Wi-Fi: An integral part of the wireless landscape

Part of the solutions to "1000x mobile data challenge"

At the center of connected home

Opening new frontiers for wireless connectivity

Wireless Display

Peer-to-peer

Indoor Location

Wi-Fi supported in all smart devices

The universal technology in smart connected homes

Leveraging ubiquity of indoor Wi-Fi for many new applications and services

Wi-Fi is becoming ubiquitous

Growing Global Reach

5.8M

4.5M

3.3M

2.1M

1.3M

2011 2012 2013 2014 2015
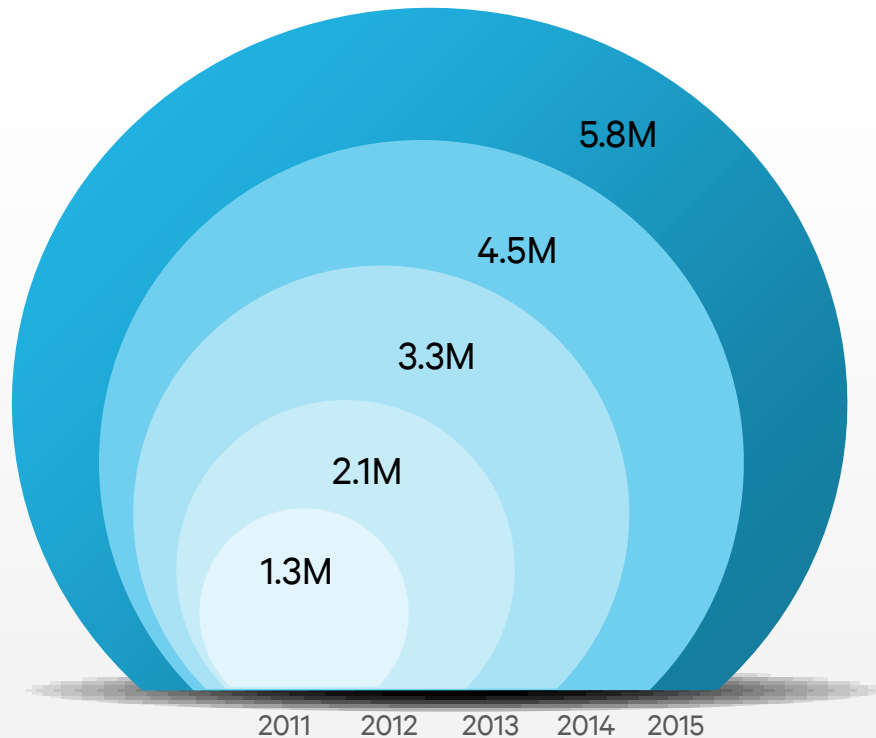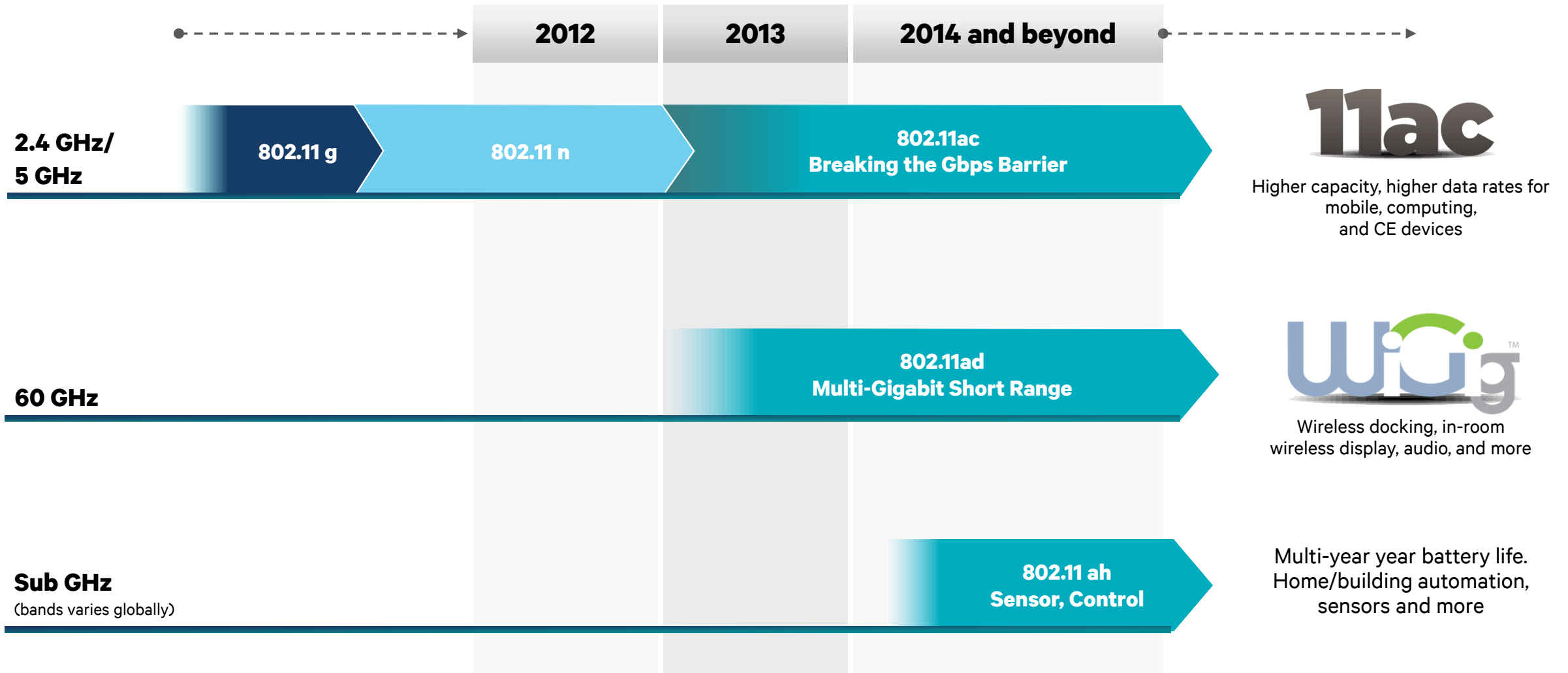
Number of public hotspots worldwide.
Source: Wireless Broadband Alliance (WBA) and Informa Telecoms & Media.

