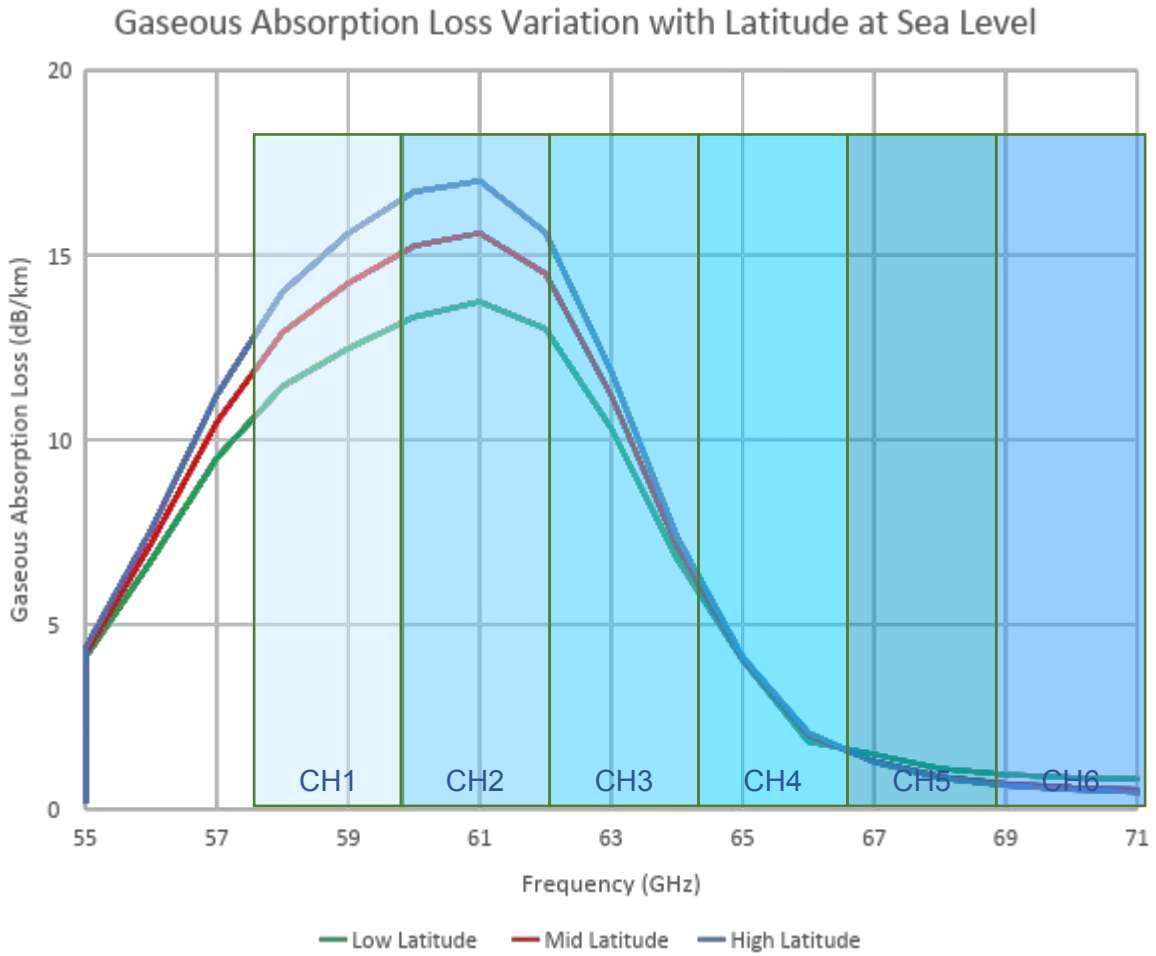
Water Absorption

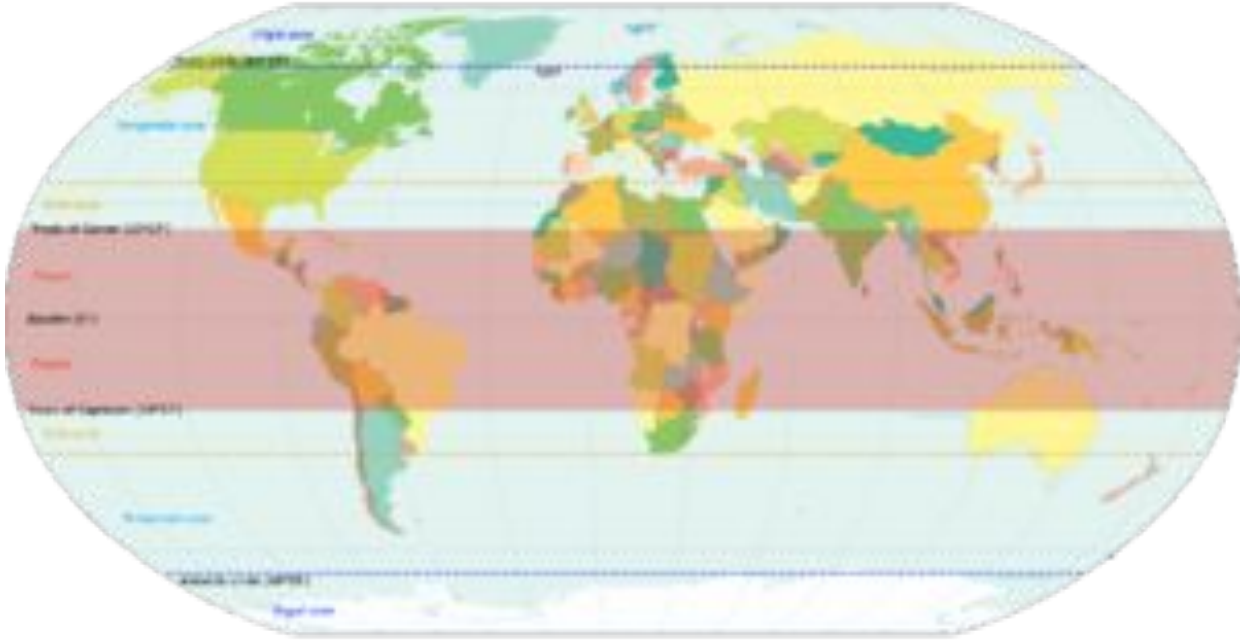
Rain	Attenuation
Drizzle (0.25 mm/hr)	0.2 dB/km
Light Rain (2.5 mm/hr)	1.8 dB/km
Medium Rain (12.5 mm/hr)	5.6 dB/km
Heavy Rain (25 mm/hr)	9.5 dB/km
Downpour (50 mm/hr)	17 dB/km
Tropical (100 mm/hr)	28 dB/km
Monsoon (200 mm/hr)	38 dB/km

