Piedmont Chapter Technical Training

Current state of Wi-Fi

Agenda

- Wireless and the MSOs
  - Opportunities, Challenges
- IEEE 802.11 Standards and Wi-Fi Alliance Activity
- Other Wi-Fi related innovations

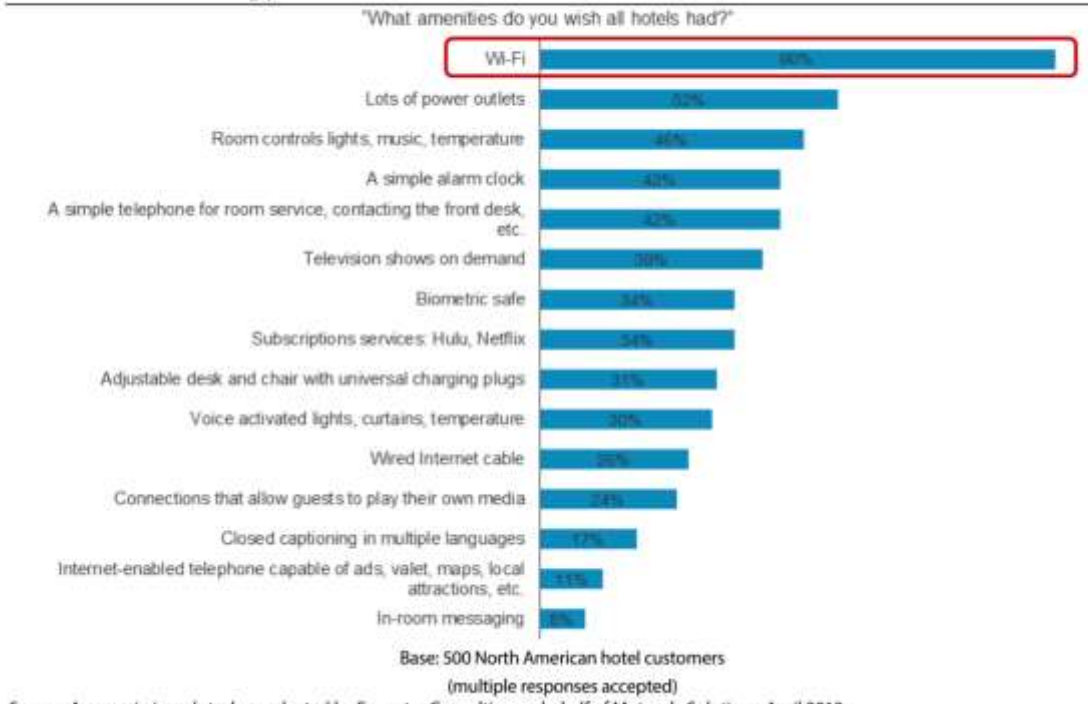
The current state of Wi-Fi

- Wi-Fi has gone from a nice-to-have to a must-have technology for many consumers
- Wi-Fi has gone from a personal technology (me, in my house) to one used to provide a service to customers (MSOs in the lead here, with community deployments, MDU solutions, etc.)
  - Wi-Fi First service providers are the other good example
- Wi-Fi has gone from a data-oriented technology to one offering a complete range of services (e.g Wi-Fi Calling)

Everybody wants Wi-Fi
(I probably don't need to convince you of this.)

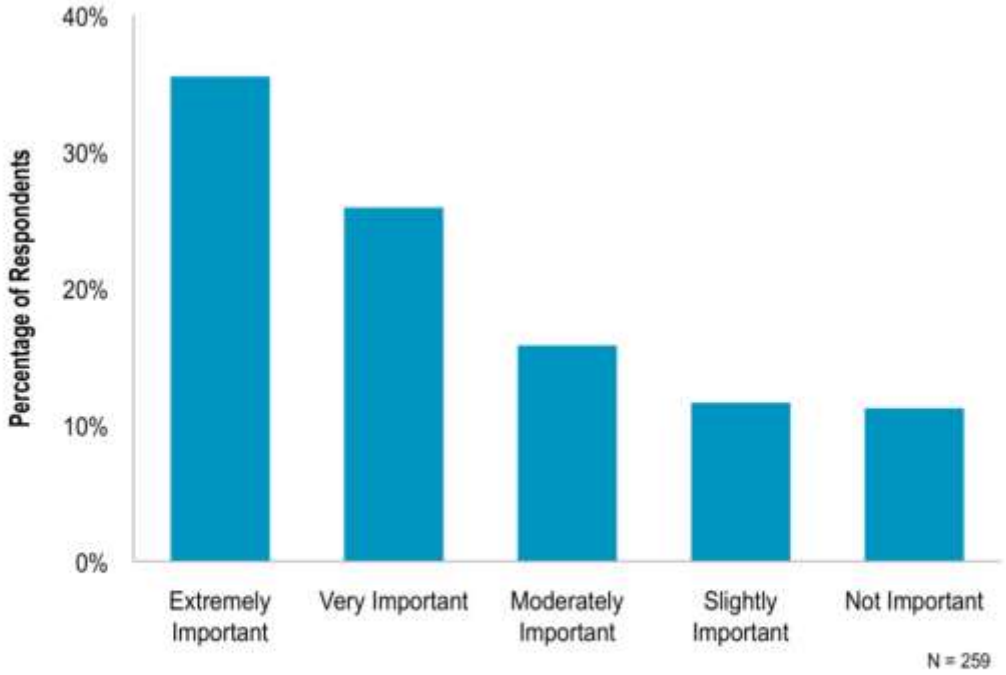
Figure 2

Customers Overwhelmingly Want Wi-Fi Connections And Wish It Was At All Hotels



Source: A commissioned study conducted by Forrester Consulting on behalf of Motorola Solutions, April 2013

Figure 7. Importance of Free Wi-Fi in Broadband Provider Choice.*



Q26. How important was free access to public Wi-Fi hotspots in your choice of home broadband service provider?