Expanding Device Support

Wi-Fi Enabled Devices Shipped	2012 MU	2015 MU
Phones/Accessories	685	1,459
Tablets, E-Readers, Media Players, etc	199	360
Laptops, Desktops, Peripherals, etc.	392	717
Connected Home	107	287
Others	39	338
TOTAL	**1,422**	**3,161**

Source: ABI Research forecast, December 2012. "Connected Home" category includes
Flat Panel TVs, Set-top Boxes, Gaming Consoles, Gaming Console Controllers, DVD/Blu-ray Players/Recorders,
OEM Remote Controls,3D Glasses, Digital Photo Frames. "Others" include Automotive Health, Fitness and
Medical, Smart meters, automation, industrial

A strong Wi-Fi evolution path

		2012	2013	2014 and beyond	

2.4 GHz/ 5 GHz

802.11 g → 802.11 n → **802.11ac Breaking the Gbps Barrier**

11ac

Higher capacity, higher data rates for mobile, computing, and CE devices

60 GHz

802.11ad Multi-Gigabit Short Range

WiGig™

Wireless docking, in-room wireless display, audio, and more

Sub GHz (bands varies globally)

802.11 ah Sensor, Control

Multi-year year battery life. Home/building automation, sensors and more

Qualcomm VIVE™: Enabling end-to-end 11ac ecosystem

Computing

Mobile

Consumer Electronics

Network

Driving 11ac in migration in mobile through pin compatible solutions

Extending industry leading Wi-Fi performance[1]

~6x lower power consumption (v/s our own 11n)

[1]AnandTech -The HTC One X for AT&T Review by Brian Klug on 5/1/2012; "Unsurprisingly the One X posts the highest WLAN throughput I've seen from a smartphone to date." ; This devices uses Qualcomm's 802.11n solution
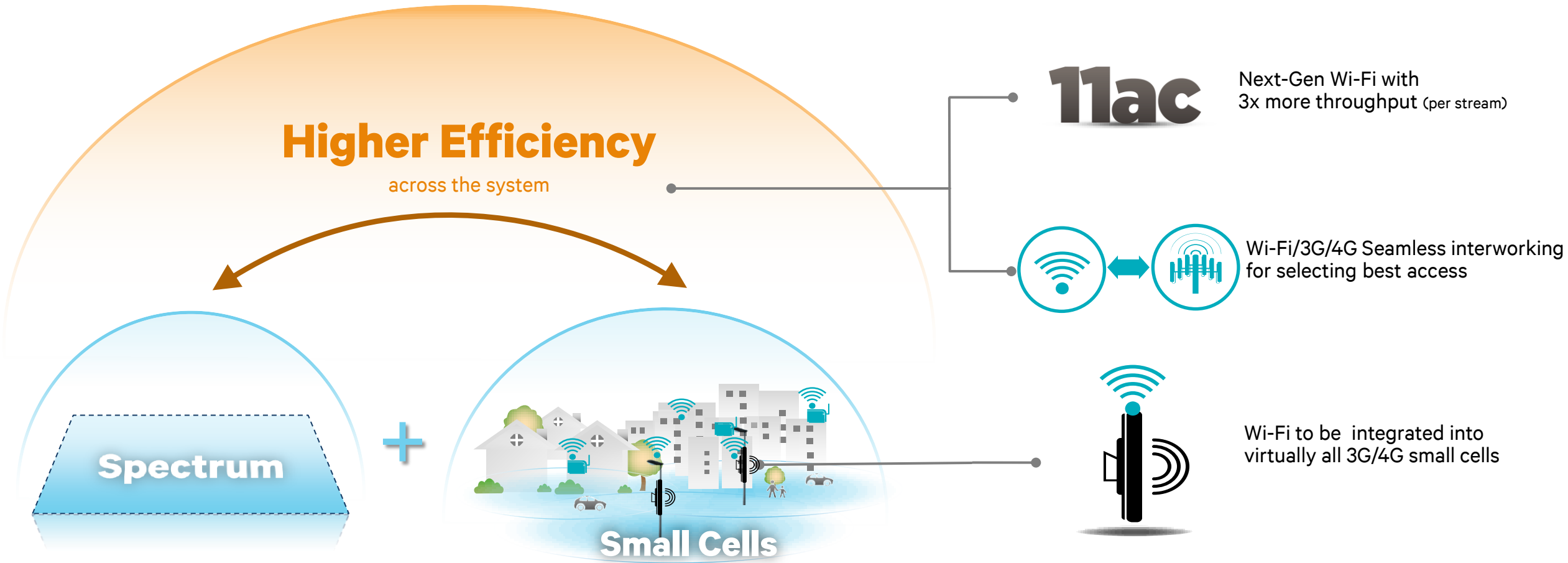
11ac

3G/4G/Wi-Fi Smallcells/Hetnet

Network Quality — Smart Connectivity Engine — Operator Policies
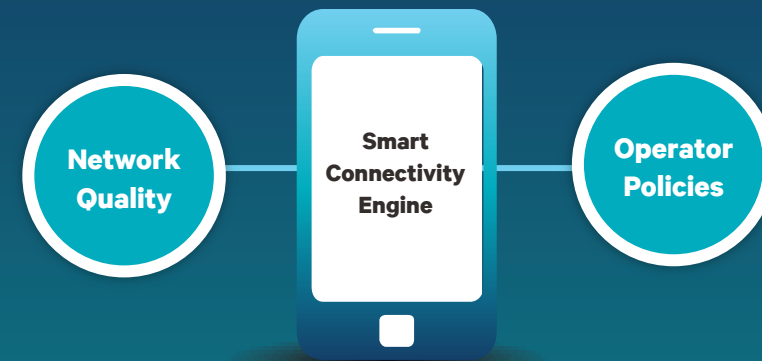
Seamless 3G/4G/Wi-Fi Interworking

Wi-Fi: Part of the solutions to the "1000x Mobile Data Challenge"

