Dorothy Stanley, Aruba Networks
Craig Mathias, Farpoint Group

Fact vs. Fiction
Gigabit Wi-Fi 802.11ac

Webinar Overview

- The next major development in wireless LAN technologies – 802.11ac
- Features, benefits, and limitations
- Availability and timelines
- Real-world throughput expectations
- Migration planning, requirements, and related costs
- Gigabit Wi-Fi use cases
- Setting expectations for the enterprise

Our Speakers for Today

Dorothy Stanley

- Head of Standards Strategy, Aruba Networks
- Chair IEEE 802.11v, IEEE 802.11Revmb
- Liaison IEEE 802.11 to IETF
- Vice-chair Wi-Fi Alliance Security Marketing, Security Technical and Wireless Network Management Marketing Task Groups

Craig Mathias

- Founder (1991) and Principal with Farpoint Group
- Advisory services for wireless and mobile
- Member, IEEE
- Advisory Board Member for Interop, Co-Chair of Mobile Connect, and Analyst Partner at 4G World
- Columns for Information Week and TechTarget
- Blog at Network World

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Standards Review

Dorothy Stanley

11ac Standards Discussion

1. IEEE P802.11ac – Project Definition, Scope & Schedule
2. Benefits: Usage Models & Application Environments
3. Key Technical Components
4. Summary

IEEE P802.11ac Basics

- **Title**: Enhancements for Very High Throughput for operation in bands below 6GHz
- **Scope:** Modifications to both the 802.11 physical layers (PHY) and the 802.11 Medium Access Control Layer (MAC)
  - **At least 1 Gbps** Multi-station (STA) throughput and a maximum single link throughput of at least 500 Mbps.
  - 6 GHz below carrier frequency operation **excluding 2.4 GHz**
  - **Backward compatible** and coexistence with legacy IEEE802.11 devices in the 5 GHz unlicensed band.
- **Project Purpose:** Significantly higher throughput for existing WLAN application areas and to **enable new market segments** for operation below 6 GHz **including distribution of multiple multimedia/data streams**.

Source: P802.11ac Project Authorization Request (PAR)

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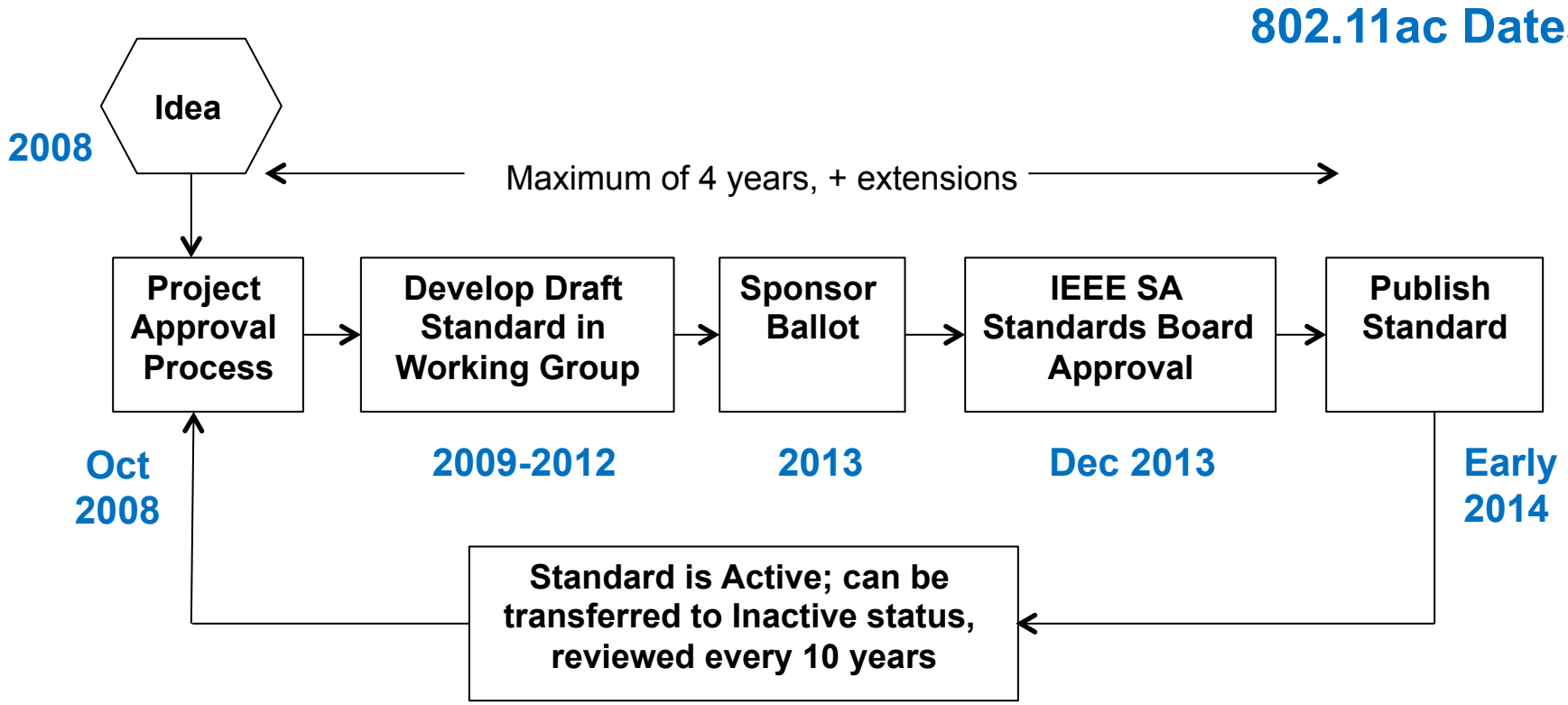
IEEE Standards Development: Process Flow – 802.11ac