Oxygen Absorption



60GHz Propagation - Oxygen Absorption





cnWave Platform

Distribution Node

V5000
Dual Sector

Client Nodes (PMP or PTP)

V3000
High Gain
44.5 dBi Dish
40.5 dBi Dish

V2000
Flexible
Mid-Range

V1000
Small
Form-Factor

All 60 GHz cnWave products include:

- Cloud or on-premises network management with cnMaestro™
- Optional advanced management features with cnMaestro X
- Network planning capabilities with cnHeat, LINKPlanner, and ANP
- On-board or Remote e2e Controller Software
- Layer 2 or layer 3 network connectivity
- IPv4 or IPv6 networking protocols
- Security with HTTPS interfaces and 128-bit AES encryption
- 3-year warranty
- Options for extended warranty, Cambium Care Pro, and advanced replacement

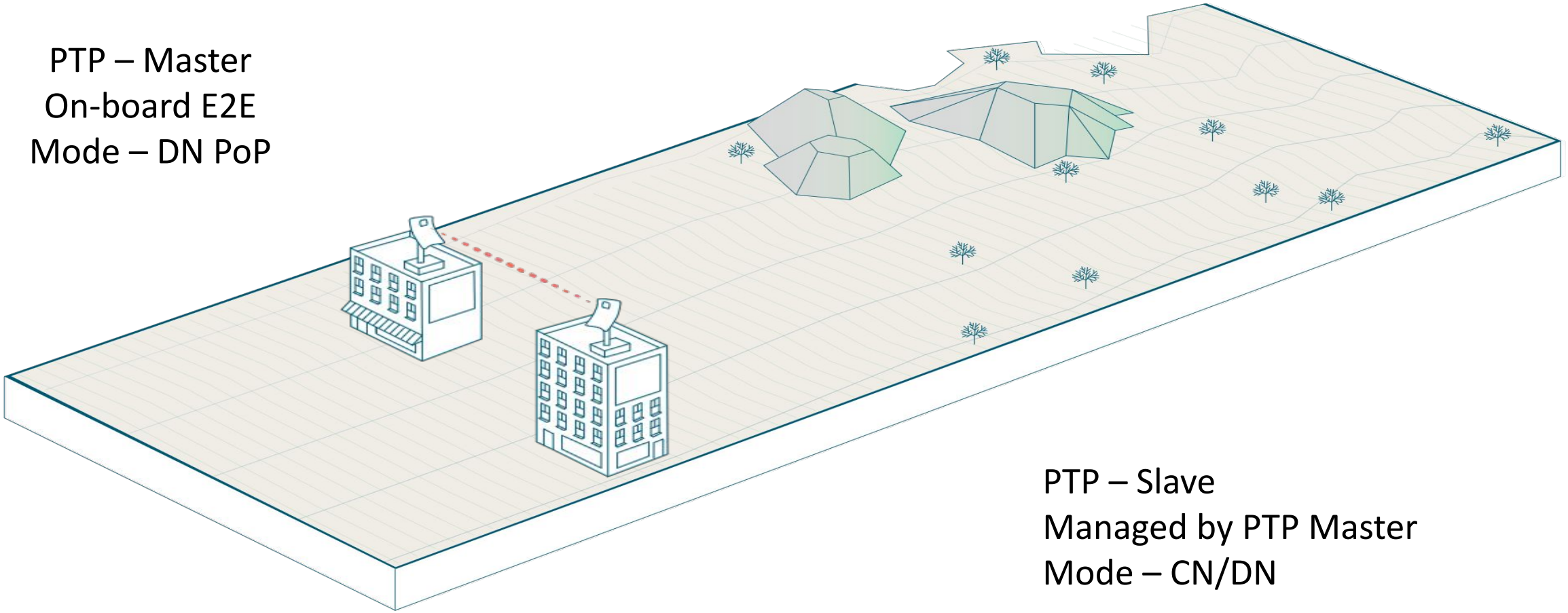
60 GHz cnWave Selection Guide

	V1000	V2000	V3000 – Small Dish	V3000 – Large Dish
Capacity (each direction)	Up to 1Gbps ✓	Up to 1.8 Gbps ✓✓✓	Up to 1.8 Gbps ✓✓✓	Up to 1.8 Gbps ✓✓✓
PTP – Range*	Up to 150 m ✓	Up to 1.0 km ✓✓	Up to 1.5 km ✓✓	Up to 2.3 km ✓✓✓
PMP – Range*	Up to 150 m ✓	Up to 470 m ✓✓	Up to 670 m ✓✓	Up to 720 m ✓✓✓
Form Factor	Small ✓✓✓	Integrated Radome ✓✓	Dish ✓	Dish ✓
Ease of PTP Alignment	Simple ✓✓✓	Simple ✓✓✓	Use the alignment tube ✓	Use the alignment tube ✓
Built-in I/O	Single 1000BaseT ✓	2.5 GbE PoE Out 2.5 GbE Poe Out ✓✓✓	1000BaseT PoE In 1000BaseT PoE Out SFP+ ✓✓✓	1000BaseT PoE In 1000BaseT PoE Out SFP+ ✓✓✓
List Price	✓✓✓	✓✓	✓	✓

* Recommended ranges are rules of thumb. (MCS9 99.9% at 32 mm/hour rain) LINKPlanner should be used to determine range, capacity and fade margin for your specific geographic location and connectivity requirements

Point to Point (PTP)