Multiple efforts needed to address 1000x – Wi-Fi is an integral part of the solutions

Higher Efficiency
across the system

Spectrum + **Small Cells**

11ac
Next-Gen Wi-Fi with 3x more throughput (per stream)

Wi-Fi/3G/4G Seamless interworking for selecting best access

Wi-Fi to be integrated into virtually all 3G/4G small cells

802.11ac: Up to 3x increase in throughput per stream

3x more in the future with MU-MIMO

40 MHz 11n/ac	80 MHz 11 ac	160 MHz 11ac

- Up to 80 or 160 MHz per channel
- Less crowded 5GHz band
- Higher order modulation (256 QAM)

3x throughput now*

3x more aggregate throughput with MU-MIMO**

Higher data rates at all ranges

Lower latency

Wider Bandwidth

Dynamic Bandwidth Management

- Improved interference detection and avoidance
- Bandwidth allocation based on interference

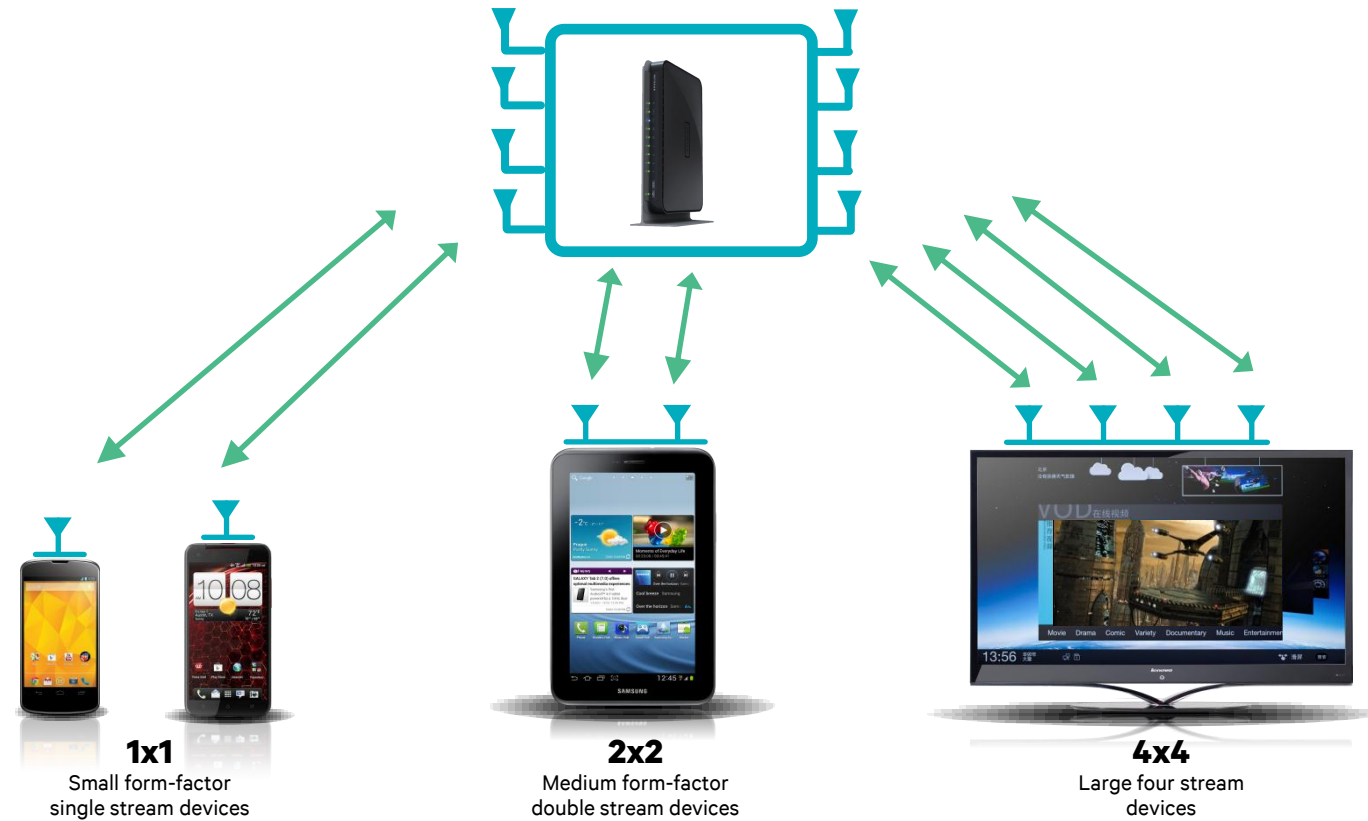**Multi User MIMO**

Serves up to 4 devices simultaneously

11ac

* As compared to 802.11.n; **When compared to 3-stream 11ac SU-MIMO, considering only single stream mobile devices; 802.11ac standard supports up to 8-stream MIMO

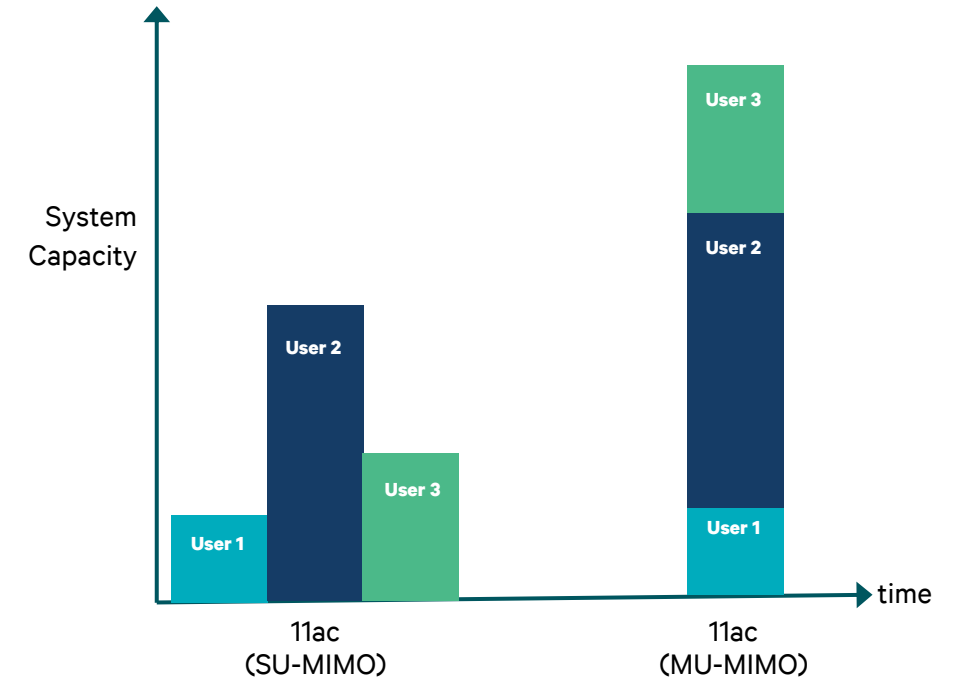# MU-MIMO: Higher capacity with mix of devices