Source: https://mentor.ieee.org/802.11/dcn/10/11-10-0617-01-0000-ieee-standards-process-overview.ppt and http://standards.ieee.org/develop/policies/opman/sb_om.pdf

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An aside: 802.11ad ≠ 802.11ac

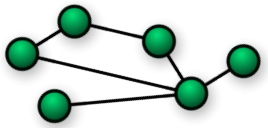
- IEEE 802.11ad:
  - 60GHz specification
  - Appropriate for shorter range in-room use cases
  - Gigabit data rates
  - Expected approval in Dec 2012

802.11ac Categories of Usage

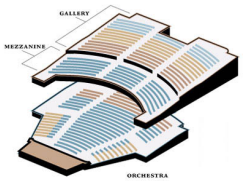
Wireless Display

In Home Distribution of HDTV and other content

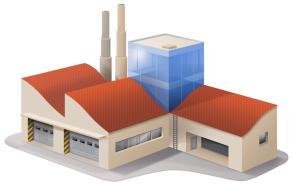
Rapid Upload/Download of large files to/from server



Backhaul Traffic (e.g. Mesh, Point-to-Point)



Campus / Auditorium deployments



Manufacturing Floor Automation

Source:
https://mentor.ieee.org/802.11/dcn/07/11-07-2988-04-0000-liaison-from-wi-fi-alliance-to-802-11-regarding-wfa-vht-study-group-consolidation-of-usage-models.ppt
also see:
https://mentor.ieee.org/802.11/dcn/09/11-09-0161-02-00ac-802-11ac-usage-model-document.ppt

Example: Video requirements

Video type	Description	Rate	Packet error rate	Jitter	Delay
Uncompressed	720p (RGB) 1280x720 pixels; 24 bits/pixel, 60 frame/sec	1.3 Gbps	10^{-8}	5 msec	5 msec
	1080i (RGB) 1920x1080/2 pixels; 24 bits/pixel, 60 frame/sec	1.5 Gbps	10^{-8}	5 msec	5 msec
	1080p (YCrCb) 1920x720 pixel; 24 bits/pixel, 60 frame/sec	1.5 Gbps	10^{-8}	5 msec	5 msec
	1080p (RGB) 1920x720 pixel; 24 bits/pixel, 60 frame/sec	3.0 Gbps	10^{-8}	5 msec	5 msec
Lightly Compressed	Motion JPEG2000	150 Mbps	10^{-7}	10 msec	10 msec
	H.264	70 – 200 Mbps	10^{-7} 10^{-8}	20 msec	20 msec
Compressed	Blu-ray™	50 Mbps	10^{-7}	20 msec	20 msec
	HD MPEG2	20 Mbps	$3x10^{-7}$	20 msec	20 msec

