The Wi-Fi Evolution
An integral part of the wireless landscape
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

Wi-Fi supported in all smart devices

The universal technology for smart connected homes

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

Growing Global Reach

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

<table>
<thead>
<tr>
<th>Frequency</th>
<th>2012</th>
<th>2013</th>
<th>2014 and beyond</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4 GHz/5 GHz</td>
<td>802.11 g</td>
<td>802.11 n</td>
<td>802.11ac Breaking the Gbps Barrier</td>
</tr>
<tr>
<td>60 GHz</td>
<td></td>
<td></td>
<td>802.11ad Multi-Gigabit Short Range</td>
</tr>
<tr>
<td>Sub GHz (bands vary globally)</td>
<td></td>
<td></td>
<td>802.11 ah Sensor, Control</td>
</tr>
</tbody>
</table>

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

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

**Multi-year year battery life. Home/building automation, sensors and more**
Qualcomm VIVE™: Enabling end-to-end 11ac ecosystem

Driving 11ac in migration in mobile through pin compatible solutions
Extending industry leading Wi-Fi performance¹
~6x lower power consumption (v/s our own 11n)

¹AnandTech - 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 device uses Qualcomm’s 802.11n solution
End-to-end portfolio maximizing 11ac benefits

**Mobile**
- 1-stream 11ac
- Integrated BT 4.0 & FM
- 433 Mbps capacity
- Dual-band 5/2.4GHz

**Computing**
- 1-, 2- and 3-stream 11ac
- Integrated Bluetooth
- 433, 866 Mbps & 1.3 Gbps
- Dual-band for all solutions

**Consumer electronics**
- 2-, 3-stream 11ac
- Integrated Bluetooth
- 866 Mbps & 1.3 Gbps
- Dual-band, dual-concurrent

**Networking**
- 2- and 3-stream 11ac
- 866 Mbps & 1.3 Gbps
- Integrated processor & switch
- Dual-band for all solutions
Wi-Fi: Part of the solutions to the “1000x Mobile Data Challenge”
Mobile data traffic growth—industry preparing for 1000x

Preparing for 1000x

Data traffic growth

Global data traffic growth

~2x

From 2010-2011*

*Global growth, some regions grew more/less
Multiple efforts needed to address 1000x – Wi-Fi is an integral part of the solutions

Higher Efficiency across the system

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

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

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

Spectrum + Small Cells
802.11ac: Up to 3x increase in throughput per stream

3x more in the future with MU-MIMO

3x throughput now*

3x more aggregate throughput with MU-MIMO**

Higher data rates at all ranges

Lower latency

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* 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
802.11ac: Higher data rates at all ranges

Up to 3x data rates (e.g. within same room)

Consistently higher data rates (e.g. within home, office)

Source – Qualcomm simulations; Assumptions - TCP/IP Throughput, Channel model D, 5GHz 11ac is 80MHz 3x3 3SS with ML and LDPC; 11n is 40MHz 3x3 3SS with ML and LDPC
MU-MIMO: Higher capacity with mix of devices

Simultaneously serving multiple devices by reusing resources

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
Passpoint™ – Seamless 3G/4G/Wi-Fi roaming

- Automatic discovery and access
  - No user intervention
  - Single set of credential for all hotspots
  - 3G/4G/ SIM/USIM based authentication
- Proven WPA2- Enterprise security
- Roaming among Wi-Fi and between 3G/4G Wi-Fi networks
- Deployments in 2013
Multi-dimensional Wi-Fi—3G/4G interworking landscape

Many Wi-Fi deployment models

- Standalone
- 3G/4G - connected (3rd party)
- 3G/4G Operator-Offered
- Converged

Different levels of interworking

- Automatic discovery/access
- Service continuity
- Traffic selection (e.g. per app basis)
- Traffic combining and future enhancements

Device in unique position to select best access/es

Network Quality

Operator Policies

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

**Discovery & access**
- Seamless Wi-Fi—3G/4G interworking is evolving

**Traffic selection**
- Per flow selection
  - E.g. - Best effort
  - E.g. - QoS

**Service continuity**
- Combining data
- Even tighter integration
- 3GPP Rel 11 and beyond

**Future enhancements**

**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

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

Smart algorithms
(In addition to standards)

Part of Qualcomm chipset solutions
Qualcomm 3G/4G – Wi-Fi converged small cell Solutions

- Highly integrated SoC
  - 3G/4G, Wi-Fi (11n & 11ac)

- 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)

<table>
<thead>
<tr>
<th>Qualcomm’s Converged Small Cell</th>
<th>Standard Converged Small Cell</th>
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<tbody>
<tr>
<td><strong>Device with CnE</strong></td>
<td><strong>Most optimized selection</strong></td>
</tr>
<tr>
<td></td>
<td><strong>with end-to-end information</strong></td>
</tr>
<tr>
<td><strong>Device w/o CnE</strong></td>
<td><strong>Intelligent selection</strong></td>
</tr>
<tr>
<td></td>
<td><strong>based only on device info</strong></td>
</tr>
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<tr>
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<td><strong>based only on AP info</strong></td>
</tr>
<tr>
<td></td>
<td><strong>N/A</strong></td>
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Wi-Fi: At the center of “Smart Connected Homes”
**Connected home vision: Multiple smarts working together**

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

- **Smart devices**
  - Deliver a personalized connected home experience (e.g. smart TV, smart appliances)

- **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”

- **CLOUD**
  - Wired or 3G/4G
  - Smart Gateway

- **Hy-Fi™**
  - PLC (Home Plug AV)
  - Others

- Multimedia
- Home Operations
- Life Management
- Bring Your Own Device (BYOD)

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PLC – Power Line Communications
Home Plug AV – Standard for Audio/Video over PLC
StreamBoost™: Taking 11ac to the next level

Intelligent traffic management for best possible performance

- Allocates appropriate bandwidth to each app/device for the best experience
- Makes the most of the finite available bandwidth
- Cloud-based updates continue to optimize network performance
- Supported in all ViVE networking chipsets
Qualcomm Hy-Fi™: Combining Wi-Fi, PLC and Ethernet

Mobility and flexibility of Wi-Fi with reliability and range of PLC
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

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**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

Dell Latitude 6430u, world’s first WiGig device – built on Qualcomm Tri-band 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

- Satellite-Based GNSS Solutions

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

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

Always-ON indoor location with near-zero power consumption

Integrated into all MSM, MDM and APQ platforms (and discrete solutions)
Qualcomm: Wi-Fi evolution leadership

Enabling robust end-to-end 11ac Ecosystem

Comprehensive connected-home solutions

Trendsetting in-door positioning & WiGig offerings

Industry leading solutions with end-to-end excellence
Questions? - Connect with Us

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