Simultaneously serving multiple devices by reusing resources

1x1
Small form-factor single stream devices

2x2
Medium form-factor double stream devices

4x4
Large four stream devices

System Capacity

User 1

User 2

User 3

11ac
(SU-MIMO)

User 3

User 2

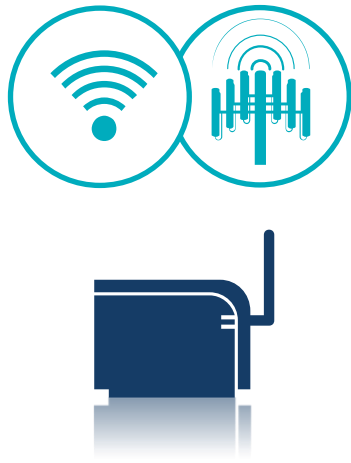User 1

11ac
(MU-MIMO)

time

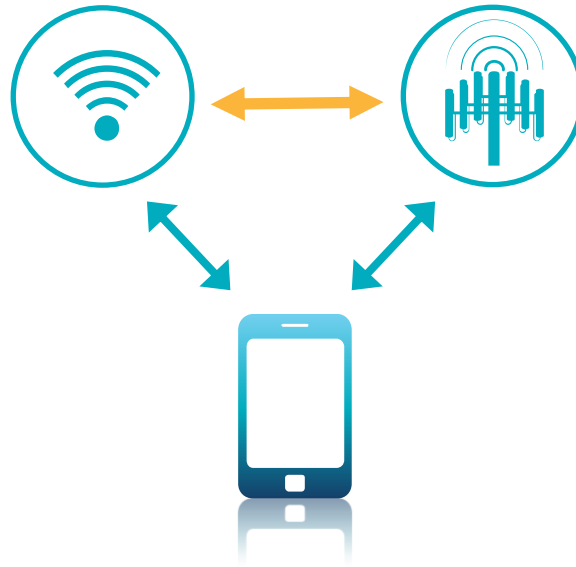**Simultaneously serves up to 4 devices**

Up to 3x more aggregate throughput*

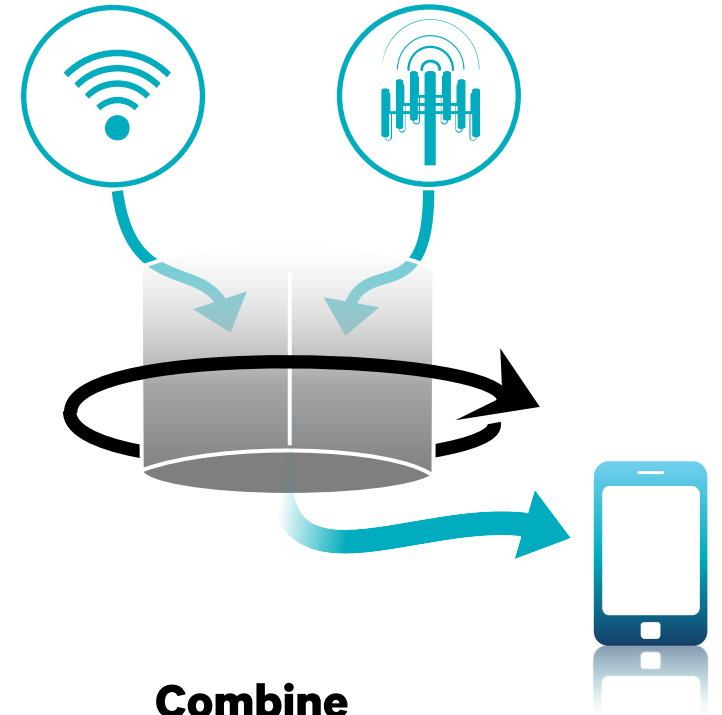*When compared to 3-stream 11ac SU-MIMO, considering only single stream mobile devices

