802.11ac – a new standard for WiFi networks

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Agenda

• Introduction
• Technology
• MIMO – Multiple Input Multiple Output
• Beamforming
• Device available on the market
What’s 802.11ac?

IEEE 802.11ac is a wireless computer networking standard of 802.11 currently under development (draft status) which will provide high-throughput wireless local area networks (WLAN) on the 5 GHz band.

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Date</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-09-26</td>
<td>D3.00</td>
<td>2012-06-25</td>
<td>91%</td>
</tr>
<tr>
<td></td>
<td>D4.00</td>
<td>2012-11-01</td>
<td>94%</td>
</tr>
<tr>
<td></td>
<td>D5.00</td>
<td>2013-02-01</td>
<td>95%</td>
</tr>
</tbody>
</table>
802.11 – The History

<table>
<thead>
<tr>
<th>Year</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>802.11</td>
</tr>
<tr>
<td>1997</td>
<td>802.11b</td>
</tr>
<tr>
<td>1999</td>
<td>802.11a</td>
</tr>
<tr>
<td>2003</td>
<td>802.11g</td>
</tr>
<tr>
<td>2009</td>
<td>802.11n</td>
</tr>
<tr>
<td>2013</td>
<td>802.11ac</td>
</tr>
</tbody>
</table>

### Wireless Performance Comparison

<table>
<thead>
<tr>
<th>Antenna Configuration</th>
<th>802.11n</th>
<th>802.11ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stream (1x1)</td>
<td>150 Mbps</td>
<td>450 Mbps</td>
</tr>
<tr>
<td>Dual Stream (2x2)</td>
<td>300 Mbps</td>
<td>900 Mbps</td>
</tr>
<tr>
<td>Three Stream (3x3)</td>
<td>Three Stream (3x3)</td>
<td>1.3 Gbps</td>
</tr>
</tbody>
</table>

- **2.4GHz WiFi band**
  - More widespread usage but high interference
  - Minimum WLAN feature required for connectivity

- **802.11ac – 5GHz WiFi Band**
  - Less interference, 8x more channels than 2.4GHz
  - Ideal for video streaming or gaming
The situation on the market

Exhibit 1: Global WiFi Handset Sales by WiFi Standard: 2010 to 2016

![Graph showing global WiFi handset sales by standard from 2010 to 2016. The graph displays sales in million units for each year and standard type.]
The demand for bandwidth

• Internet Video Streaming 2,5 do 8 Mbps
• HDTV 19 do 25 Mbps
• Blu-Ray 40 Mbps
• Uncompressed Video 8bit color, FullHD, 24fps - 796 Mbps
• Uncompressed Video 24bit color, FullHD, 60fps - 2780 Mbps
802.11ad

Parameters:
• The frequency of 60 GHz
• 4 channels, each 2.16GHz
• Up to 7 Gbps
• Distance up to 10m
• Beamforming

Application:
• Synchronization
• HDTV (HDMI)
• Bluetooth

source: http://wirelessgigabitalliance.org/whitepaper
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Types of Modulations

DSSS – Direct Sequence Spread Spectrum

Signal Before Spreading

Signal After Spreading

Frequency

Power

FHSS – Frequency Hopping

Hop Dwell Time

Time

Frequency

OFDM – Orthogonal Frequency Division Multiplexing

Available Bandwidth

Multiple Carriers (Tones)

