Time	Presentation
9:00 AM (PST)	**Day 2 Welcome Address** Tiago Rodrigues, President & CEO, Wireless Broadband Alliance.
9:10 AM (PST)	**Powering Wi-Fi® through 6 GHz** Kevin Robinson, President & CEO , Wi-Fi Alliance
9:30 AM (PST	**AFC: The Final Countdown** Sreeja Nair, Director Product Management, Qualcomm Atheros
9:50 AM (PST)	**The Second-Generation Wi-Fi 7 - What's Next for Wi-Fi 7 and Wireless Technology** Gabriel Desjardins, Director of Product Marketing - Wireless Connectivity division, Broadcom
10:10 AM (PST)	**Update on IEEE Standards** Dorothy Stanley, 802.11 Working Group, IEEE
10:30 AM (PST)	**Panel: Building Success with 6Ghz Wi-Fi Delivering Wi-Fi 6E and Wi-Fi 7 with 'AFC'** Tiago Rodrigues, President & CEO, Wireless Broadband Alliance; Matt MacPherson, CTO Wireless, Cisco; Sreeja Nair, Director Product Management, Qualcomm; Mark Hamilton, Networking Standards Director, RUCKUS Networks.
11:10 AM (PST)	**COFFEE & NETWORKING**

Powering Wi-Fi® through 6 GHz

Wireless Global Congress Americas
Kevin Robinson
June 19 – 22, 2023

The worldwide network of companies that brings you Wi-Fi®

Collaboration

Innovation

Growth

Wi-Fi ALLIANCE™

Wi-Fi Alliance vision:

connecting everyone and everything, everywhere

Wi-Fi is essential to delivering services in today's changed world

- Residential network connectivity is essential for hybrid work, e-learning, and telehealth – and Wi-Fi is the primary method for delivering these services to the residence*

- Wi-Fi supports sustainability and affordability efforts as a low-power technology that enables multiple users to share a single broadband connection

- Emerging immersive experiences such as AR/VR/XR, Industrial IoT / Automation, and 3D-video require the high speeds and deterministic latency Wi-Fi delivers

- Wi-Fi speeds have increased with each new generation, and emphasis is now being placed on consistency of performance and quality of service from Wi-Fi networks

*Cisco VNI

6 GHz momentum is building around the world

- 473 million 6 GHz devices will enter the market in 2023*, nearly 20% of Wi-Fi 6 shipments, growing to 1.1 billion in 2025

- 94.6M Wi-Fi 6E APs will ship in 2023

- 915 product models certified for Wi-Fi 6E

- 60+ countries have decided to open 6 GHz band for Wi-Fi

- Numerous large-scale deployments serving thousands of users across enterprise, healthcare, education, and sports and entertainment demonstrate Wi-Fi 6E momentum

Wi-Fi Shipment Forecast

Wi-Fi 7

Wi-Fi 6E

certification starts

Wi-Fi 6

Source: IDC, 2023
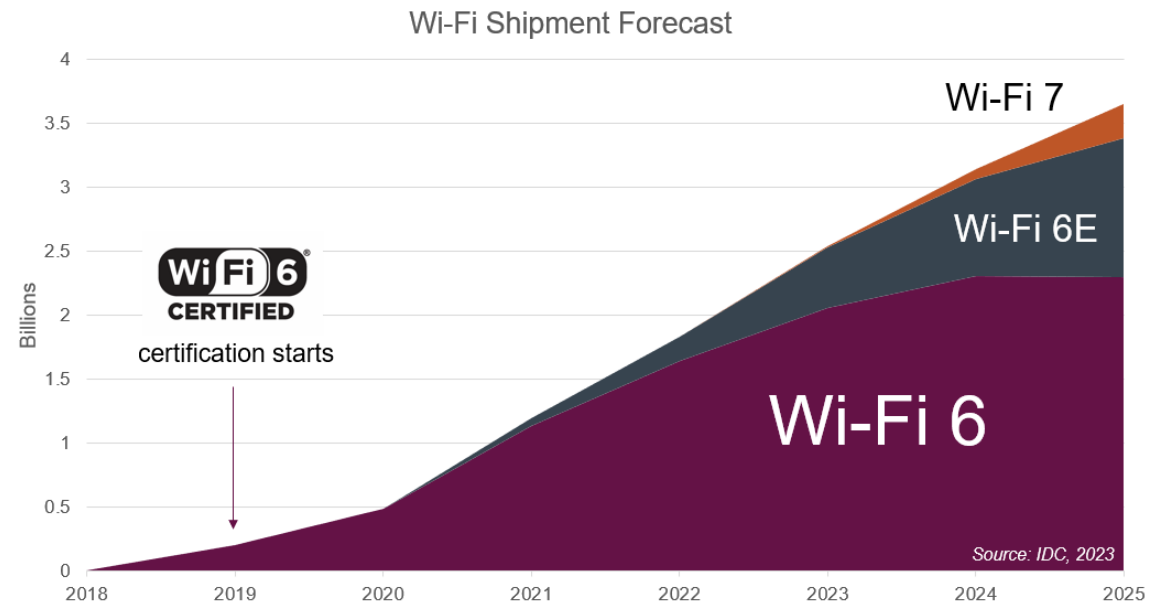
*IDC, 2023

Unlocking the most from 6 GHz with Wi-Fi 6E, Wi-Fi 7, and Wi-Fi AFC

Wi-Fi 6E unlocks greater efficiency, coverage, and performance in 6 GHz

- Wi-Fi 6E delivers the capabilities required to support advanced use cases like cloud computing, telepresence, and unified communications

- Wi-Fi 6E home trials report speeds of 1.7 Gbps downlink and 1.2 Gbps uplink

- Turk Telekom Wi-Fi 6E trial achieved connection speeds of 2 Gbps and above with low latency

- Deutshe Glasfaser reports consistently delivering 0.7 to 0.9 Gbps mesh backhaul links over 6 GHz in real-world deployments

6 GHz innovation

Source: IDC, WBA, CableLabs

Wi-Fi 7: the next level of Wi-Fi performance

- The forthcoming availability of Wi-Fi CERTIFIED 7 will drive massive adoption of next-generation Wi-Fi, initially comprising about 2.1% of all Wi-Fi shipments in 2024*

- Wi-Fi 7 will offer significant advancements with extremely high throughputs, low latency and jitter, and high reliability:
  - Over 40 Gbps speeds for intensive use cases
  - 320 MHz channels (only available in 6 GHz) for massive throughput gains
  - 4K QAM can boost transmission rates by 20% over Wi-Fi 6

- Wi-Fi 7 will deliver more advanced experiences in 2.4 and 5 GHz, and will provide maximum benefit to users in countries that make the full 6 GHz band available

Source: IDC

Wi-Fi AFC supports 6 GHz protection and advancement

- Wi-Fi Alliance has made it our mission to support 6 GHz innovation and opportunity, and standard power operation is essential to success of 6 GHz

- Automated Frequency Coordination (AFC) maximizes spectrum availability for unlicensed devices by dynamically determining channel availability at specified locations to protect licensed operations in 6 GHz

- Wi-Fi Alliance leadership in the development of specifications, test plans, and training modules will enable 6 GHz standard power devices under the control of an AFC system

- Wi-Fi Alliance recently established Wi-Fi Alliance Services, a subsidiary committed to providing a trusted, vendor-agnostic AFC service to help industry extract more value from 6 GHz while protecting incumbent operations in the band
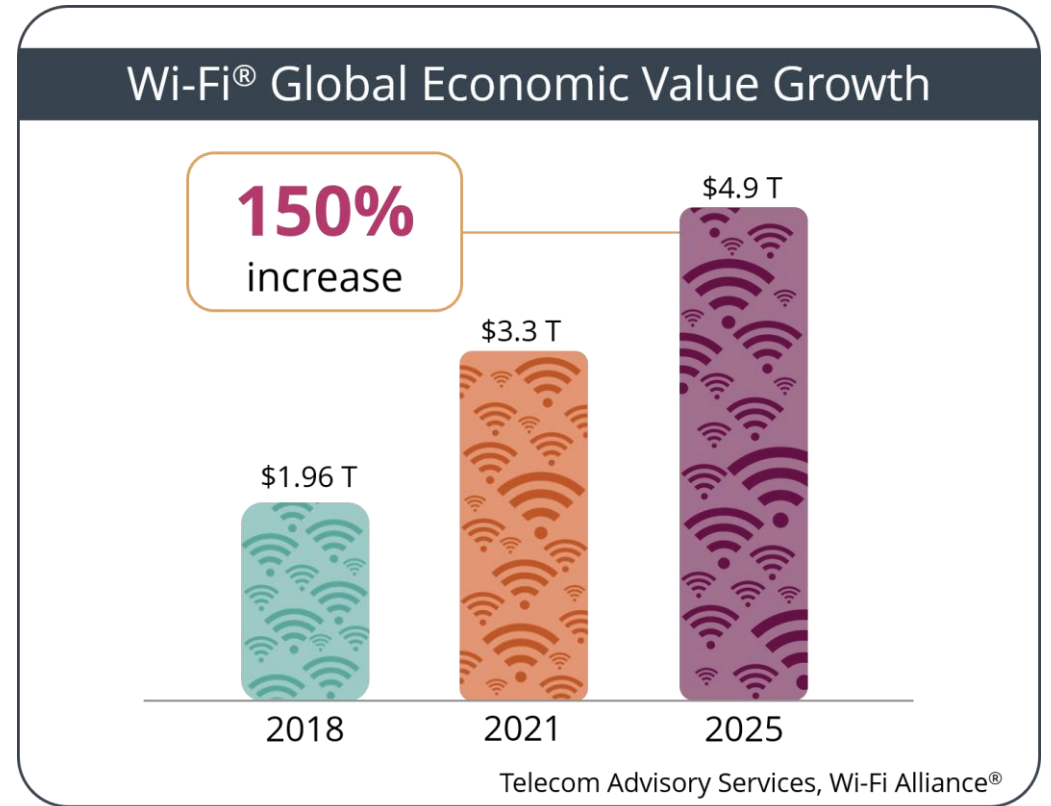
Regulatory considerations

Wi-Fi is key to growing the global economy

- 2025 value represents a 150% increase from 2018

- A highly affordable form of connectivity, Wi-Fi enables shared connections, making it accessible to more users

- Wi-Fi delivers sustainable connectivity

- New generations of Wi-Fi and unlicensed access to 6 GHz will expand innovation and capabilities in all economies

- Releasing the full 6 GHz band for unlicensed use would allow Wi-Fi to access wider channels to further improving its efficiency and maximize spectrum re-use to increase capacity

Wi-Fi® Global Economic Value Growth

150% increase

$4.9 T
$3.3 T
$1.96 T

2018   2021   2025

Telecom Advisory Services, Wi-Fi Alliance®

6 GHz is uniquely suited to meet the growing demand for Wi-Fi connectivity – there is *no alternative spectrum* now or in the future
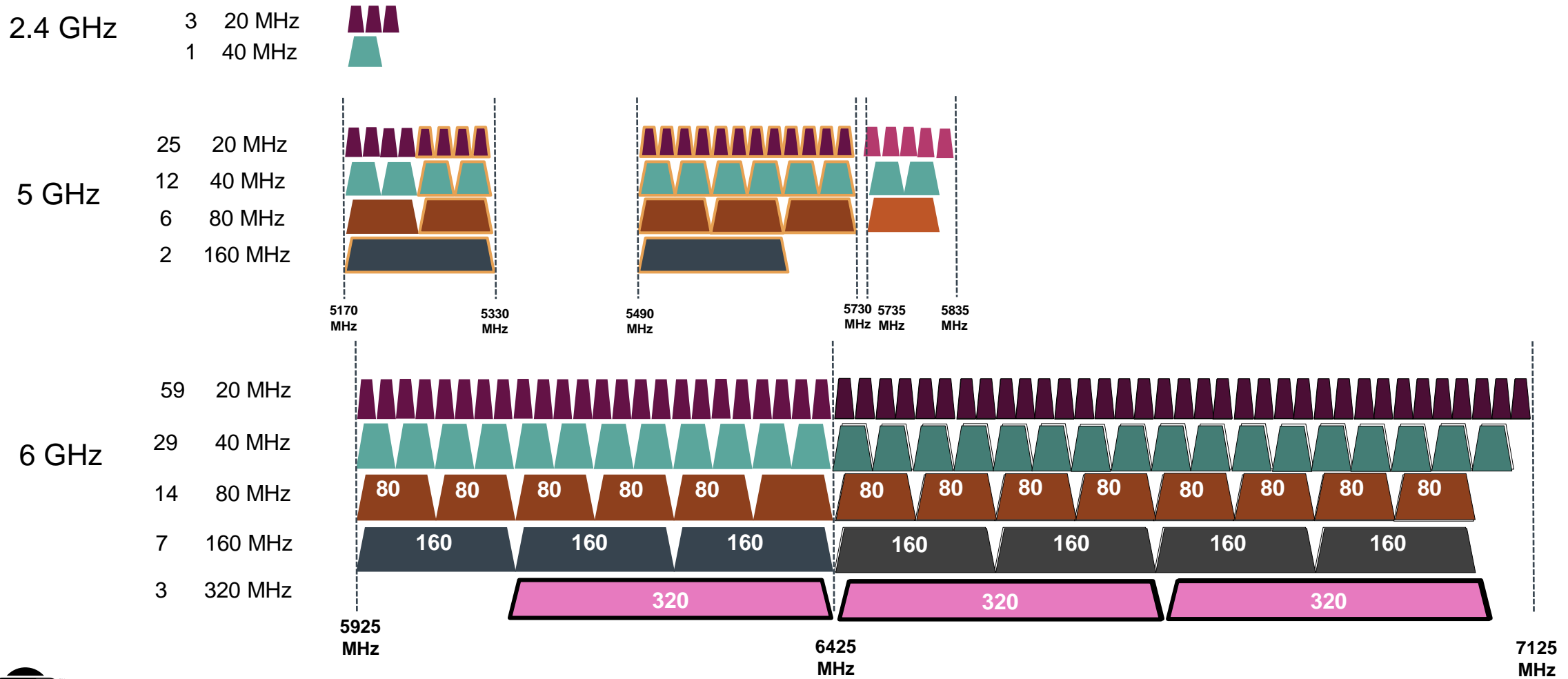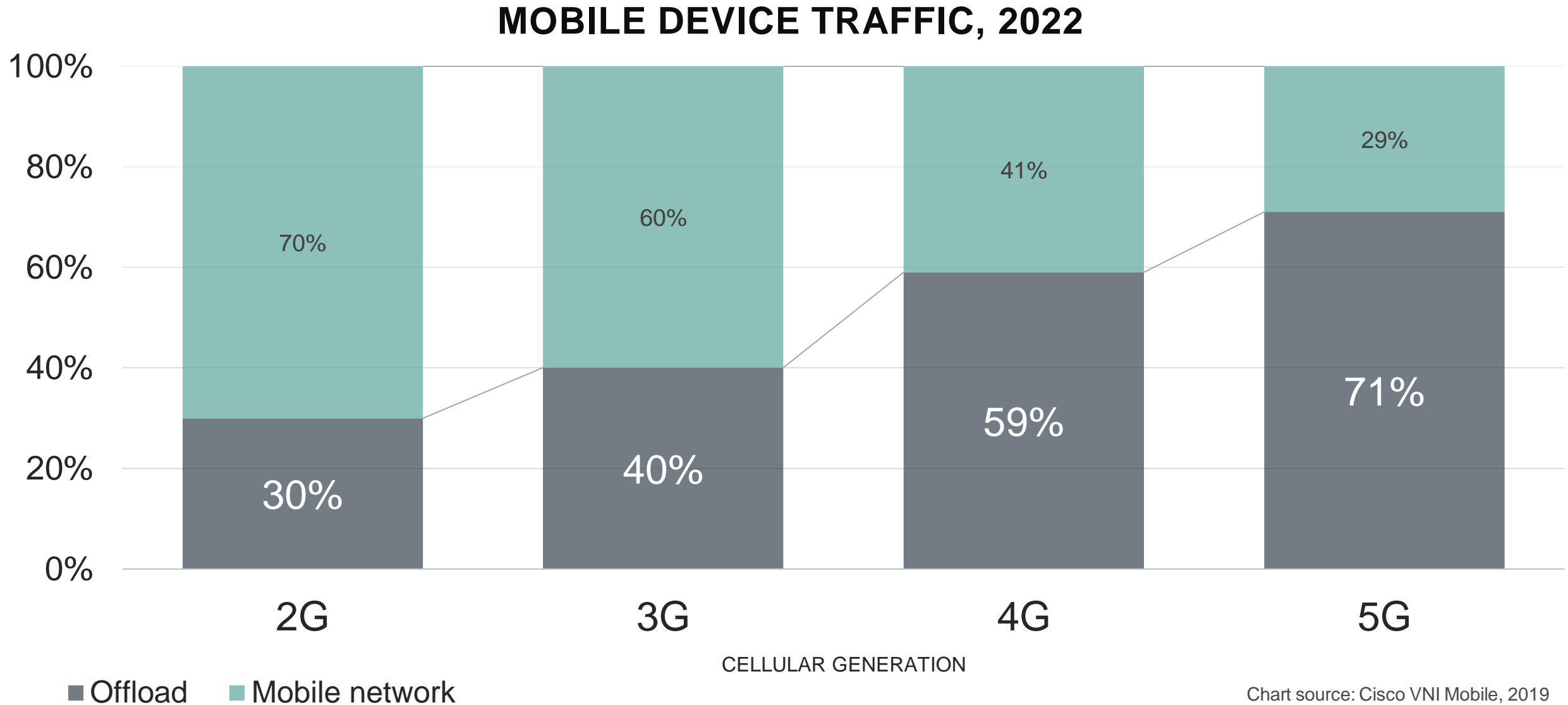
IMT networks in 6.425-7.125 GHz are not feasible