* Respondents answering "yes" to "bundled in subscription"

Source: Cisco IBSG, 2012

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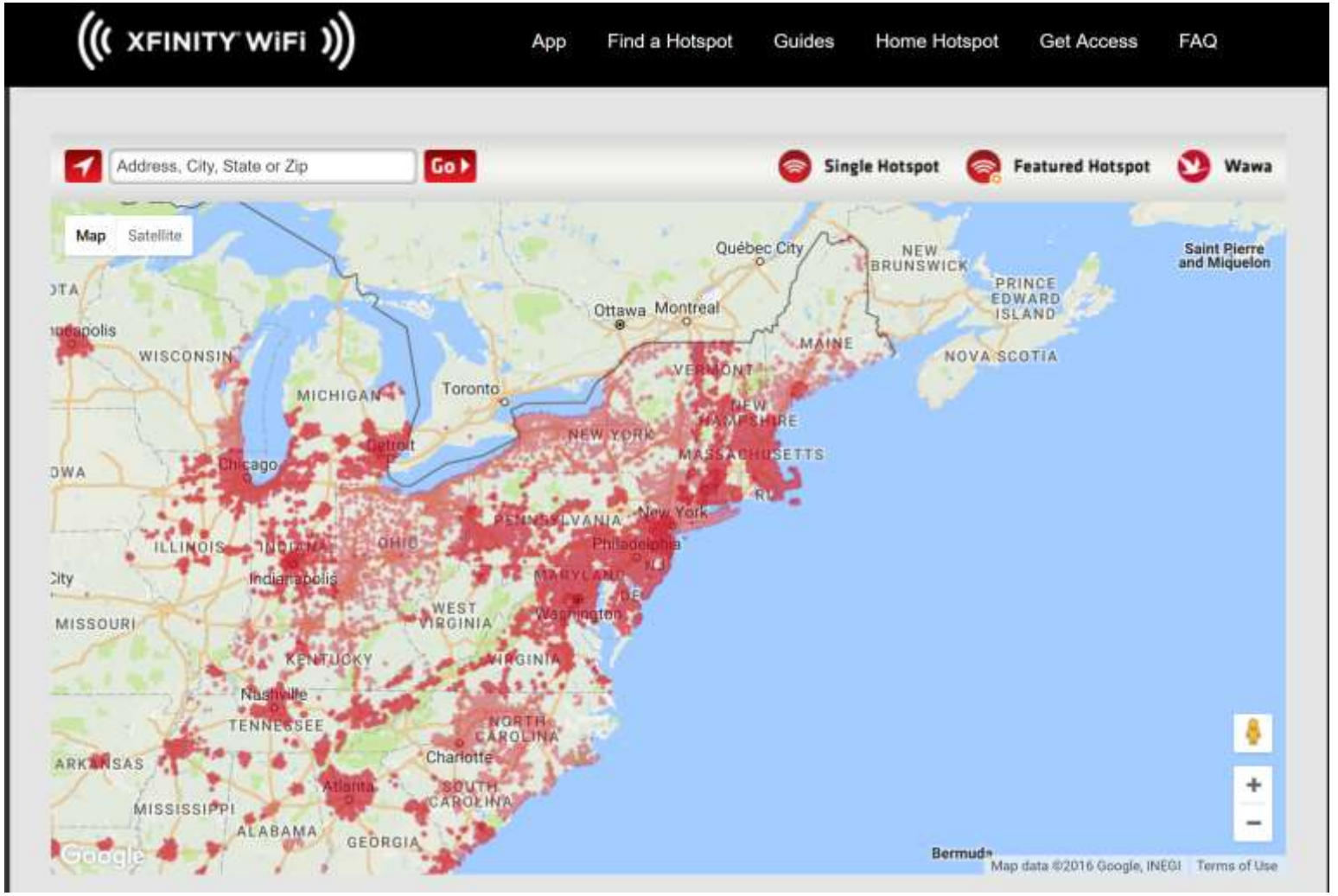
MSOs are already doing this…



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Now they see opportunities in places like MDUs…

- Upsell differentiated service
- Independent of AP Vendor
- Solution for wired and wireless connected devices

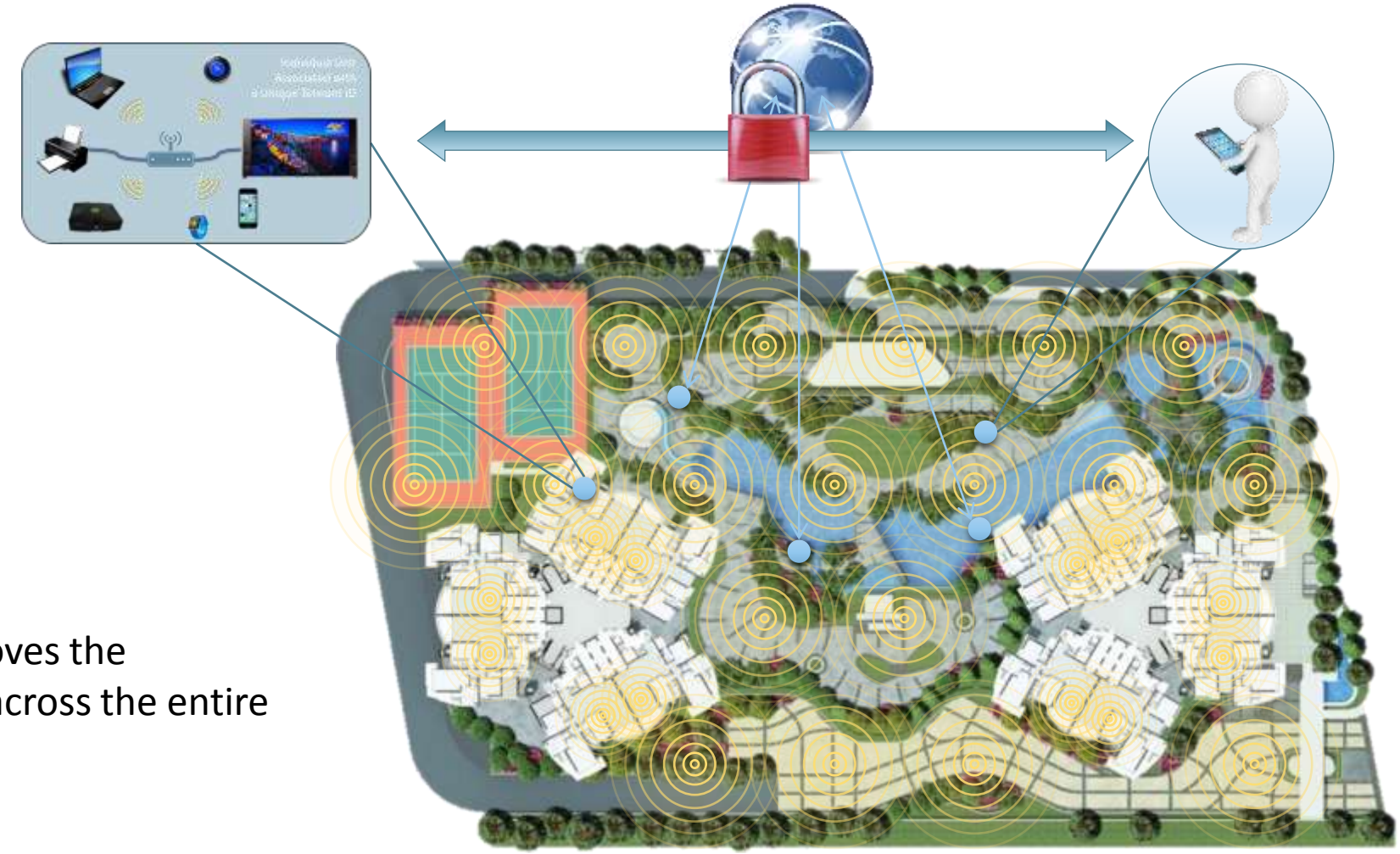
MDU Service with Virtual Tenant MDU Service Offering