Amplitude

Frequency
802.11 – Comparison

<table>
<thead>
<tr>
<th></th>
<th>802.11</th>
<th>802.11b</th>
<th>802.11a</th>
<th>802.11g</th>
<th>802.11n</th>
<th>802.11ac</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Available Bandwidth</strong></td>
<td>83.5MHz</td>
<td>83.5MHz</td>
<td>325MHz</td>
<td>83.5MHz</td>
<td>83.5MHz</td>
<td>600MHz</td>
</tr>
<tr>
<td><strong>Frequency range</strong></td>
<td>2,400-2,483GHz</td>
<td>2,400-2,483GHz</td>
<td>5,150-5,850GHz</td>
<td>2,400-2,483GHz</td>
<td>5,150-5,850GHz</td>
<td>5,150-5,850GHz</td>
</tr>
<tr>
<td><strong>Nonoverlapping channels</strong></td>
<td>3</td>
<td>3</td>
<td>12</td>
<td>3</td>
<td>2(40MHz) 2,4G 12(40MHz) 5G</td>
<td>6(80MHz) 2(160MHz)</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>FHSS/DSSS</td>
<td>DSSS/CCK</td>
<td>OFDM</td>
<td>CCK/OFDM</td>
<td>DSSS/OFDM</td>
<td>OFDM</td>
</tr>
<tr>
<td><strong>Data speed per channel</strong></td>
<td>1,2</td>
<td>5.5,11</td>
<td>6,9,12,18,24,36,48,54</td>
<td>6,9,12,18,24,36,48,54</td>
<td>6.5-150</td>
<td>433 (80MHz) 867 (160MHz)</td>
</tr>
<tr>
<td><strong>Max throughput</strong></td>
<td>2Mbps</td>
<td>11Mbps</td>
<td>54Mbps</td>
<td>54Mbps</td>
<td>600Mbps</td>
<td>6930Mbps</td>
</tr>
</tbody>
</table>
Channels in 802.11ac

• 160 MHz channel bandwidths (contiguous 80+80)
• 80+80 MHz channel bonding (noncontiguous 80+80)
• Mandatory 20, 40, 80 MHz channels

Source: http://www.eetimes.com
Frame format

802.11n PPDU (Mixed Mode)
- L-STF: 2 SYMBOLS
- L-LTF: 2 SYMBOLS
- L-SIG: 1 SYMBOL BPSK
- HT-SIG: 2 SYMBOLS QPSK
- HT-STF: 1 SYMBOL
- HT-LTFs: 1 SYMBOL/LTF, 4 LTFs max
- HT-Data

1 SYMBOL = 4 μs

802.11ac VHT PPDU
- L-STF: 2 SYMBOLS
- L-LTF: 2 SYMBOLS
- L-SIG: 1 SYMBOL BPSK
- VHT-SIG-A: 1 SYMBOL QPSK
- VHT-STF: 1 SYMBOL
- VHT-LTFs: 1 SYMBOL/LTF, 8 LTFs max
- VHT-SIG-B: 1 SYMBOL
- VHT-Data

Source: http://www.eetimes.com
Mandatory and optional features

- Mandatory features (carried over from 802.11a/802.11n)
  - 800 ns Regular Guard Interval
  - Binary Convolutional Coding (BCC)
  - Single spatial stream
- New mandatory features (newly introduced in 802.11ac)
  - 80 MHz channel bandwidths
- Optional features (carried over from 802.11n)
  - 2 to 4 spatial streams
  - Low-density parity-check code (LDPC)
  - Transmit Beamforming (TxBF)
  - 400 ns Short Guard Interval (SGI)
- Optional features (newly introduced in 802.11ac)
  - 5 to 8 spatial streams
  - 160 MHz channel bandwidths (contiguous 80+80)
  - 80+80 MHz channel bonding (noncontiguous 80+80)
  - MCS 8/9 (256-QAM)
Technology development

Technologies to improve the transferring rate of 802.11N

- **More steams**: single transfer stream to 2/3/4 streams,
  - 300 /450/600 Mbps
  - 200%/300%/400%

- **Larger bandwidth of channel**: larger bandwidth of channel from 20Mhz to 40 Mhz, and carrier wave higher to 108
  - 150 Mbps
  - 108%

- **Shorter GI**: shorter GI from 800ns to 400ns
  - 72.2 Mbps
  - 11%

- **More coding rate**: coding rate from 3/4 in 802.11g to 5/6
  - 65 Mbps
  - 11%

- **More carrier wave**: more carrier wave from 48 to 52 in 20Mhz bandwidth channel
  - 58.5 Mbps
  - 8.3%

- **11g**: in 20M HZ channel, carrier wave: 48
  - 54 Mbps
Technologies to improve the transferring rate of 802.11ac