- Countries in all regions are deploying Wi-Fi in 6.425 - 7.125 GHz, and IMT frequency harmonization cannot be achieved

- Market fragmentation precludes economies of scale necessary for a viable IMT ecosystem in 6 GHz
  - Billions of $ to design and produce cellular chipsets for 6.425-7.125 GHz
  - Billions of $ to integrate chipsets into devices and bring them to market
  - Billions of $ to deploy IMT networks
  - Billions of $ to operate IMT networks

- All this adds up to billions of $ that no one is going to risk without a stable regulatory framework that offers market scope and scale

- No 6 GHz IMT equipment on the market now or in the near future, placing a huge opportunity cost on any IMT designation

Together, 5G and Wi-Fi are the Foundation of Future Connectivity

Wi-Fi traffic share increases with each cellular generation

MOBILE DEVICE TRAFFIC, 2022

Chart source: Cisco VNI Mobile, 2019

■ Offload ■ Mobile network

CELLULAR GENERATION

Wi-Fi is vital to the success of private 5G in enterprise

- Wi-Fi is the preferred choice for connectivity in most enterprises and will account for nearly 50 percent of business internet traffic in 2023, up from 36 percent in 2017*

- As complementary technologies, Wi-Fi and 5G may be used together to ensure seamless, cost-effective coverage for critical enterprise applications, e.g.,
  - chemical leak detection
  - factory management
  - flood management

- The success of private 5G, particularly for expanding coverage for mobility, will likely depend on the individual organization's ability to implement it in tandem with Wi-Fi

* Statista 2023

Wi-Fi CERTIFIED QoS Management™ improves user experiences across Wi-Fi and Private 5G

- Wi-Fi CERTIFIED QoS Management™ provides robust service delivery and higher quality experiences with real-time and latency-sensitive applications in Wi-Fi networks

- Delivers consistent, end-to-end QoS treatment to meet demands of advanced use cases that require deterministic latency such as videoconferencing and IoT applications

- Enables Wi-Fi devices, applications, and network managers to prioritize traffic flows

- Helps ensure consistent traffic management and QoS across Wi-Fi, wired, and cellular networks

- Benefits residential, enterprise, and public networks and works with all Wi-Fi generations

Wi-Fi QoS Management™ highlights

Thank you

Countries Enabling Wi-Fi in 6 GHz (Wi-Fi 6E)

■ Adopted 5925-6425 MHz   ■ Adopted 5925-7125 MHz

▥ Adopted 5925-6425 MHz, Considering 6425-7125 MHz

■ Considering 5925-6425 MHz
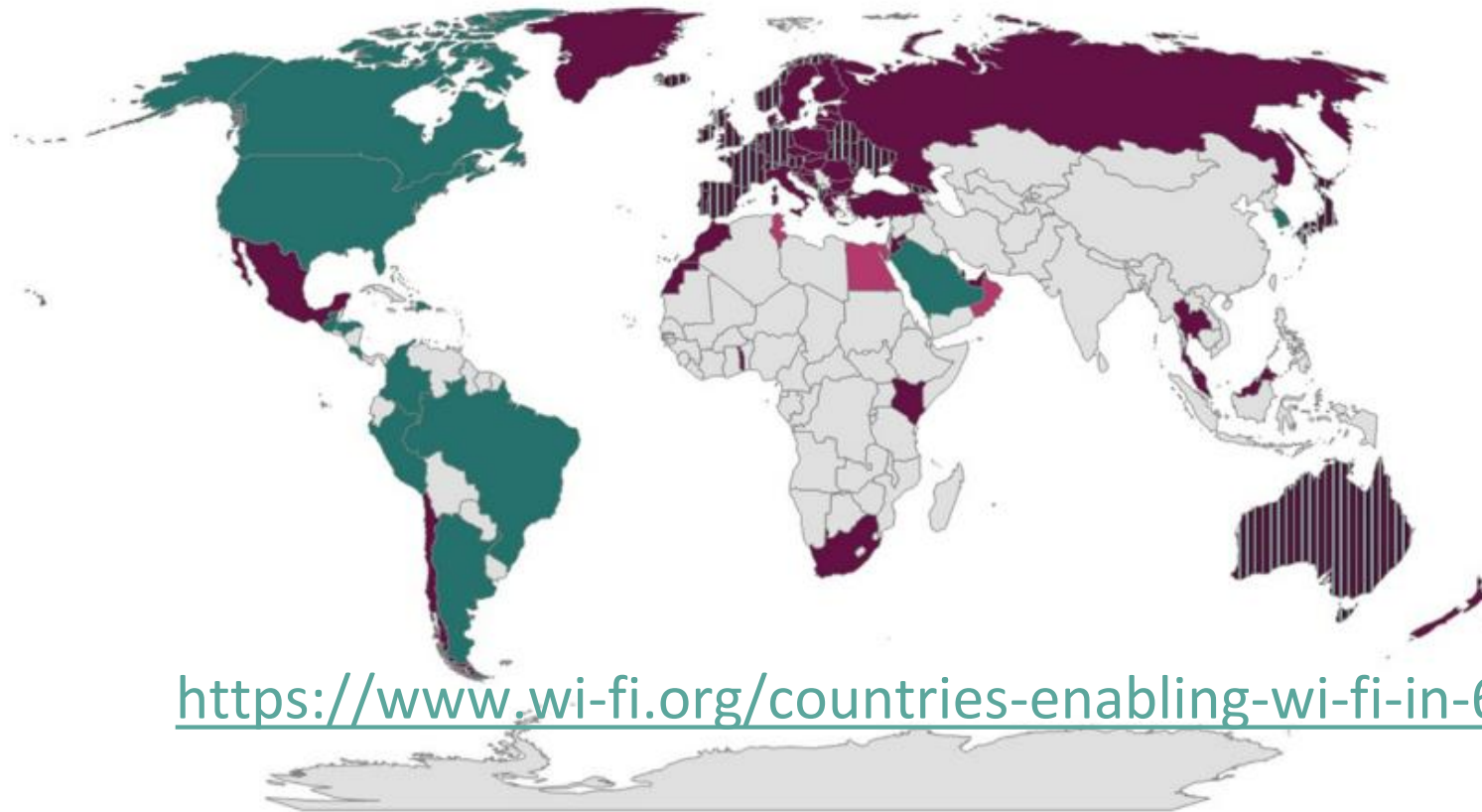
https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e

AFC: The final countdown

Sreeja Nair

Director, Product Management, Qualcomm Atheros, Inc.

Automated Frequency Coordination (AFC)
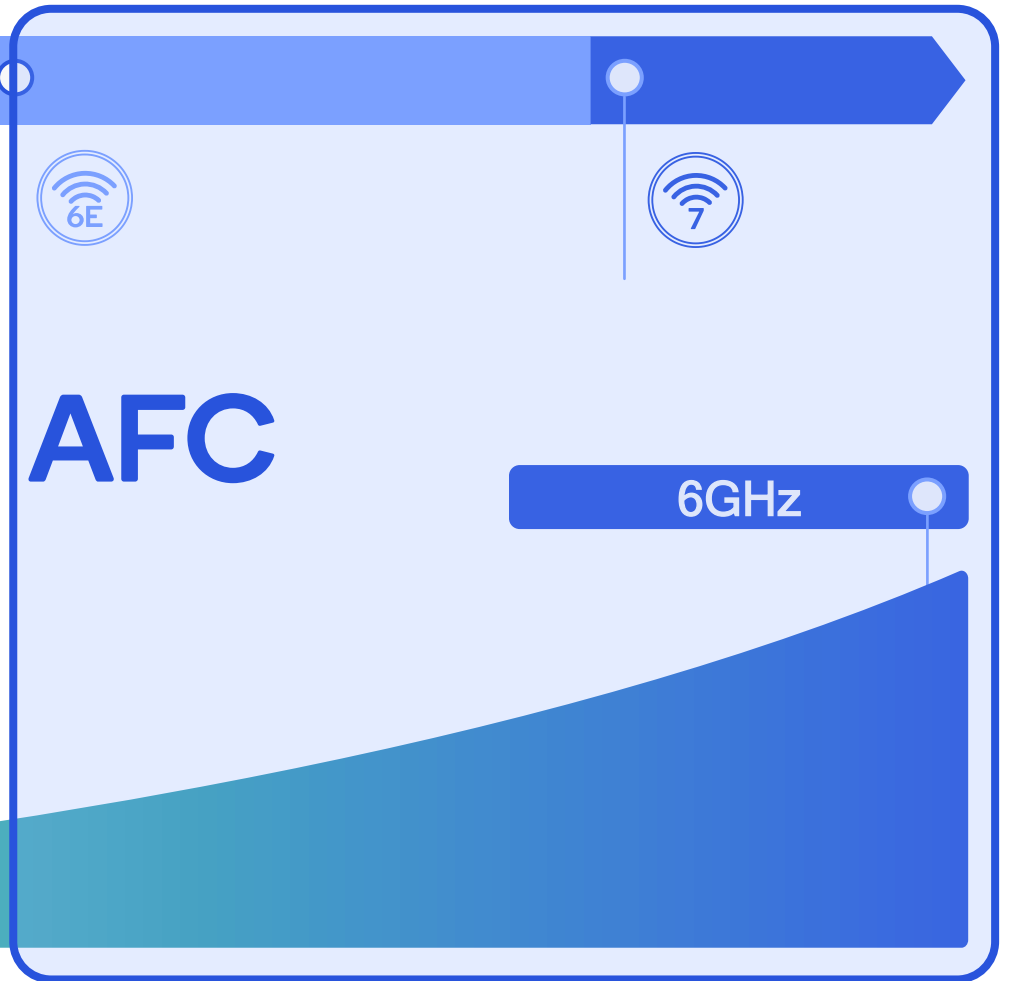
at the intersection of standards and spectrum

Standards Evolution

AFC

6GHz

5GHz

2.4GHz

Spectrum Evolution

Low Power Indoor (LPI)
Fixed Indoor Only
(Typically around 24 dBm)

- Residential Multi-AP/ mesh networks
- High-density enterprise networks
- Indoor public venues
- Industrial IoT

Very Low Power (VLP)[1]
Mobile Indoor/Outdoor
(Typically around 14 dBm)

- Augmented/Virtual/ Extended Reality (AR/VR/XR)
- 4k/8k Video Streaming & Multicasting
- High Speed Tethering
- In-Vehicle Entertainment

Standard Power (SP)[2]
Fixed Indoor/Outdoor
(AFC required, typically around 36 dBm)

- Outdoor coverage: stadiums, campus, parks
- Point-to-point connectivity (WISP)
- SMB / Residential Multi-AP / mesh networks

6GHz Wi-Fi device classes enable optimal operation

Industrial operation

Whole home mesh systems

Wireless ISP

Stadium and outdoor venues

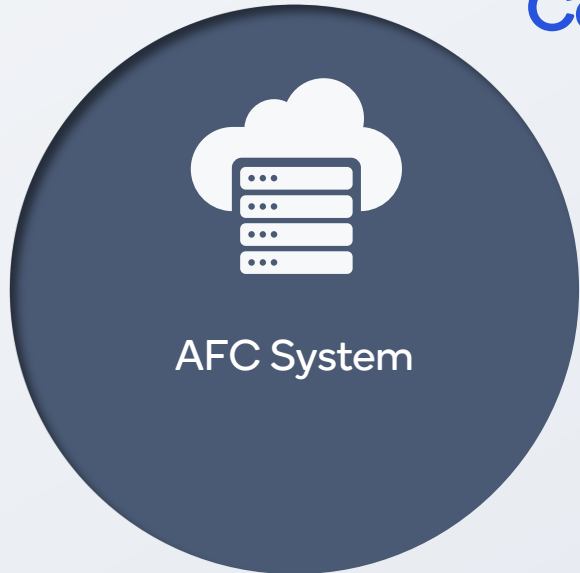AFC unlocks increased performance and new use cases for 6GHz spectrum

From 4x to 64x
higher power indoors

Outdoor
operations

Weatherized
enclosure

Standard Power Client

Standard Power AP with AFC Agent

Automated Frequency Coordination (AFC)

AFC System

Geolocation

6GHz Standard Power operation require a complete end-to-end AFC solution
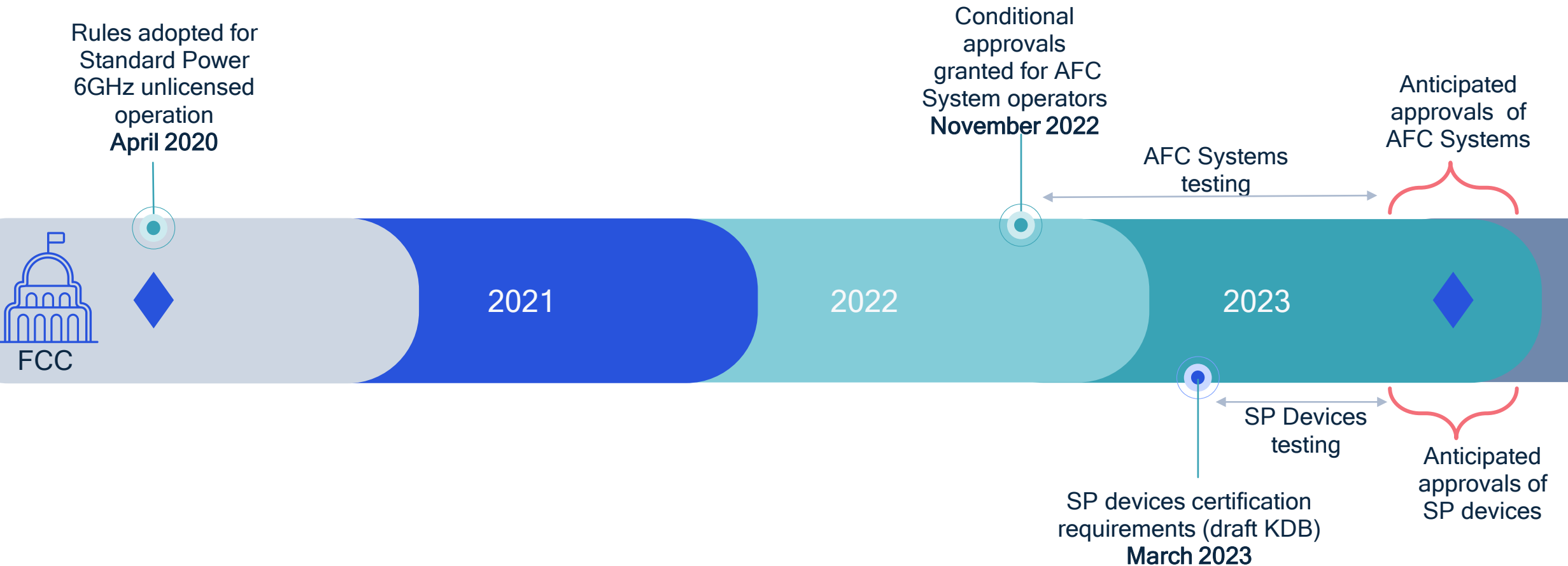
Standards based and interoperable