Single SSID

Covers MDU

In Unit

Ethernet



Single SSID simplifies and improves the residents' Internet experience across the entire property

Services like “Wi-Fi Calling” go beyond basic data

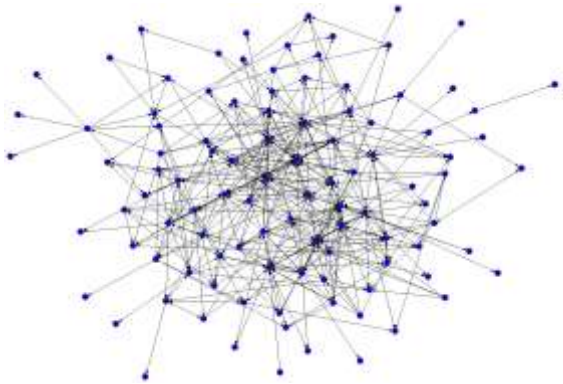
Coverage

10-20% of subscribers have no to poor cellular voice coverage at home

Modern building materials block signals

Capacity

Video traffic is taking over; demands capacity



M2M traffic is looming

Cost

Building radio coverage and capacity is expensive

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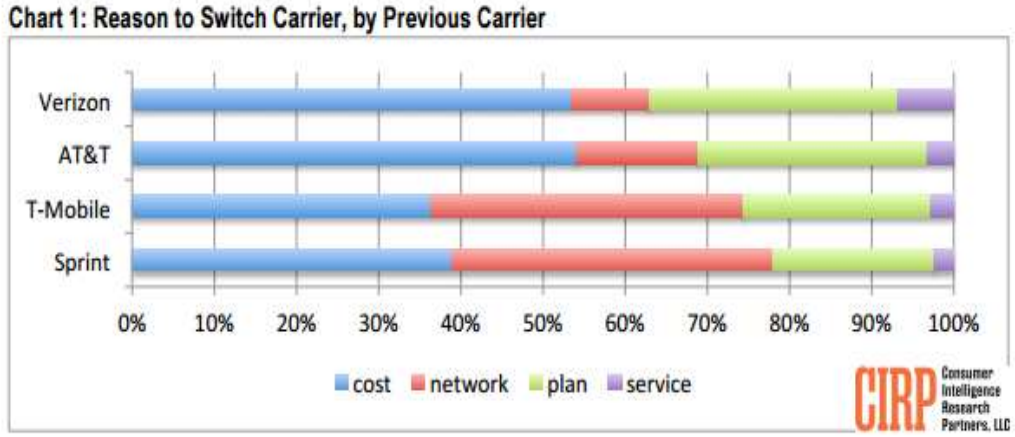
Users Expectations, Behaviors Are Changing

Users do not expect to have to put up with poor network performance – they will switch carriers instead



https://mlsvc01-prod.s3.amazonaws.com/150f9af2201/35529ccc-19af-41d2-ab1d-fc3d7a6605a9.pdf

International roaming customers refuse to put up with bill shock – they will use other communication modes instead.

WhatsApp Google Messenger Yik Yak Viber Connect. Freely. kik skype

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The time is right for Wi-Fi Calling

Handsets: Ecosystem in place

Availability: Wi-Fi is everywhere

User familiarity: Most smartphone users use Wi-Fi for data traffic when at home, at work, or at play

Significant operator momentum

Networks: Operator shift to all-IP infrastructure automatically supports Wi-Fi Calling

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Wi-Fi Calling; How does it help?

Available	Any Wi-Fi network, anywhere, can be used to extend/enhance the network
Secure	Connections are secured by IPsec down to the handset
Native	Native clients support Wi-Fi calling on many smartphones
Multi-Application	Supports any operator-provided service

Address coverage issues

Provide coverage for users when they are in weak macro coverage; reduce churn

Serve roaming customers

Address customers' service needs when they attach to Wi-Fi even when roaming

Maintain customer relationship

Maintain connection with customers; not an OTT service

Leverage existing technology

Reuse existing clients and networks, saving capex and opex

Enhance network capacity

Not just for voice. Provide enhanced capacity for all applications – video, music, IoT, etc.

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MSOs see more and more opportunity in wireless

- Elaborating on his MSO's appeal to the FCC to begin experimenting in new and proposed millimeter wave bands, Charter Communications Chairman and CEO Tom Rutledge said the company wants to try out those products in "several markets so that we can learn how to use them to our advantage competitively."
- "I think 5G-type technologies or millimeter wave technologies or small cell, high-frequency, high-capacity, low-latency wireless networks are products that we will develop," Rutledge said Thursday during Charter third-quarter earnings call with investment analysts. "They may or may not be connected to an MVNO relationship or a mobility relationship. I think that there are opportunities to create wireless drops in certain cases, so direct wireless connections that mimic a physical connection, to connect malls and other things in the enterprise space and buildings that are not contiguous or have big parking lots or, in some cases, low density areas, it might make some sense."

Wait. What?
mm wave bands?
5G?

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5G?

WHAT IS 5G? CONTRIBUTION OF EU RESEARCH

European Commission

What 5G will bring to you?	What's new with 5G?	EU projects	5G applications	Why not today?
amazing volume amazingly fast	spectrum extension; millimetre waves; cell densification: increase spectrum efficiency; advanced antennas; 3D beam-forming techniques; new electronic components; backhaul optimization; D2D; moving networks (vehicle based cells)	5GNOW, HARP	hologram TV, immersive presence, augmented reality, ultra large volume transfers	spectrum saturation; limited spectrum aggregation; current hardware not able to function at high frequencies; expensive deployment & maintenance of small cells
always best connected	combination of 4G, 3G, Wi-Fi, & new radio access to create an integrated & dynamic radio access network; connectivity management mechanisms	MCN, CROWD	staying connected everywhere including high-speed trains, planes, crowds	seamless handover (e.g. cellular to Wi-Fi) not supported
no perceived delay	ultra-low latency; software-defined networks; decoupling functional architecture from the underlying physical infrastructure; network intelligence closer to users; MEC (mobile edge computing), D2D	MCN	tactile internet; reactive interfaces; electricity grid control, vehicle to vehicle, robot control; connected cars, remote surgery	4G latency ≥ 10ms
massive amount of connected things & people	new waveform; cell densification; much less signalling traffic & no synchronisation; RAN architecture	5GNOW	internet of things, smart cities, connected cars, e-health	current OFDM waveform limitations; interference prevents scaling up; 4G chipsets cost; energy consumption
energy efficiency	millimetre waves for front-haul & backhaul; new operation mechanisms for dense networks; pooling of base station processing; on-demand consumption; massive machine communications; power amplifiers; DSP (digital signal processing) - enabled optical transceivers; harvesting ambient energy; optimization of sleep mode switching	MCN, CROWD	80% energy saving; deployment in developing countries	Base stations idle time not optimised; unused functions activated; air interface/hardware not energy optimized
flexible programmable networks	software-defined networks; network function virtualisation; decoupling functional architecture from the underlying physical infrastructure; APIs	unify	new business models for innovative SMEs providing network functions; emergence of super MVNOs; pan European operators, faster innovation in network services	many various network management software; not interoperable; bundling of network functions in hardware boxes
secure networks	physical channel authentication; virtualised authentication		networks for police & security professionals; privacy	Security as add-on not by design; fragmented approach