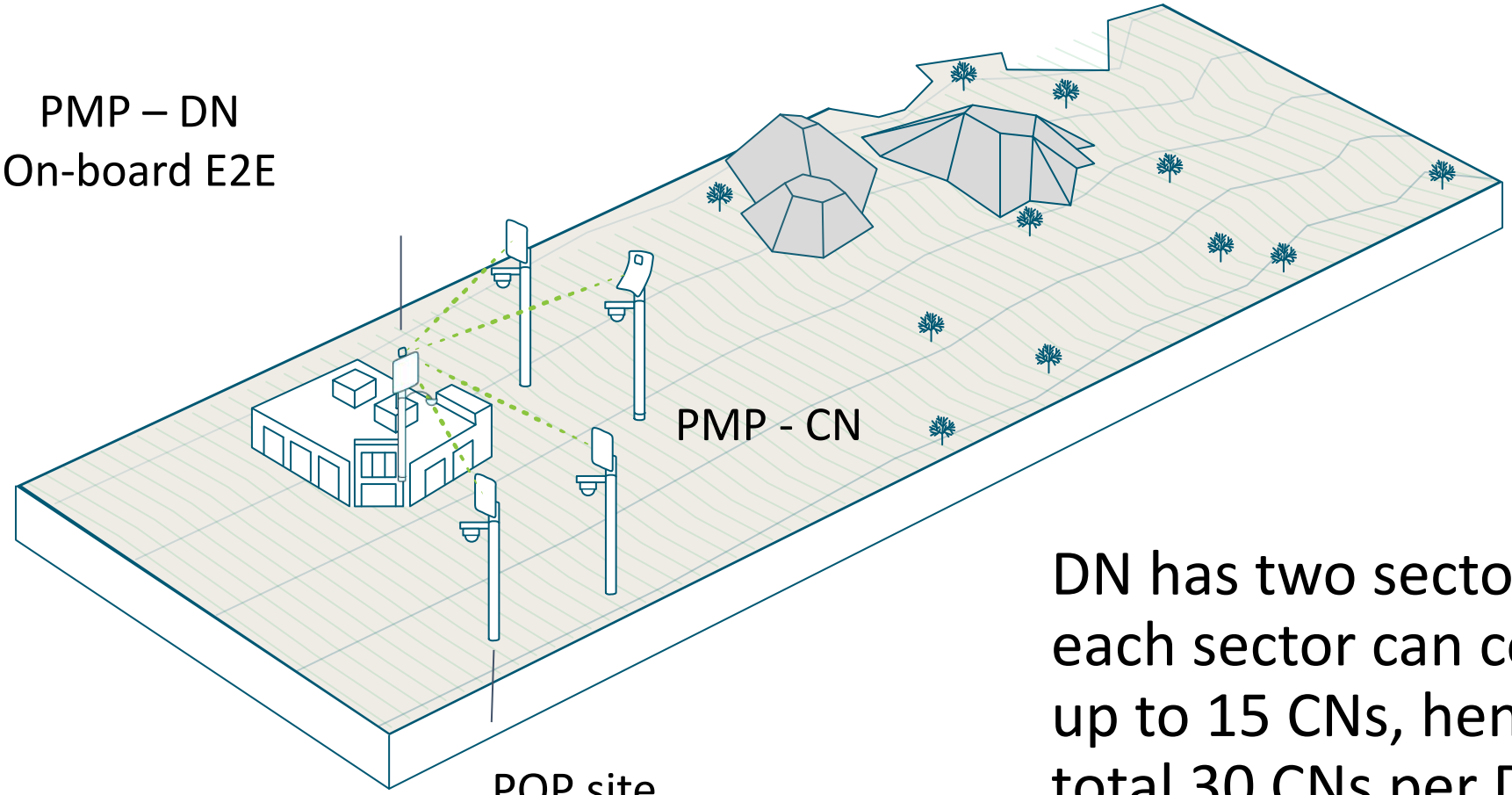
PTP – Master
On-board E2E
Mode – DN PoP



PTP – Slave
Managed by PTP Master
Mode – CN/DN

Point to MultiPoint (PMP)

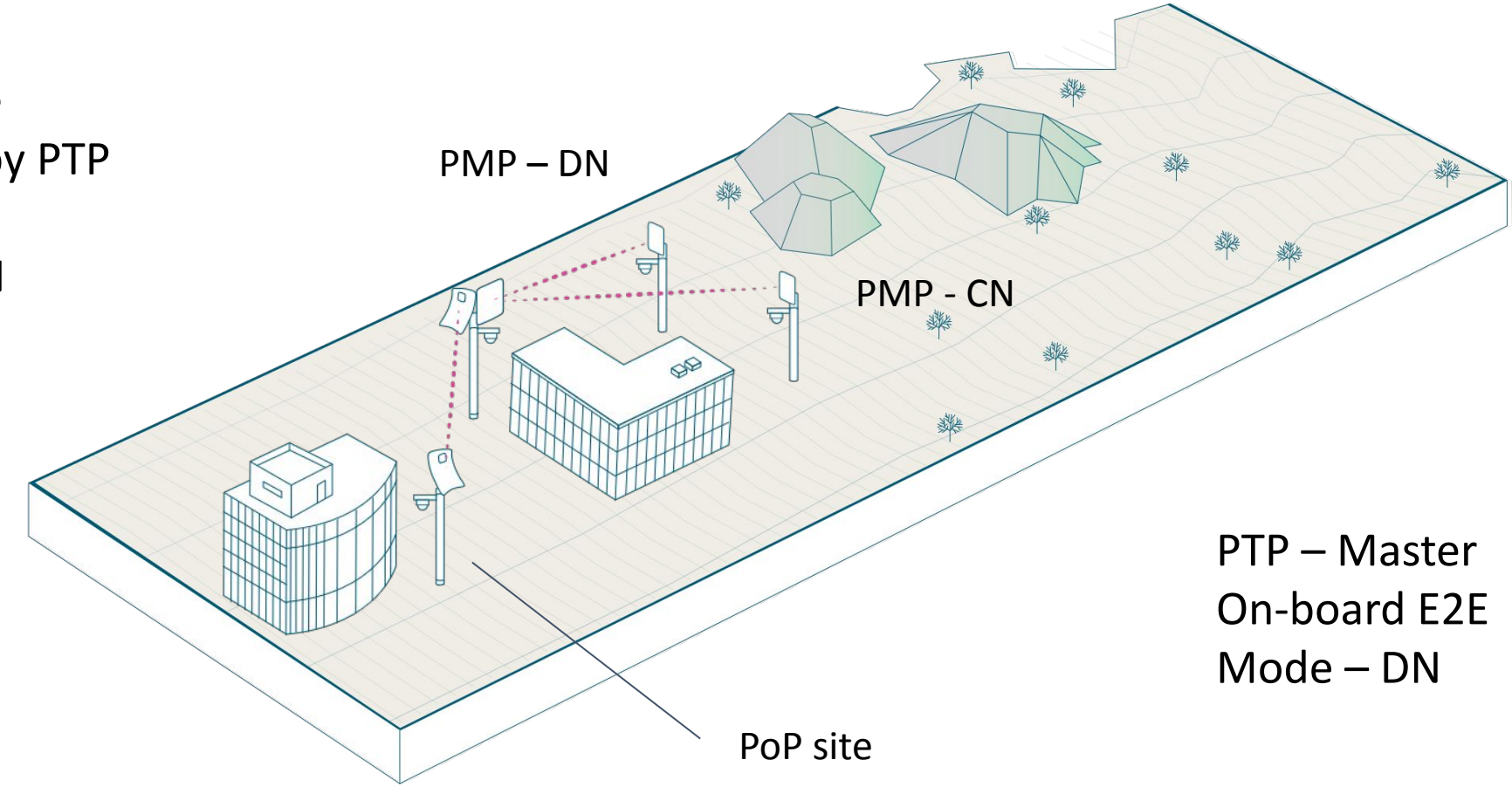
PMP – DN
On-board E2E



DN has two sectors, each sector can connect up to 15 CNs, hence total 30 CNs per DN

