

PERASO

Peraso 60GHz for FWA

WISP America March 5, 2024

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Hot off the Press

BITAG

Broadband Internet Technical Advisory Group

Overview of Broadband Technologies

A BROADBAND INTERNET TECHNICAL ADVISORY GROUP
TECHNICAL WORKING GROUP REPORT

Issued:
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We aim to provide a broad overview of current and emergent broadband access technologies. The report does not recommend a particular technology but instead explains the capability and applicability of each technology. This report also shows that there is no one 'best' technology; consumers, businesses, and communities have a wide variety of budgets, requirements, interests, and other needs. This report should appeal to a diverse audience, ranging from policymakers, regulators, and lawmakers to academic researchers, network engineers, historians, and many others.

Broadband Technology Overview

HFC

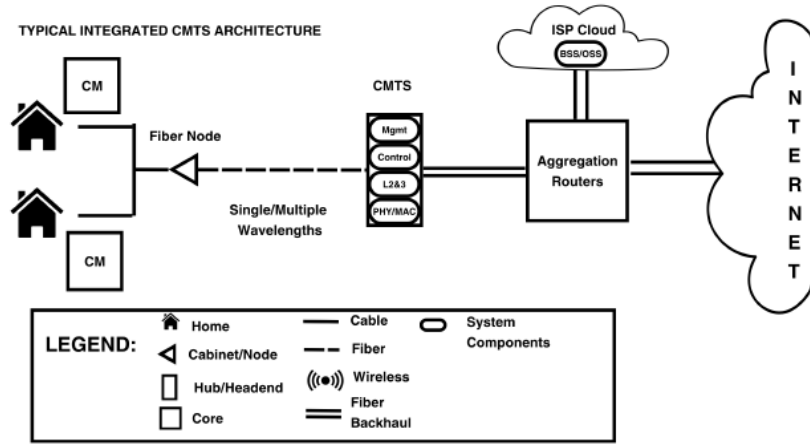


Figure 1: Centralized HFC Network Architecture

DSL

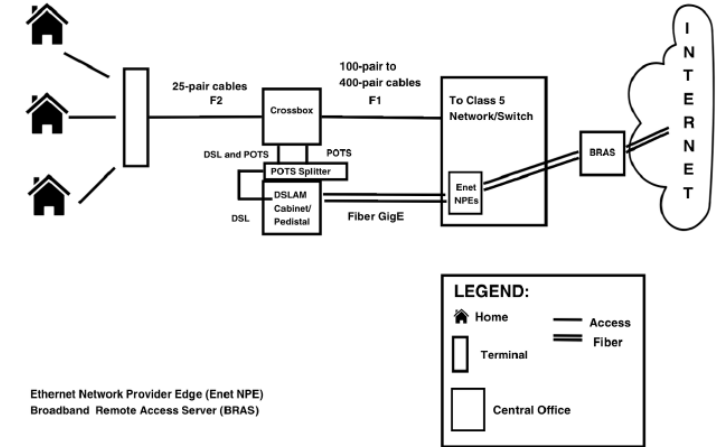


Figure 3: DSL Network Architecture

FTTH

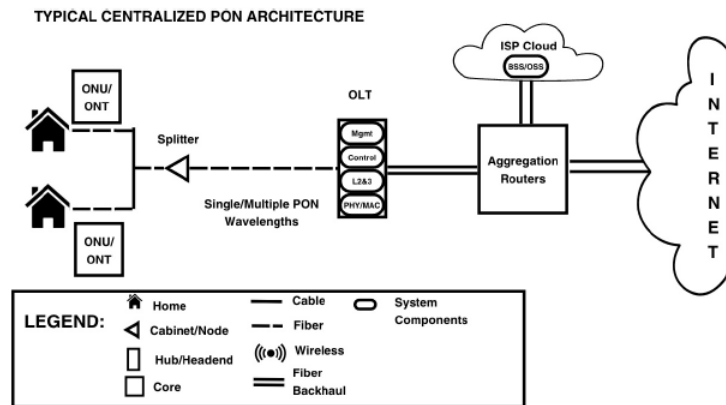
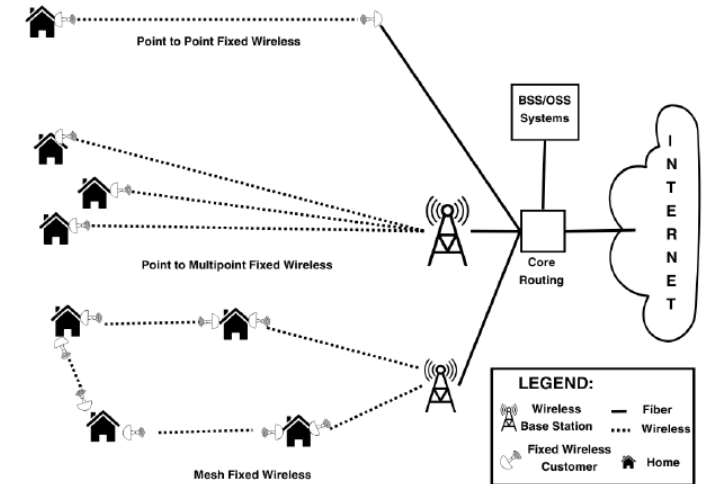


Figure 4: Centralized PON Architecture

FWA



BITAG Unlicensed FWA Summary

- 2.4 – 5/6 GHz
 - 801.11 to 802.11ax
 - Tarana ng-FWA
- What's Missing ??

What don't they want you to know ??

Table 4: Unlicensed FWA Specifications

Platform Type	Description	Standards	Max Speed Down	Max Speed Up	First Issue Date
802.11 DSSS	2.4 GHz 802.11 based Outdoor FWA using Direct Sequence	IEEE 802.11	1 Mbps	1 Mbps	1998
802.11 FHSS	2.4 GHz 802.11 based Outdoor FWA using Frequency Hopping	IEEE 802.11	2 Mbps	2 Mbps	1998
802.11b DSSS	2.4 GHz 802.11b based Outdoor FWA using Direct Sequence	IEEE 802.11b	11 Mbps	11 Mbps	1999
802.11a OFDM	5.8 GHz 802.11a based Outdoor FWA using OFDM	IEEE 802.11a	54 Mbps	54 Mbps	1999
Motorola Canopy	Proprietary Motorola FWA system using FM modulation	None	10 Mbps	10 Mbps	2001
802.11n MIMO-OFDM	2.4 GHz and 5 GHz 802.11n based Outdoor FWA using MIMO-OFDM	IEEE 802.11n	600 Mbps	600 Mbps	2008
802.11ac MUMIMO-OFDM	2.4 GHz and 5 GHz 802.11ac based Outdoor FWA using MUMIMO-OFDM	IEEE 802.11ac	1.6 Gbps	1.6 Gbps	2013
802.11ax MUMIMO-OFDMA	2.4 GHz and 5 GHz 802.11ax based Outdoor FWA using MUMIMO-OFDMA	IEEE 802.11ax	2.3 Gbps	2.3 Gbps	2021
Tarana ng-FWA	Proprietary Tarana FWA system with noise cancelling systems	None	2.4 Gbps	2.4 Gbps	2021

WISP Talk Knows

Gino Villarini
Top Contributor · 5h · 🌐

WISP, offering or planning Gigabit service, what would be your platform of choice?

7 likes · 28 comments

Like Comment Send

All comments ▾

Elijah Michael Top Contributor
Ubiquiti Wave
5h Like Reply 2 likes

Angel Doel Muñiz Top Contributor
Ubiquiti wave
5h Like Reply 1 like

Lynn Earl Top Contributor
Depending on the area and density, Wave or Tachyon
5h Like Reply 1 like

#1 answer to Gino's question

Wave or Tachyon
(i.e. Peraso 60 GHz)

... And why wouldn't you be planning to roll out Gigabit service ?

60 GHz – The Gigabit Performer

- 14 GHz uncongested spectrum
- Higher capacity per sector
- Lower complexity and cost
- Low cost for AP(DN) and CPE !