Tighter Wi-Fi—3G/4G interworking

**Convergence of Cellular
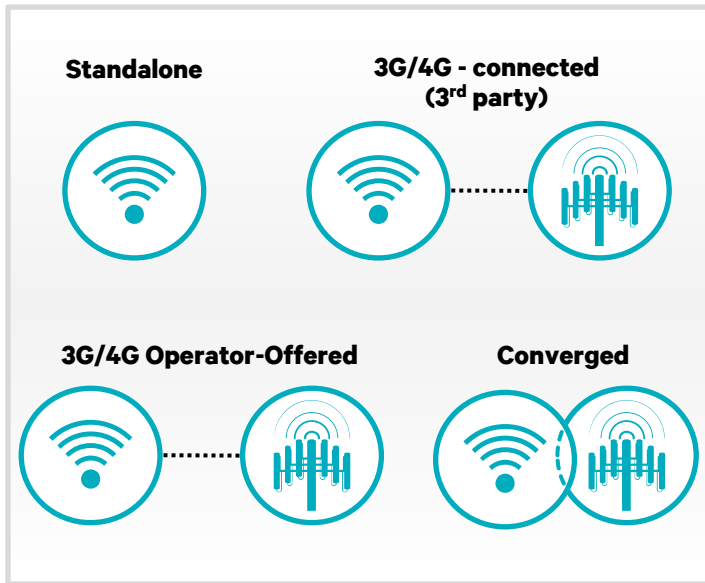and Wi-Fi Infrastructure**
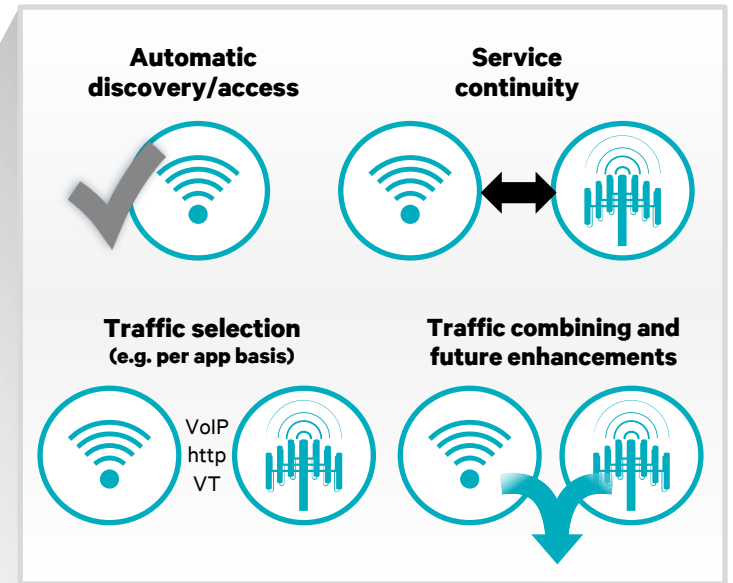
**Seamless Access
and Connectivity**

**Combine
Wi-Fi and 3G/4G**

Multi-dimensional Wi-Fi—3G/4G interworking landscape

Many Wi-Fi deployment models

Standalone

3G/4G - connected (3rd party)

3G/4G Operator-Offered

Converged

Device in unique position to select best access/es

Different levels of interworking

Automatic discovery/access

Service continuity

Traffic selection (e.g. per app basis)

VoIP
http
VT

Traffic combining and future enhancements

Smart Connectivity Engine

Network Quality

Operator Policies

Seamless Wi-Fi—3G/4G interworking is evolving

Future enhancements

Service continuity

Data

signaling

Traffic selection

signaling

Discovery & access

signaling

E.g.
- Best effort

E.g.
- QoS

◦ Combining data
◦ Even tighter integration
◦ 3GPP Rel 11 and beyond

◦ Per flow selection

Service continuity & seamless transition

Adherence to operator policies (ANDSF)

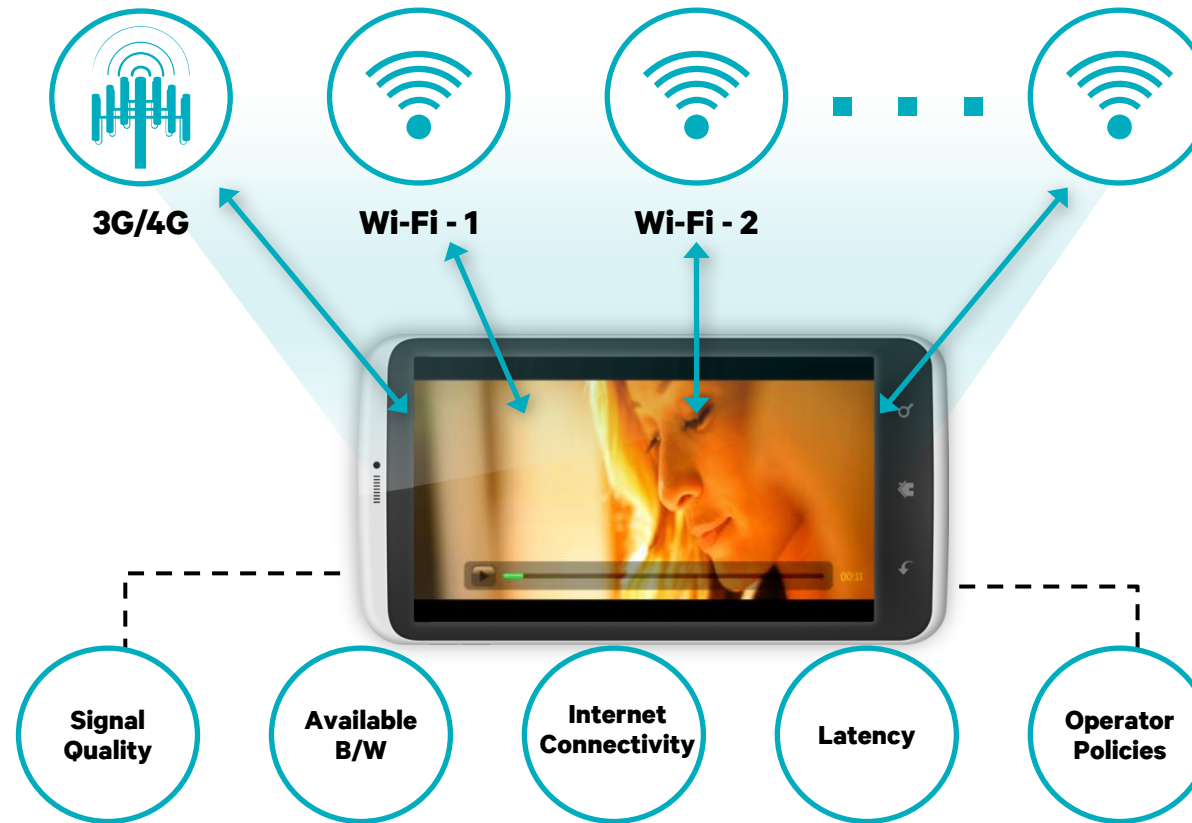Passpoint / Hotspot 2.0 + some features from ANDSF
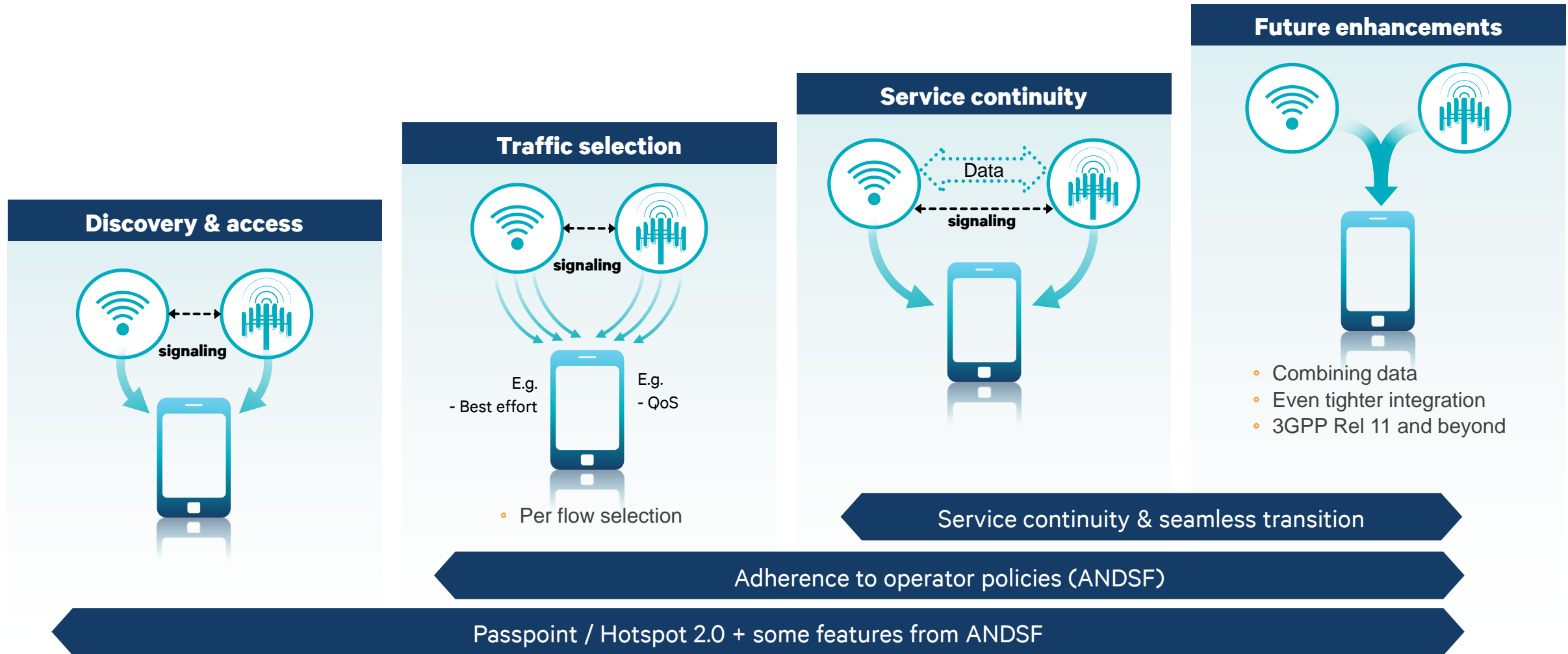
Notes: 1) ANDSF - Access Network Discovery and Selection Function defined in 3GPP :
2) The evolution shown here represents the trend in commercialization. 3GPP supports Service continuity in Rel 8 and Traffic selection in Rel. 10