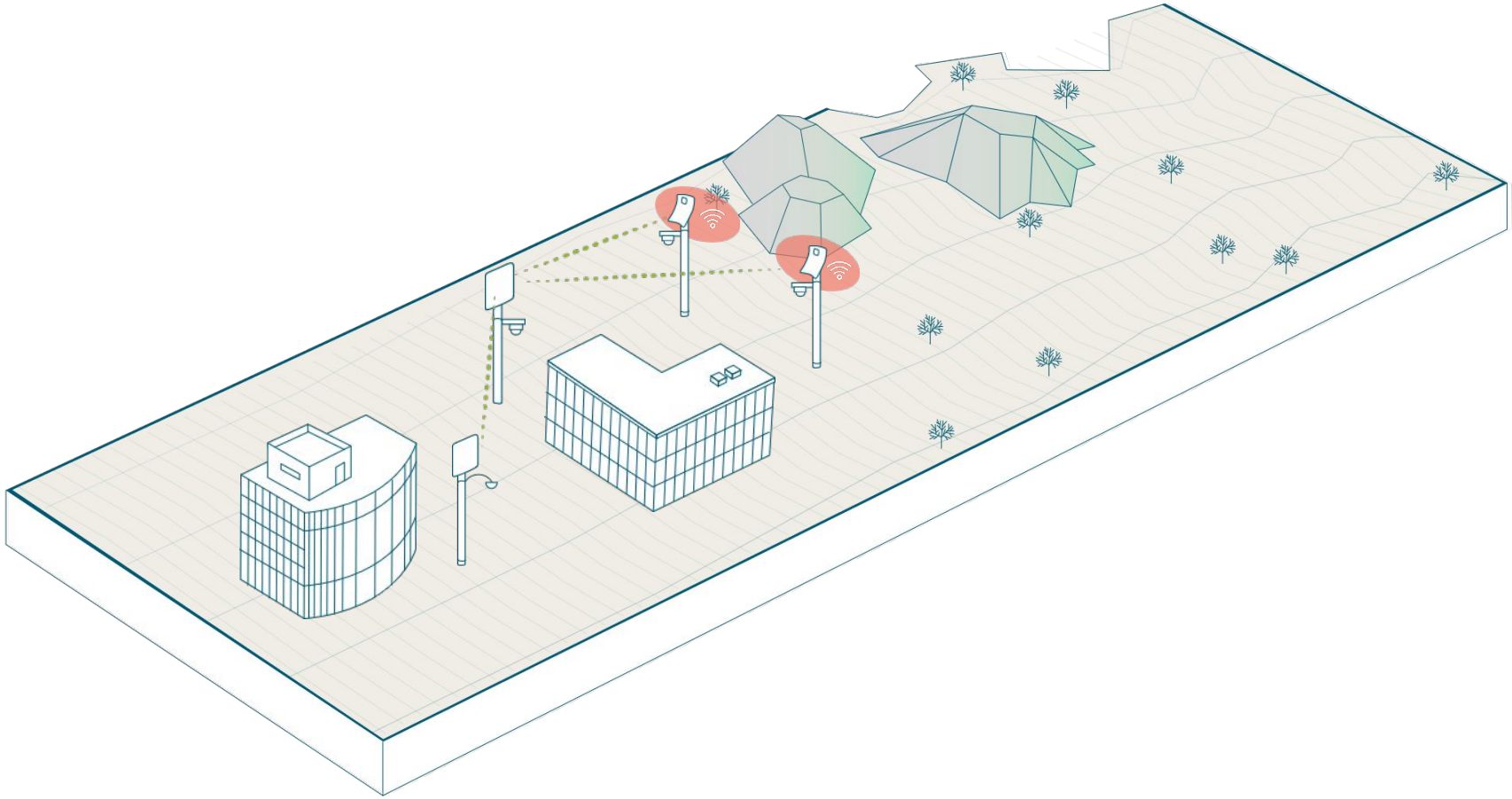
Extended PMP with PTP

PTP – Slave
Managed by PTP
Master
Mode – DN

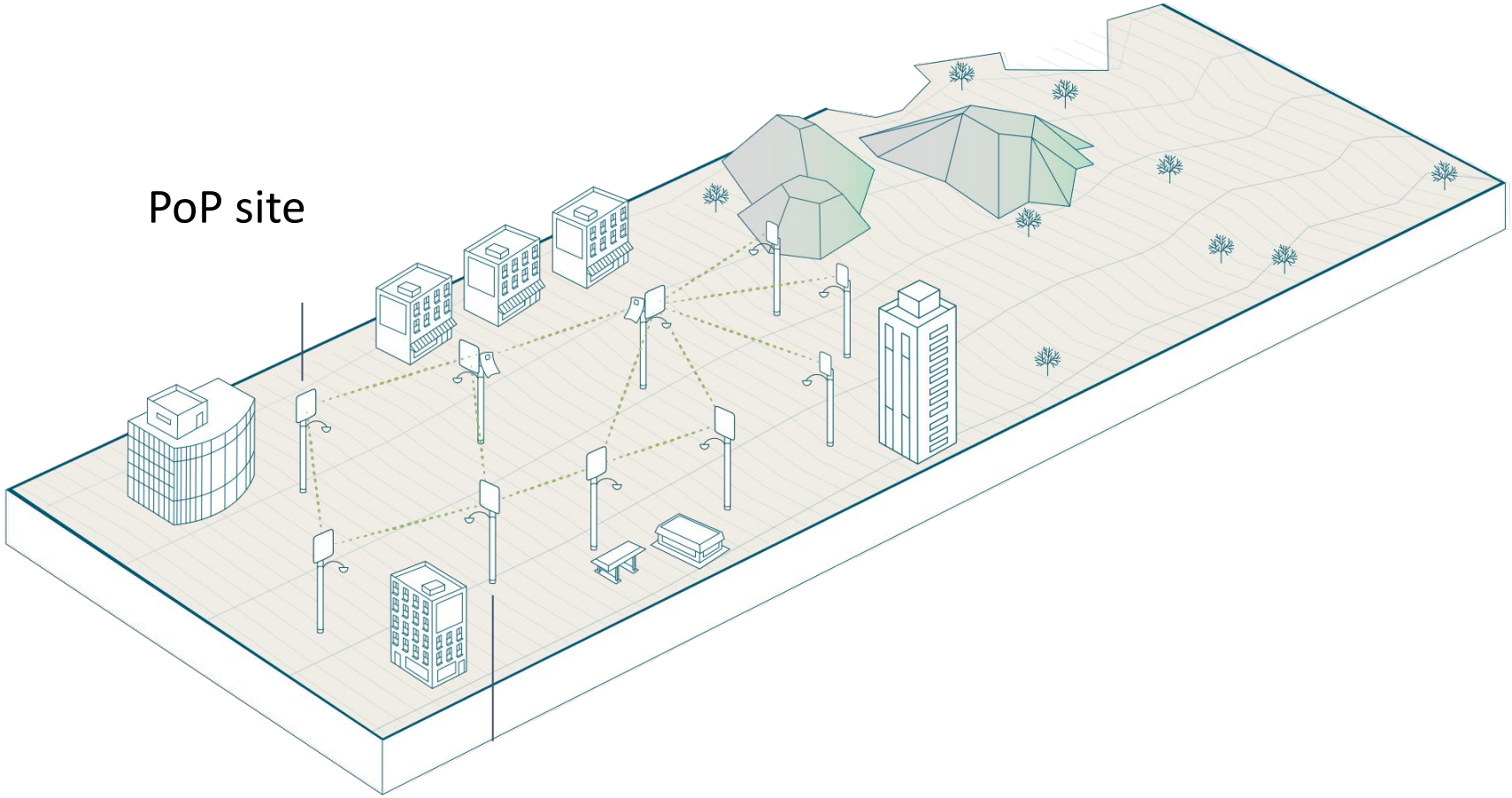


PTP – Master
On-board E2E
Mode – DN

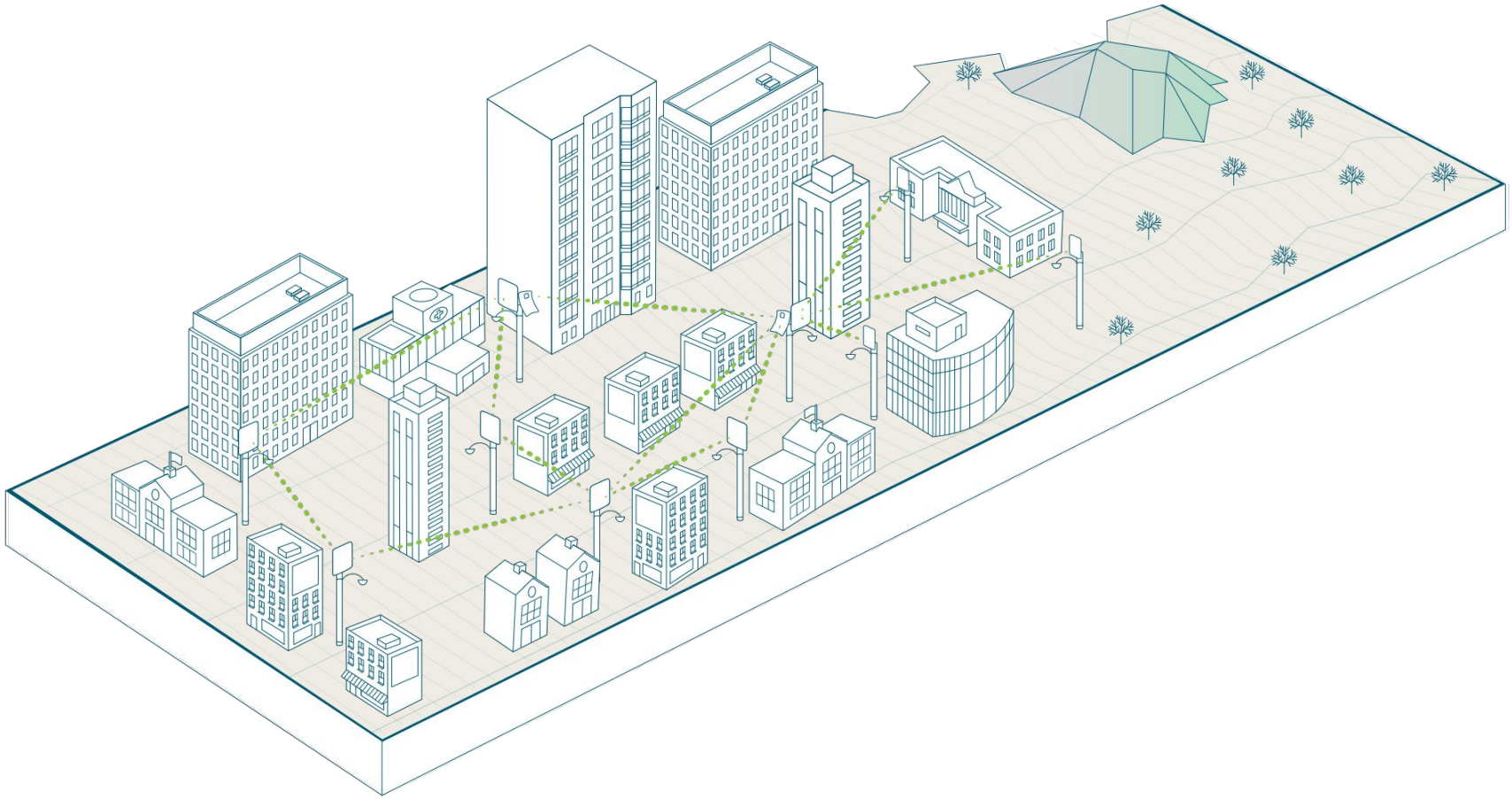
Small Cell Backhaul



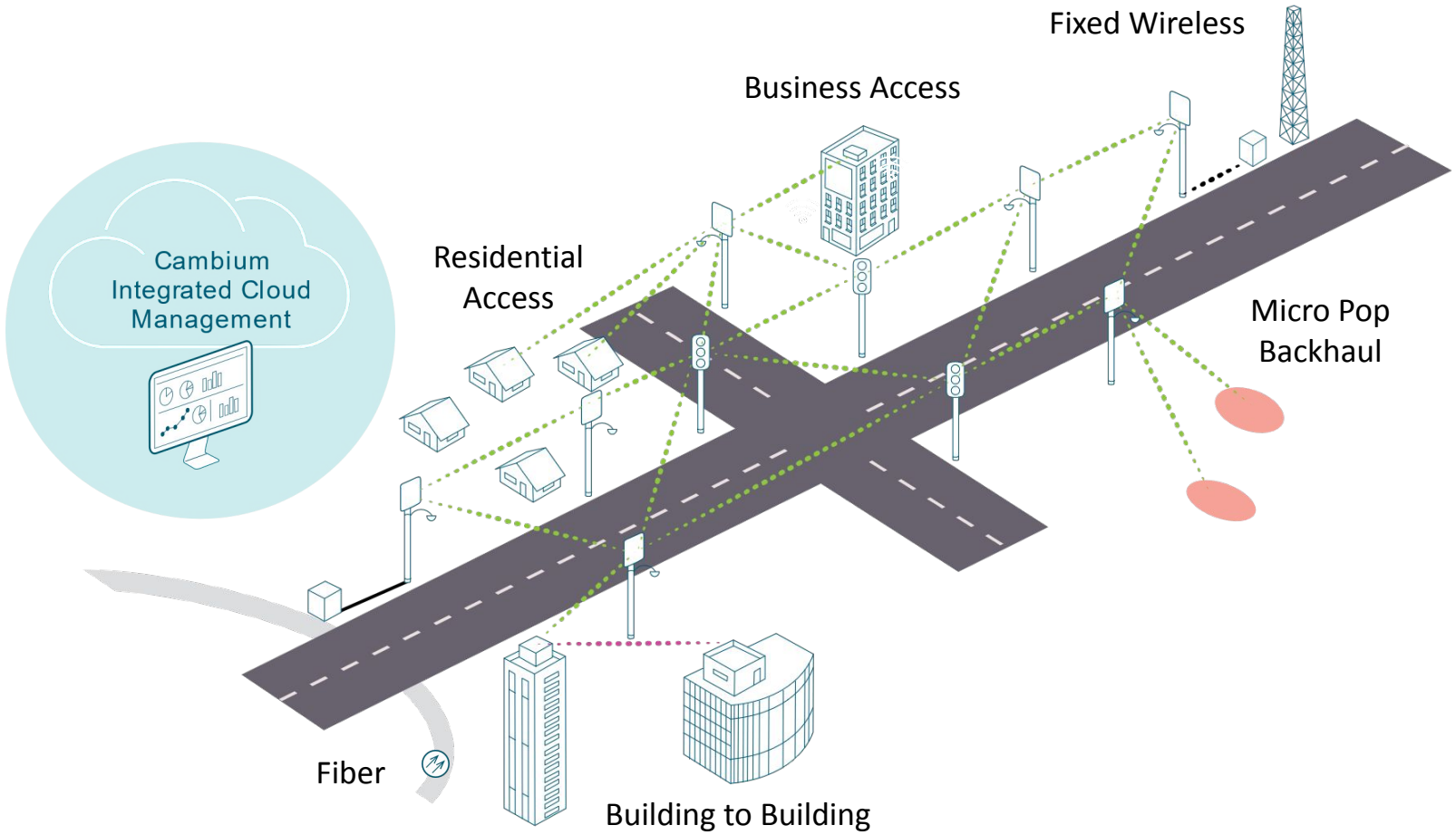
Mesh



Urban Mesh



60 GHz Deployment Architecture



- **Wireless To The Home (WTTH)**
  - Providing Wireless Broadband access directly to the home.
- **Wireless To The Building (WTTB)**
  - Wireless Broadband access is provided to rooftops or sides of buildings, which then get distributed to individual offices and homes via wire.
- **RTTRT – Roof-Top To Roof-Top**
  - Long range Point to Point with high gain dish
  - Multi Dwelling Distribution
- **Fiber Extension**
- **Backhaul**
  - For 5G Small Cell, outdoor Wi-Fi, MicroPoP and CCTV