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Platform Type	Description	Standards	Max Speed Down	Max Speed Up	First Issue Date
802.11ac MUMIMO-OFDM	2.4 GHz and 5 GHz 802.11ac based Outdoor FWA using MUMIMO-OFDM	IEEE 802.11ac	1.6 Gbps	1.6 Gbps	2013
802.11ax MUMIMO-OFDMA	2.4 GHz and 5 GHz 802.11ax based Outdoor FWA using MUMIMO-OFDMA	IEEE 802.11ax	2.3 Gbps	2.3 Gbps	2021
Tarana ng-FWA	Proprietary Tarana FWA system with noise cancelling systems	None	2.4 Gbps	2.4 Gbps	2021
<i>802.11ad SC – 16Q</i>	<i>60GHz FWA</i>	<i>802.11ad</i>	<i>3.5 Gbps</i>	<i>3.5 Gbps</i>	<i>2012</i>
<i>802.11ay SC – CB – 64Q</i>	<i>60GHz FWA with channel bonding</i>	<i>802.11ay</i>	<i>10 Gbps</i>	<i>10Gbps</i>	<i>2021</i>

6 GHz - A Savior for Wi-Fi ?

- 1200 MHz new Bandwidth
 - 14000 MHz 60 GHz
- AFC Required
 - FCC Approved (conditionally)
 - “The FCC also noted that the seven approved AFC applicants had expressed a commitment to establish a centralized way to receive and address harmful interference complaints resulting from AFC-authorized operations, and the agency conditioned their continued AFC operations on such a process being implemented by April 23, 2024.”
 - Is 6 GHz a Long Term Solution ?
 - How beneficial as Wi-Fi 7 home equipment becomes common?
- Cost model remains the same
 - High cost of Distribution Nodes



Fixed Wireless Access

The Better Path to Gigabit

- Why License-free FWA Makes Sense
 - 10x better geographic coverage for cost
 - 12,000 homes covered vs 120
 - 30x faster install
 - 3-4 days to schedule install vs 3-5 months
 - Accessible to any operator
 - Accelerates positive economic return
 - Scalable for any size community
 - Meets topographical challenges
 - True Broadband capability

- Why 60 GHz Makes Sense
 - 14 GHz spectrum
 - Easily meets Broadband and Gigabit capability
 - No Wi-Fi interference
 - Affordable, low SWAP hardware
 - Flexible system features
 - Reliable



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Fiber: **Good** **Cheap** **Fast**

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Fiber: **Good** **Cheap** **Fast**

FWA: **Good** **Cheap** **Fast**

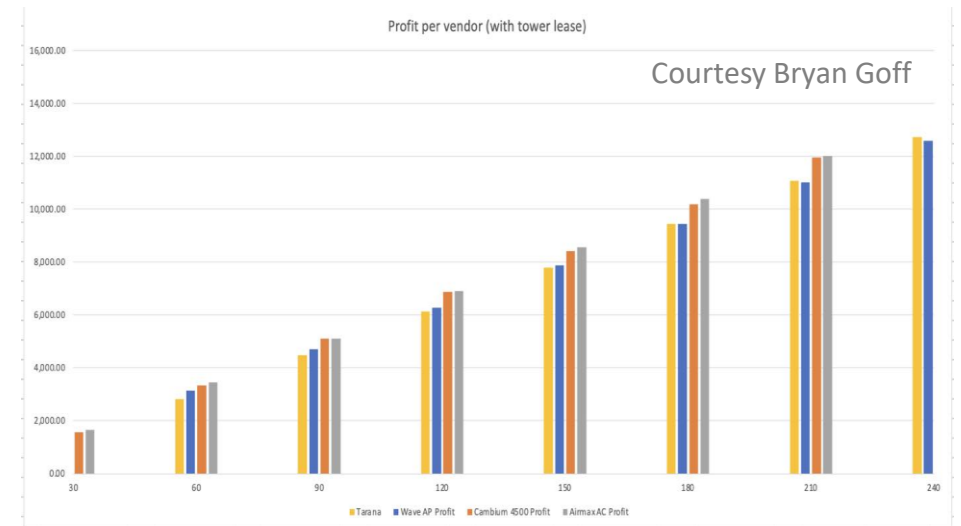
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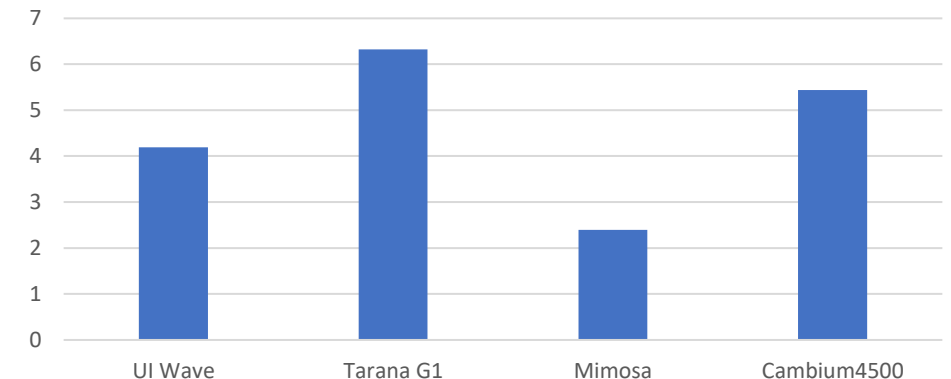
ROI (Not the Last Word)

- Each scenario deserves its own analysis
 - Dense Urban
 - Suburban
 - Rural
- Direct Costs
 - AP (DN) cost
 - Subscriber station cost
 - Subscribers per AP
 - Tower lease
 - Power consumption
 - Installation labor (AP and Sub)
- Weighting factors
 - Right sizing
 - Initial costs
 - Subscriber growth forecast
 - Wi-Fi interference
 - Competitive performance
 - Real World experience – What works !

Profitability at Maximum Capacity
Tarana vs. UI Wave vs Cambium 4500 vs UI Airmax AC



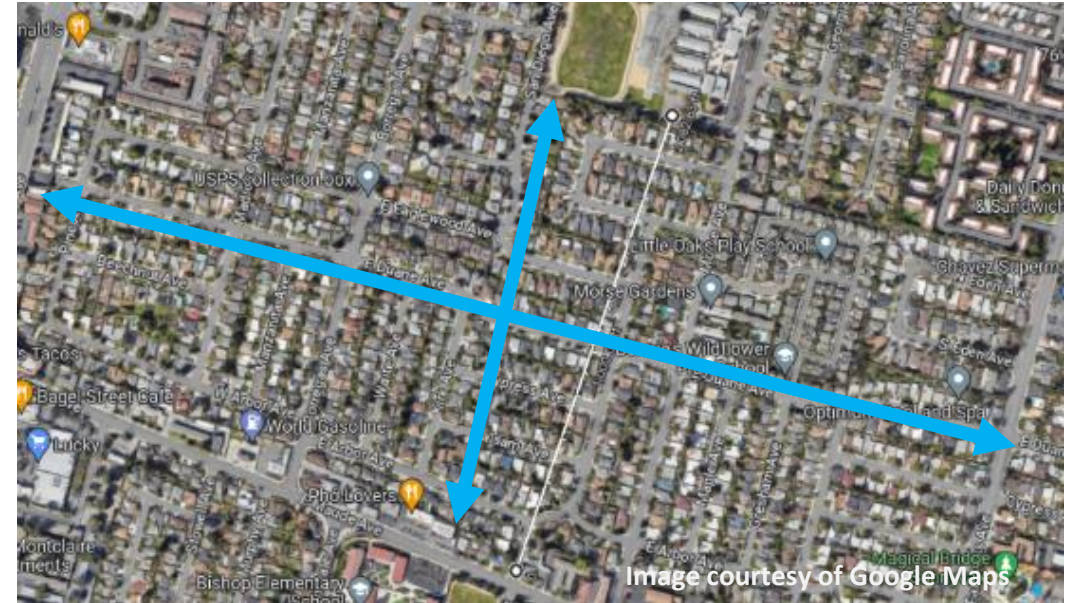
Payback Period [months]
100 Installs



Case Study – Suburban Neighborhood

- Sunnyvale, CA
 - 4100 x 2000 feet (1240 x 610 m)
 - ~900 homes on 188 acres (5/acre)
 - Assume 25 % penetration 225 homes