- **More spatial streams**
  - • Maximum eight spatial streams
  - 6933 Mbps
  - 400%

- **Four streams**
  - • Up to four spatial streams
  - 3466 Mbps
  - 400%

- **Larger channel bandwidth**
  - • 160 Mhz: carrier wave 468
  - 866.7 Mbps
  - 100%

- **Larger channel bandwidth**
  - • 80 Mhz, and carrier wave higher to 234
  - 433 Mbps
  - 117%

- **Modulation change**
  - • 40MHz channel, 256QAM modulation carrier wave: 108
  - 200 Mbps
  - 33%

- **11n**
  - • 40MHz channel, 64QAM modulation carrier wave: 108
  - 150 Mbps
  - 33%
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MIMO – Multiple Input Multiple Output

2x2 with 1 spatial stream

Wireless chipset

Radio 1

A B C D E F G

Radio 2

A B C D E F G

Same data streams (slight different encoding) transmitted on 2 radios

2x2 with 2 spatial streams

Wireless chipset

Radio 1

A B C D

Radio 2

A B C D

Different data streams (from the original stream) transmitted on each radio

3x3 with 3 spatial stream

Wireless chipset

Radio 1

A D

Radio 2

B E

Radio 3

C F

Three different data streams – one Per radio

3x3 with 2 spatial stream

Wireless chipset

Radio 1

A B C D E F G

Radio 2

A B C D E F G

Two different streams on the radio, With a combination encoding of the 2 streams on the 3rd radio
MU-MIMO – Multiple User - Multiple Input Multiple Output

- Downlink only
- Total 8 streams max
- Up to 4 users
- Increase system efficiency
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Coverage effect diagram

AP Omnidirectional antenna signal

AP Omnidirectional antenna Signal with beamforming
Beamforming

-75dBm
Beamforming

-65dBm

+ 10% Phase
Beamforming

Chip-Based Beamforming and Subtypes
• Legacy beamforming
• Implicit beamforming
• Explicit beamforming

Smart Antenna-Based Beamforming
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## 802.11ac Chipset of the industry

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Part #</th>
<th>Streams</th>
<th>LDPC</th>
<th>TxBF</th>
<th>256-QAM</th>
<th>Applications</th>
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</thead>
<tbody>
<tr>
<td>Broadcom</td>
<td>4335</td>
<td>1</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Handsets</td>
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<td>Broadcom</td>
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<td>2</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Tablets</td>
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<tr>
<td>Broadcom</td>
<td>4360</td>
<td>3</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Routers</td>
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<tr>
<td>Marvell</td>
<td>Avastar 88W8897</td>
<td>2</td>
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<td>Y</td>
<td>Y</td>
<td>Tablets</td>
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<tr>
<td>Mediatek</td>
<td>MT7610</td>
<td>1</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>PC (PCle or USB)</td>
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<tr>
<td>Mediatek</td>
<td>MT7650</td>
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<td>?</td>
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<td>Y</td>
<td>Handsets</td>
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<tr>
<td>Qualcomm</td>
<td>WCN3680</td>
<td>1</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Handsets</td>
</tr>
<tr>
<td>Qualcomm</td>
<td>QCA9862</td>
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<td>Y</td>
<td>N</td>
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<tr>
<td>Qualcomm</td>
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<td>Quantenna</td>
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<td>Redpine Signals</td>
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<td>3</td>
<td>Y</td>
<td>?</td>
<td>Y</td>
<td>Routers</td>
</tr>
</tbody>
</table>
### Example configurations