Compliant to test specifications

Certified by regulatory authorities

AFC Timeline: standardization and compliance

Rules adopted for Standard Power 6GHz unlicensed operation
April 2020

Conditional approvals granted for AFC System operators
November 2022

AFC Systems testing

Anticipated approvals of AFC Systems

2021

2022

2023

FCC

SP Devices testing

SP devices certification requirements (draft KDB)
March 2023

Anticipated approvals of SP devices

Global momentum for 6GHz SP and AFC

Canada

US

Mexico

Costa Rica

Brazil

CEPT

Saudi Arabia

South Korea

Japan

Indonesia

Australia

⬤ Rules approved

⚪ Under consultation

Countries with 6GHz Standard Power
operation approved or under discussion

Data generated from each respective country's regulatory agency

Qualcomm® Automated Frequency Coordination solution

Designed to deliver a complete end-to-end turnkey solution for Standard Power operation

Qualcomm AFC service conditionally approved for operation by FCC to enable standard power for unlicensed devices in the 6GHz band
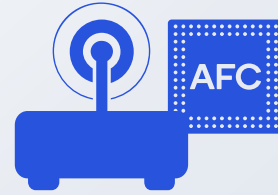
AFC Device Agent

- Embedded device agent
- AFC messaging
- Channel/Power setting

Geolocation

- GNSS
- Wi-Fi based

AFC Service

- Qualcomm AFC cloud System
- AFC protection area
- List of permissible operation

Management

Cloud based provisioning and management

6GHz outdoor – Gabriele D'Annunzio

First 6GHz outdoor in Latin America launched in Dec/22

Implemented by:

Qualcomm

Cambium Networks™

TELIUM AllWaysON

Tecexpert

With the support from Anatel

Wi-Fi 6E

Wi-Fi 6E

Telium
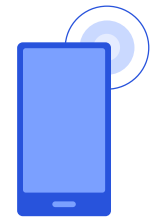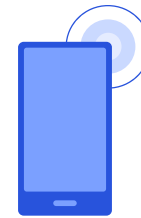
Key takeaways

6GHz Standard Power operation presents tremendous opportunities supported by a fast-growing Wi-Fi 6E and Wi-Fi 7 ecosystem

The industry has worked jointly to deliver an innovative, practical, and scalable solution for spectrum sharing

AFC-like solutions are being considered around the globe to maximize 6GHz operations

Qualcomm Technologies' AFC silicon-to-cloud solution is designed to deliver turnkey Standard Power operation

Thank you

Second Generation Wi-Fi 7

What's Next for Wi-Fi 7 and Wireless Technology

Wi-Fi 7 Fuels the Digital Revolution

**Over-the-top video,
Mobile video consumption**

Wi-Fi 5

**Videoconferencing,
Social media uploads**

Wi-Fi 6

**Whole home Multi-gig
broadband and gaming**

Wi-Fi 7

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The Look Ahead: Broadband Trends

Comcast tests 4-Gig speeds on DOCSIS 4.0 modem prototype

January 13, 2022

AT&T becomes fastest major Internet provider, delivering fiber with up to 5-Gigs of speed

January 24, 2022

Charter advances on DOCSIS 4.0

September 21, 2022

Comcast gets its mitts on missing piece of its DOCSIS 4.0 network

February 27, 2023

READING

10 Gbps

Wireless needs to keep up

1 Gbps

100 Mbps

1 Mbps

2000   **2014**   **2018**   **2024**

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6 GHz Regulatory Momentum

67

Countries that opened up 6 GHz for Wi-Fi

6
GHz

70%

World's GDP Designated
As of 6 June 2023

64

Other countries actively looking to open 6 GHz for Wi-Fi

78%

World's GDP designating or considering as of 6 June 2023

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Connecting Everything with Wi-Fi 7

Key Use Cases

6**GHz** Spectrum

10G Broadband

BROADCOM®

Wi-Fi 7 Improves Congested Network Performance As Well

Capacity

5x

network capacity[1]

Latency

100x

Improvement in worst case latency[2]

Determinism

15x

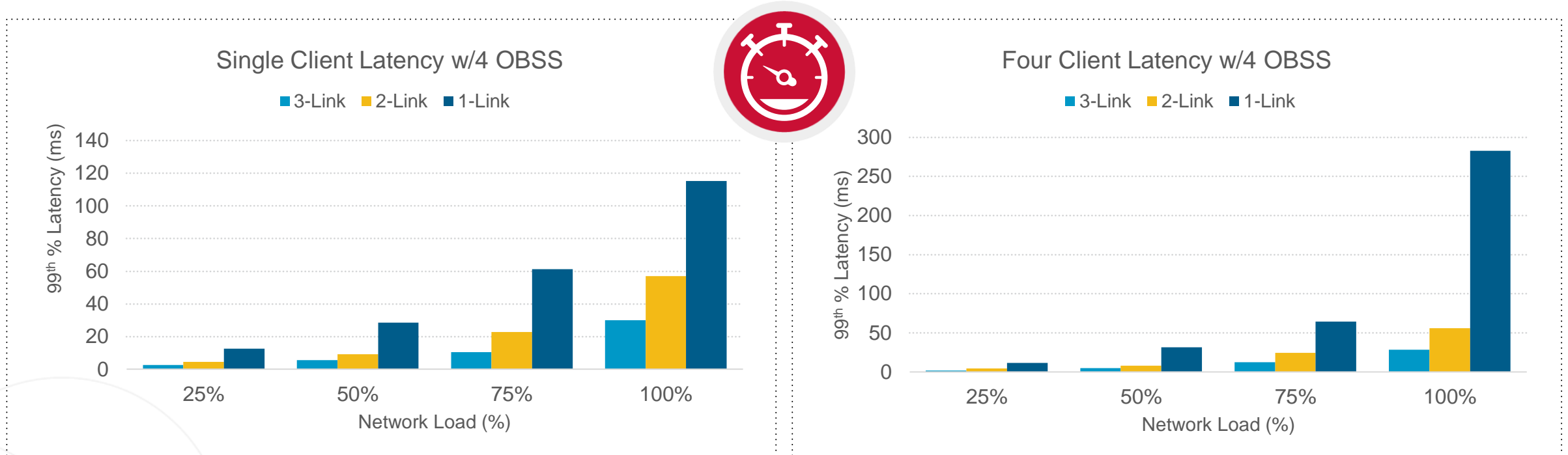Improved AR/VR latency performance[3]

Coverage

63x

Higher transmit power than indoor 6 GHz Wi-Fi

1 – scenario described in IEEE 11-13/1081r0. 20 apartments on a single floor, 1 AP and 1-4 WLAN devices per apartment; compares 80 MHz Wi-Fi 6/6E devices vs 320 MHz/MLO capable Wi-Fi 7 devices
2 – congested 20 apartment scenario compares best effort latencies for Wi-Fi 6 and MLO-capable Wi-Fi 7 client; simulation comparison is improvement in number of times latency requirements are not met due to traffic congestion
3 – similar set-up as 2, but run for AR/VR latency

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Multi-Link Operation (MLO) Latency Benefits

Single Client Latency w/4 OBSS

■ 3-Link ■ 2-Link ■ 1-Link

99th % Latency (ms) vs *Network Load (%)*

Y-axis: 0, 20, 40, 60, 80, 100, 120, 140
X-axis: 25%, 50%, 75%, 100%

Four Client Latency w/4 OBSS

■ 3-Link ■ 2-Link ■ 1-Link

99th % Latency (ms) vs *Network Load (%)*

Y-axis: 0, 50, 100, 150, 200, 250, 300
X-axis: 25%, 50%, 75%, 100%

- **Wi-Fi 7 Multi-Link Operation allows device to connect on multiple links simultaneously**

- **Dual-Band MLO Designs (2.4 GHz + 5 GHz)**
  - 2-Link MLO reduces 99$^{th\%}$ latency reductions by 60-80% versus single-link 11ax

- **Tri-Band MLO Designs (2.4 GHz + 5 GHz + 6 GHz)**
  - 3-Link MLO using three 11be radios further improves latency by 50% versus 2-link MLO

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First-Generation Products Come to Market

ASUS Debuts Wi-Fi 7, Quad-Band Gaming Router

ASUS ROG GT-BE98 and RT-BE96U Announcement – January 4, 2023

ASUS Exhibits Compelling Innovations Across Product and Solutions Portfolios Along with Sustainability Achievements at Computex 2023

ASUS ZenWiFi BQ16 Pro Announcement – May 30, 2023

TP-Link is going straight to Wi-Fi 7 with its latest generation of routers

TTP-Link BE900 Announcement – November 14, 2022

TP-Link already has some Wi-Fi 7 routers for you to buy

TP-Link BE800 Announcement – May 15, 2023

NETGEAR introduces the first WiFi 7 router, unlocking the next generation of high-performance connectivity

NETGEAR RS700 Announcement – March 14, 2023

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There's More to Do

Bring Wi-Fi 7 to Mass-Market Access Points and Mesh Devices

Support growing Enterprise IoT Market

Support broader Market for Smartphones

BROADCOM®

Wi-Fi 7 Product Ecosystem

Gen 1

BCM67263

BCM43740

BCM4398

Gen 2

BCM6765

BCM47722

BCM4390

|

BROADCOM®

BCM6765
Key Features

1. Two-Stream Wi-Fi 7 with 320 MHz Channels
2. 8.45 Gbps Data Rate
3. Simultaneous Transmit Receive MLO
4. 3-Link MLO Support
5. Native AFC Support

BCM47722
Key Features

1. Two-Stream Wi-Fi 7 with 320 MHz Channels
2. 8.45 Gbps Data Rate
3. Simultaneous Transmit Receive MLO
4. Bluetooth Low Energy, Zigbee and Thread Support
5. Native AFC Support

BCM4390
Key Features

1. Two-Stream Wi-Fi 7 with 160 MHz Channels
2. 3.2 Gbps Data Rate
3. Client MLO Operation
4. Bluetooth Denver Support
5. Zigbee and Thread Support

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IoT Ecosystem

Enterprise IoT networks are experiencing significant growth and need routers to control them

Enterprise Access Points support growing IoT technologies like Bluetooth Low Energy, Zigbee, and Thread

Service a variety of enterprise verticals and enable asset tracking and secure distance measurement

Residential IoT can start incorporating smartphones into the smart home by adding Zigbee and Thread support

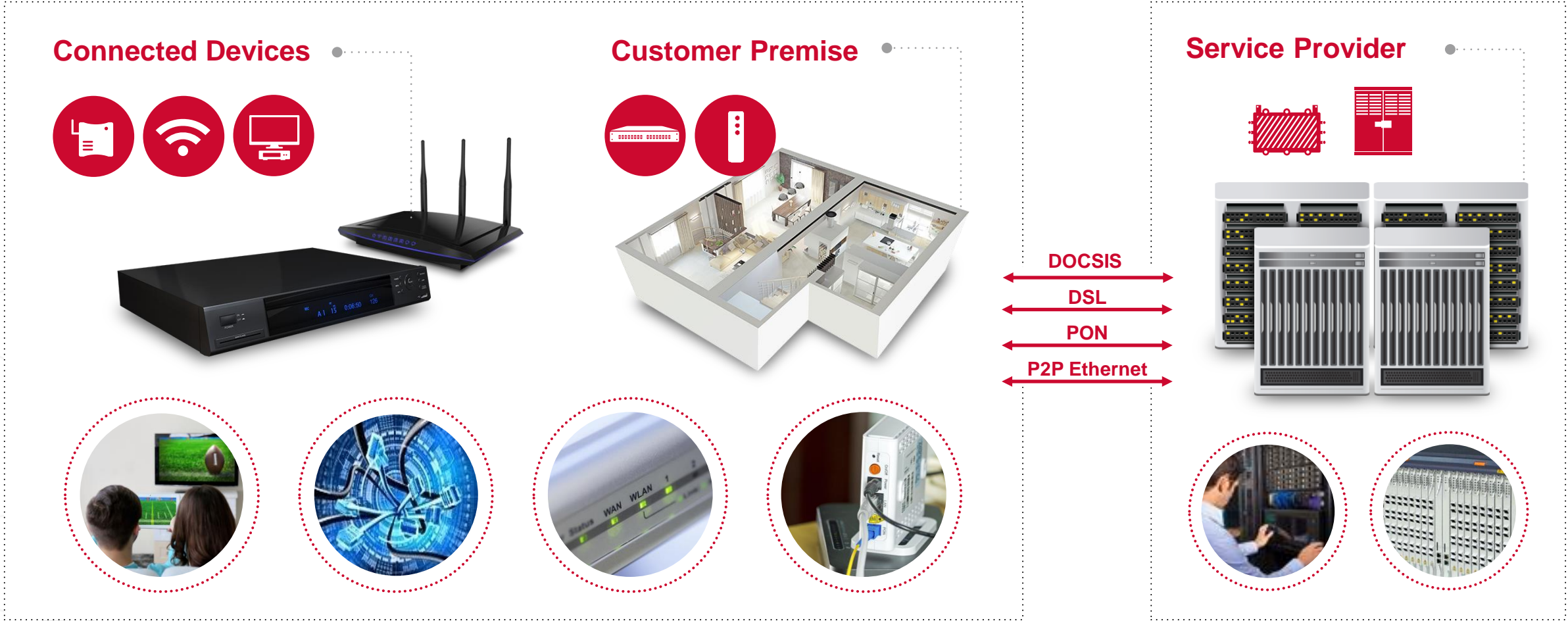Next-Gen Bluetooth enables new use cases like vehicle keyless entry

BROADCOM®

Connected by Broadcom

Full ecosystem powered by Broadcom

Connected Devices

Customer Premise

Service Provider

DOCSIS

DSL

PON

P2P Ethernet

BROADCOM®

IEEE 802.11 standard update

Current and new work areas
Recently completed amendments
Connecting the unconnected

2023 June
Presenter: Dorothy Stanley, IEEE 802.11 Working Group Chair

"At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE." IEEE-SA Standards Board Operation Manual (subclause 5.9.3)

Wireless Broadband Alliance

IEEE 802 LAN/MAN Standards Committee standard development covers both Wireless & Wired Media

- Focus on **link and physical layers** of the network stack

- Leverage IETF protocols for upper layers
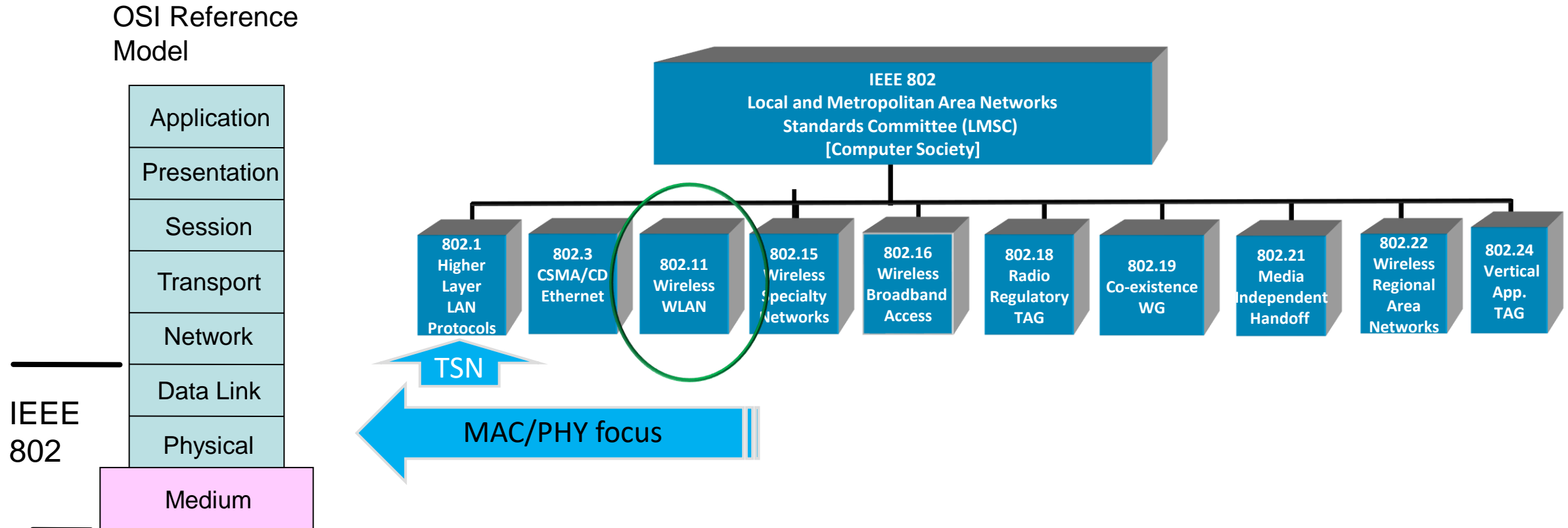
In progress: New 802.11 Radio technologies are under development to meet expanding market needs and leverage new technologies