Service Provider: City center deployment network

Roof Top to Roof Top

PMP with Mesh

Wi-Fi

WISP Suburban Deployment

DN-DN

DN-CN

Wi-Fi

Enterprise Deployment

Roof Top to Roof Top

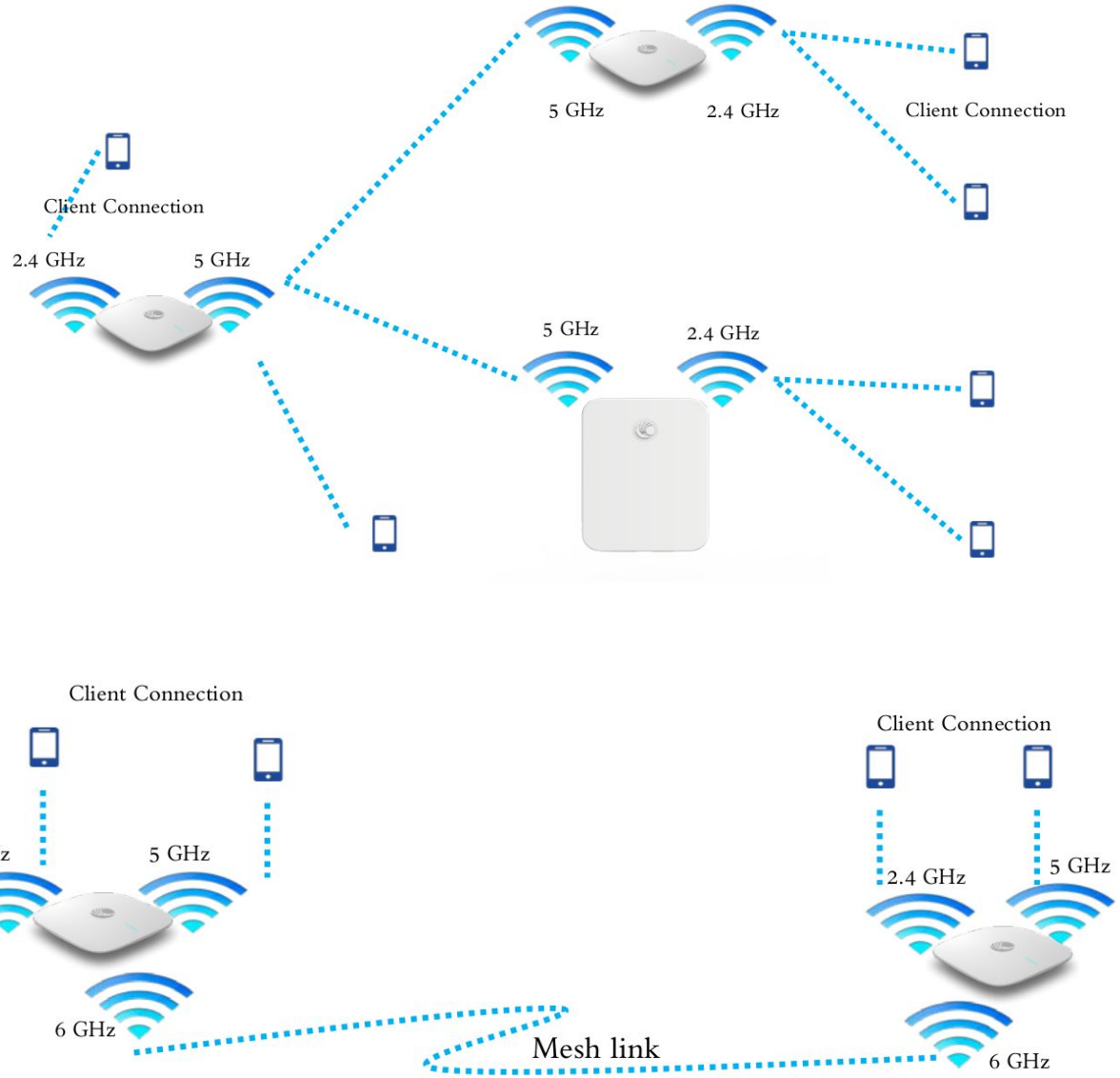
Multi-point with Mesh

Wi-Fi

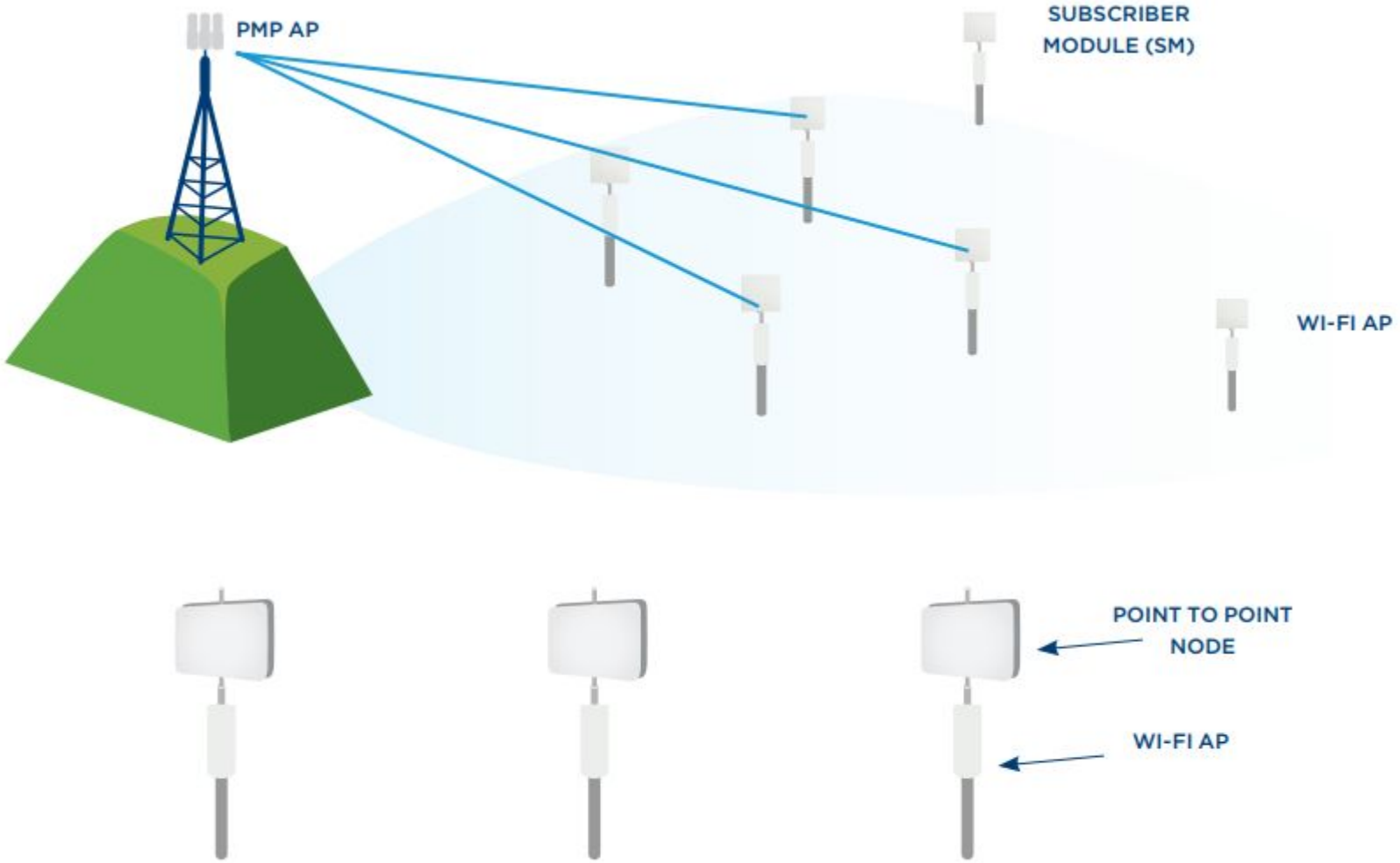
CnWave 60Ghz
Link Planner Demo

Traditional WIFI Outdoor Public WIFI Design Review

MESH


5 GHz
2.4 GHz
Client Connection
Client Connection
2.4 GHz
5 GHz
5 GHz
2.4 GHz
Client Connection
2.4 GHz
5 GHz
6 GHz
Mesh link
Client Connection
2.4 GHz
5 GHz
6 GHz

