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Research and Technological Development

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Pre-incubation of Technology-based Companies



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Outline

- What is 802.11ac ?
- 802.11 standards evolution
- Spectral allocation
- First generation devices in 2013
- Downlink Multiuser MIMO and beamforming
- Opportunities and Threats
- 802.11ad/WiGig
- Conclusion

What is 802.11ac ?

- 802.11ac is an improved version of 802.11n offering higher speeds over wider bandwidths, PHY and MAC improvements
- Targeted at 5 GHz, up to 6.93Gbit/s
- Backwards compatible with 11n/11a

Technology	Mandatory	Optional
Bandwidth	20, 40, 80 MHz	160, NC: 80+80 MHz
MIMO (Number of spatial streams)	Client: 1 AP: 2	SU: up to 8 MU: up to 4 per user
MCS	0-7	8-9 (256-QAM)
Enhanced Feature		Tx Beamforming
New Feature		DL MU-MIMO



802.11 Standards Evolution

Year	Standard 802.11	Datarate (Mbit/s)		Freq. (GHz)	Spatial streams	Notes
		20MHz	40MHz			
1999	b	11		2.4	1	CCK
1999	a	54	108	5	1	OFDM: 64-QAM
2003	g	54	108	2.4	1	OFDM: 64-QAM
2009	n	72.2	150	2.4/5	4 MIMO	OFDM: 64-QAM