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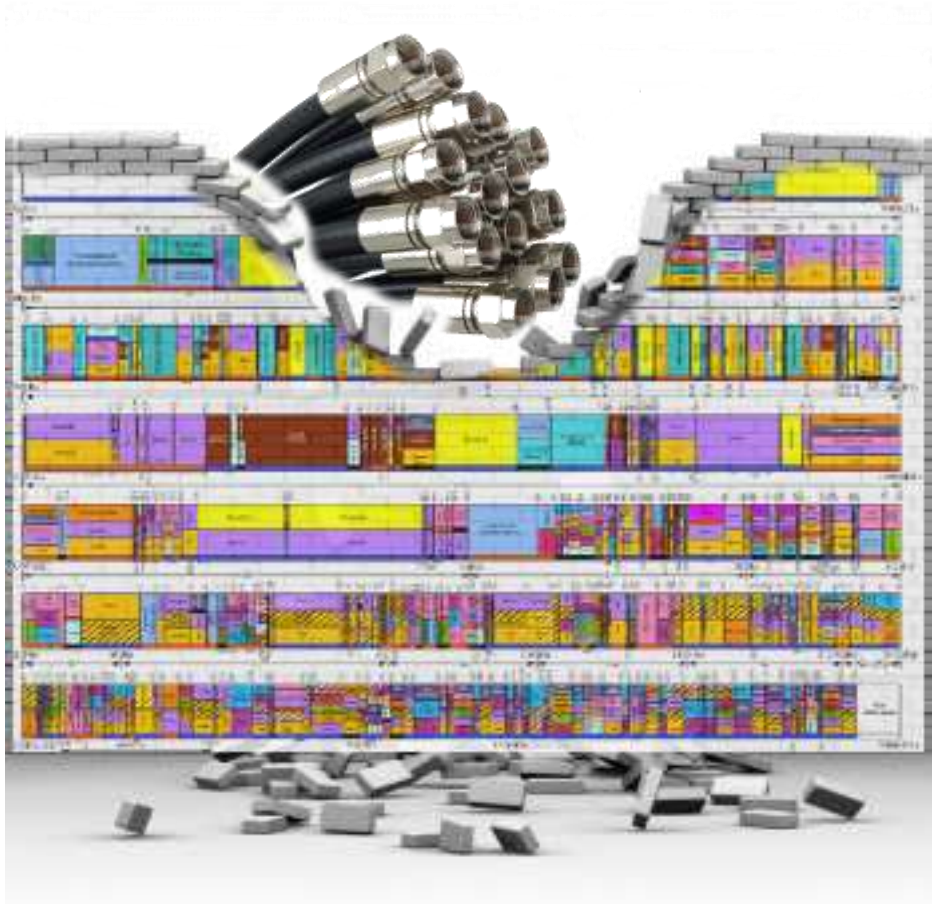
And why would MSOs be talking about 5G?

Spectrum beyond unlicensed and “traditional” Wi-Fi

One of the biggest hurdles for fixed operators to get into the mobile space has been access to spectrum

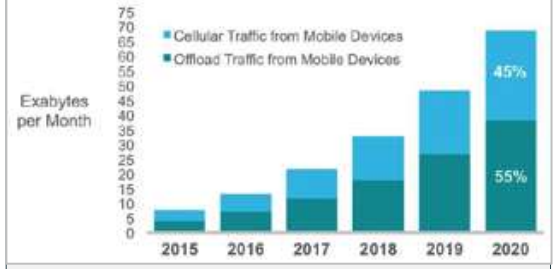


The walls to that barrier are quickly eroding

New Spectrum, New Opportunities

The Age of Separation

Licensed Spectrum
Mobile Operators



Cable already the dominant carrier of wireless traffic.

Unlicensed Spectrum
Everyone else (e.g. MSOs)

A few licensed operators

The Age of Aggregation

Licensed Spectrum

LTE-U, LAA, LWA, LWIP, MulteFire

The technology debate obscures a bigger issue… mobile operators and vendor community admit they can deliver services using unlicensed spectrum.

Unlicensed Spectrum

+ Wi-Fi first and MVNOs

The Age of Sharing

TV Whitespace, 3.5 GHz, SAS, CBRS

Licensed Spectrum

PCAST finds that "the best way to increase capacity is to leverage new technologies that enable larger blocks of spectrum to be shared."

Shared Spectrum

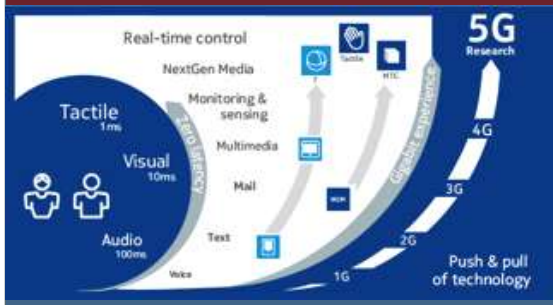
Unlicensed Spectrum

Anyone can be a wireless operator!

The Age of Flexibility

mmW: 28 GHz, 37 GHz, 39 GHz, 64-71 GHz

Flexible Spectrum



Anyone can be a wireless operator!

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Plenty of Wi-Fi/wireless activity from *big, new* players