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Key Technical Components

1. **Wider channels**: 80 MHz &160 MHz channel bandwidths
2. **New modulation & coding**: 256-QAM, rate ¾ and 5/6, added as optional modes
3. **More spatial streams**: Up to 8 (had 4 in 802.11n)
4. **Multi-user MIMO** (MU-MIMO)

Source: IEEE 802.11ac framework document, see
https://mentor.ieee.org/802.11/dcn/09/11-09-0992-21-00ac-proposed-specification-framework-for-tgac.doc

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80 MHz and 160 MHz channel bandwidths

- **80 MHz mandatory, 160 MHz optional**
- **80 MHz channels are 'new' channels:**
  - Like two 40 MHz channels but with tones in the middle filled in
- **160 MHz channels are defined as two 80 MHz channels**
  - May be contiguous or non-contiguous

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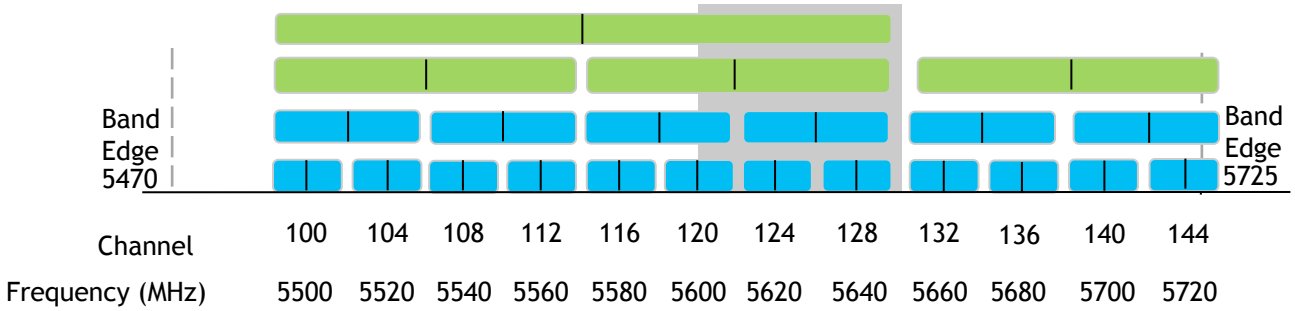
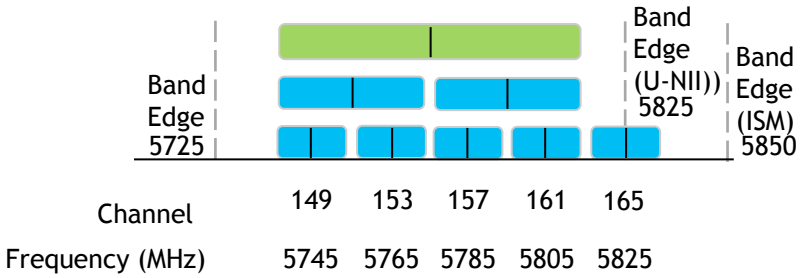
20/40 and 80/160 Channelization

US U-NII I and U-NII II bands
U-NII I: 5150-5250 MHz (indoors only)
U-NII 2: 5250-5350 MHz
8x 20 MHz channels
4x 40 MHz channels
2x 80 MHz channels
1x 160 MHz channel
U-NII II requires DFS (& TPC if over 500mW / 27dBm EIRP)



US intermediate band (U-NII 2 extended)
5450-5725 MHz
12x 20 MHz channels
6x 40 MHz channels
3x 80 MHz channels
1x 160 MHz channel
- Requires DFS (& TPC if over 500mW / 27dBm EIRP)
- 5600-5650 MHz is used by weather radars and is temporarily not available in the U.S.