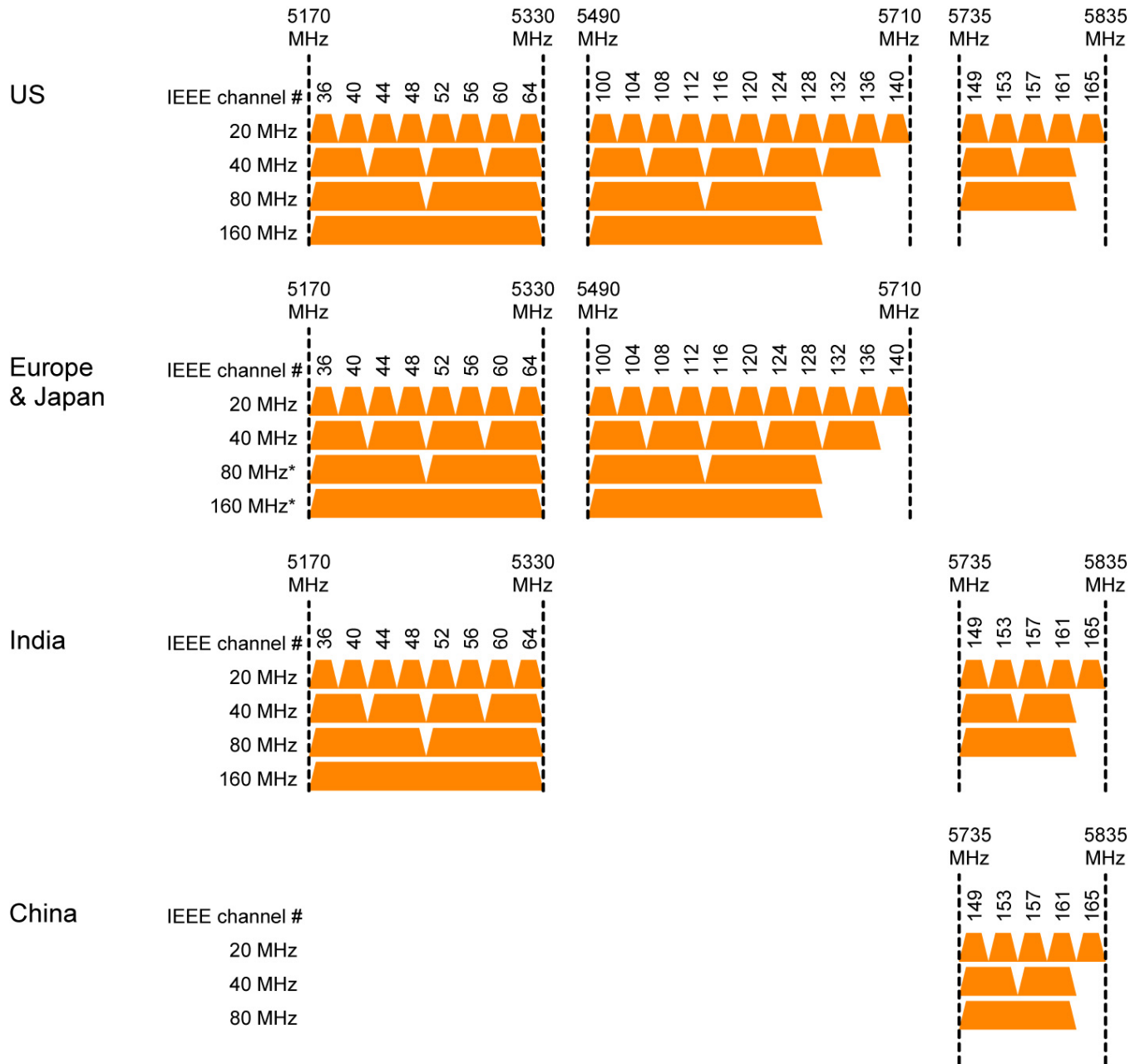


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2009	n	72.2	150		2.4/5	4 MIMO	OFDM: 64-QAM
2013/ 2014	ac	86.7	200	433.3	5	8 MIMO	OFDM: 256-QAM



Spectral allocation



First generation devices - 2013

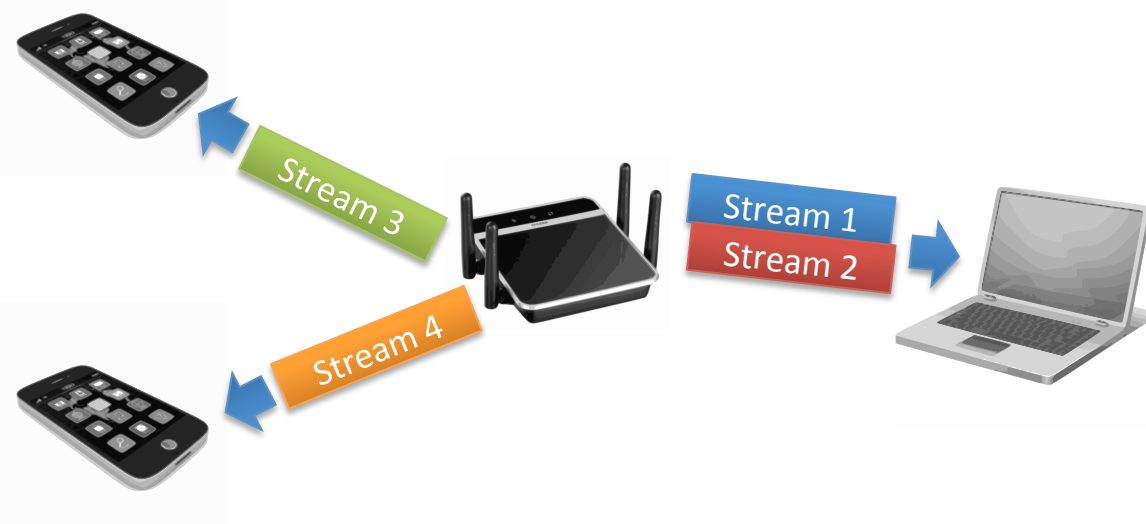
- Bandwidths: 20, 40, 80 MHz
- Modulation: 256-QAM
- 3 streams
- Up to 1.3Gbit/s
- Interoperability with 11n and 11a using RTS-CTS extensions
- Dynamic bandwidth selection
- Increased sensitivity of the clear channel assessment (CCA)
- No DL MU-MIMO
- Second generation: Q2 2014
 - 4x4 MU-MIMO
 - 160MHz likely
 - Up to 3.47Gbit/s