Google Wifi

Project Fi

amazon echo

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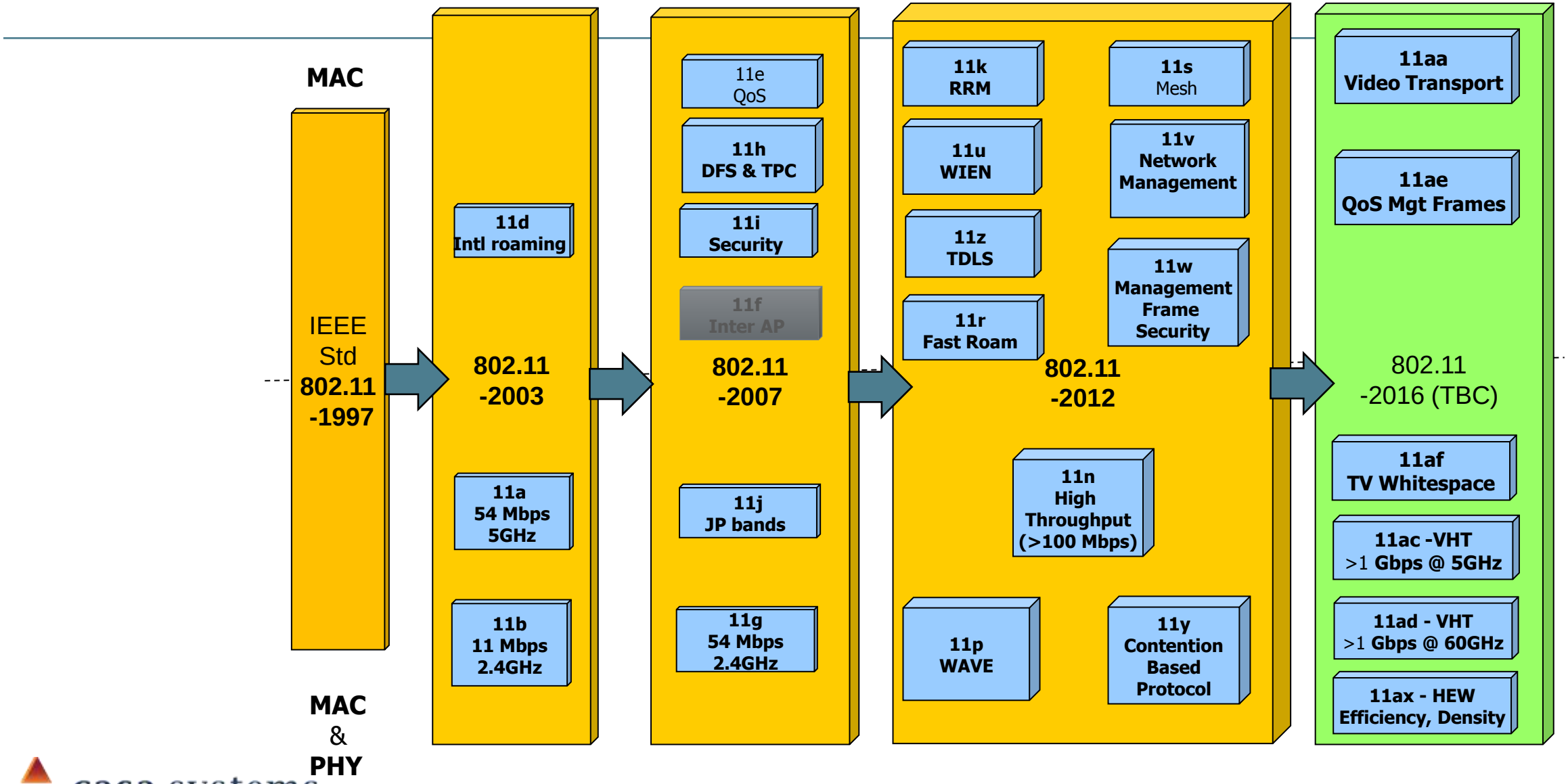
Facebook achieves ultra-fast 20Gbps millimetre wave wireless data transmission over 13km

So how does Wi-Fi, specifically, play into all of this?

- Required disclaimer:
- The following views should be considered my personal views rather than the formal position, explanation, or interpretation of the IEEE.
- Or the Wi-Fi Alliance, for that matter.

802.11 Revisions



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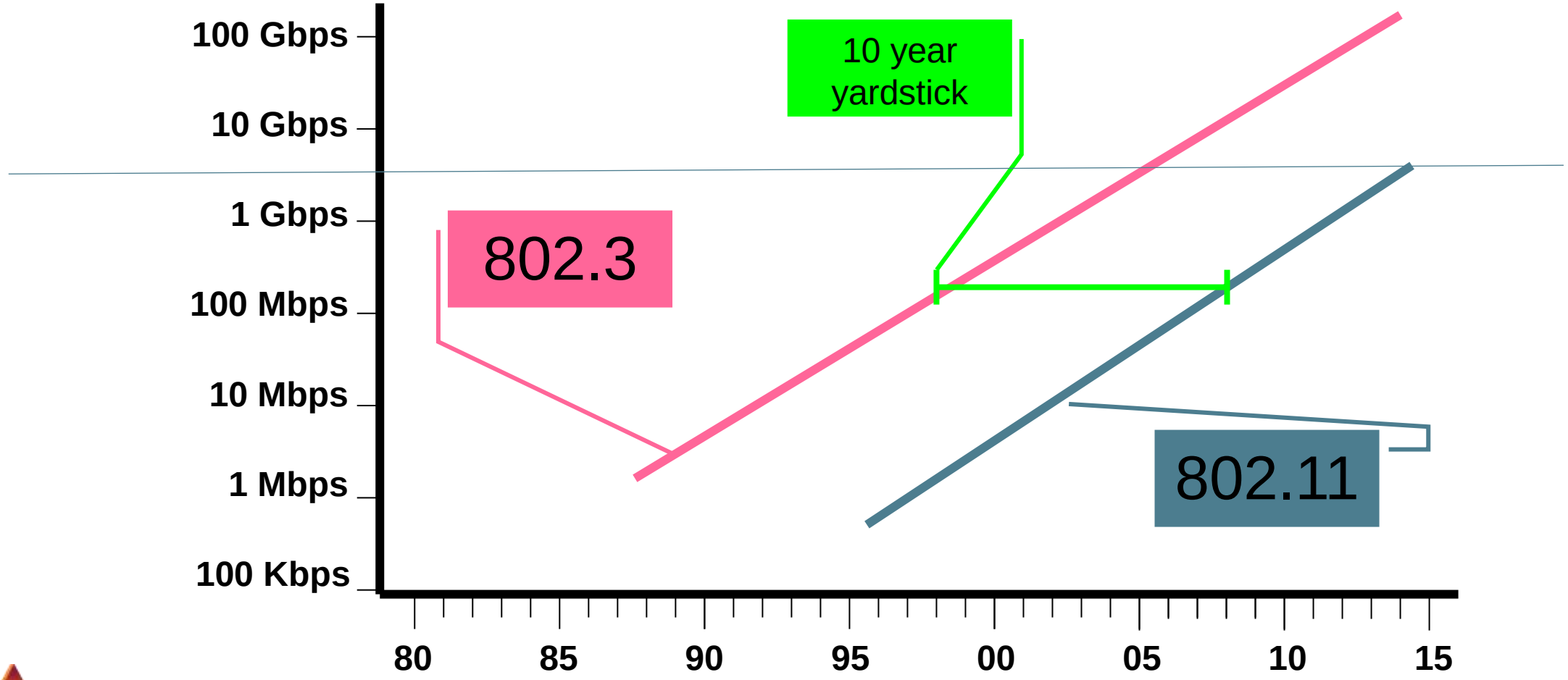
PHY Project Sequence