US-only U-NII 3 / ISM band
5725-5825 MHz
5x 20 MHz channels
2x 40 MHz channels
1x 80 MHz channel
- Slightly different rules apply for channel 165 in ISM spectrum

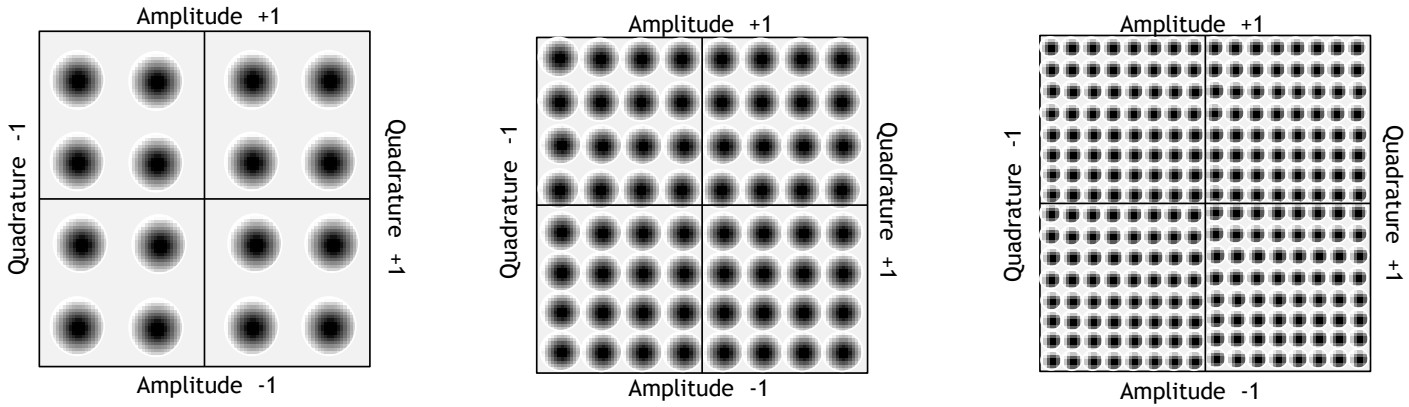
Channels defined for 5 GHz bands (U.S. regulations), showing 20, 40, 80 and 160 MHz channels
(channel 144 is now allowed in the U.S. for one additional 20 MHz, one 40 MHz and one 80 MHz channel)

Deployment Considerations – RF Planning

- 160MHz
  - It is unlikely we will see wide adoption of 160MHz channels, but no doubt some special applications will emerge to use this option.
- 80MHz
  - Five available 80MHz channels (three require DFS) should be sufficient for overlapping access points to provide contiguous coverage
- <80MHz:
  - Some networks will have reasons to prefer a higher number of smaller-width channels

Modulation

- Adds 256-QAM options with coding of 3/4 and 5/6.
  - Compared to 802.11n: 64-QAM 5/6
- Provides a higher ‘raw data’ top speed
- Higher order modulation leverages advances in radio technology, to better distinguish constellation points
- All the earlier options are still available, used if SNR is too low to sustain the highest rates.