5Ghz PMP/PTP Backhaul



Design Outdoor Public WIFI using CnWave 60Ghz

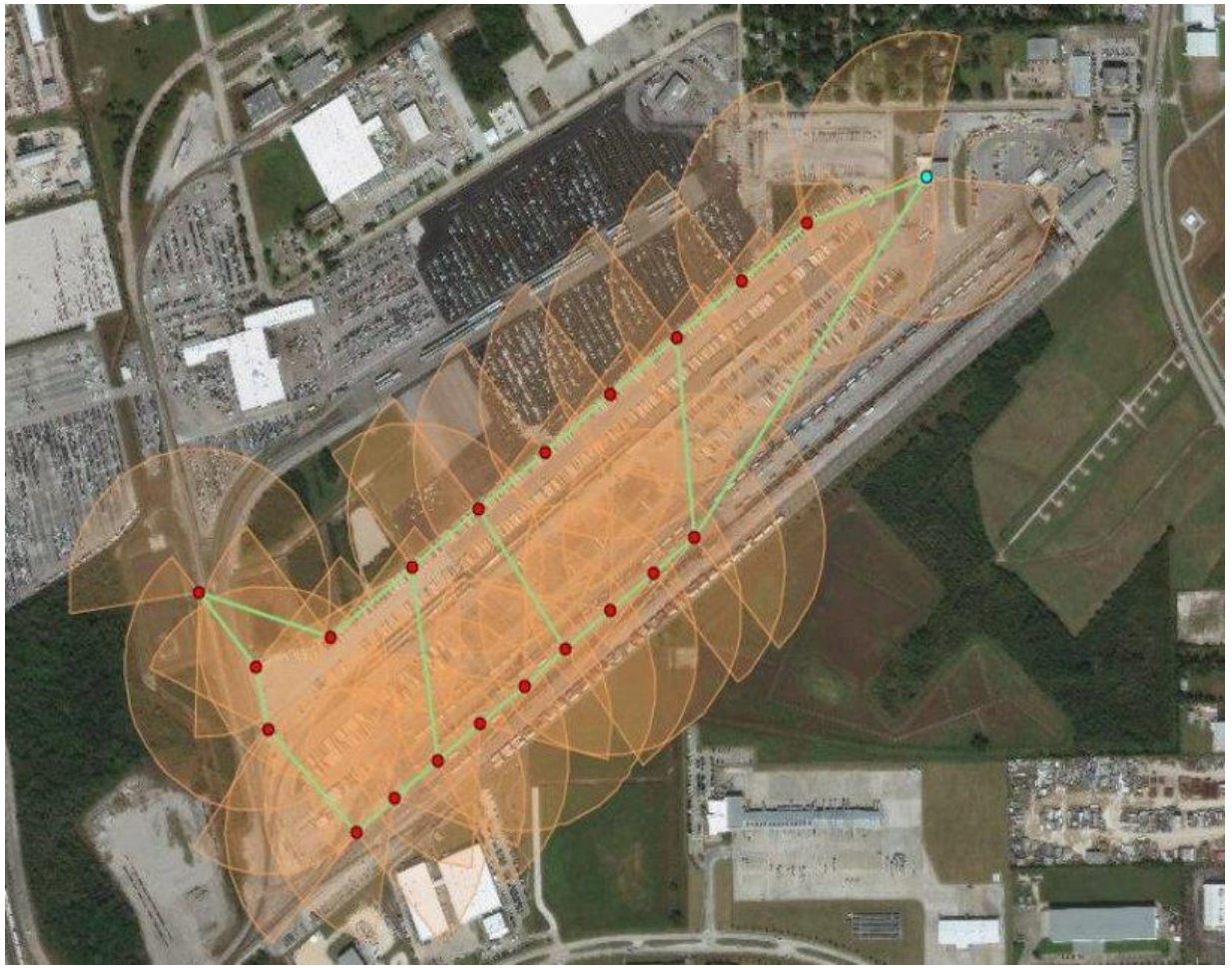
Design Outdoor Public WIFI using CnWave 60Ghz

REQUIREMENTS

- Provide backhaul for Wi-Fi coverage and video surveillance network.
- Off load large telemetry and video data payloads (Gigabyte/Terabyte) from the train.

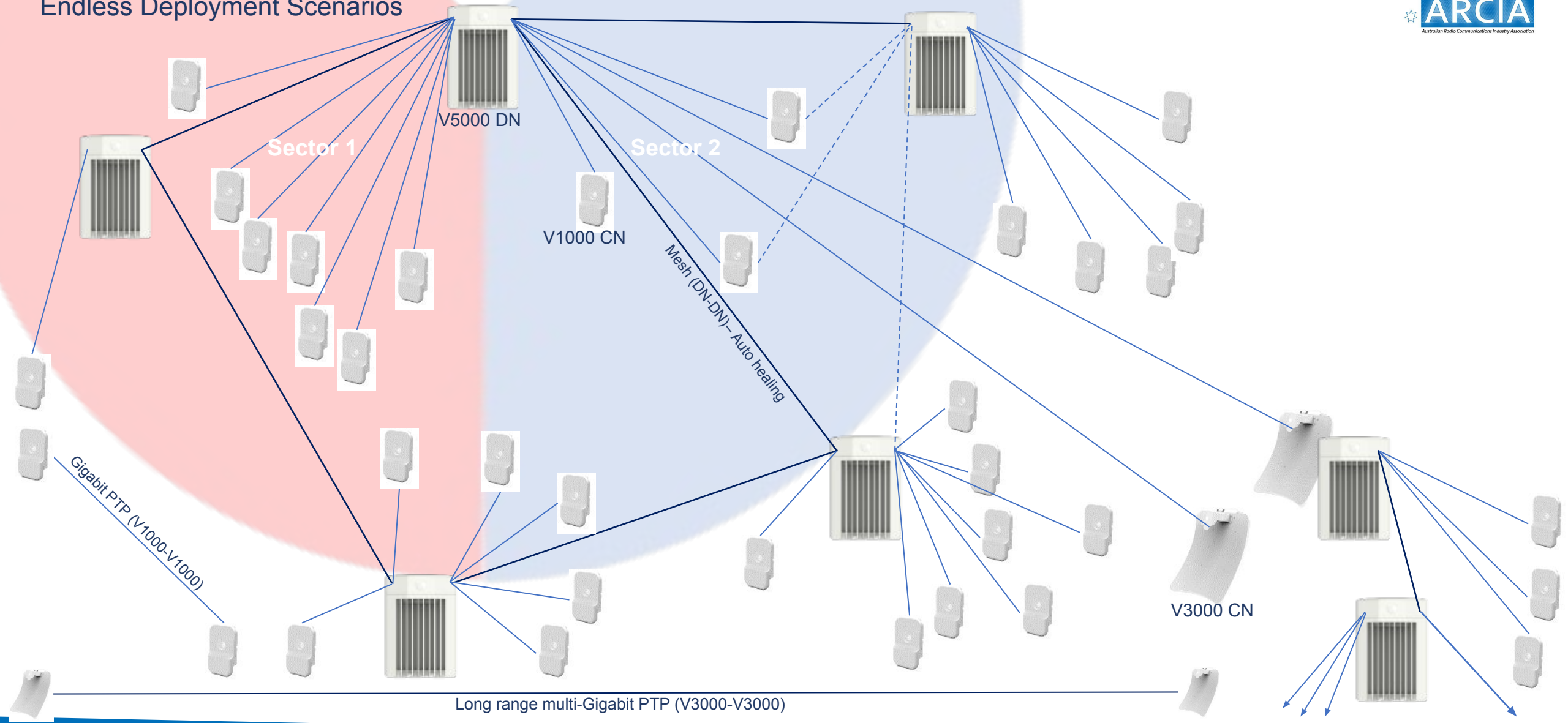
SOLUTION

- Deploy 60 GHz cnWave V5000, V3000, and V1000 with Point-to-Point, Point-to-Multipoint, and Mesh configurations.



Deployment Example – Building a mesh network

Endless Deployment Scenarios



Questions