Qualcomm connectivity engine (CnE) – Selecting best access

Based on end-to-end link performance

3G/4G **Wi-Fi - 1** **Wi-Fi - 2**

Signal Quality · Available B/W · Internet Connectivity · Latency · Operator Policies

Standards compliant
(Passpoint/Hotspot2.0, 3GPP (ANDSF), IWAN)

Smart algorithms
(In addition to standards)

Part of Qualcomm chipset solutions

Qualcomm 3G/4G – Wi-Fi converged small cell Solutions

- Wi-Fi and 3G/4G cellular SoCs & RF

- **Complete reference designs**

  - Modular, Flexible RF band support
  - RF Coexistence considerations fully addressed

- Intelligent end-to-end connection management

  - Hotspot 2.0/Passpoint support
  - Access selection based on information from both Wi-Fi and 3G/4G (QoS, resource constraints, loading, link quality etc)
  - Works even better with Qualcomm's connectivity engine (CnE)

	Qualcomm's Converged Small Cell	Standard Converged Small Cell
Device with CnE	Most optimized selection with end-to-end information	Intelligent selection based only on device info
Device w/o CnE	Intelligent selection based only on AP info	N/A

Wi-Fi: At the center of "Smart Connected Homes"

Connected home vision: Multiple smarts working together

Manage devices/apps to maximize efficiency, and provide homogenized user experience
(e.g. smart bandwidth management based on app requirements)