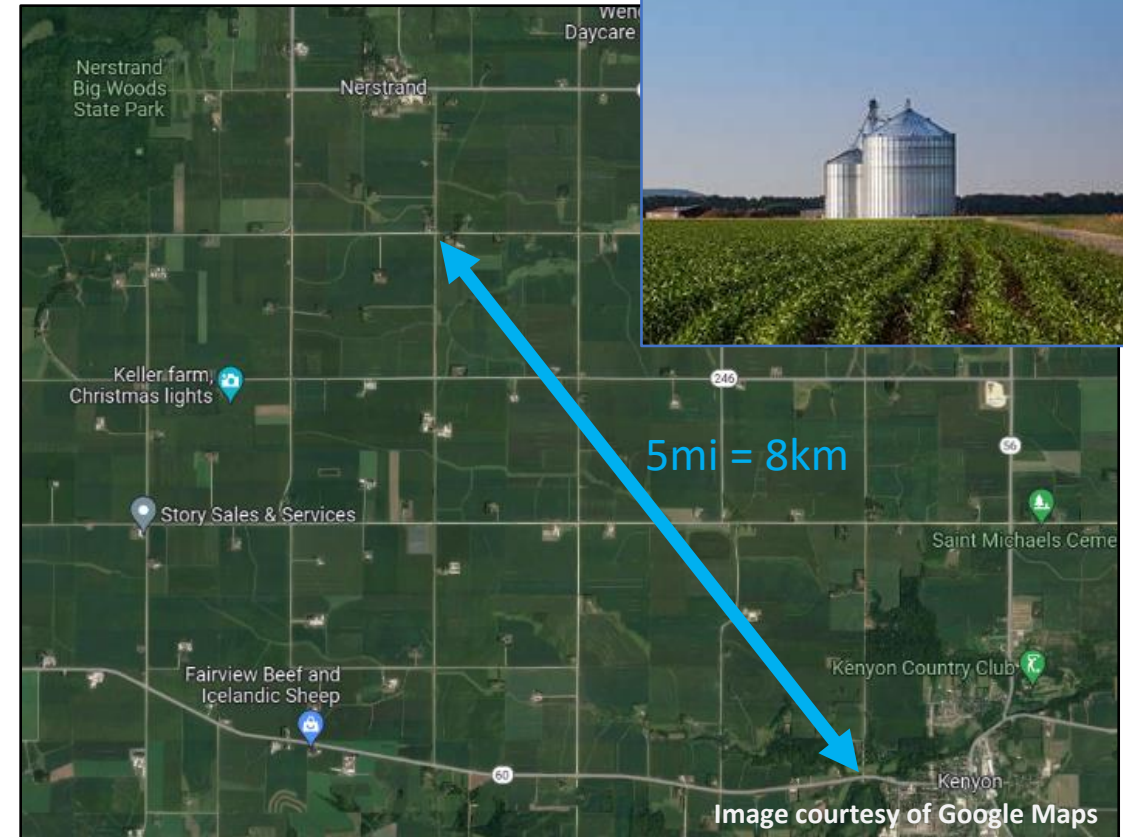
Parameter	60 GHz	WiFi 6/7		Tarana G1	
Homes	225				
#AP	12	2	4	1	2
Total User BW [Gbps]	36	14	28	2.4	4.8
BW/Sub* [Mbps]	160	62	64	11	22
AP/DN Cost	\$6,000	\$4,000	\$8,000	\$12k	\$24k



- mmWave similar cost basis to Wi-Fi
- Much lower investment than G1 solution
- No interference at mmWave
- Option to scale as you grow

Case Study – Rural

- Midwest Farmland
 - 1 home per sq. mile
- 60 GHz Access
 - 3 AP + 16 CPE: < \$500 per home
 - Extremely cost effective
 - Utilize available grain towers for radios
 - Rapid deployment
 - Can co-locate backhaul and access
- Competition
 - Starlink
 - \$\$
 - 4G LTE / 5G
 - Spotty coverage
 - Wi-Fi FWA
 - Higher AP/DN cost
 - lower throughput, higher latency



High Density Challenge – Mobile Home and RV Parks

- Challenge
 - Provide internet service to high-density scenario
 - Sub-6 Wi-Fi heavily utilized already
 - No significant isolation from buildings
- 60 GHz benefits
 - No spectrum competition with Wi-Fi
 - Beamforming separation avoids 60 GHz overcrowding
 - Antenna beam patterns from 6 ° to 25° available
- Low cost at AP and CPE
 - Relatively short ranges allow lowest cost hardware
 - Quick install
 - Scalable - Easy to add AP if network grows
 - Use 60 GHz for backhaul if needed
 - RV-Parks enable transient users with rental CPE
- Alternative Power Friendly
 - Solar and battery back up feasible for hours of operation



From the Field

“With 60GHz we can offer symmetric, gigabit speeds which beats the competition. Installation has been straight forward, and performance is solid.”
–Brandon Hardy, Cobalt Ridge

"Peraso's mmWave technology has been a game changer for GigFire. Gig symmetrical point to multipoint FWA, using low cost AP's and CPE's resets the narrative on what is possible with FWA."
– Corey Hauer, GigFire



Reality Check

- Can I meet customer performance expectations?
- What will be subscriber base growth rate?
 - Under-utilized AP ties up capital and slows expansion opportunities
- How long can I afford to cover equipment costs ?
 - High CPE \$ = Long Return on Investment
- Is the risk of Wi-Fi interference worth it ?



Better take a deeper look at mmWave !

License Free Standards and Features

IEEE 802.11ad Wi-Fi/WiGig

- Modulation: TDD; Single carrier MCS0-12 (16QAM)
 - OFDM option (never productized)
 - 64QAM added in update
- Channel Bandwidth: 2GHz (1/2 channel available from some vendors)
- Throughput per channel: 4.6Gbps OTA / 3+ Gbps user available
- CSMA, Wi-Fi like access protocol
- Dynamic beamforming and tracking

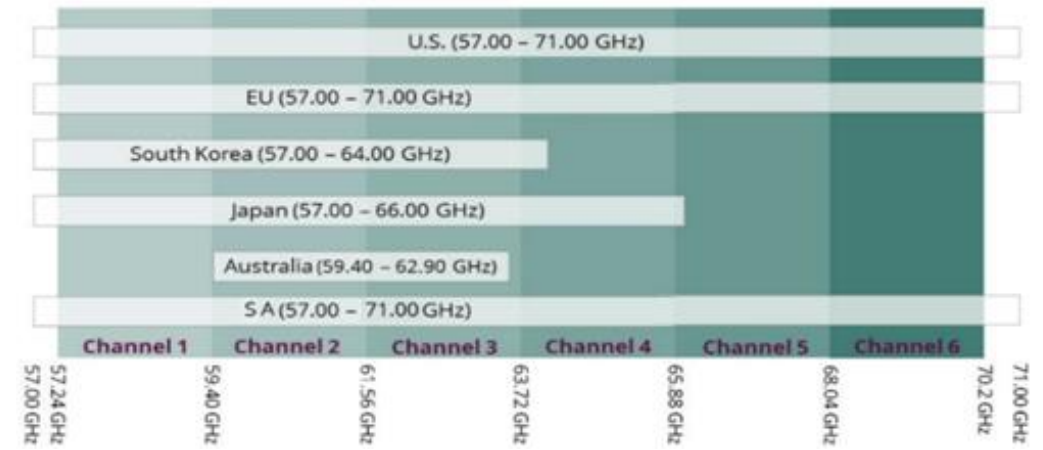
802.11ay

- Channel bonding
- Higher MCS, MCS 12.6 64QAM
- 8Gbps with channel bonding 2x.
- Programmable Golay codes
- TDMA (Terragraph) extensions
- More OFDM and MIMO options (not productized so far)

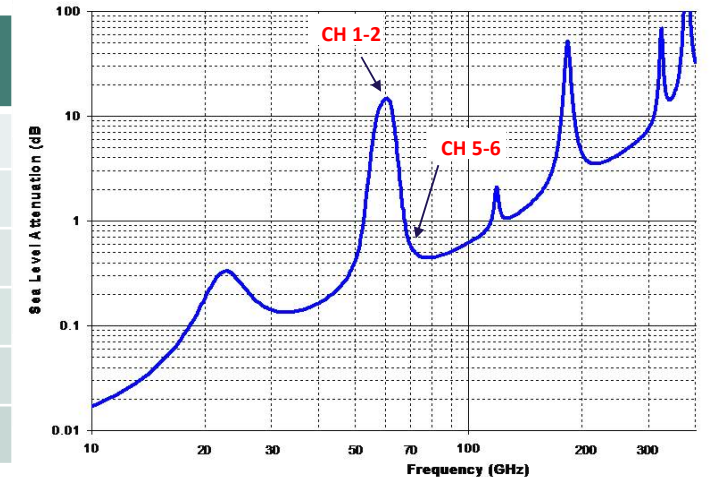
Transmit power (NA and EU)

- Steerable antennas great for Access point and easy-install STA (CPE)
 - 40dBm(43 peak) EIRP for point-to-multipoint
- High gain Dish - extends range and narrows beam
 - 82 dBm max EIRP
 - Back off 2dB/1dB when antenna gain < 51dBi
 - no/little steerability