802.11be – Extremely High Throughput in 2.4, 5 and 6 GHz bands, aka Wi-Fi 7
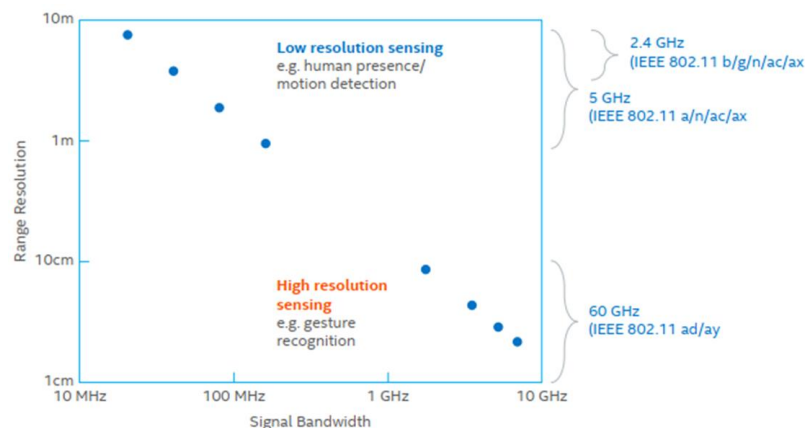
802.11bf – WLAN Sensing

802.11bh – Randomized MAC Addresses

802.11bi – Enhanced Data Privacy

P802.11bk – 320 MHz Ranging

802.11be (est. 2024)
Wi-Fi 7

- **2.4GHz, 5GHz and 6GHz supported**
- Wider channels (40, 80, 160, 240, **320MHz**)
- Better modulation (**4096-QAM**)
- Backward compatibility with 11a/b/g/n/ac/ax
- Standard targets throughput minimum of 30Gbps, expect 40Gbps+

Range Resolution vs. Signal Bandwidth

Low resolution sensing
e.g. human presence/ motion detection

High resolution sensing
e.g. gesture recognition

2.4 GHz (IEEE 802.11 b/g/n/ac/ax)

5 GHz (IEEE 802.11 a/n/ac/ax)

60 GHz (IEEE 802.11 ad/ay)

UHR SG: Ultra High Reliability Study Group was approved in July 2022 to define scope and purpose of next MAC/PHY project
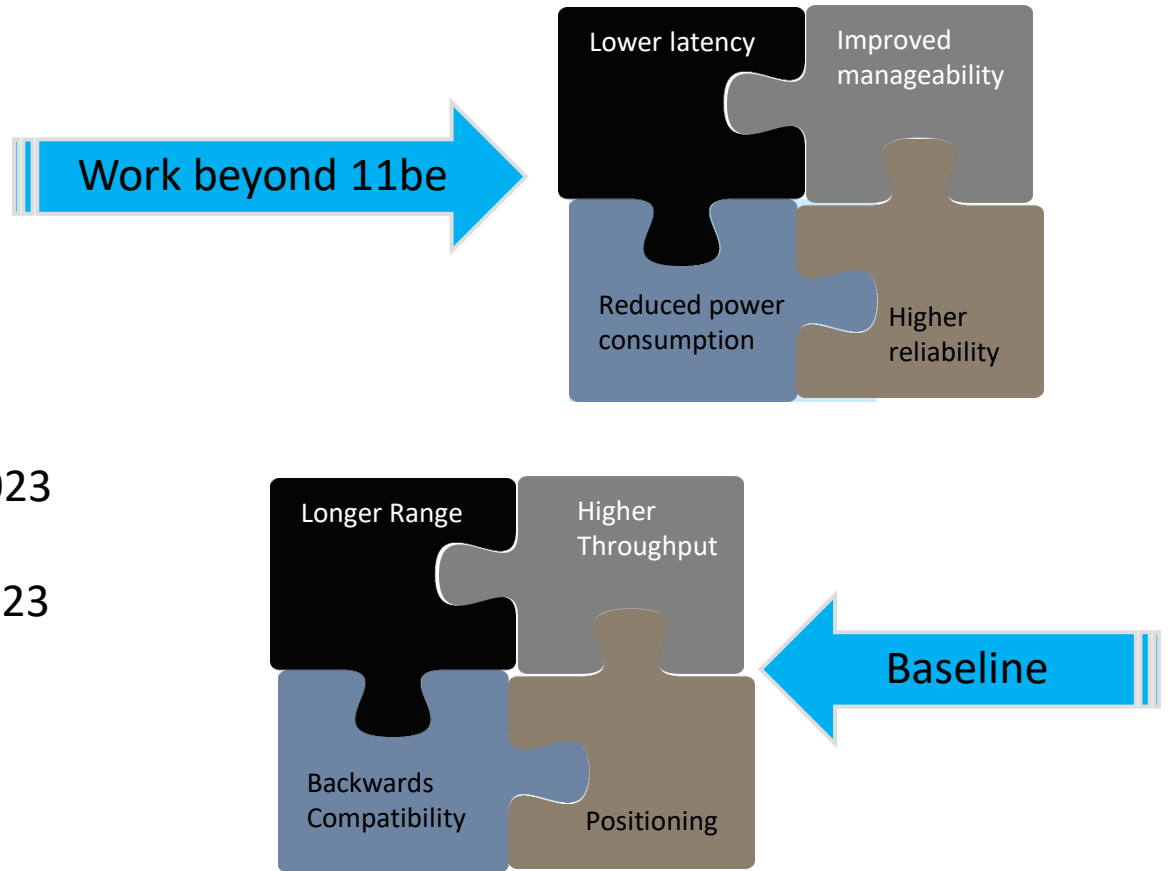
The Study Group will investigate technology to

improve reliability of WLAN connectivity,
reduce latencies,
increase manageability,
increase throughput including at different SNR levels, and
reduce device level power consumption

➡ Project Authorization Request approved in WG11 in March 2023

➡ The Task Group (for P802.11bn) to start work in November 2023

➡ March 2023: Also approved a Study Group to investigate Integrated Millimeter Wave, to begin in November 2023

Work beyond 11be

Lower latency | Improved manageability
Reduced power consumption | Higher reliability

Baseline

Longer Range | Higher Throughput
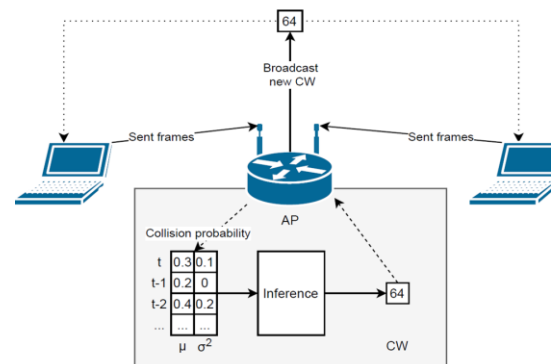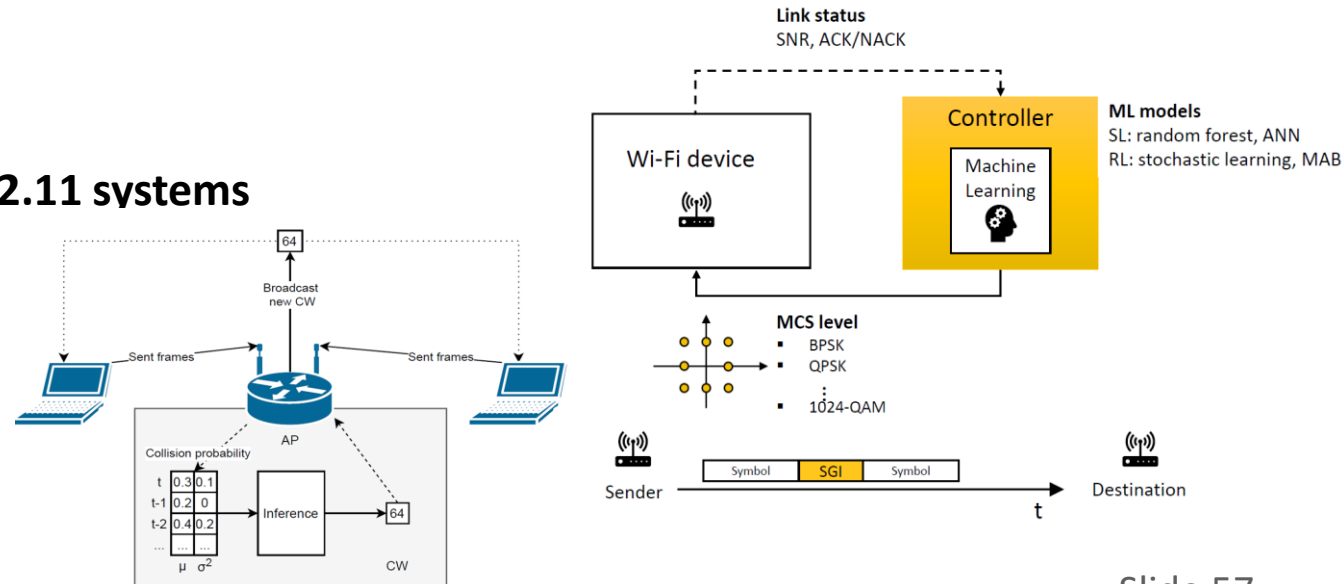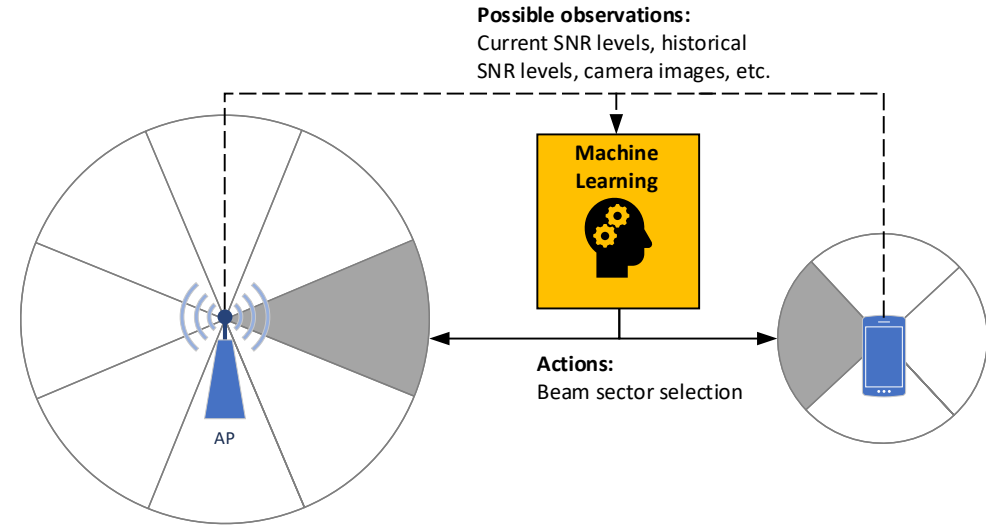Backwards Compatibility | Positioning

AIML TIG: Investigate WLAN support of Artificial Intelligence/ Machine Learning

Use of AIML for 802.11 applications is an active area of work in the research community. See **Applying ML to 802.11: Current Research and Emerging Use Cases**

Current applications focus on performance improvement parameter selection for channel access control and link adaptation, multi-user parameters, contention window sizes, channel usage, improved BSS transition

Work underway:
Describe use cases for AI/ML applicability in 802.11 systems
Investigate the technical feasibility of features enabling support of AI/ML.

Possible observations:
Current SNR levels, historical SNR levels, camera images, etc.

Machine Learning

Actions:
Beam sector selection

AP

Link status
SNR, ACK/NACK

Wi-Fi device

Controller

Machine Learning

ML models
SL: random forest, ANN
RL: stochastic learning, MAB

MCS level
- BPSK
- QPSK
- 1024-QAM

Sender

Symbol   SGI   Symbol

Destination

t

64

Broadcast new CW

Sent frames

Sent frames

AP

Collision probability

t	0.3	0.1
t-1	0.2	0
t-2	0.4	0.2
...	...	...
	μ	σ^2

Inference

64

CW

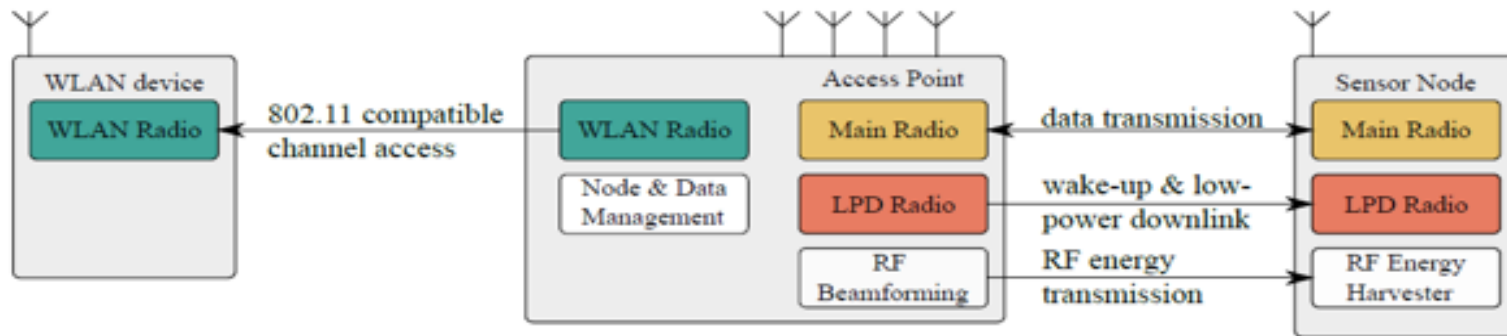# **AMP TIG/Study Group**: Investigate WLAN support of Ambient Power

Research into ambient power (energy harvesting) and prototype development has been ongoing using 802.11 based devices

Optimizing M2M Energy Efficiency in IEEE 802.11ah, IEEE GLOBECOM 2015
"the battery dependency of an 802.11ah sensor is significantly lowered by energy harvesting provided that the sensor size and energy harvesting efficiency are sufficient for the utilized ambient energy source."