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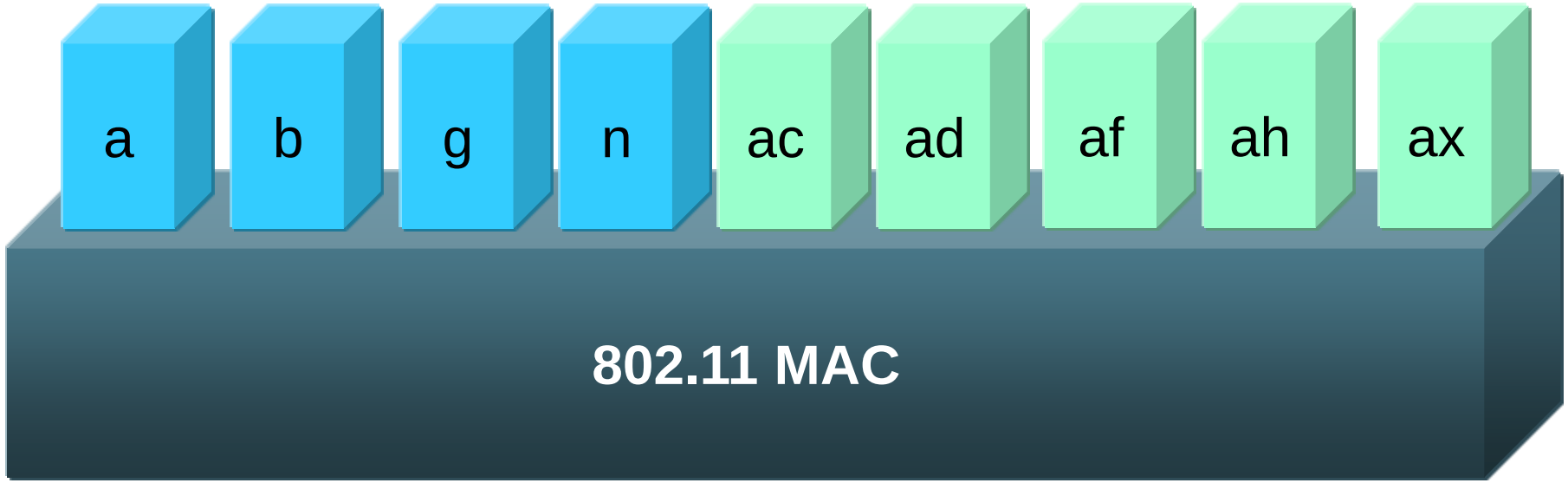
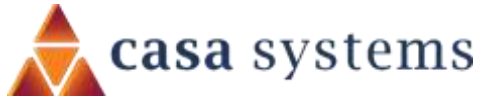
802.11 Architecture Overview

- Multiple Over the Air PHY options
- One common MAC based on CSMA/CA



(Some of the) Current Projects



TGah

- The purpose of this amendment defines operation of license-exempt IEEE 802.11 wireless networks in frequency bands below 1 GHz excluding the TV White Space bands.
- Wi-Fi Alliance HaLow

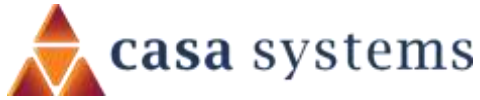
CRUNCH NETWORK

HaLow Is The Natural Next Step In The Evolution Of IoT

Posted Feb 10, 2016 by Jim Hunter (@theiotguru)

Here's how it works: While most modern routers operate in the 2.4GHz and 5GHz spectrum, HaLow (pronounced "halo") transmits in the 900MHz band. This band transmits twice as far as the 2.4GHz standard and offers better wall penetration.

Think of it as a souped-up Bluetooth signal. Essentially, HaLow is all about low-power and long-range Wi-Fi, two elements critical to the production of small, affordable smart devices.



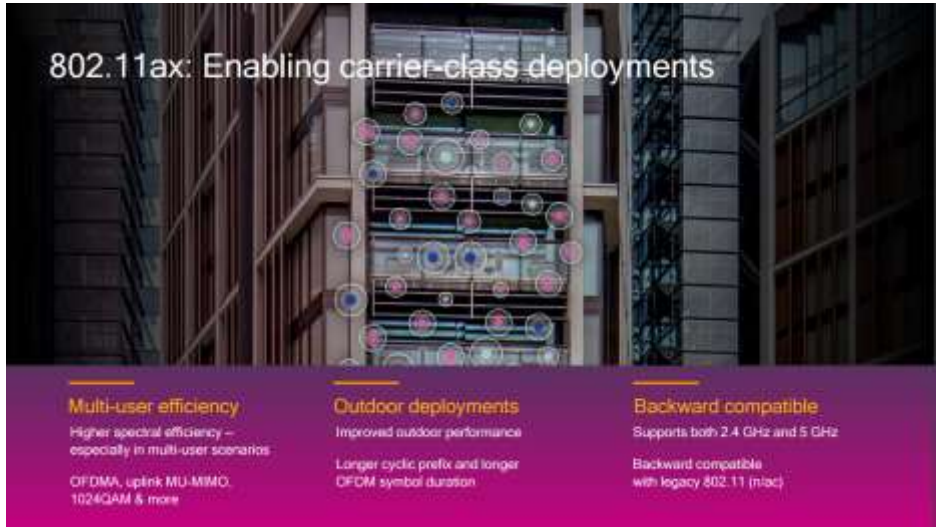
TGah

- This amendment defines an Orthogonal Frequency Division Multiplexing (OFDM) Physical layer (PHY) operating in the license-exempt bands below 1 GHz, e.g.,
  - 868-868.6 MHz (Europe), 950 MHz -958 MHz (Japan), 314-316 MHz, 430-434 MHz, 470-510 MHz, and 779-787 MHz (China), 917 - 923.5 MHz (Korea) and 902-928 MHz (USA),
  - and enhancements to the IEEE 802.11 Medium Access Control (MAC) to support this PHY, and provides mechanisms that enable coexistence with other systems in the bands including IEEE 802.15.4 and IEEE P802.15.4g.
- The data rates defined in this amendment optimize the rate vs range performance of the specific channelization in a given band.
- This amendment also adds support for:
  - -transmission range up to 1 km
  - -data rates > 100 kbit/s
  - while maintaining the IEEE 802.11 WLAN user experience for fixed, outdoor, point to multi point applications

TGax

- Improve performance of WLAN deployments in dense scenarios
  - Targeting at least 4x improvement in the per-STA throughput compared to 802.11n and 802.11ac.
  - Improved efficiency through spatial reuse and enhanced power save techniques.
- Dense scenarios are characterized by large number of access points and large number of associated STAs deployed in geographical limited region, e.g. a stadium or an airport.