International “60GHz” License Free Spectrum



Channel	Center (GHz)
1	58.32
2	60.48
3	62.64
4	64.80
5	66.96
6	69.12



Benefits of 60GHz band for FWA

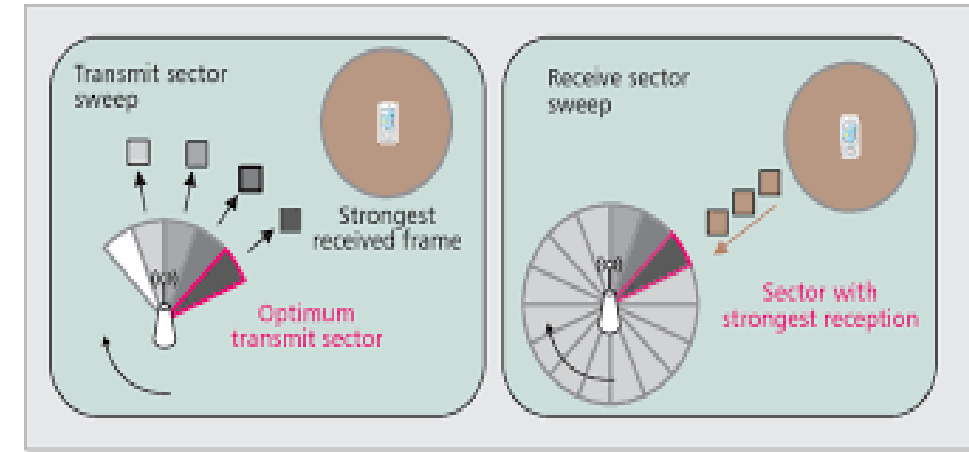
- High Data Rates: Multiple Gbps
- Wide Spectrum Availability: 14GHz of unlicensed spectrum
- Low Interference:
 - Limited propagation range (CH1 and CH2)
 - Narrow, high directional beams
- Low Latency: Short wavelength allows for low-latency communication
- Point-to-Multipoint Connectivity: Lead to cost-effective network deployments
- Low SWAP: smaller, more compact antennas and equipment, making installation less obtrusive
- Fast, easy deployment: FWA systems operating in the 60GHz band are relatively easy and quick to deploy
- Last-Mile Connectivity: bringing cost-effective high-speed internet access to locations that are difficult to reach with traditional wired networks, bridging the digital divide in underserved or remote areas



Beamforming at 60GHz

Beamforming rather than broadcasting:

- Multiple Antennas: Multiple antennas at both Tx and Rx create and focused, directional beam
- PAAs: An array of small antenna elements can be controlled individually to steer the beam in a specific direction
- Adaptive beamforming: Adapts in real-time to changing conditions to maintain a strong and stable connection

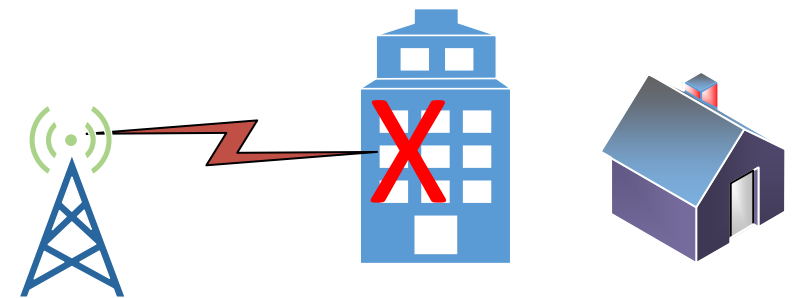
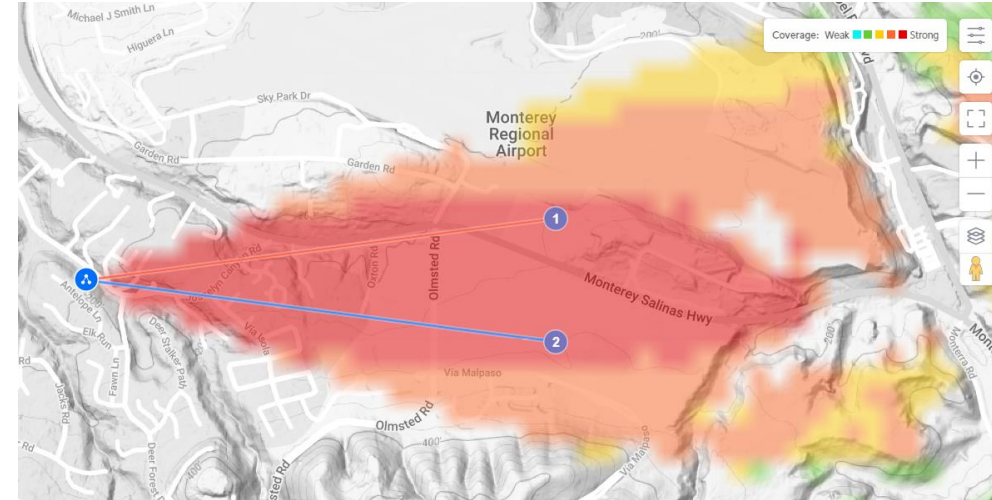


Benefits:

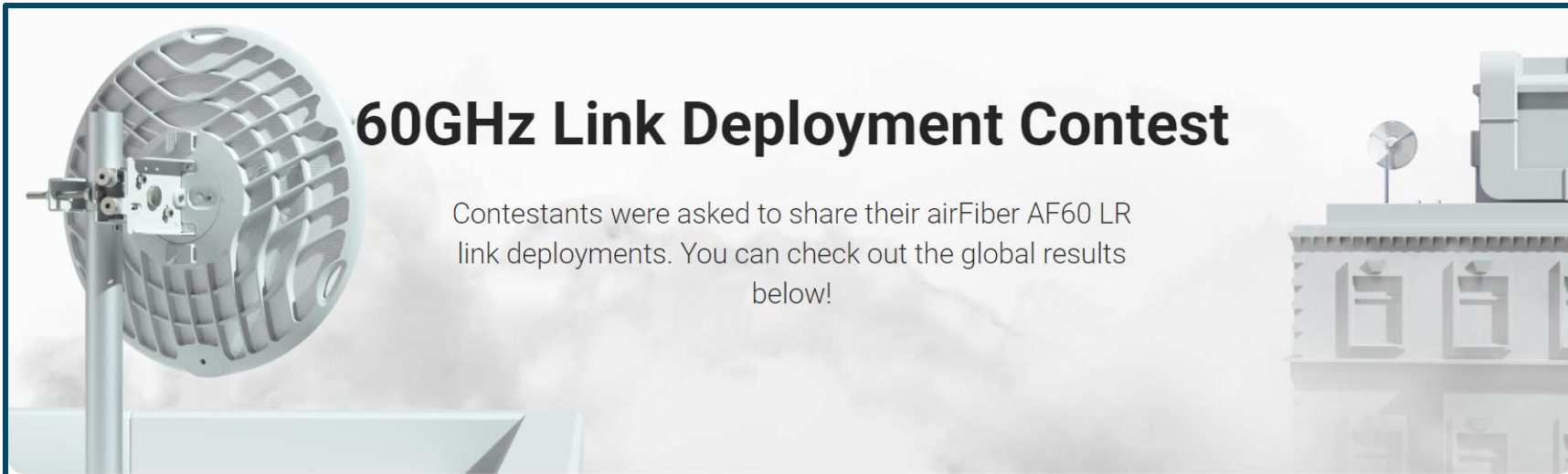
- Enhanced Range: Signal focused into a narrow beam extends the effective range of communication
- Higher Signal Strength: Concentrated signal power results in higher signal strength
- Improved Reliability: Directional nature reduces interference and improves connection reliability
- Higher Data Rates: Allows for more efficient use of available bandwidth.
- Better QoS: Prioritization of signals to specific devices
- PtMP: A single transmitter can communicate with multiple receivers simultaneously via beam steering

mmWave Deployment

- Planning
 - Link budget calculation tool
 - Site planning tools with LIDAR topographic data
- Hardware selection
 - 1 – 32 users / AP
 - Channel Flexibility
 - 6 full channels or 13 “1/2” channels
 - Range and availability
 - Phased Array options
 - Dish/Lens
 - 5GHz backup
- Installation
 - Installation mode on Peraso-based gear aids antenna pointing



Link Performance with Dish



Leaderboard

All Time ▼ All Countries ▼ Search... 🔍

#	LINK DISTANCE	LOCATION	LINK POTENTIAL	SIGNAL STRENGTH	CAPACITY
1	27.13 km	Grantsville, UT, US	98%	-73.0 dBm	900 Mbps
2	24.69 km	Marlena AH, South Africa	100%	-74.0 dBm	134 Mbps
3	24.59 km	Luis Moya, Mexico	93%	-73.0 dBm	600 Mbps
4	23.86 km	Vitkovice, Czechia	88%	-74.0 dBm	673 Mbps
5	22.82 km	Cedar Fort, UT, US	90%	-72.0 dBm	900 Mbps