Low-Power Downlink for the Internet of Things using IEEE 802.11-compliant Wake-Up Receivers, IEEE INFOCOM 2021

Use Cases include Smart Home, Logistics/Warehouse/Inventory, Industrial Wireless Sensor Networks

See https://mentor.ieee.org/802.11/dcn/23/11-23-0436-00-0amp-technical-report-on-support-of-amp-iot-devices-in-wlan.docx

June 2023

Completed: Meet expanding market needs and leverage new technologies

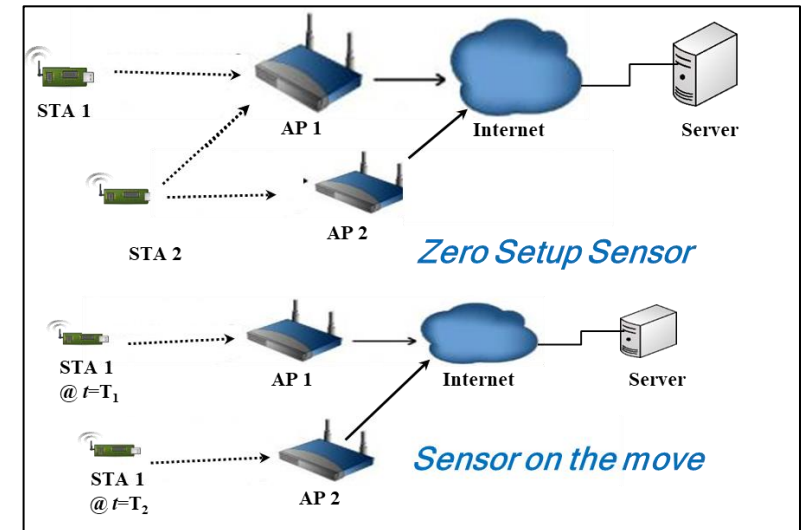802.11az – 2nd generation positioning features (Published 2023)

802.11bb – Light Communications (summer 2023 publication)

802.11bc – Enhanced Broadcast Service (summer 2023 publication)

802.11bd – Enhancements for Next Generation V2X (Published 2023)

See IEEE Webinar re: 802.11bb, 802.11bc

See Wi-Fi Now tutorial on 802.11az

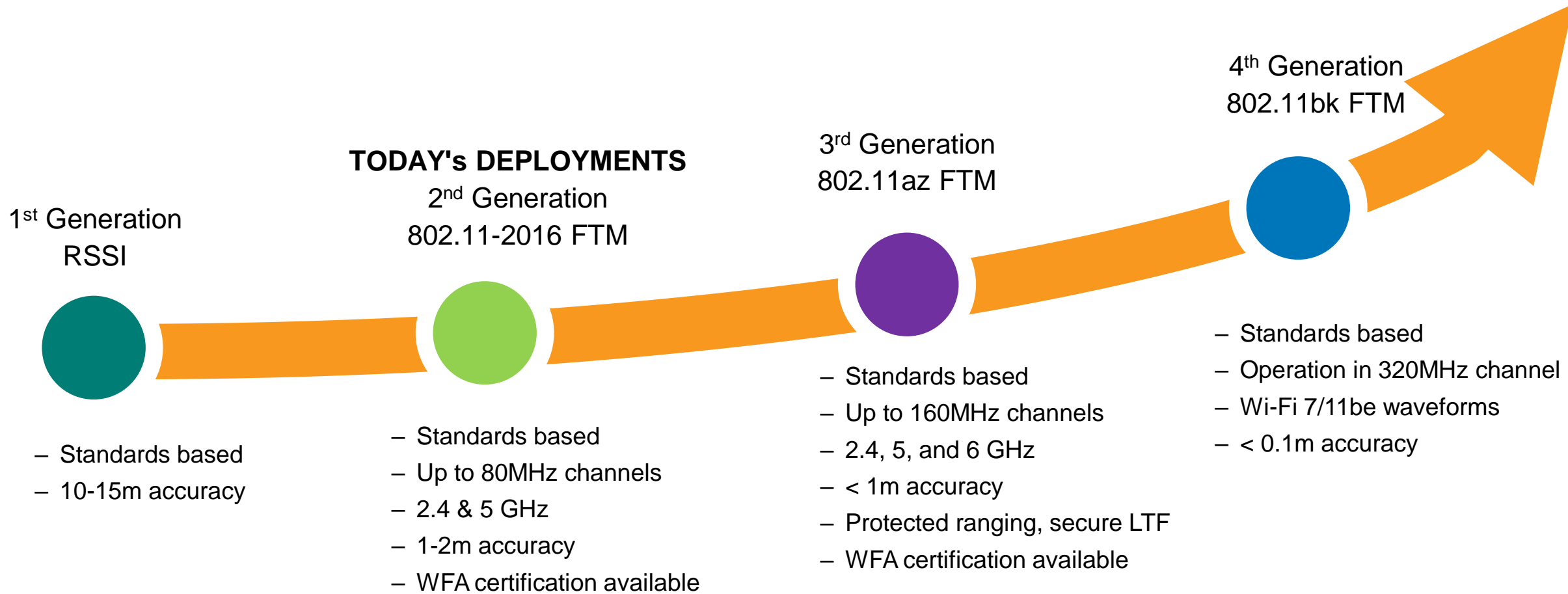# IEEE Std 802.11az-2022 Next Generation Positioning (published 3/23)

P802.11az project Next Generation Positioning extends accurate IEEE Std 802.11-2016 Fine Timing Measurement capabilities

- Accurate indoor Navigation (sub 1m and into the <0.1m domain).

- Enables self-locating networks for easy, fast and cost efficient WLAN deployment for navigation and 6GHz AFC operation.

- Secured (authenticated and private) positioning – open my car with my smartphone, position aware services (money withdrawal).

- Unlock computer with a wearable device, adapt TV content to audience presence.

- Location based link adaptation for home usages (connect to best AP).

- Navigate in extremely dense environments (stadium/airport scenarios).

# The Evolution of Wi-Fi Location-based Services

Each generation enables greater accuracy

1st Generation
RSSI

– Standards based
– 10-15m accuracy

TODAY's DEPLOYMENTS
2nd Generation
802.11-2016 FTM

– Standards based
– Up to 80MHz channels
– 2.4 & 5 GHz
– 1-2m accuracy
– WFA certification available

3rd Generation
802.11az FTM

– Standards based
– Up to 160MHz channels
– 2.4, 5, and 6 GHz
– < 1m accuracy
– Protected ranging, secure LTF
– WFA certification available

4th Generation
802.11bk FTM

– Standards based
– Operation in 320MHz channel
– Wi-Fi 7/11be waveforms
– < 0.1m accuracy

802.11bc Uplink broadcast use cases

Focus on unassociated stations

– Asset tracking

  – Inexpensive, low-power mobile tracker sends ping to a cloud server

    – Baggage tracking at airports

    – Inventory tracking in a warehouse

    – Parcel tracking

  – No association between tracker and serving AP(s)

– Zero-config, low-power sensors

  – sends data to a remote server

  – Headless IoT device

  – Zero setup (no association)
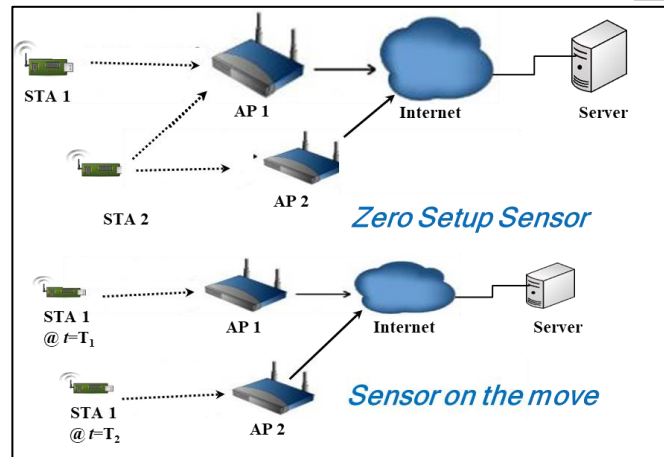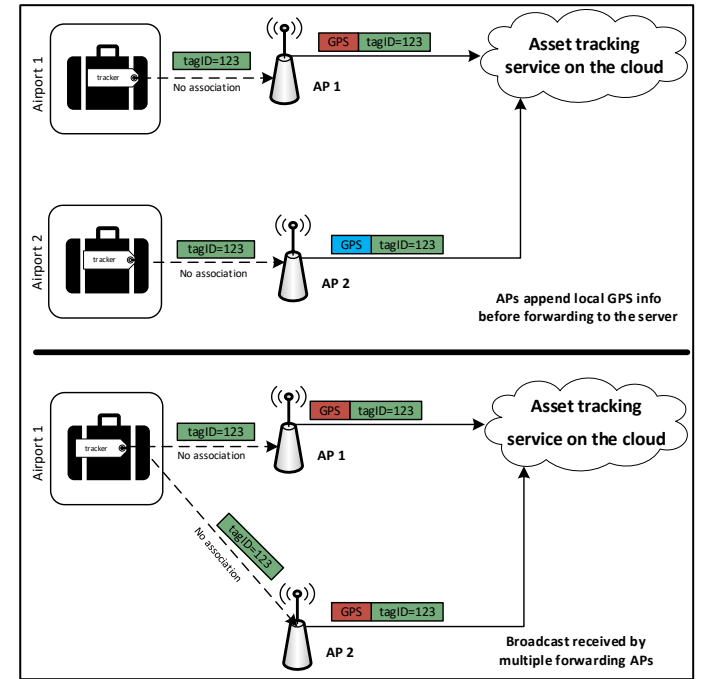
802.11bc enabled Uplink (UL) Relaying Service
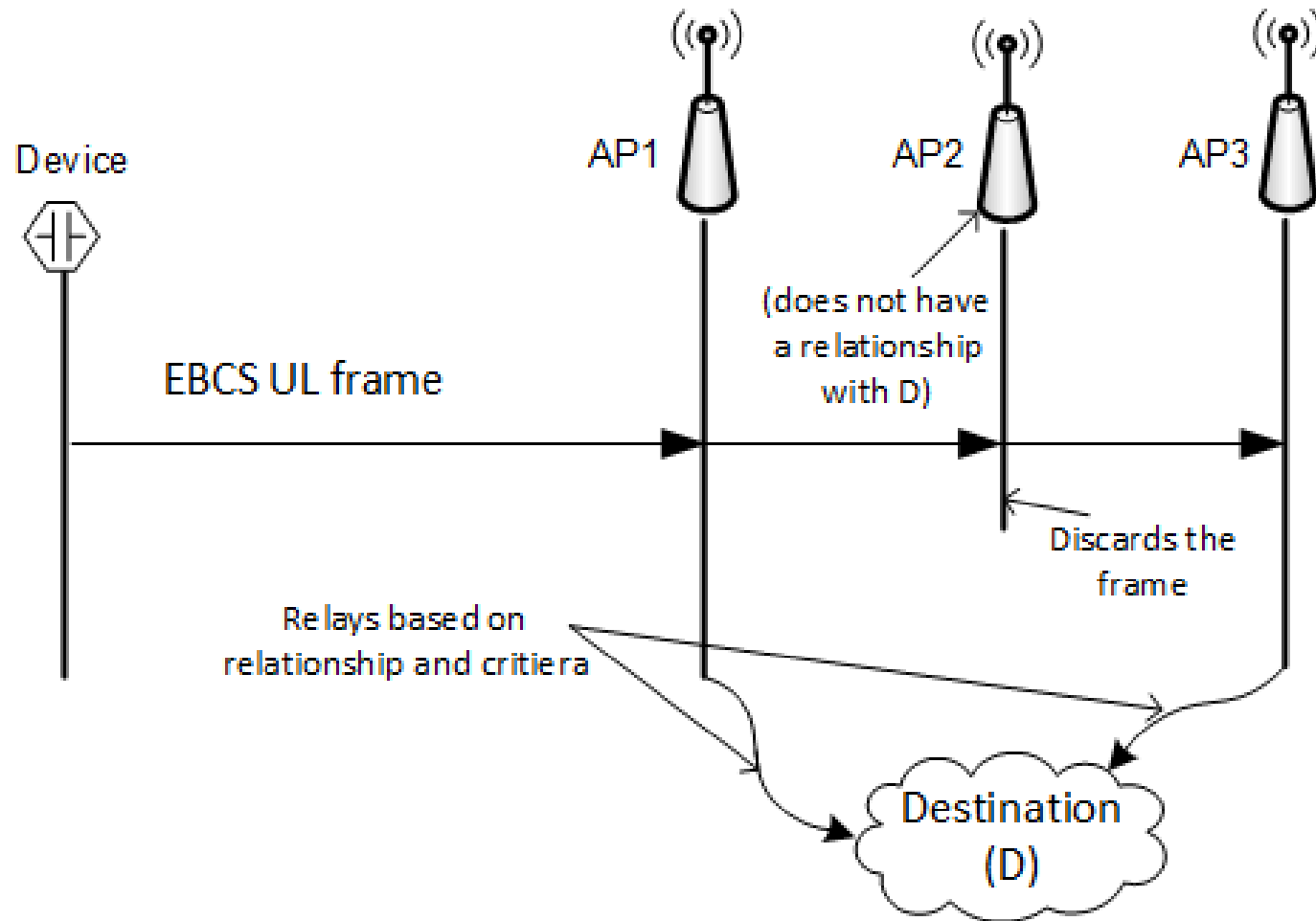
- The UL relaying service provides a means for a device to send short data to a cloud service without having to join an AP's network
  - The frame carrying the data is broadcasted by the device and includes the address of the destination, security parameters and ID of the device.

- The relaying service is best effort and is targeted to serve low-power low-cost devices
  - The transmitting device is not required to spend power in monitoring the wireless medium to determine if it is in range of any AP that can relay its data
  - In addition, a relay AP might not forward if the criteria for relaying are not met

Completed: 802.11bd Next Generation V2X Use Cases

5.9 GHz band mainly, and optionally 60 GHz; Completion in 2022, published 2023
http://www.ieee802.org/11/Reports/tgbd_update.htm
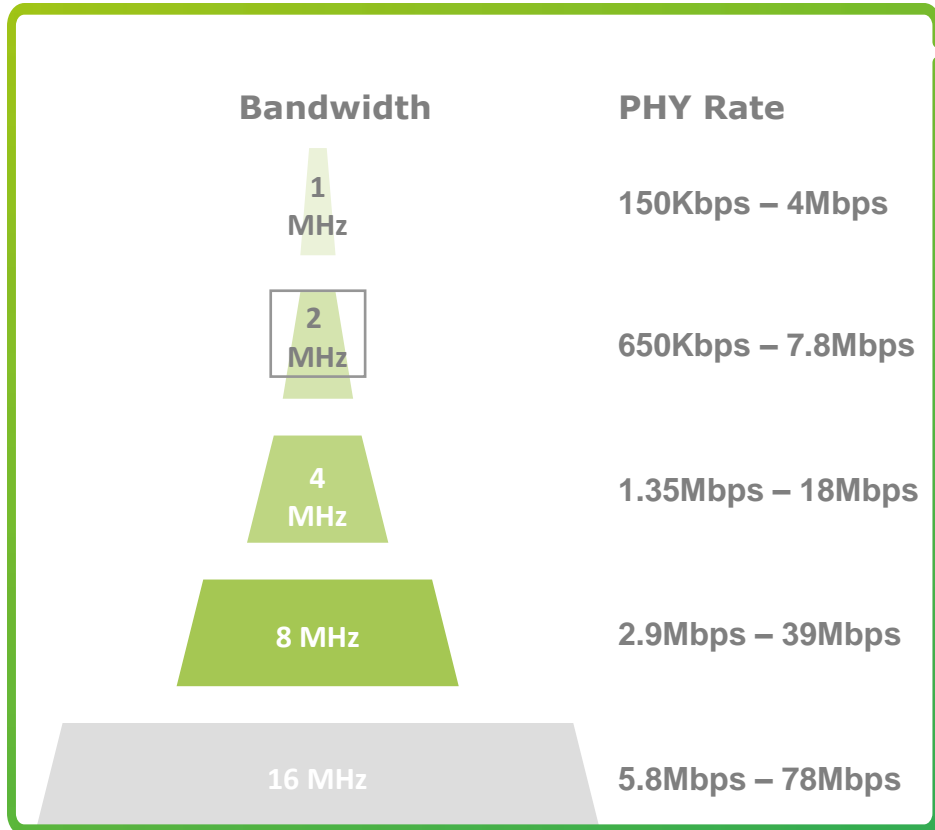
V2X Use Cases:
- Support all defined DSRC/802.11p use cases, including Basic safety message (safety, range, backward compatibility, fairness)
- Sensor sharing (throughput)
- Multi-channel operation (safety channel + other channels)
- Infrastructure applications (throughput)
- Vehicular positioning & location (LoS and NLOS positioning accuracy)
- Automated driving assistance (safety, throughput)
- Aerial vehicle IT application (video)
- Train to train (high speed)
- Vehicle to train (high speed, long range)

Key additions :
- Backward compatibility with 11p
- Higher throughput (2x) than 802.11p
- Longer range (3dB lower sensitivity level)
- Support for positioning

Slide 64

Completed: IEEE Std 802.11ah-2016 enables Wi-Fi for M2M and IoT applications with products now coming to market

Bandwidth	PHY Rate
1 MHz	150Kbps – 4Mbps
2 MHz	650Kbps – 7.8Mbps
4 MHz	1.35Mbps – 18Mbps
8 MHz	2.9Mbps – 39Mbps
16 MHz	5.8Mbps – 78Mbps

Long range indoor/outdoor connectivity up to 1 km

Robust connections for superior penetration through walls and other obstacles in home and industrial environments

Low power consumption for multi-year battery operation

Bidirectional monitoring and control of IoT client devices enable over the air software updates

Moderate data rates **support IETF TCP/IP, discovery protocols**

WFA **Wi-Fi Certified HaLow** certification program
Japan: **802.11ah Promotion Council**
New market entrants emerged to develop the technology