Downlink Multi-user MIMO and Beamforming



11n: Single user MIMO

- Allows 1 AP to transmit different data to multiple stations simultaneously
- Up to 8 spatial streams in both single-user and multi-user modes



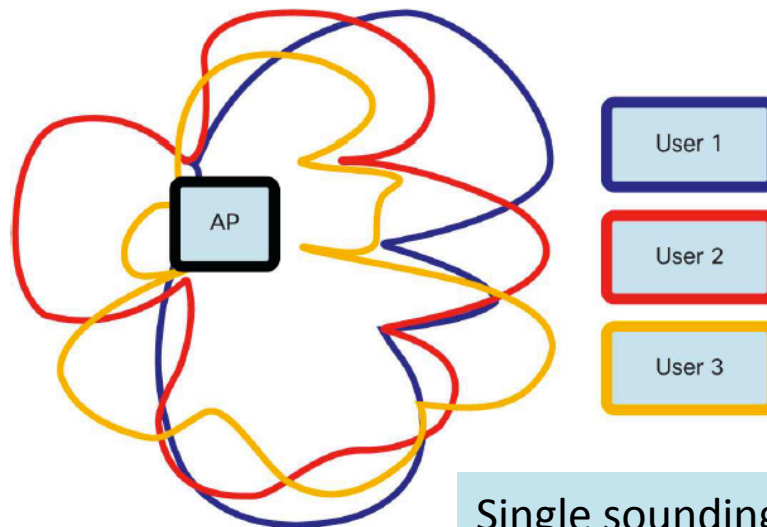
11ac: Multi-user MIMO

Downlink Multi-user MIMO and Beamforming



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11ac: Multi-user MIMO

Single sounding & feedback format for **beam forming**
(as opposed to multiple, incompatible formats in 11n) ¹⁰

Opportunities and Threats

- Background noise:
 - 5 GHz spectrum will become polluted due to cheap 802.11ac hardware occupying 80MHz channels
 - Channel bandwidths of 160 MHz will present some RF challenges to enterprise environments and may not be used
 - Tx Beam-forming is likely to get wide industry adoption and attenuate the problem
 - Nothing is for free:
 - Increased power draws due to faster CPUs and radios
 - Consuming more spectrum using the same RF power
 - Going from 64QAM to 256QAM
 - More spatial streams require more [power, cost]:
 - antennas, RF connectors, and RF chains at transmitter and receiver
- Signal to Noise Ratio requirements are increased**



802.11ad/WiGig

- 60 GHz based
- Up to 7Gbit/s over 2.16GHz bandwidth
- Unified beamforming scheme
- New MAC:
 - Channel access supporting directionality (random and scheduled access)
- Seamless integration with 802.11a/b/g/n/ac
 - Fast session transfer for multiband operation across 2.4/5/60 GHz
- 60 GHz incurs large free-space path loss (22dB higher than 5 GHz), and penetration loss
- Replacement for shorter cables like HDMI, USB
 - Wireless laptop docks, wirelessly pushing video to HDTVs

Conclusion

- 802.11ac is a faster and more scalable version of 802.11n
- More bandwidth, denser modulation and more MIMO
- Provides a better experience for each client:
 - More available bandwidth (parallel video streams)
 - Battery life is extended (due to faster data exchanges)
 - Low-lag Gigabit speeds
- MU-MIMO and beamforming
 - Particularly well suited to bring-your-own-device (BYOD) situations

Thank you!

References:

- [1] Aruba Networks, 802.11ac, Frequently asked questions, December 2011
- [2] Cisco, 802.11ac: The fifth generation of Wi-Fi, Technical White Paper, August 2012
- [3] Qualcomm, IEEE802.11ac: The next evolution of Wi-Fi standards, May 2012
- [4] Ruckus Wireless, 802.11ac: Very High Throughput, White Paper, February 2013