<= limited by Ethernet port (1 Gbps) with overhead

Point-to-Point Networking

- Range depends on antenna gain
 - EIRP limited to 40 dBm on phased array modules per regulatory limits
 - Channels 4, 5 and 6 have best range
- 5-6 GHz secondary channel
 - Employed for rain-fade backup
 - Capacity increase also feasible
- Max Throughput per channel (2 GHz)
 - 3.5 Gbps max at 16 QAM
 - 2.2 Gbps QPSK
- Adjacent channel link aggregation
 - Adjacent channels possible today with antenna isolation (dish)
 - Synchronization under-development to allow in-unit parallel operation



PRM2143
module

Approx.
1.5 km

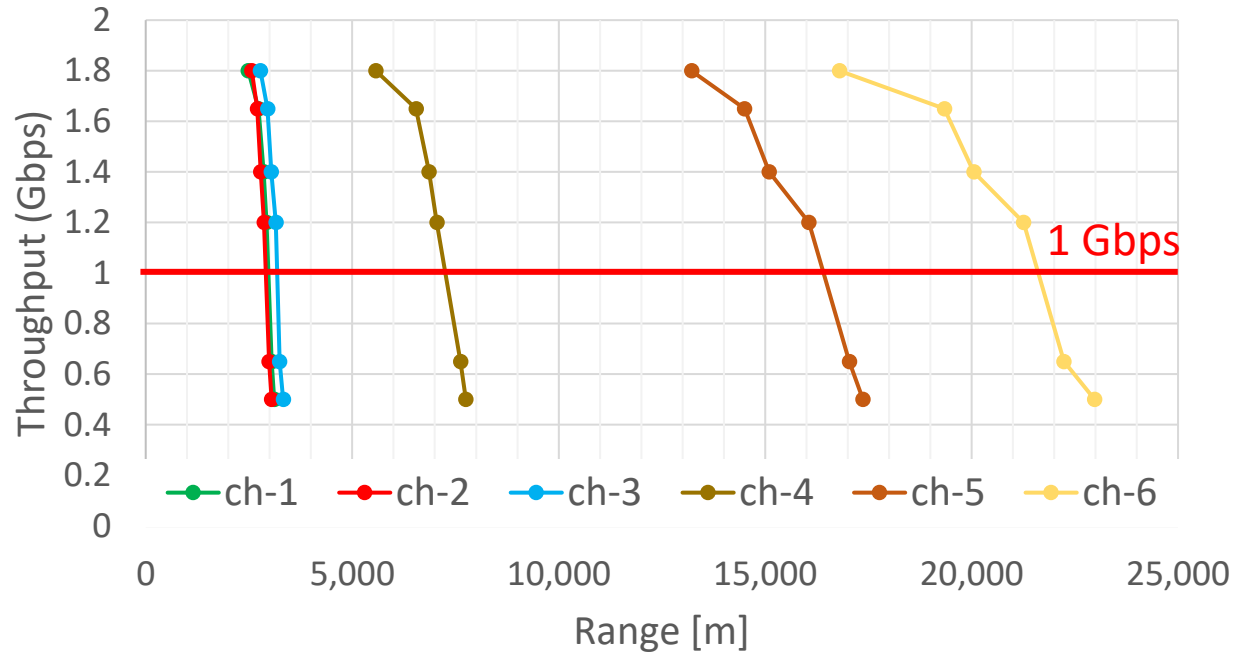


PRM2141
module
with
420mm dish
and
5GHz backup
Approx.
> 20 km

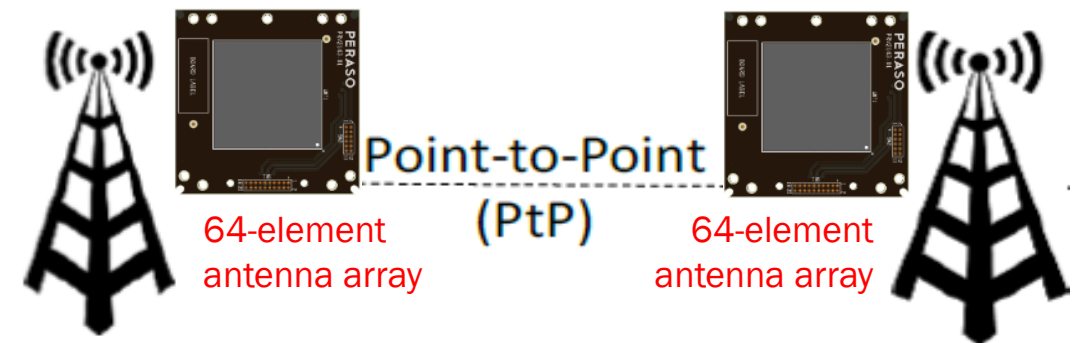
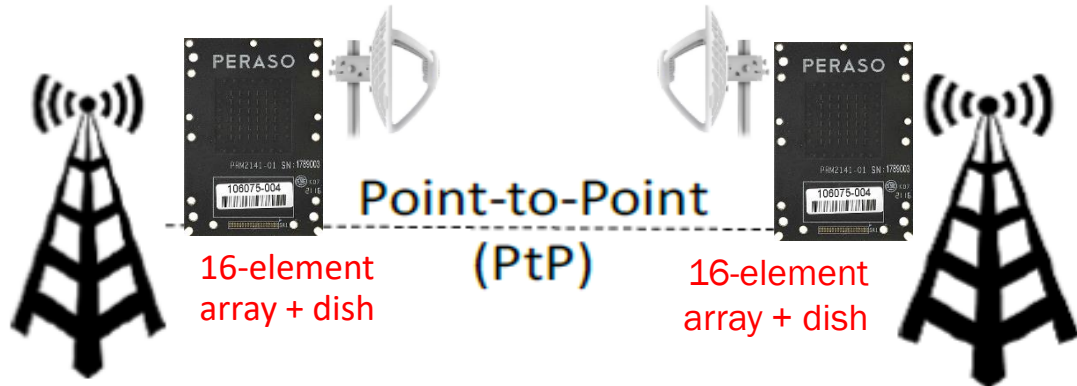
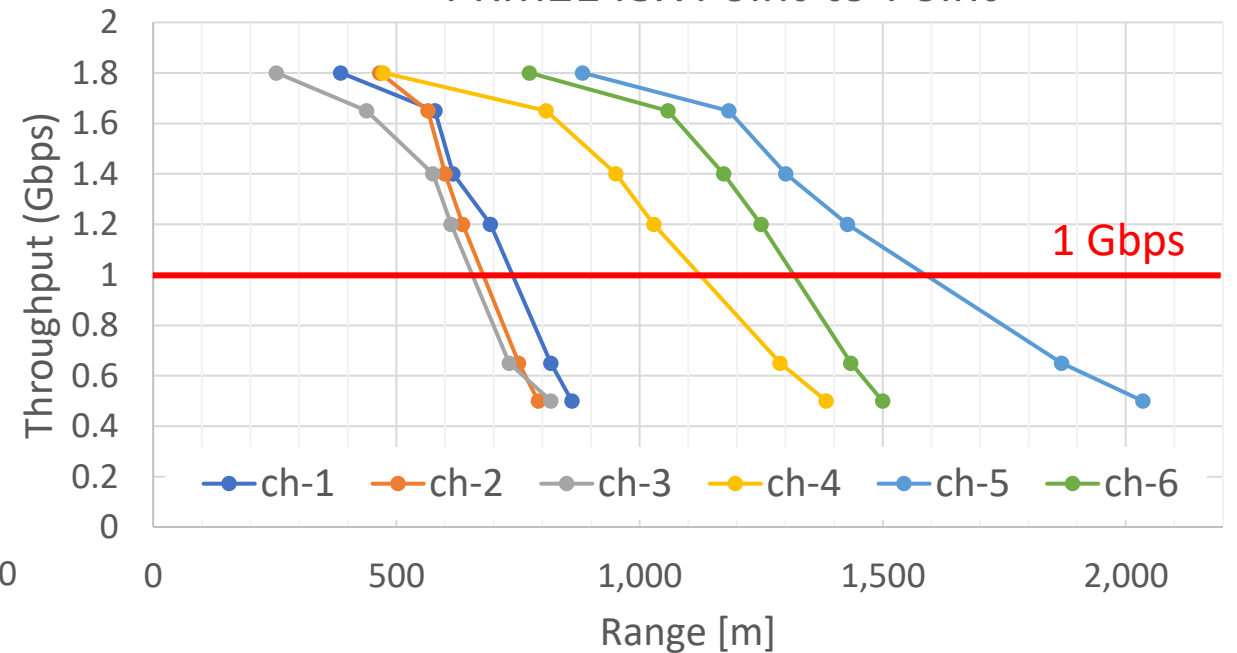


Link Analysis (PtP)