IEEE 802.11 based products are an essential component for connecting the unconnected: IEEE & ISOC Initiative for Building Wireless Community Networks (BWCN)

- *Use cases: Hotspot access, Community Wi-Fi using satellite, optical for backhaul*

- *Installation of the internet in 200 villages and Installation of 100 digital class across three states (Karnataka, Kerala and Bihar)*

  - Internet: will be provided to schools in the villages through service provider who can provide last mile connectivity Digital classroom : 65-inch touch screen which will run through Android and Windows, prefilled with global level syllabus and later state wise syllabus is installed in partnership with state government

- *BWCN course will be translated to 5 languages to benefit more people*

- *250 VLEs / VLTs (Village Level Technicians / Entrepreneurs) and 500+ junior technician will be trained extensively and the BWCN course, BLP platform will be used to deliver the training*

  - Entrepreneurs are trained to deploy, repair, troubleshoot internet so that they can reconnect internet service with the help of service provider after any disaster situation in the village

June 2023
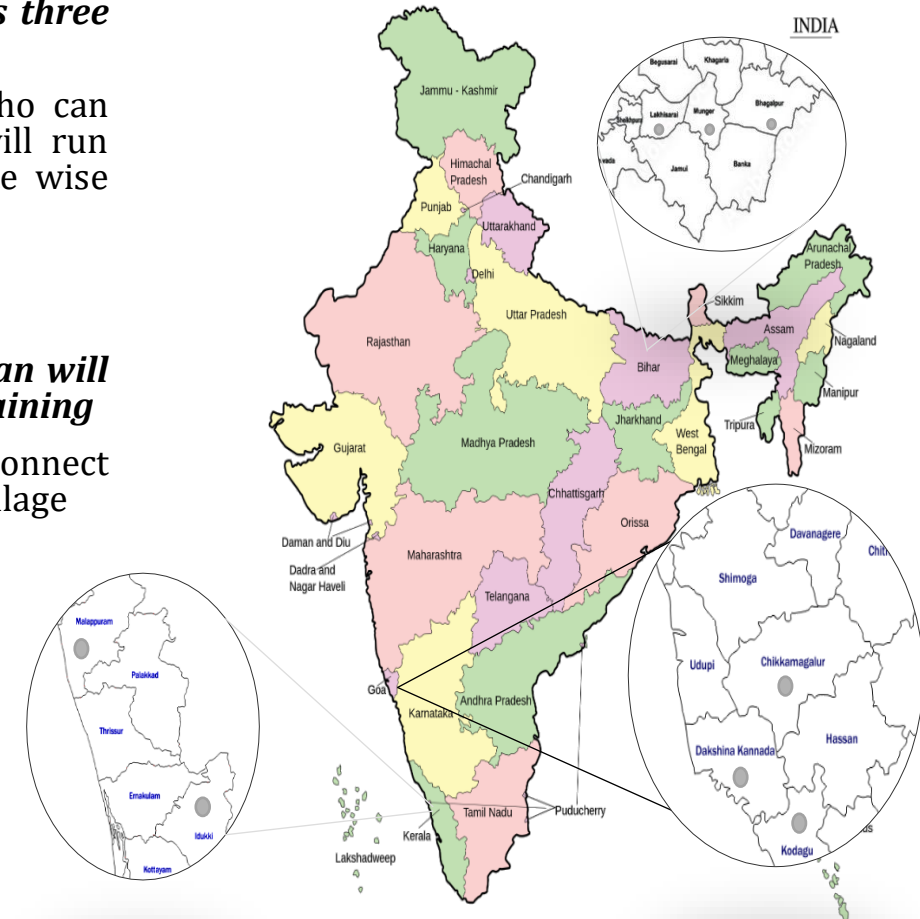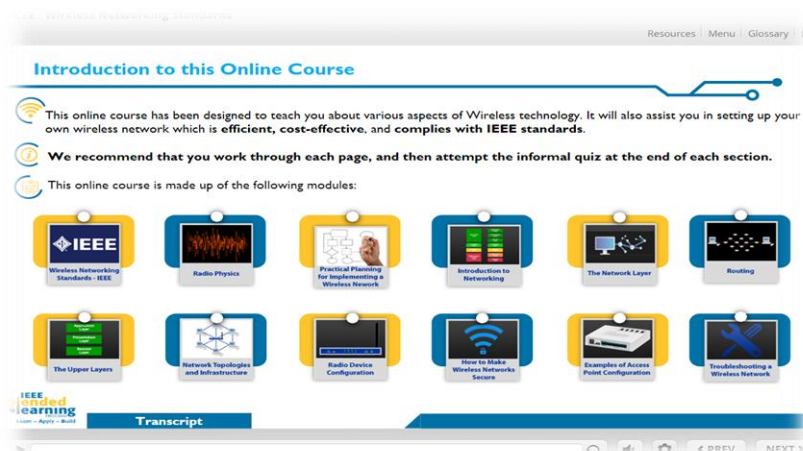
Wi-Fi evolution needs 1200 MHz of global harmonized 6GHz spectrum to support next generation use cases

– <u>Future connectivity</u> and <u>economic value</u> increase will depend on Wi-Fi 6E and Wi-Fi 7

– 6 GHz band is uniquely suited (no alternative) to support growing Wi-Fi spectrum needs

– Next use cases: immersive AR/VR/XR for training, industrial, telehealth, automation, 3-D video, also, critically, dense deployments

– Standard Power Devices with AFC is the most efficient and practical solution to deliver connectivity to underserved areas while coexisting with existing fixed services in the band.

– See https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e

The IEEE 802.11 standard continues to be enhanced to support innovative services and business models

IEEE 802.11 standard development

Defines Wi-Fi operation in sub 1GHz, 2.4, 5 and 6 GHz spectrum bands

Supports existing and new innovative services, business models, including 5G

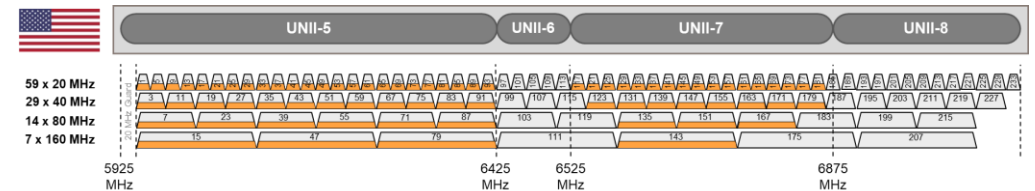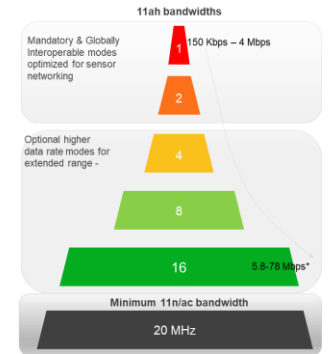Delivers significant economic value

Enables economic growth and societal development
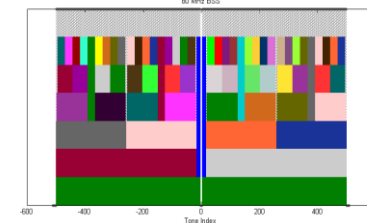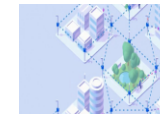
Power Saving
Scheduled sleep and wake times
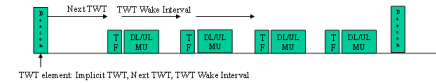
20 MHz-only clients

11ah bandwidths

THANK YOU
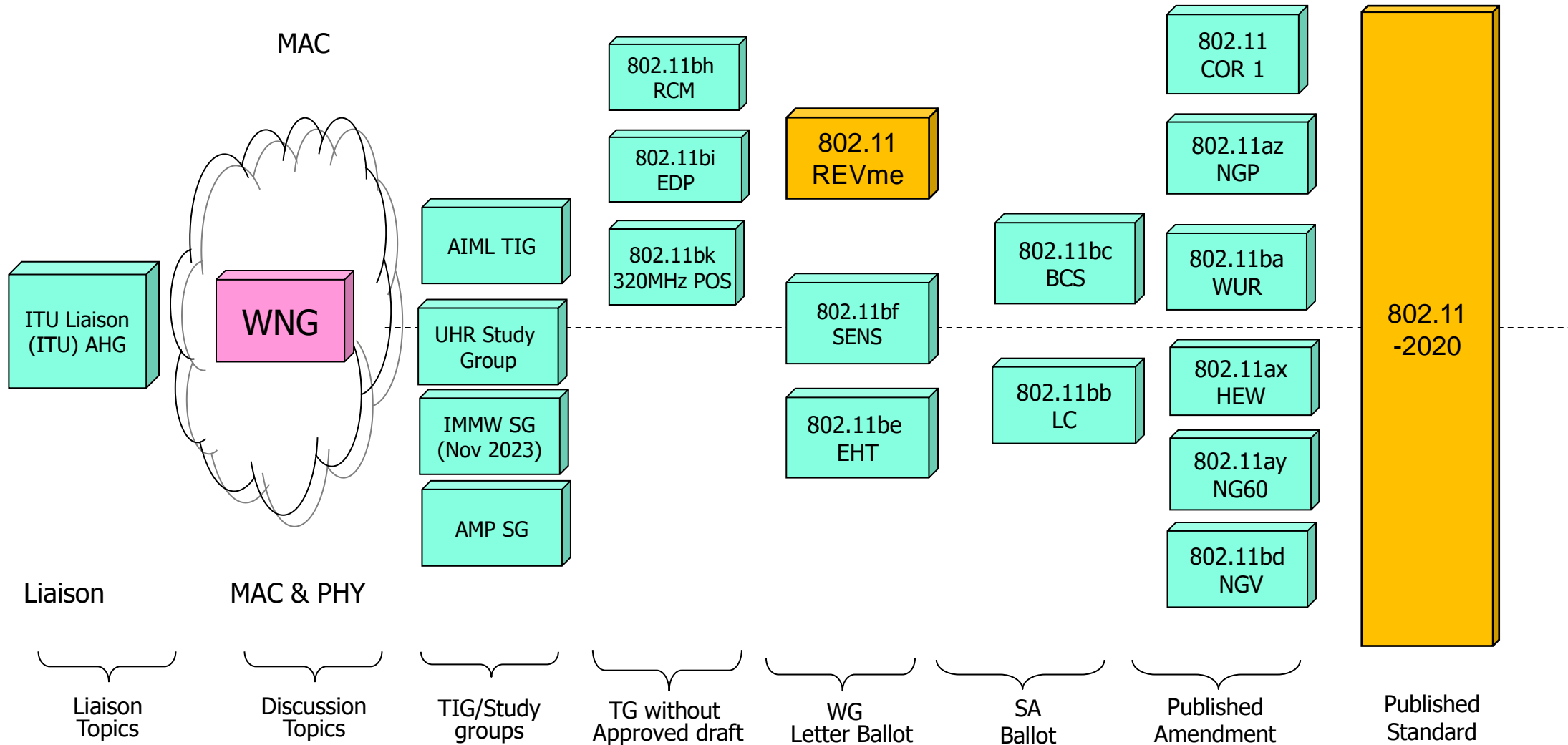

QUESTIONS

IEEE 802.11 Standards Pipeline/Roadmap

MAC

ITU Liaison (ITU) AHG

WNG

AIML TIG

UHR Study Group

IMMW SG (Nov 2023)

AMP SG

802.11bh RCM

802.11bi EDP

802.11bk 320MHz POS

802.11 REVme

802.11bf SENS

802.11be EHT

802.11bc BCS

802.11bb LC

802.11 COR 1

802.11az NGP

802.11ba WUR

802.11ax HEW

802.11ay NG60

802.11bd NGV

802.11 -2020

Liaison

MAC & PHY

Liaison Topics

Discussion Topics

TIG/Study groups

TG without Approved draft

WG Letter Ballot

SA Ballot

Published Amendment

Published Standard

June 2023

IEEE 802.11 Wi-Fi standard MAC/PHY evolution

802.11n (2009) Wi-Fi 4	802.11ac (2013) Wi-Fi 5	802.11ax (2021) Wi-Fi 6 6E	802.11be (est. 2024) Wi-Fi 7
• 2.4GHz and 5GHz supported • Wider channels (40MHz) • Better modulation (64-QAM) • Additional streams (Up to 4) • Backward compatibility with 11a/b/g • Standard supports up to 600Mbps	• 5GHz only • Wider channels (80, 160MHz) • Better modulation (256-QAM) • Additional streams (Up to 8, implemented up to 4) • Backward compatibility with 11a/b/g/n • Standard supports up to 7Gbps	• **2.4GHz, 5GHz and 6GHz supported** • Wider channels (80, 160MHz) • Better modulation (1024-QAM) • Additional streams (Up to 8, implemented) • Backward compatibility with 11a/b/g/n/ac • Standard supports up to 9.6Gbps	• **2.4GHz, 5GHz and 6GHz supported** • Wider channels (40, 80, 160, 240, **320MHz**) • Better modulation (**4096-QAM**) • Backward compatibility with 11a/b/g/n/ac/ax • Standard targets throughput minimum of 30Gbps, expect 40Gbps+

(Ratification date) Products available in the market typically ~2 years prior

June 2023

IEEE 802.11ax meets the MAC/PHY requirements for 5G IMT-2020 Indoor Hotspot and Dense urban test environments defined by ITU-R

Simulation conforming to the ITU-R evaluation methodology shows that performance of IEEE 802.11ax systems meet or exceed MAC and PHY requirements for the 5G Indoor Hotspot and Dense Urban test environments

	Metric (Indoor Hotspot)	ITU-R Evaluation Method	Minimum Requirement	802.11ax Performance
1	Peak data rate	Analytical	DL/UL : 20/10 Gbps	DL/UL : 20.78 Gbps
2	Peak spectral efficiency	Analytical	DL/UL : 30/15 bits/s/Hz	DL/UL : 58.01 bits/s/Hz
3	User experienced data rate	Analytical for single band and single layer; Simulation for multi-layer	Not applicable for Indoor Hotspot	Not applicable
4	5th percentile user spectral efficiency	Simulation	DL/UL : 0.3/0.21 bits/s/Hz	DL/UL : 0.45/0.52 bits/s/Hz
5	Average spectral efficiency	Simulation	DL/UL : 9/6.75 bits/s/Hz/TRxP	DL/UL : 9.82/13.7 bits/s/Hz/TRxP
6	Area traffic capacity	Analytical	DL : 10 Mbit/s/m^2	Required DL bandwidth = 170 MHz with 3 TRxP/site
7	Mobility	Simulation	UL : 1.5 bits/s/Hz	UL : 9.4 bits/s/Hz
8	Bandwidth	Inspection	100 MHz, scalable	20/40/80/80+80/160 MHz
9	User plane latency	Analytical	DL/UL : 4 ms	DL/UL : 80 us

Useful Links

- 802 home page: http://www.ieee802.org/

- 802.11 home page: http://ieee802.org/11/

- Help if you want to contribute: http://www.ieee802.org/11/help.html

- 802.11 document server: https://mentor.ieee.org/802.11/documents

- Wi-Fi Alliance http://www.wi-fi.org/

- Get 802.11 standards:
  - http://standards.ieee.org/about/get/802/802.11.html
  - http://www.techstreet.com/ieee

Time	Presentation
11.40 AM (PST)	**Neutral Host For Sustainable And Equitable Growth** Andy Penley, Group SVP, Global RAN Solutions VP Wireless Solutions, Zenfi Networks (a Boldyn Company)
12:05 PM (PST)	**Digital Equity in Emerging Markets** Ellie de Villiers, Group Head of Affordable Access Initiatives, Liquid Intelligent Technologies.
12:20 PM (PST	**Fireside Chat** Irvind Ghai, Vice President, Silicon Labs with Tiago Rodrigues, President & CEO, Wireless Broadband Alliance;
12:40 M (PST)	**Priority Telecommunications Services (PTS)** Frank Suraci, Senior Advisor, NS/EP Communications, Cybersecurity and Infrastructure Security Agency
10:10 AM (PST)	**Session Close** Tiago Rodrigues, President & CEO, Wireless Broadband Alliance
12:55 PM (PST)	**LUNCH & NETWORKING**

The unrelenting demand
for high-quality, always-on
connectivity is here to stay.

Over the last decade, we've
made progress towards
digital equity, but we have
a long way to go.