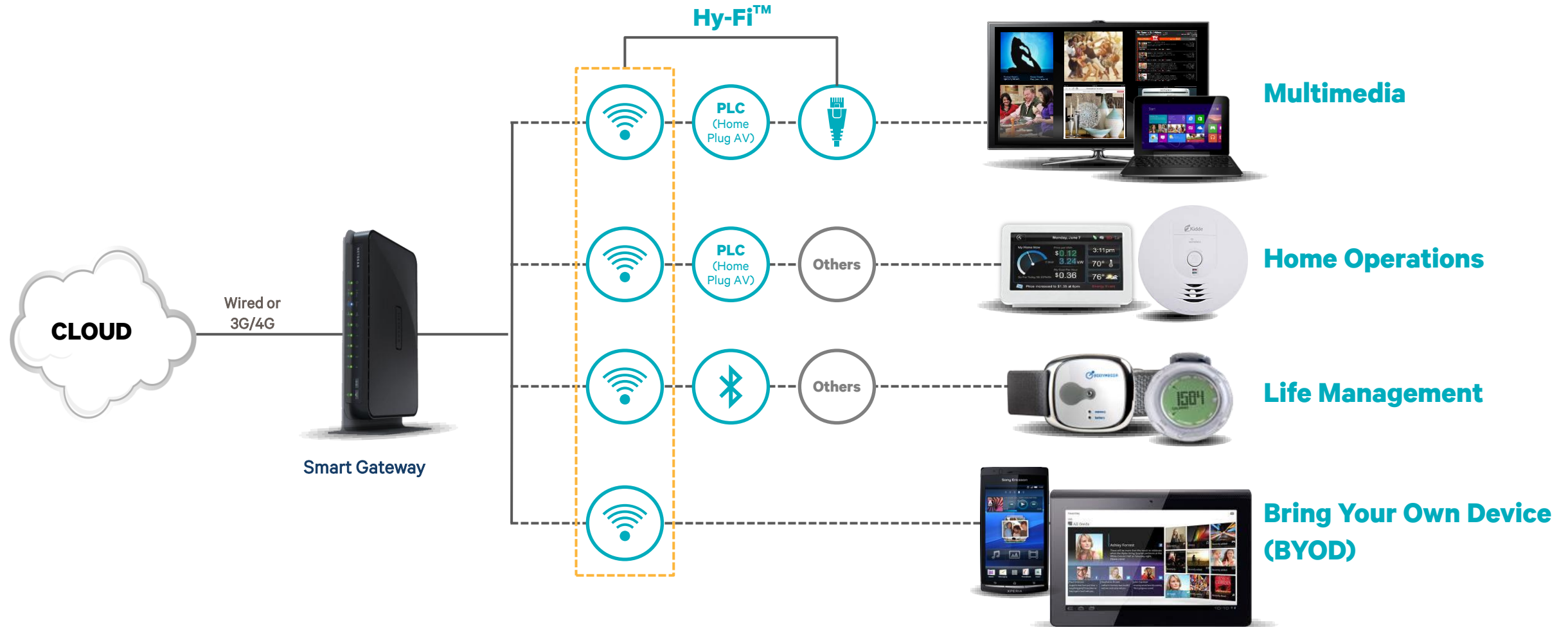**Smart connectivity / gateway**

Connected home

Deliver a personalized connected home experience
(e.g. smart TV, smart appliances)

Smart devices

Smart cloud

Extend resources of the home network when needed, by providing additional data, storage space and computing capabilities

Wi-Fi: Universal technology in "Connected Homes"

Hy-Fi™

CLOUD

Wired or 3G/4G

Smart Gateway

PLC (Home Plug AV)

PLC (Home Plug AV)

Others

Others

Multimedia

Home Operations

Life Management

Bring Your Own Device (BYOD)

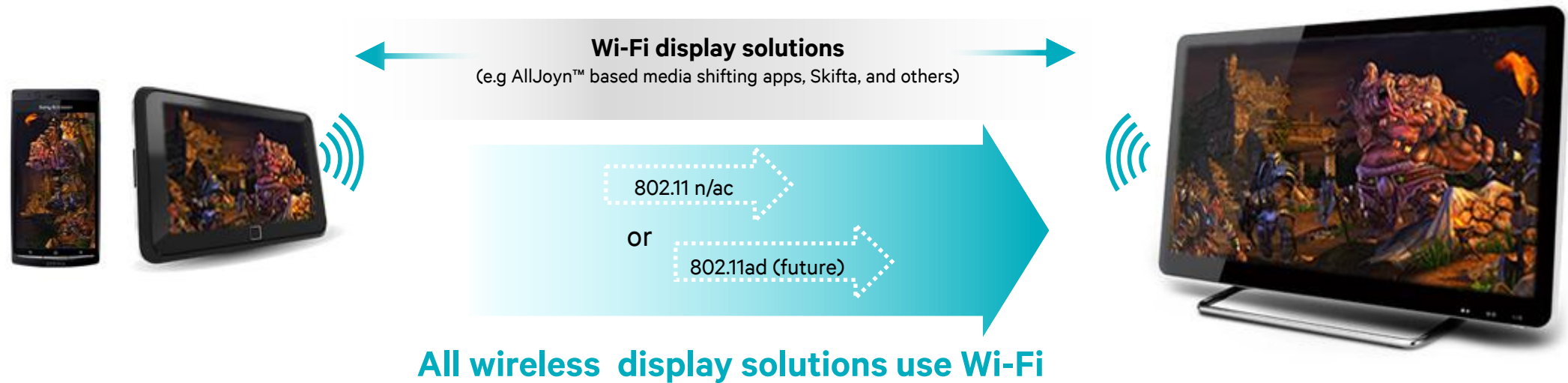PLC – Power Line Communications
Home Plug AV – Standard for Audio/Video over PLC

Wireless Display

Indoor Location

Wi-Fi: Opening new frontiers

Wi-Fi : Foundation for all wireless display technologies

Wi-Fi display solutions
(e.g AllJoyn™ based media shifting apps, Skifta, and others)

802.11 n/ac

or

802.11ad (future)

All wireless display solutions use Wi-Fi

Miracast™
Global industry standard
for Wireless Display

○ Mandatorily uses Wi-Fi Direct

○ Captures contents of source display and renders on the target
  - Mirrors the entire display, not just "transferring" media

WiGig: Short-distance multi-gigabit connectivity

Leveraging bandwidth-rich 60 GHz spectrum with 802.11ad

Globally Harmonized Band
(Up to 9 GHz available in most countries)

Complements 11ac
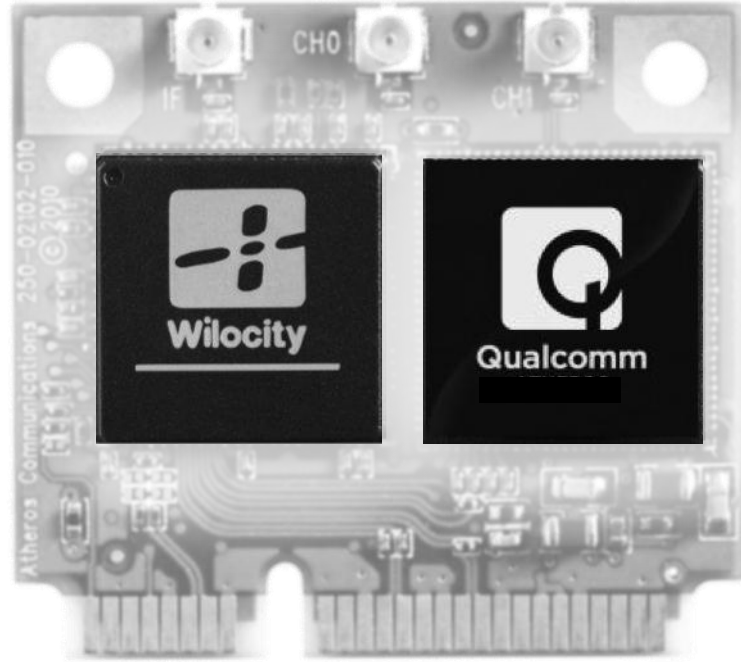(for short distance/same-room communication)