Access to Internet, latest airlines' announcements, and digital media such as movies and sport events



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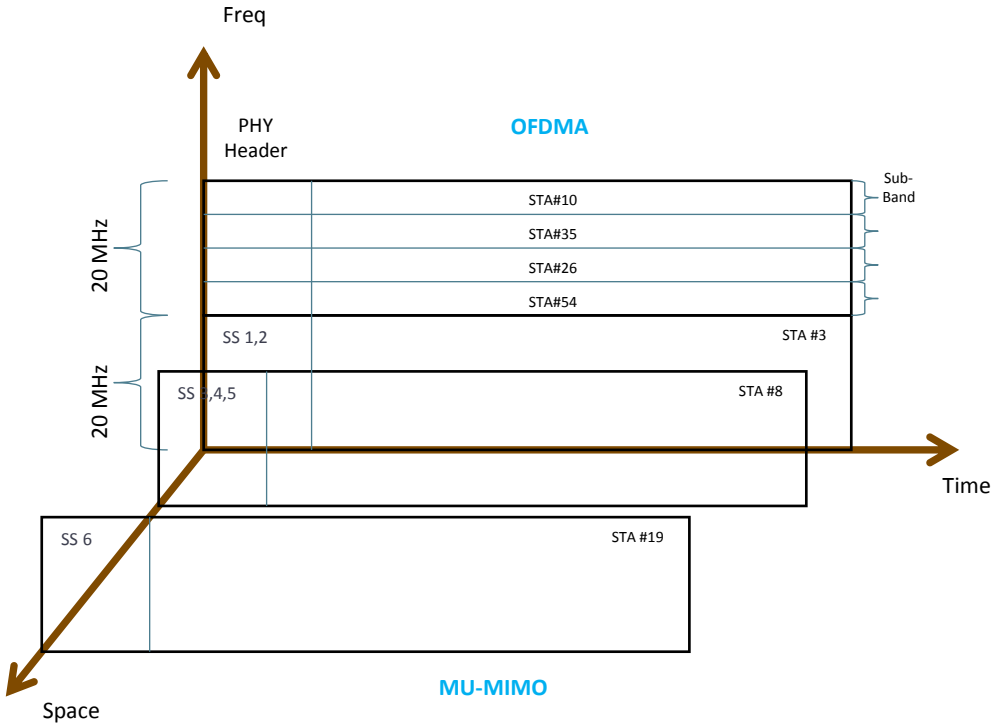
TGax



- Support multi-user (MU) transmissions both in the frequency and in the spatial domains
  - Extend IEEE 802.11ac DL MU-MIMO to UL direction
  - Introduce OFDMA PHY layer and the associated scheduling to ensure per STA throughput.
  - MAC enhancements to support newly introduced mechanisms
  - Compatible with legacy devices.

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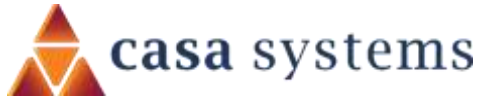
TGay (next generation 802.11ad)

- Current generation 60 GHz (802.11ad) achieves 7Gbps
- Tgay is expected to develop a mode of operation capable of supporting a maximum throughput of at least 20 gigabits per second (measured at the MAC data service access point), while maintaining or improving the power efficiency per station.
- Next Generation 60 GHz increases throughput, range and reliability
- Technical approaches are likely to include channel bonding and MIMO

Wi-Fi Alliance



Passpoint

- “Make Wi-Fi as easy and secure as cellular”
- Enables SIM and non-SIM mobile devices to discover, select and connect to Wi-Fi networks without user intervention. Passpoint devices “see behind” the SSID (network name) to select a network based on ownership, services and performance characteristics. Wi-Fi network connections use an enhanced set of industry-standard WPA2 security protections; compatibility with legacy devices can be retained through deployment of multiple SSIDs. Passpoint certifies products which implement technology defined in the Wi-Fi Alliance Hotspot 2.0 Technical Specification. The technology behind Passpoint is foundational to Wi-Fi roaming and has been specified by both Wireless Broadband Alliance and the GSMA Terminal Steering Group.

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WiGig

- Handle the high-bandwidth, short range use cases (802.11ad, ay)
- Utilizes the 60 GHz frequency band to enable extremely high performance, multi-gigabit connectivity and low latency for a range of applications, including wireless docking, augmented reality/virtual reality (AR/VR), multimedia streaming, gaming and networking.

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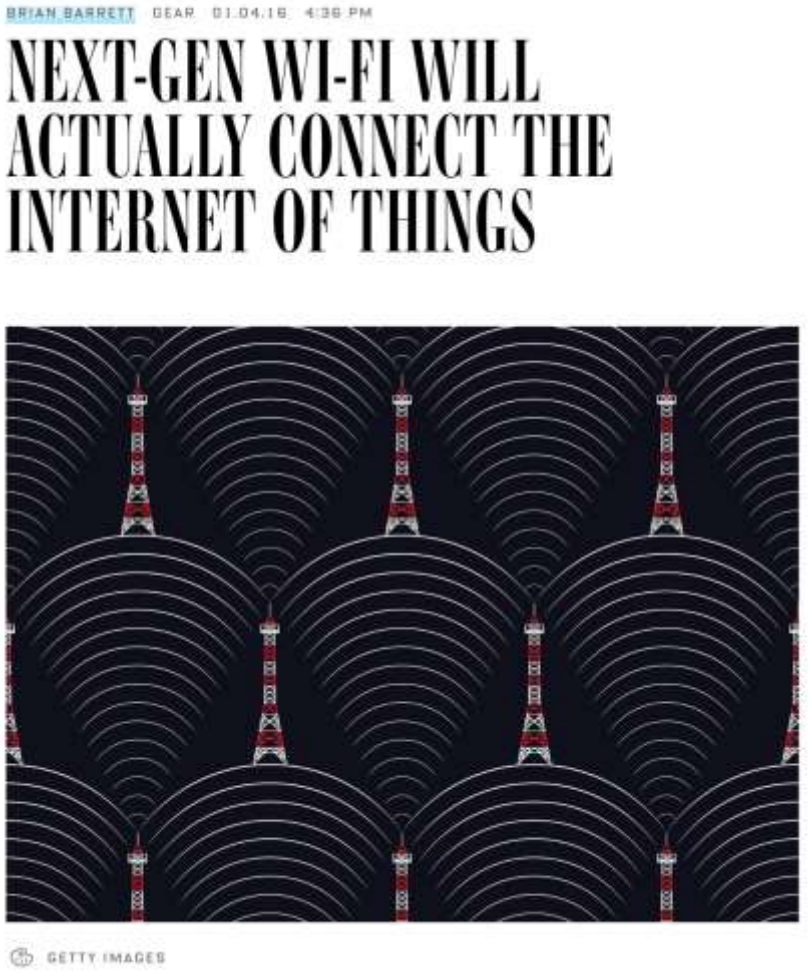
HaLow