Wireless demand driving fiber demand

91%

people believe all world-class cities should have seamless mobile coverage above and below ground[1]

1. Respondents to the 2021 BAI Connectivity Outlook Report

Seamless mobility requires a seamless fixed/wireless approach

As the demand for small cells grows, so does accessibility to fiber through existing city ducting

SUSTAINABLE NETWORK GROWTH

LONG-TERM INVESTMENT HORIZON

COMMITTED FINANCIAL BACKER

MULTI-DECADE COMMITMENT TO CITIES

MULTIPLE GENERATIONS OF TECHNOLOGY

SINGLE SHARED NETWORK

Impact on equitable access?

33% of New York City households lack the combination of home and mobile broadband.

More than **18%** – lack both.

Holistic approach to infrastructure

Providing equitable access

Equally available to all providers and their customers

Available to local governments for private ISP's

Partnerships with local community advocates

Leading edge technology

Sustainable deployment

Scalable connectivity

Multi-Network Operator capability

Connectivity for underserviced communities

Smart city solutions

Integrated citywide network

IoT

Robust fiber backbone for local businesses

Public safety using enhanced data and connectivity

Speed to market

Carriers can tap into existing networks

Unlocks reach to new customers

Flexible funding models

New revenue

Shared Cost Model

Asset Monetization

Revenue share with municipalities, agencies, or authorities

LinkNYC provides free, equitable access to connectivity, information, and telecommunications services

High-speed, free public Wi-Fi throughout NYC

Free nationwide digital calling

- 911 / 311 access
- Access to all social services hotlines
- Video-relay service for deaf and hard-of-hearing community

Access to government and social services websites

Advertising space for the City, community information, and local businesses
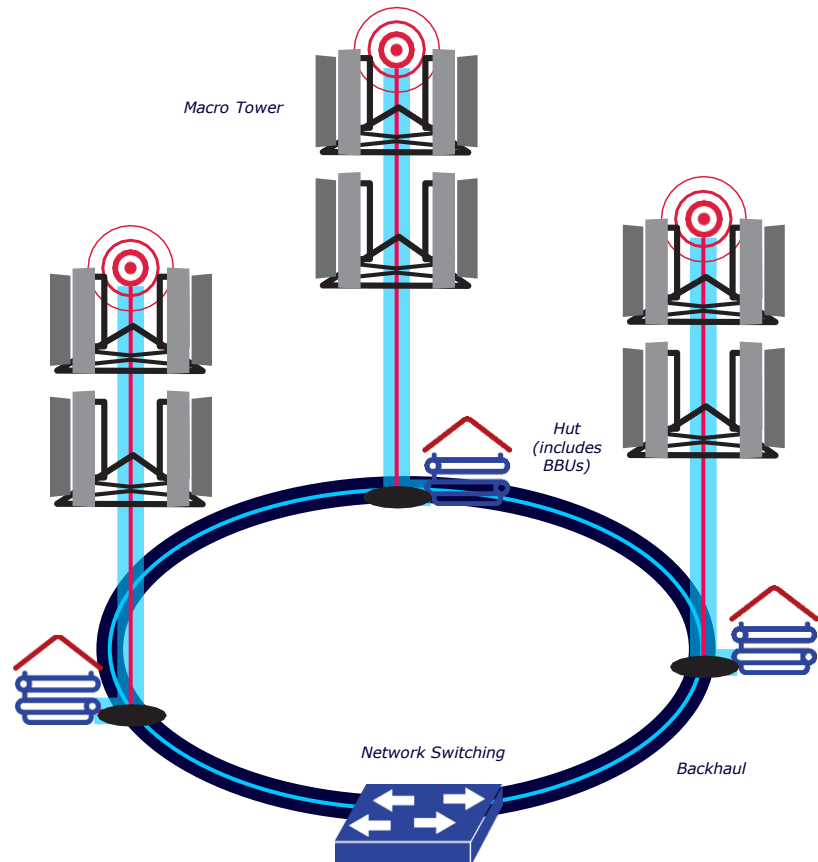
USB port for free charging of mobile devices

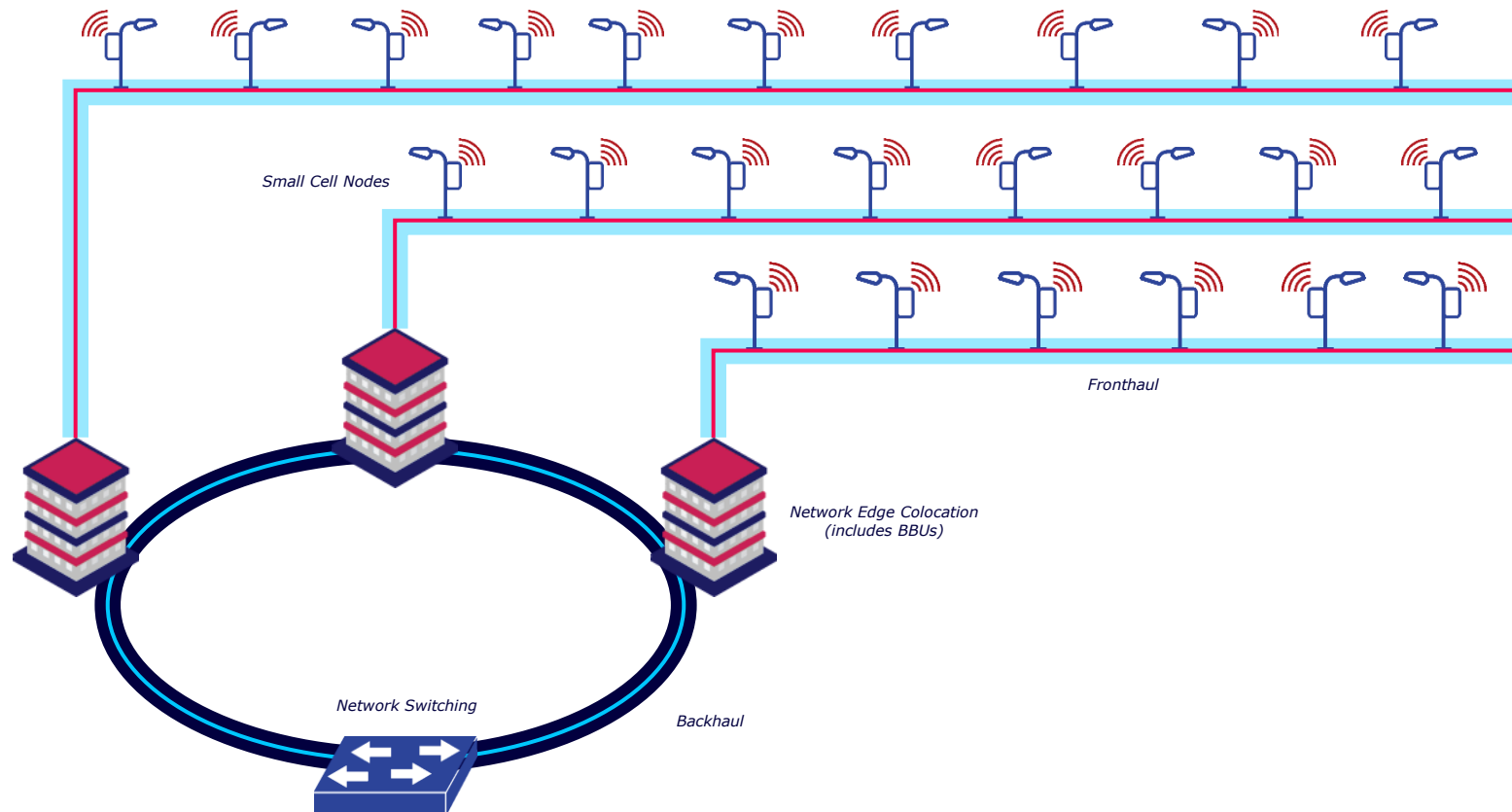NYC Information Technology & Telecommunications

C-RAN mobile network architecture

Due to the use of higher frequency spectrum, 5G will drive the transition from the traditional sparsely distributed, macro-focused model to the densely distributed small cell model which will advantage easily accessible fiber networks

Traditional Mobile Network Architecture

C-RAN Mobile Network Architecture

Macro Tower

Hut (includes BBUs)

Network Switching

Backhaul

Small Cell Nodes

Fronthaul

Network Edge Colocation (includes BBUs)
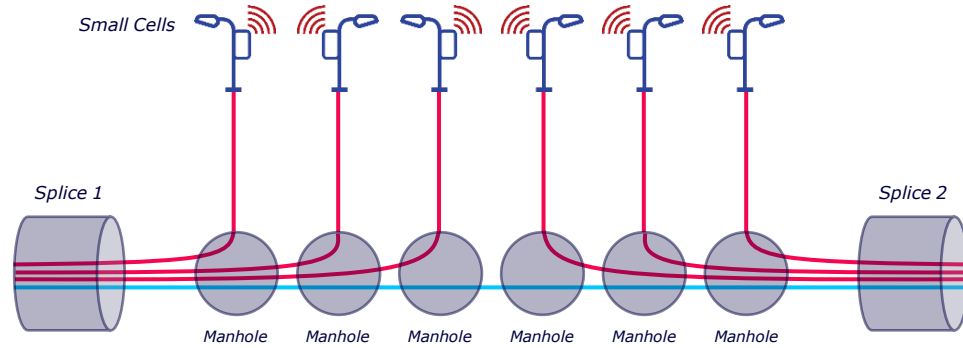
Network Switching

Backhaul

Fronthaul network

Our fronthaul fiber network is solves the unique cost and duct capacity challenges faced in ultra-dense urban underground networks. Delivering fiber connectivity wherever next generation wireless network operators require.

Legacy Network Architecture

Small Cells

Splice 1   Splice 2

Manhole   Manhole   Manhole   Manhole   Manhole   Manhole

Fiber Backbone   Lateral

Boldyn Networks Fronthaul Network Architecture

Small Cells

Splice 1   Splice 2

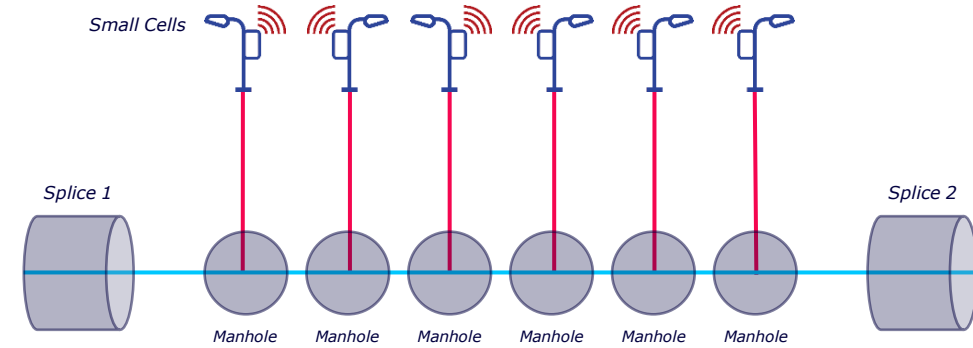Manhole   Manhole   Manhole   Manhole   Manhole   Manhole

ARCHITECTURE
Legacy networks contain limited access points, making the connection of densely distributed wireless sites both complicated and expensive.

COST
Given limited access points, legacy networks require long, expensive laterals back to the nearest fiber splice point in order to connect to the network backbone.

ARCHITECTURE
Boldyn has installed a microduct system which enables splicing at any manhole that the network traverses, providing ubiquitous accessibility across its footprint.

COST
The microduct network design allows Boldyn to connect to wireless nodes at a fraction of the time and cost (10%+ opex and 60%+ capex savings) of its competitors.

Link5G design expands broadband accessibility

Millimeter Wave Bay for Operator 1 Ultra-Fast 5G Service	Ultra-Fast 5G Services from multiple providers, giving NYers freedom of choice and the fastest possible wireless services
Millimeter Wave Bay for Operator 2 Ultra-Fast 5G Service	Ultra-Fast 5G Services from multiple providers, giving NYers freedom of choice and the fastest possible wireless services
Sub 6 GHz Shared Bay for 4G LTE + 5G for additional coverage and capacity for CBRS and/or IOT to support neutral host providers and technologies	Coverage and capacity at Sub 6GHz bands, increasing reliability and number of NYers served from a single site, while alternative technology offerings increase competitive landscape and open doors to alternative wireless providers
Optimized WiFi structure and siting locations improve coverage and performance of free public gigabit WiFi	Improved free public WiFi Service
Operator Equipment	Safe, secure, efficient use of space to house required radio equipment concealed from view
LinkNYC Wireless Services Equipment, Pole controls and connection to fiber and power	Provides critical public City services
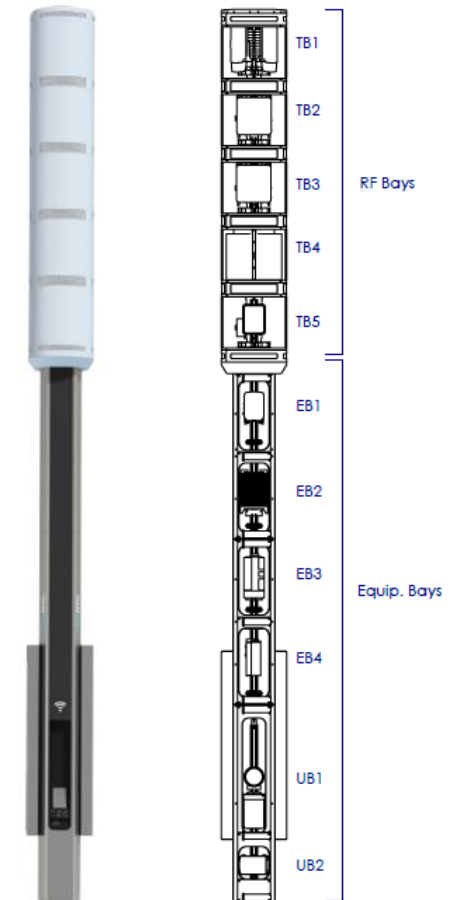
FRONT VIEW
(SHROUDS HIDDEN
FOR CLARITY)

Below ground fiber infrastructure that can be used by other carriers to deliver connectivity throughout NYC

THE NEXT EVOLUTION- SHARED DIGITAL INFRASTRUCTURE

UBIQUITOUS COVERAGE

_____

ULTRA DENSE

_____

DEMOCRATIZED SPECTRUM

_____

COMPLETE CONTROL FOR MNO ACROSS NEUTRAL RAN

5G ADOPTION
+ FIBER ADOPTION
+ NEUTRAL HOST

= **INTERCONNECTED FUTURE**

UNLOCK THE POWER OF AN INTERCONNECTED FUTURE

boldyn
NETWORKS

What is digital equity?

Three-legged stool

Access
- Is there access?
- What is broadband?
- Can customers afford it?

Devices
- Do people have devices?
- Is there power to recharge?

Skills
- Do people know how to use devices?
- Can people use the internet, safely?
- Can businesses find the right skills?

LIQUID
INTELLIGENT TECHNOLOGIES

Digital Skills and Education

- Low-cost connectivity to innovation hubs and other entrepreneur support organizations; focus on rural hubs

- Partnerships with local ed tech companies to provide hyper-local relevant solutions

- Developed a tech skills program for post-secondary graduates; 7,000+ trained so far in data analytics, cloud, and AI

LIQUID
INTELLIGENT TECHNOLOGIES

Liquid Access Initiatives

- 5,000+ schools connected (target: 145,000)
- Nearly 2,000 community anchor institutions in South Africa
- Reaching the last mile through partnerships & innovation
- Aggregation POC planned
- Key partners include Microsoft, UNICEF, and the ITU

https://schools.liquid.tech/

LIQUID
INTELLIGENT TECHNOLOGIES

Public Wi-Fi Best Practices

- Clear and researched customer value proposition

- Put the Wi-Fi where people dwell

- Ensure sufficient density

- Design for the entire customer journey

- Make sure people know about the network

LIQUID
INTELLIGENT TECHNOLOGIES

Implications

## Consider emerging markets in the design process

Access

- Does the design assume users have unlimited bandwidth vs pay-as-you go?

- Does the design presume users have high speed broadband?

Devices

- How flexible are the low-power options in my device?

Skills/Usage

- Is the design able to be localized?

- What's the balance between learnability and usability?