All rates assume 256-QAM, rate 5/6:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Typical Client Form Factor</th>
<th>PHY Link Rate</th>
<th>Aggregate Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-antenna AP, 1-antenna STA, 80MHz</td>
<td>Handheld</td>
<td>433 Mbit/s</td>
<td>433 Mbit/s</td>
</tr>
<tr>
<td>3-antenna AP, 3-antenna STA, 80MHz</td>
<td>Tablet, Laptop</td>
<td>1.3 Gbit/s</td>
<td>1.3 Gbit/s</td>
</tr>
<tr>
<td>4-antenna AP, 4-antenna STA, 80MHz</td>
<td>Laptop</td>
<td>1.73 Gbit/s</td>
<td>1.73 Gbit/s</td>
</tr>
<tr>
<td>2-antenna AP, 2-antenna STA, 160MHz</td>
<td>Tablet, Laptop</td>
<td>1.73 Gbit/s</td>
<td>1.73 Gbit/s</td>
</tr>
<tr>
<td>4-antenna AP, 4 1-antenna STAs, 160MHz (MU-MIMO)</td>
<td>Handheld</td>
<td>867 Mbit/s to each STA</td>
<td>3.47 Gbit/s</td>
</tr>
<tr>
<td>8-antenna AP, 160MHz (MU-MIMO) -- 1 4-antenna STA</td>
<td>Digital TV, Set-top Box, Tablet, Laptop, PC, Handheld</td>
<td>3.47 Gbit/s to 4-antenna STA</td>
<td>6.93 Gbit/s</td>
</tr>
<tr>
<td>8-antenna AP, 160MHz (MU-MIMO) -- 1 2-antenna STA</td>
<td></td>
<td>1.73 Gbit/s to 2-antenna STA</td>
<td></td>
</tr>
<tr>
<td>8-antenna AP, 160MHz (MU-MIMO) -- 2 1-antenna STAs</td>
<td></td>
<td>867 Mbit/s to each 1-antenna STA</td>
<td></td>
</tr>
<tr>
<td>8-antenna AP, 4 2-antenna STAs, 160MHz (MU-MIMO)</td>
<td>Digital TV, Tablet, Laptop, PC</td>
<td>1.73 Gbit/s to each STA</td>
<td>6.93 Gbit/s</td>
</tr>
</tbody>
</table>
iF Product Design Award 2013

Huawei AP7030DN-AC

• Complies with IEEE 802.11 a/b/g/n/ac
• Supports 3x3:3 MIMO
• Provides a maximum rate of 1.74 Gbit/s
• Supports 80MHz bandwidth
• 256QAM modulation
Huawei WLAN Product Portfolio

WLAN 802.11n access point

**Standard Series**
- AP5010SN-GN (Indoor single-band AP)
- AP5010DN-AGN (Indoor dual-band AP)

**Enhanced Series**
- AP6010SN-GN (Indoor single-band AP)
- AP6010DN-AGN (Indoor dual-band AP)
- AP6310SN-GN (Indoor DAS AP)

**Premium Series**
- AP6510DN-AGN (Outdoor dual-band AP, RJ45, PoE power supply)
- AP6610DN-AGN (Outdoor dual-band AP, SPF, AC power supply)
- AP7110SN-GN (Indoor 3x3 MIMO single-band AP, 450 Mbit/s)
- AP7110DN-AGN (Indoor 3x3 MIMO dual-band AP, 450Mbit/s × 2)

**WLAN access controller**
- AC6605-26-PWR
- SPU Value-added service board for S9700/S7700

Enhanced Series

Standard Series

Premium Series
10 GE AC - The Engine of Wireless Campus Networks

- Smooth evolution to 11ac
- Meets requirements for gigabit access and 10 GE aggregation on campus networks

- 2×10 GE optical ports
- 4×GE combo ports
- 20×GE electrical ports

AC6605-26-PWR

Support for all types of APs (11a/b/g/n/ac)

24 port PoE+

CAPWAP line-speed forwarding
Wireless ridge management
Huawei Wireless Network Tools, high quality network

WLAN Planner

- 95% area signal assurance
- Reduce 30% building WLAN network time
- Reduce 20% network problem

WLAN Professional Service

Probe Handset Unit (PHU)

- Cell phone tester, easy to carry
- Easy to test the signal of WLAN.
- Fast, accurate, complete the 1,000 square meters in 10 minutes...

WLAN Tester

- Resolve 80% Problems
  - Slow internet speed
  - Blur image, unclear voice
  - Roaming business interruption

95%

Reduce 30%

Reduce 20%

80%
Thank you
www.huawei.com

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