- Handle the long-range, low data rate use cases
- Low power, long range Wi-Fi (802.11ah)
- With industry momentum mounting around a low power Wi-Fi® solution, Wi-Fi Alliance® has introduced Wi-Fi HaLow™ as the designation for products incorporating IEEE 802.11ah technology. Wi-Fi HaLow operates in frequency bands below one gigahertz, offering longer range, lower power connectivity to Wi-Fi CERTIFIED™ products. Wi-Fi HaLow will enable a variety of new power-efficient use cases in the Smart Home, connected car, and digital healthcare, as well as industrial, retail, agriculture, and Smart City environments.
- Wi-Fi HaLow extends Wi-Fi into the 900 MHz band, enabling the low power connectivity necessary for applications including sensor and wearables. Wi-Fi HaLow's range is nearly twice that of today's Wi-Fi, and will not only be capable of transmitting signals further, but also providing a more robust connection in challenging environments where the ability to more easily penetrate walls or other barriers is an important consideration. Wi-Fi HaLow will broadly adopt Wi-Fi protocols and deliver many of the benefits that consumers have come to expect from Wi-Fi today, including multi-vendor interoperability, strong government-grade security, and easy setup.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NEXT-GEN WI-FI WILL ACTUALLY CONNECT THE INTERNET OF THINGS

GETTY IMAGES

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Commercial Status

- Wi-Gig (11ad) – emerging
  - TP-Link has introduced what it calls the first wireless router based upon 802.11ad technology from Qualcomm.
- 11ax – emerging
  - Quantenna Claims First 802.11ax WiFi Product
- Passpoint – emerging
  - Time Warner announces massive Hotspot 2.0 deployment
  - AT&T in process of upgrading Wi-Fi in NYC parks with Passpoint
- 11ah/HaLow – impending
  - In ABI Research's latest report, Market Opportunities for Low Power Wi-Fi and 802.11ah, it finds that annual IC shipments are set to reach just 11 million units by 2020, four years after the appearance of the first chipsets expected in 2016.
- 11ay – impending

Innovations on top of Wi-Fi

- The Wi-Fi environment is the source of innovation beyond the IEEE standards and WFA certifications
- For example:
  - “MegaMIMO” reports from MIT
    - Results from a 10-AP software-radio testbed show a linear increase in network throughput with a median gain of 8.1 to 9.4.
  - Wi-Fi self-optimization products
  - Fixed broadband solutions using Wi-Fi
  - Residential Wi-Fi mesh
  - Wi-Fi First service providers
  - Cellular Offload
  - Premium services and roaming
  - Ad-supported free services

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Gateway innovations in Wi-Fi network architecture
Merging Wi-Fi with other wireless access

Any Access Point

Access Point Agnostic

Virtual Wireless Access Gateway (WAG) at the Edge

Intelligent Data Plane Management and Processing at the Edge for performance

Ultra-broadband Edge Platform

Any Access

Trusted / Untrusted Wi-Fi

3G / 4G
LTE-U, LTE-LAA, LTE-LWA, and MuLTEfire™ support

Key Access and Core Functions

WAG	TWAG	ePDG	SeGW	…
PGW	HeNB-GW	H(e)MS	SGW	…

Multiple NFVs for Multiple Access types from the Same Platform for Efficiency

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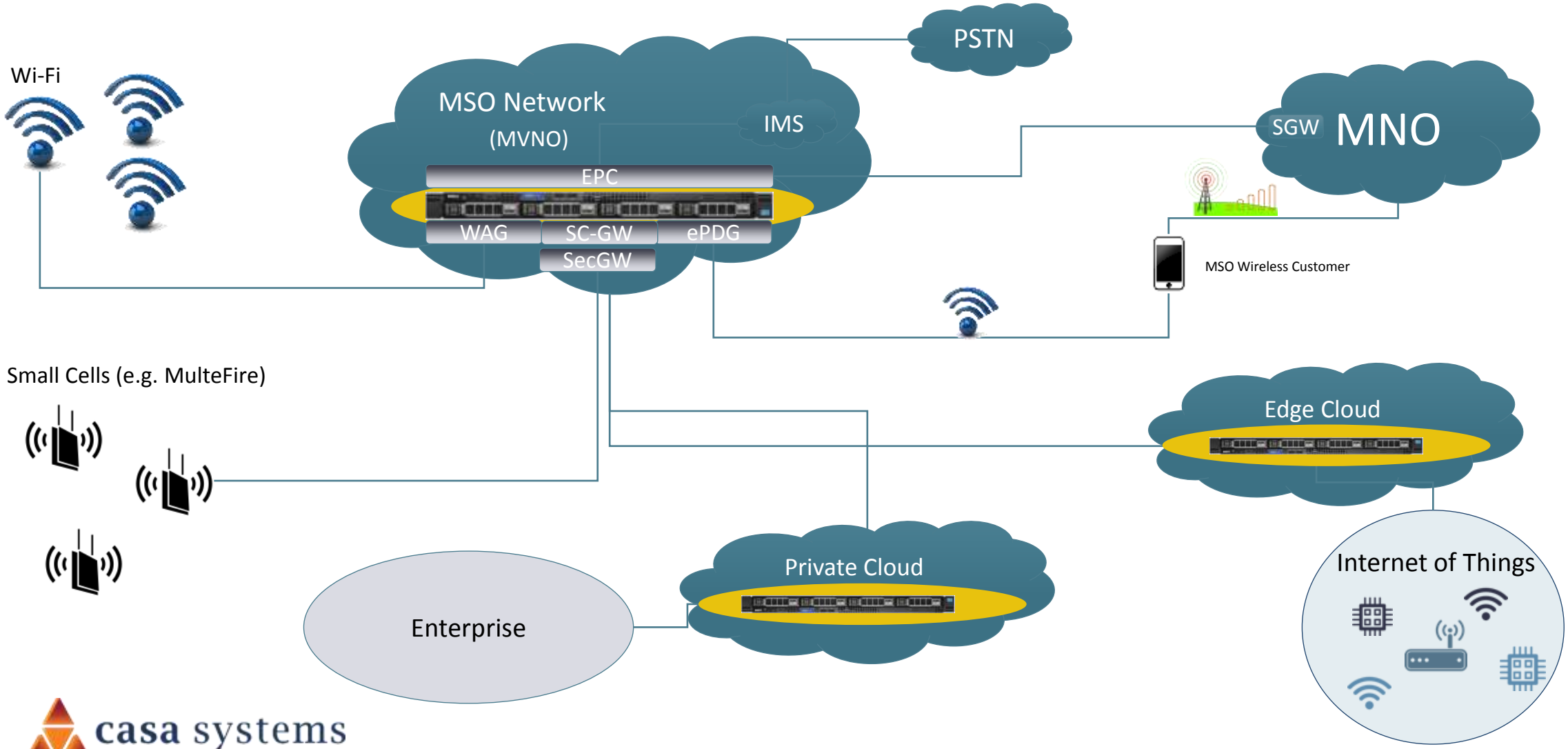
MSO Opportunities in Wireless abound (Wi-Fi and beyond)



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Summary

- Many new opportunities in wireless for operators without traditional wireless backgrounds
- Traditional Wi-Fi was the start, and still the bulk of the activity
- New spectrum and new markets are opening new doors
  - Manageability → Network performance, user experience
  - Gateways → offload, monetization via services, tiers, unified access, etc.
  - Technology → new markets, IoT, smart homes, etc.
- 802.11/Wi-Fi technologies are being developed across this range of opportunities