PRM2141X-dish Point-to-Point

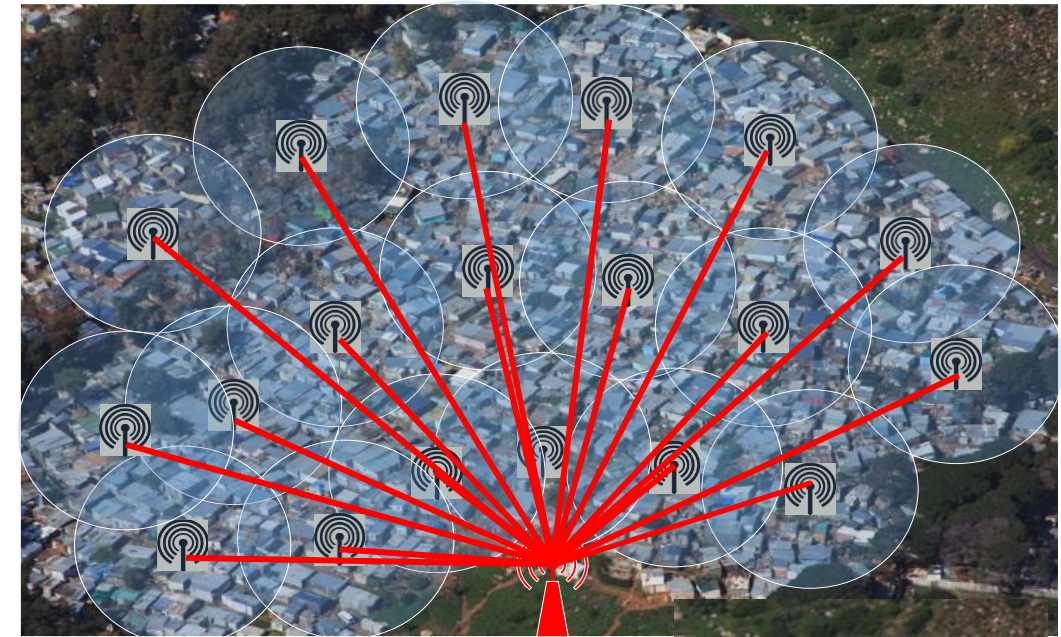


PRM2143X Point-to-Point



Point-to-Multipoint Topology

- Up to 32 direct connections from AP (DN)
 - Hub-and-spoke topology
- Range depends on antenna gain
 - EIRP limited to 40dBm for phased array
 - Up to 8km with dish/lens based CPE and high-gain AP
- Throughput per channel (2 GHz)
 - 3.5 Gbps max at 16 QAM
 - 2.2 Gbps QPSK



CPE
Examples



33 dBi lens



22 dBi array



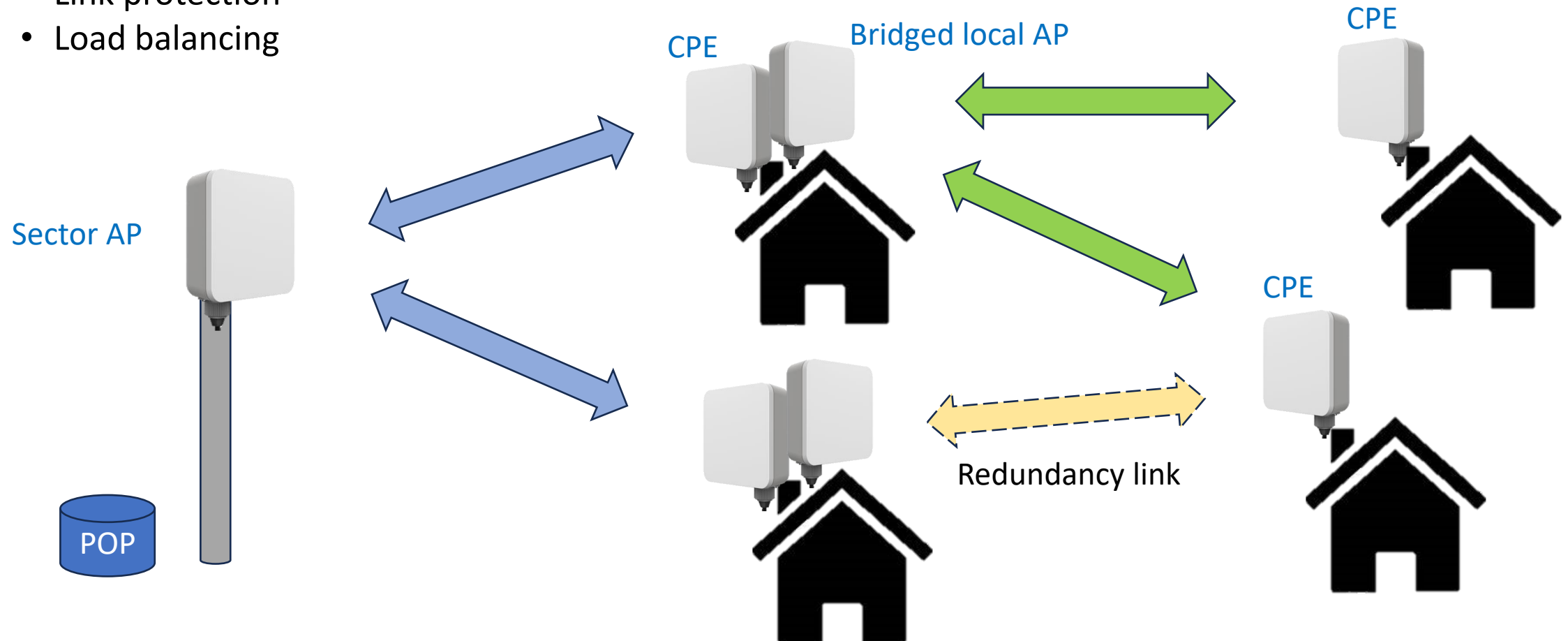
27.7 dBi dish



41 dBi dish

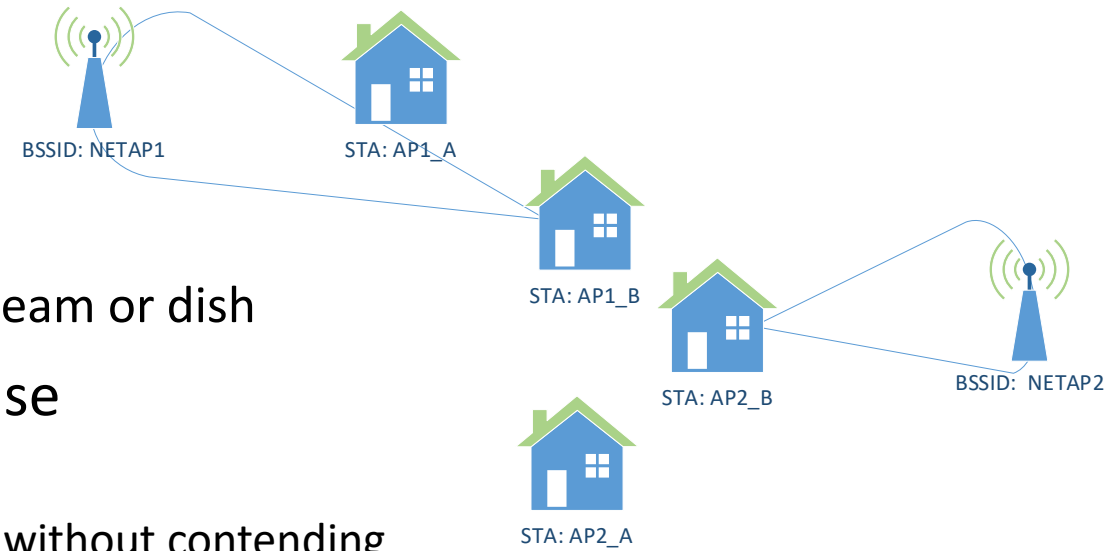
Hybrid Multi-point Topology

- Any location can be installed with bridge to extend network
- Redundancy links activated with automatic roaming
 - Link protection
 - Load balancing