- Have I considered the safety and onboarding of users relatively new to the internet?
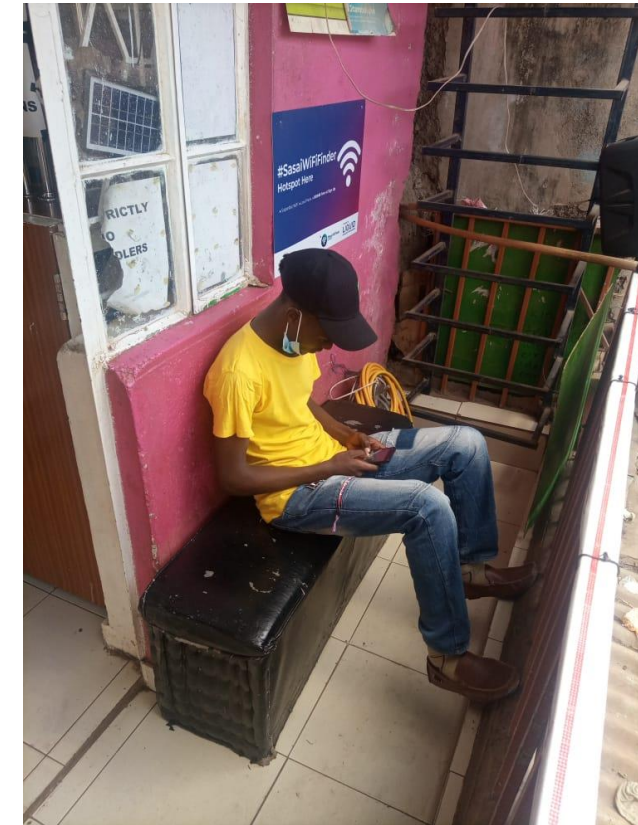
LIQUID
INTELLIGENT TECHNOLOGIES

THANK YOU

PRIORITY TELECOMMUNICATIONS SERVICES (PTS)

Emergency Communications Division (ECD)

Agenda

- Introduction

- Priority Telecommunications Services in the USA and Other Countries

- Priority Telecommunications Services Providers

- Future Plans

National Security and Emergency Preparedness (NS/EP) Communications: Authority/Policy

- In the United States, government directions provide the authority and lay the policy groundwork for NS/EP communications

  - Executive Order 13618, Assignment of National Security and Emergency Preparedness Communications Functions, 6 July 2012

  - Presidential Policy Directive 40, National Continuity Policy, 15 July 2016

  - OSTP/OMB Directive D-16-1, Minimum Requirements for Federal Executive Branch Continuity Communications Capabilities, 15 December 2016

Executive Order 13618

"The Federal Government must have the ability to communicate at all times and under all circumstances to carry out its most critical and time sensitive missions … ensure national security, effectively manage emergencies, and improve national resilience."

"The Secretary of Homeland Security shall:

- oversee the development, testing, implementation, and sustainment of NS/EP communications, …

- incorporate, integrate, and ensure interoperability and the necessary combination of hardness, redundancy, mobility, connectivity, interoperability, restorability, and security to obtain, to the maximum extent practicable, the survivability of NS/EP communications

- satisfy priority communications requirements through the use of commercial, Government, and privately owned communications resources, when appropriate …"

Presidential Policy Directive 40 (PPD-40)

"Priority commercial communications services shall provide priority access and routing for user-to-user voice, data, and video communications and information services on commercial and Federal wireline and wireless networks."

"The Secretary of Homeland Security shall:

- In coordination with the Secretary of Defense and the Chairman of Federal Communications Commission, ensure the continuous availability for key leadership and critical continuity personnel of priority access and routing of voice, data, video, and information services, as well as priority restoration and emergency provisioning capabilities on commercial and Federal wired and wireless communications networks; …"
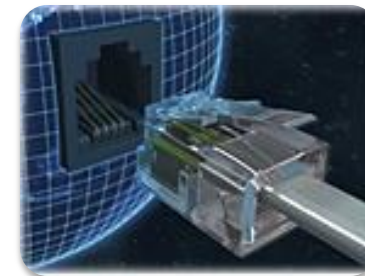
NS/EP Communications Overview
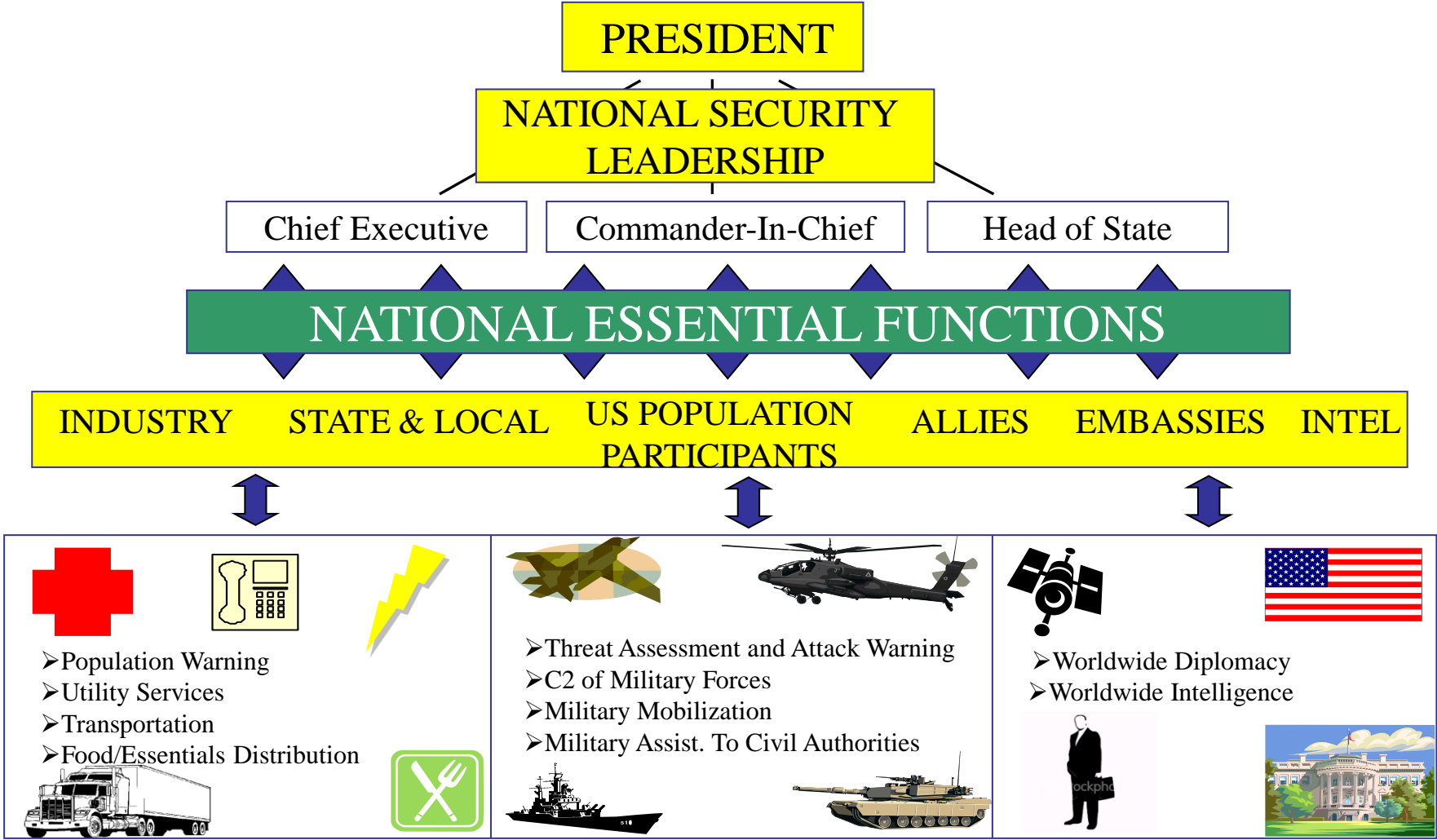
Priority Services in the USA

- Emergency Telecommunications Service (ETS) specified in [ITU-T E.107]: A national service, providing priority telecommunications to the ETS authorized users in times of disaster and emergencies (e.g., floods, earthquakes, hurricanes, terrorist attacks)

- In United States, DHS/CISA/ECD Priority Telecommunications Services (PTS) programs provide national security and emergency preparedness (NS/EP) and public safety users the ability to communicate on telecommunications networks during times of congestion

  - Government Emergency Telecommunications Service (GETS)

  - Wireless Priority Service (WPS)

  - Next Generation Network Priority Services (NGN Priority Services)

  - Telecommunications Service Priority (TSP)

Government Emergency Telecommunications Service

John Smith
Department of Defense

Dial Access Number: **1-710-627-4387**
After Tone, Enter PIN: ********
When Prompted, Dial: **Area Code + Number**

NS/EP Priority Services Programs

NS/EP priority services are subscription based, operator managed, enabled through global Standards, and are offered over commercial network infrastructure. There is a growing need for priority support for next generation services on Wi-Fi access networks.

GETS

Landline Phone   **Satellite Phone**

- Operational since 1994

- Calling Card service

- Accessible from any domestic or international PSTN phone.

WPS

Cell Phone

- Operational since 2002

- Accessible from a WPS subscribed phone of a participating carrier by dialing *272 + Destination Number

NGN PRIORITY

IP Networks

- Priority Voice (VoIP)
  Core Operational from : 2014
  Wireless Access from : 2017
  Wireline Access from: 2020

- Priority Data, Video and Information Services (e.g., Multimedia Priority Service (MPS) in 5G, Wi-Fi): Planning Stage
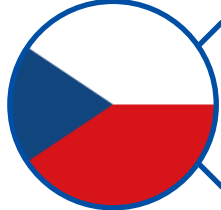
Operational Concept
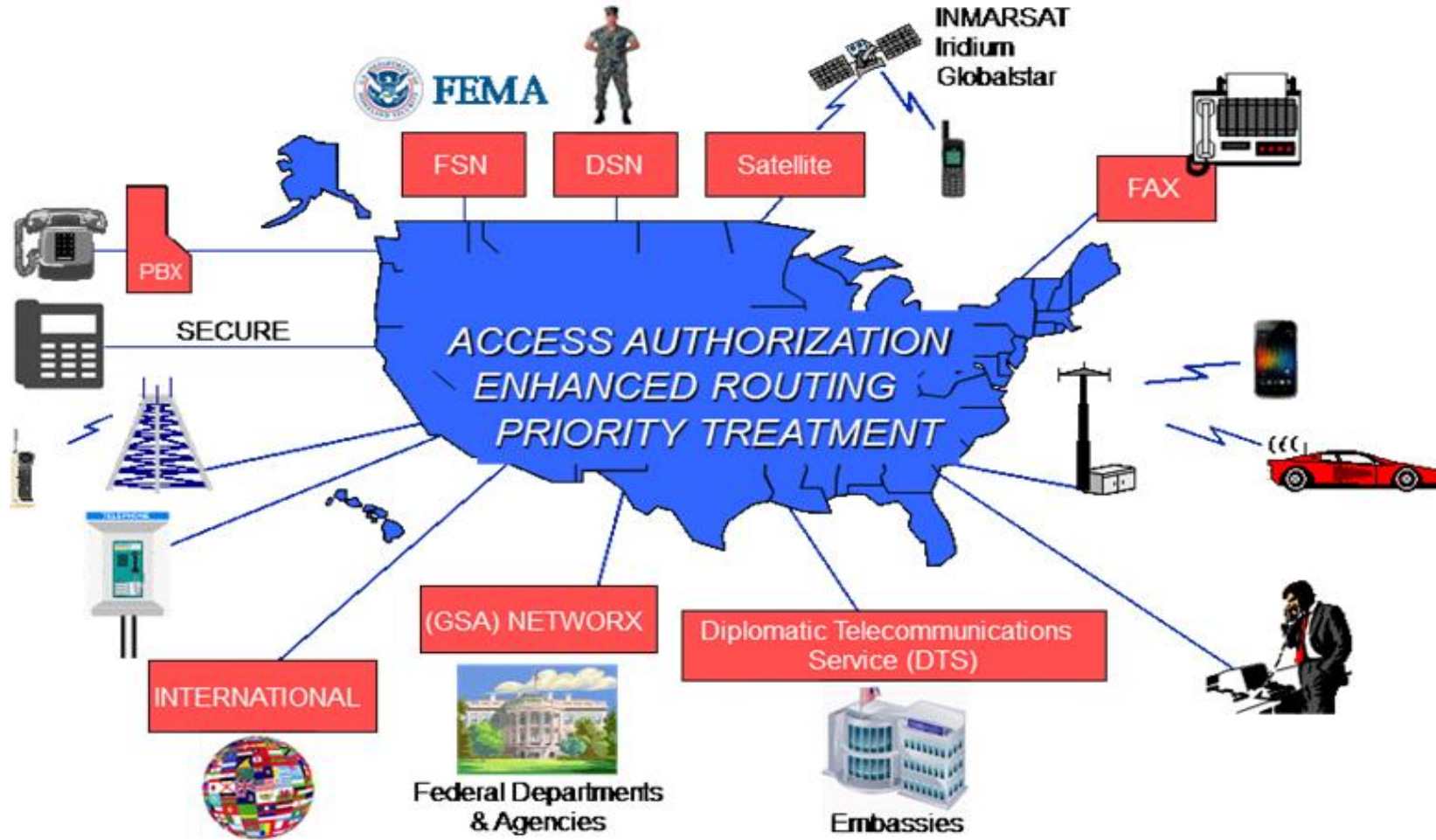
* Wi-Fi is being added in this Ops Concept

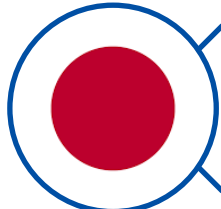# Priority Services in Other Countries

Blue Light Mobile

Mobile Crisis Communications

Mobile Telecommunications Access Scheme

Disaster Priority Telephone (優先電話)

Wireless Priority Services

WPS Providers and Coverage

CARRIER/ REGION	AT&T MOBILITY	FIRSTNET [NPSBN]	T-MOBILE	VERIZON WIRELESS	REGIONAL CARRIERS
CONUS (Mainland USA)	YES	YES	YES	YES	C Spire U.S. Cellular
Alaska	YES	YES	YES	YES	
Hawaii	YES	YES	YES	YES	
Puerto Rico	YES	YES	YES	No WPS Service	Claro-PR
Virgin Islands	YES	YES	Roams onto AT&T	No WPS Service	

WPS Full Operational Capability on VoLTE

AT&T	✓
verizon	✓
T··Mobile·	✓
U.S. Cellular	
Claro	

Our Vision

- To realize Next Generation Network - Priority Services: VoIP, Data, Video and Information Services over cellular, Wi-Fi, and wireline broadband networks (e.g., cable, FiOS)

  - VoIP priority over major US Service Provider's core networks is completed

- To allow NS/EP users roam seamlessly between heterogeneous access networks (e.g., cellular and Wi-Fi)

- To extend priority to Wi-Fi capable mobile devices (laptops, smartphones, IOT devices, etc.)

- To expand the NS/EP user base to 10 million by 2033

Why are Wi-Fi Access Networks Critical for NS/EP?

- In many situations, Wi-Fi access networks are best/only access option available to NS/EP community for communications

  - Situations where cellular networks are not available, or are temporarily unavailable

    - Uncovered regions (e.g., rural areas)

    - Shielded spaces (e.g., building interiors)

  - Circumstances where Wi-Fi offers best capacity

  - Wi-Fi networks are integral part of next generation (e.g., 5G/6G) networks

Progress in supporting Priority in Wi-Fi

- What has been accomplished to date

  - NS/EP priority access features (a.k.a. Emergency Preparedness Communications Service (EPCS) are specified in IEEE 802.11be

  - The Wi-Fi Alliance included EPCS features in Wi-Fi 7 program

- What needs to happen

  - Availability of certified Wi-Fi 7 products that support EPCS

  - Readiness of Service Provider Networks for supporting Wi-Fi priority

  - Solutions for Wi-Fi priority access authorization and roaming

Next Step

- Work with the WBA to realize the goals of seamless priority access over Wi-Fi networks

This will allow DHS to meet its mission requirements in Executive Order 13618

Resources

- GETS webpage: www.cisa.gov/gets

- WPS webpage: www.cisa.gov/wps

- TSP webpage: www.cisa.gov/tsp

- CISA BLOG:

The Next Frontier in Priority Services Capabilities: Multimedia Applications And Information Services Over Wi-Fi, Cellular, and Cable Networks | CISA

Questions?

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