Strong Industry Support
(Major players from PC, Mobile & CE segments)

Instantaneous Docking/Synching
(Peer-to-peer)

Internet Access
(complementing 11ac)

High-Performance Wireless Display/Audio
(Uncompressed transfer, Peer-to-peer)

Industry's first tri-band WiGig solution

Tri-band - 2.4, 5 and 60 GHz

10x more in-room performance*

Seamless transition with 11n & 11ac

Commercial now (PC/Docking Station)

Combining Qualcomm's VIVE™ 11ac solutions with Wilocity's 802.11ad

Precise indoor positioning – Using Wi-Fi, sensors and more

Wi-Fi network based determination

◦ Signal strength and delay measurements

◦ Accuracy 5-7 mts

Device-based determination

◦ Signal strength and delay measurements

◦ Sensor augmentation

◦ Accuracy 3-5 mts

End-to-end solution provides highest accuracy and reliability

Qualcomm IZat™ – Precise positioning everywhere

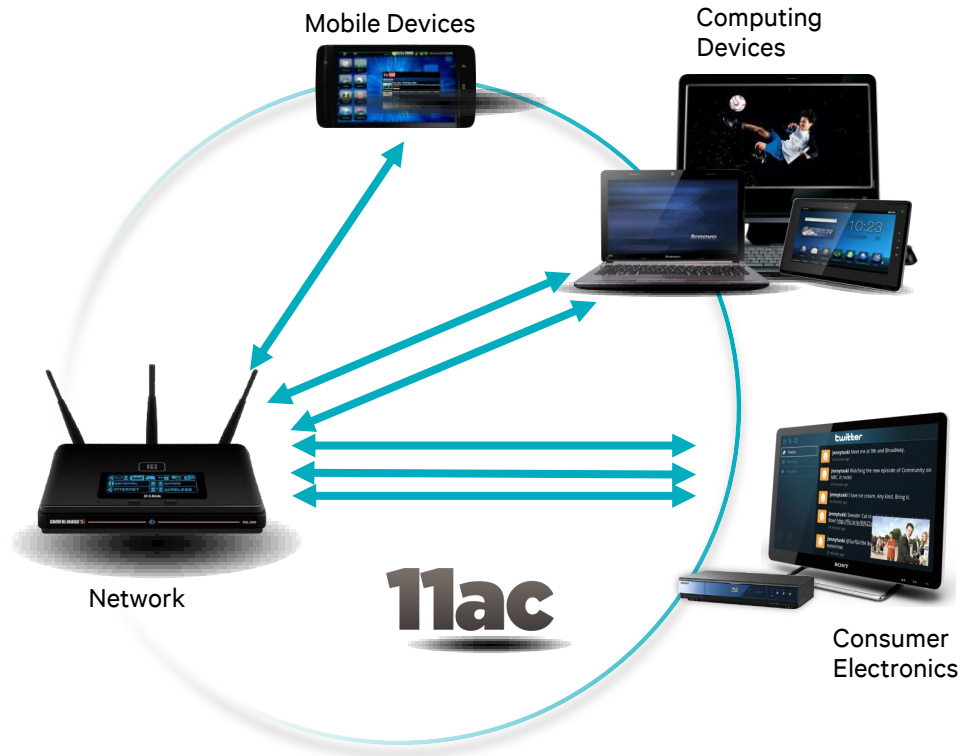## Comprehensive end-to-end solutions

1st **to market with GPS + Glonass**

Always-ON indoor location with near-zero power consumption

Indoor Location Solutions
(inlcuding cloud based data bases & services)

Qualcomm IZat™

Satellite-Based GNSS Solutions

Augmentation Technologies
(Cellular, Wi-Fi, Sensors, Servers)

Integrated into all MSM, MDM and APQ platforms
(and discrete solutions)

Qualcomm: Wi-Fi evolution leadership

Enabling robust end-to-end 11ac Ecosystem

Mobile Devices

Computing Devices

Network

11ac

Consumer Electronics

Comprehensive connected-home solutions

Trendsetting in-door positioning & WiGig offerings

WiGig
Wireless Gigabit Alliance

Wilocity
Wil6120
Qualcomm ATHEROS

Qualcomm
Izat

Industry leading solutions with end-to-end excellence

Questions? - Connect with Us

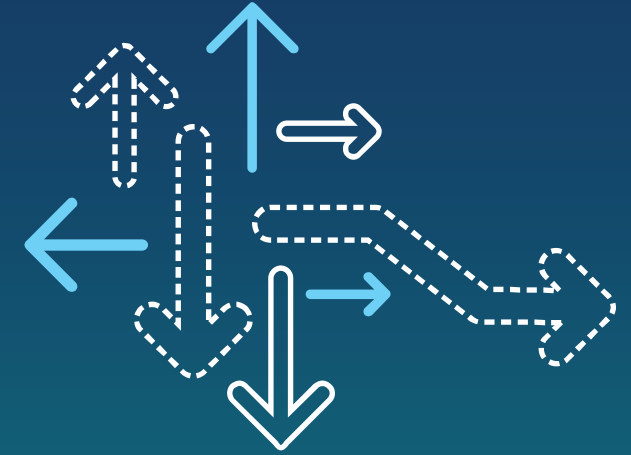www.qualcomm.com/technology

http://www.qualcomm.com/blog/contributors/prakash-sangam

BLOG

@Qualcomm_tech

http://www.youtube.com/playlist?list=PL8AD95E4F585237C1&feature=plcp

http://www.slideshare.net/qualcommwirelessevolution

http://storify.com/qualcomm_tech

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