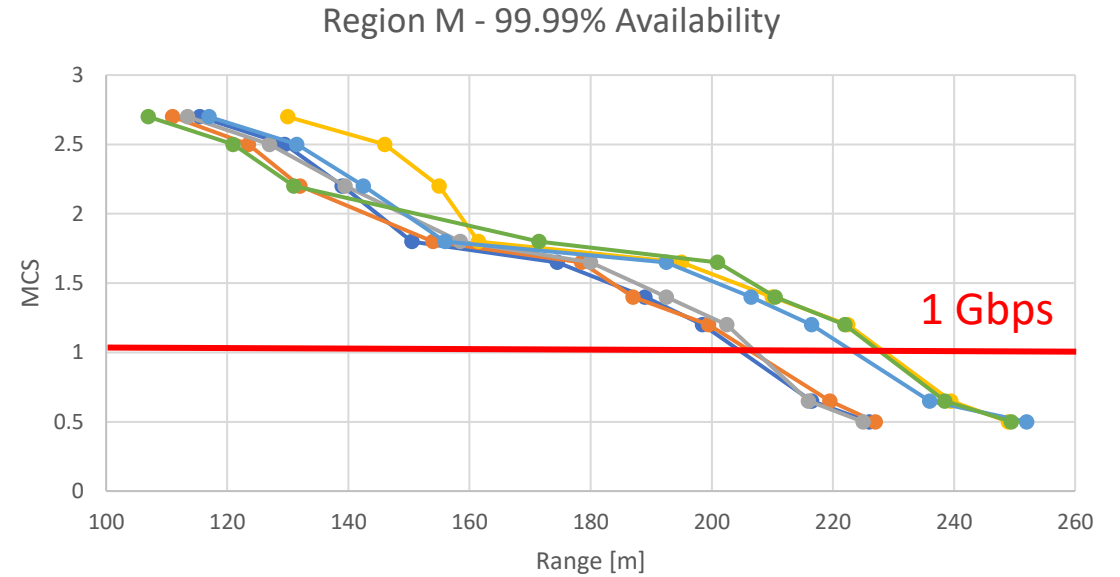
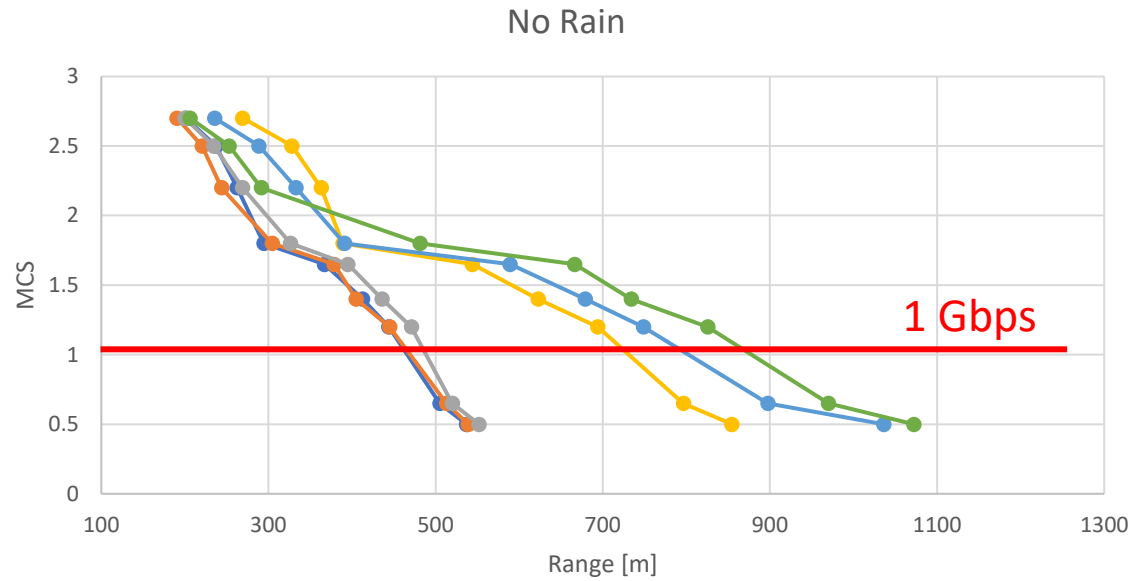


Contention & Congestion

- FWA use-case introduces opportunity for optimization
 - Static installations
 - Reliable RSL and Distance measurements
- Beamforming improves spatial separation
 - Narrow beams used for data packet transmission
 - “STA Focus” mode allows STA to always use narrow beam or dish
- Protocols can be adapted to improve FWA use case
 - 802.11ad introduced “Reverse Direction” process
 - Listener has a chance to respond after sender is done without contending
 - Predictable RSL and propagation times due to static nature of users
 - Listeners can filter out interference which is too-weak or arrives at wrong time

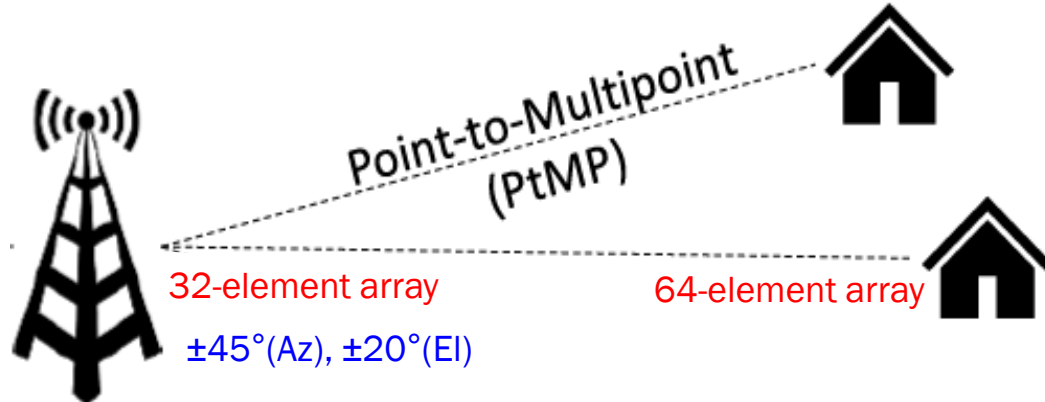


Link Analysis – Channel Comparison



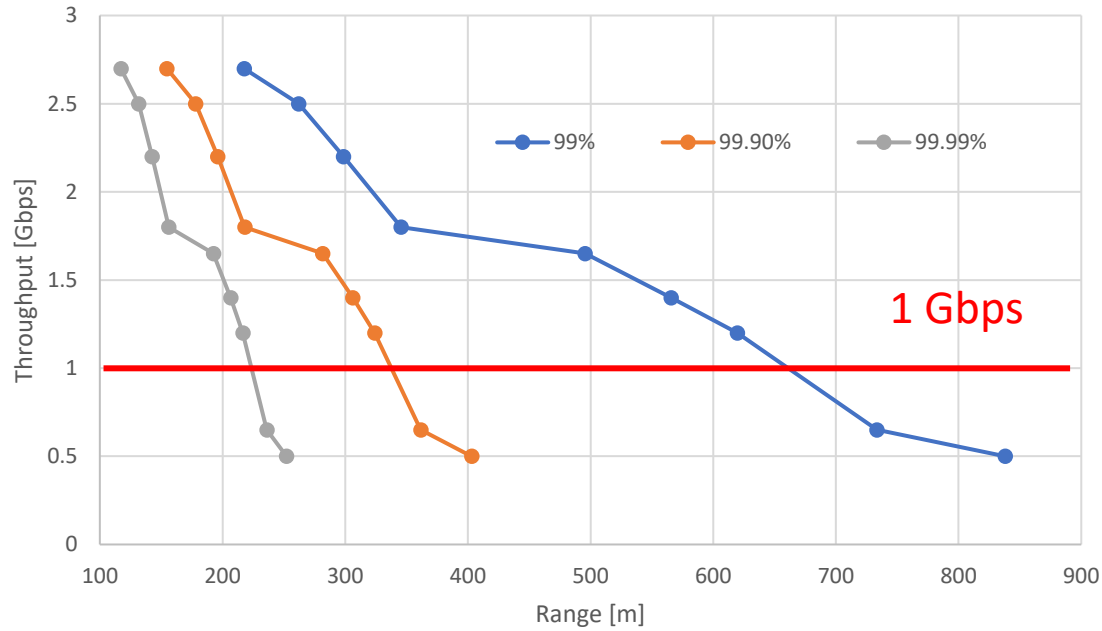
Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6

Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6

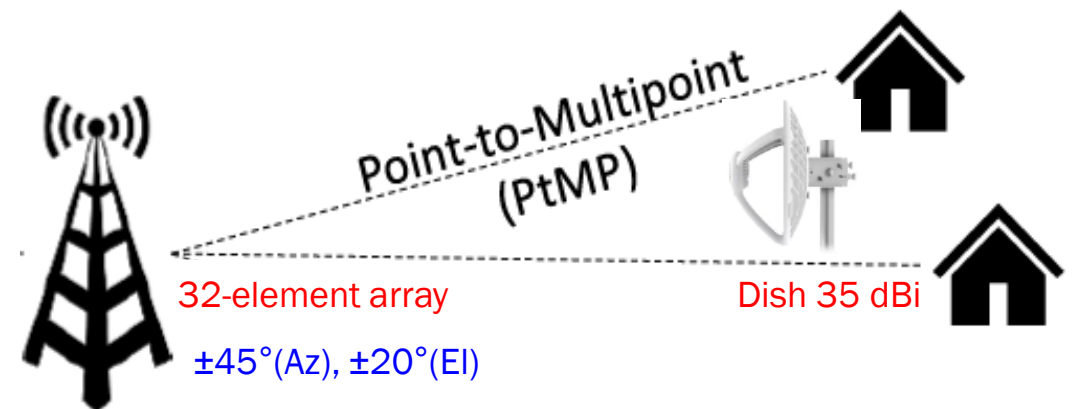
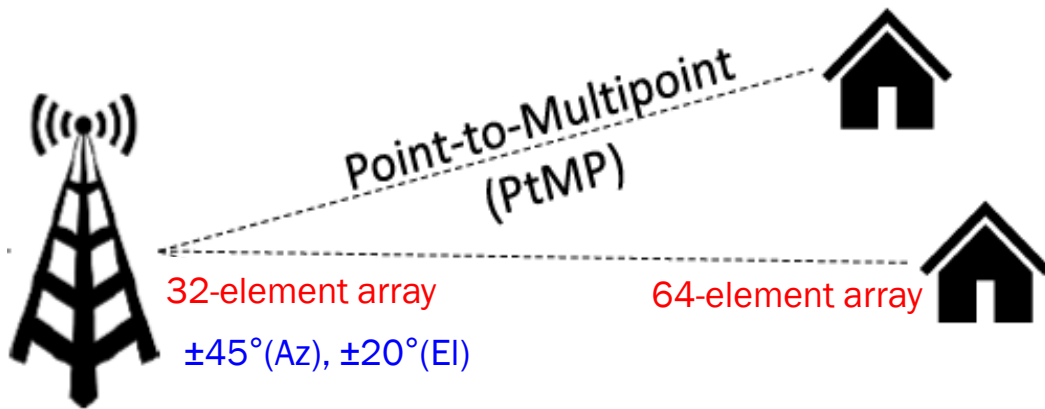
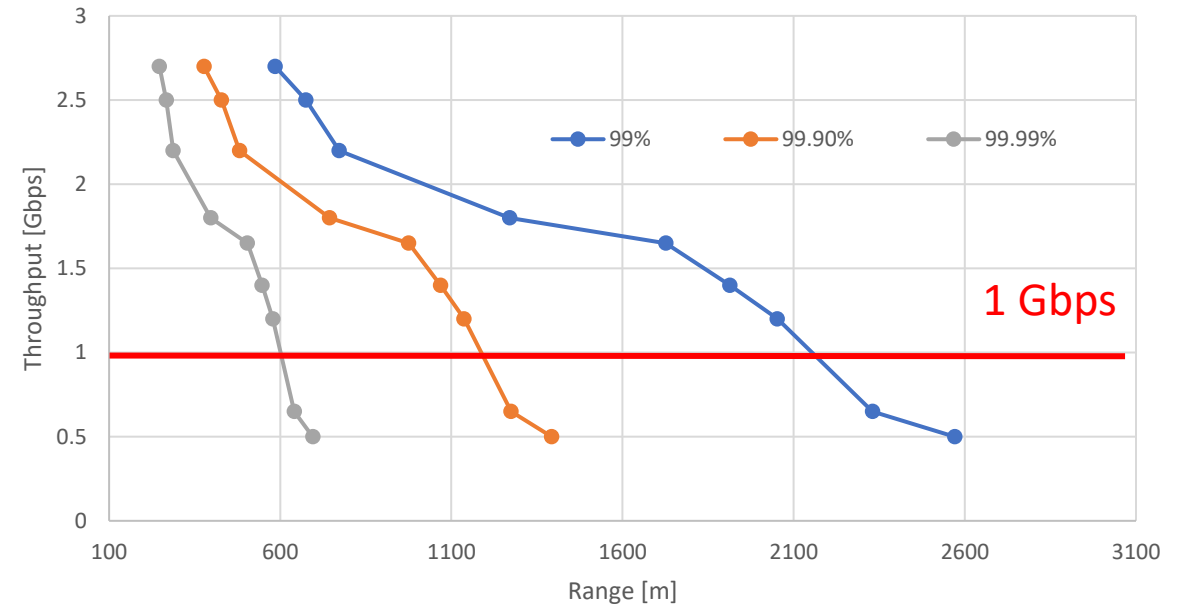


Link Analysis (PtMP)

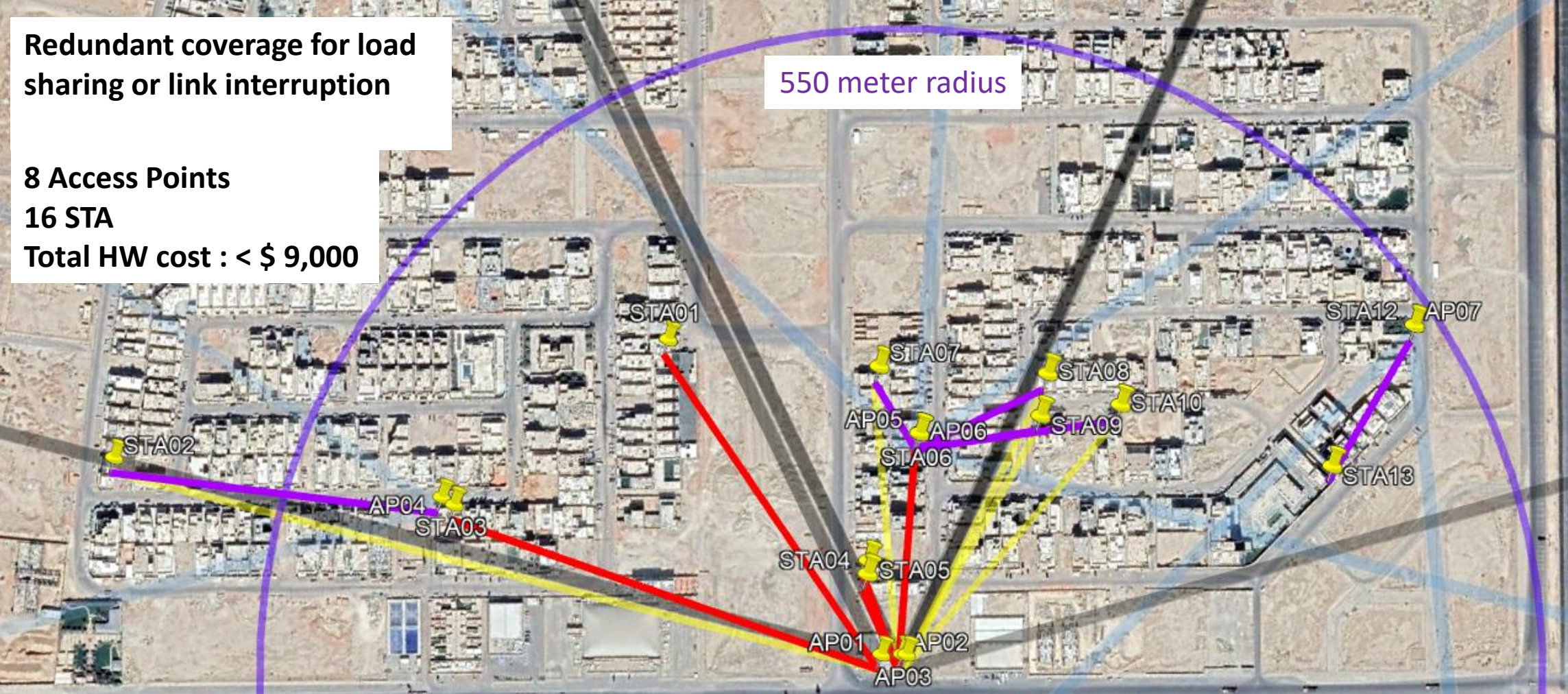
Channel 5 - Region K: 99%, 99.9%, 99.99%



Channel 5, 35dBi STA – Region K: 99%, 99.9%, 99.99%



Network Topology with Redundancy



Wrap Up

- 60GHz FWA systems are:
 - Cost effective
 - Low SWAP
 - Quick and easy to deploy
 - Provide high-speed internet access to locations that are difficult to reach with traditional wired networks, bridging the digital divide in underserved or remote areas
- 60GHz beamforming enables the use of the 60GHz for various applications, helping to overcome the limitations of short-range propagation while providing higher data rates and improved reliability
- System developers easily integrate Peraso's module solutions, with 10s of 1000s of systems deployed in the field today
- High quality user experience reported by WISPs deploying 60GHz networks

PERASO

WIRELESS
UNLEASHED™



Thank you

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nhatto@perasoinc.com