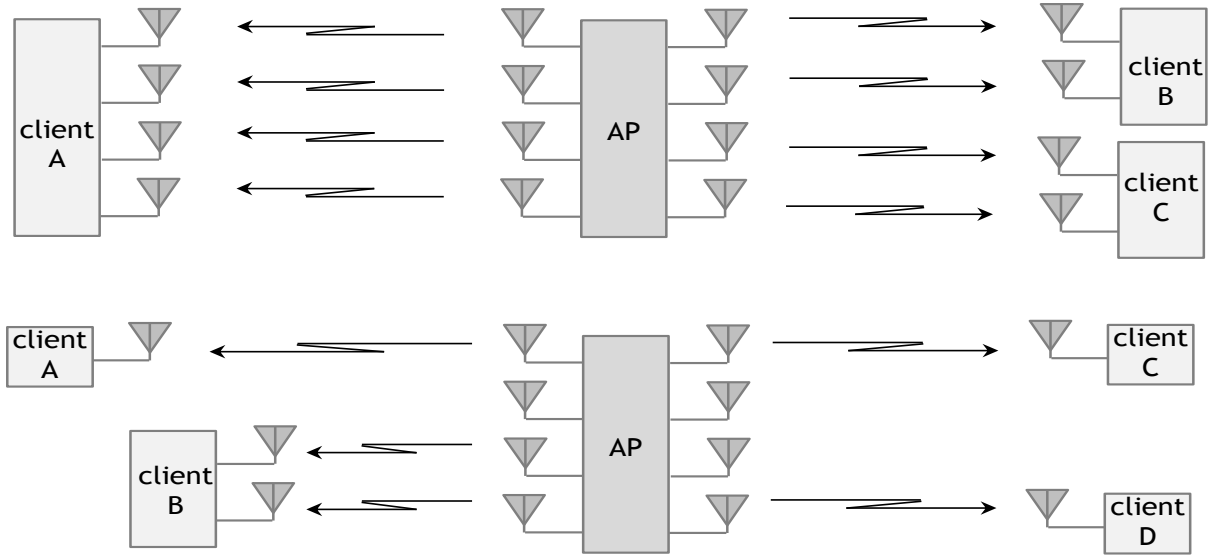
Constellation diagrams for 16-, 64-, 256-QAM

More Spatial Streams

- Up to 8 spatial streams in both single-user (SU) and multi-user (MU) (was 4 max in 802.11n)
  - 8SS performance will only be possible where both devices have 8 antennas.
  - Without innovative antenna designs, this probably precludes handheld devices, but access points, set top boxes and the like will be able to use multiple streams.
- Adding spatial streams increases throughput proportionally. Assuming multipath conditions are favorable,
  - Two streams offer double the throughput of a single stream
  - Eight streams increase throughput eight-fold

11ac Multi-User MIMO

- MIMO:
  - 802.11n Introduced MIMO (Multiple Input, Multiple Output) spatial division multiplexing for dramatic improvements in data rate
- Multi-User MIMO
  - Multiple devices, each with potentially multiple antennas, **transmit or receive independent data streams simultaneously**
  - **Requires beamforming** techniques to steer signal maxima over the desired clients while minimizing interference at other clients.



802.11ac achievable link rates

Channel bandwidth	Transmit - Receive antennas	Modulation and coding etc	Typical client scenario	Throughput (individual link rate)	Throughput (aggregate link rate)
80 MHz	1x1	256-QAM 5/6, short guard interval	Smartphone	433 Mbps	433 Mbps
80 MHz	2x2	256-QAM 5/6, short guard interval	Tablet, PC	867 Mbps	867 Mbps
160 MHz	1x1	256-QAM 5/6, short guard interval	Smartphone	867 Mbps	867 Mbps
160 MHz	2x2	256-QAM 5/6, short guard interval	Tablet, PC	1.73 Gbps	1.73 Gbps
160 MHz	4x Tx AP, 4 clients of 1x Rx	256-QAM 5/6, short guard interval	Multiple smartphones	867 Mbps per client	3.47 Gbps
160 MHz	8x Tx AP, 4 clients with total of 8x Rx	256-QAM 5/6 , short guard interval	Digital TV, set-top box, tablet, PC, smartphone	867 Mbps to two 1x clients 1.73 Gbps to one 2x client 3.47 Gbps to one 4x client	6.93 Gbps
160 MHz	8x Tx AP, 4 clients of 2x Rx	256-QAM 5/6, short guard interval	Multiple set-top boxes, PCs	1.73 Gbps to each client	6.93 Gbps

802.11ac vs 802.11n

802.11ac enhancement	Notes	Improvement over current 802.11n	Max theoretical improvement over 802.11n
80 MHz, 160MHz channel	Over 40MHz in 802.11n (but how often is a 160MHz channel practical?)	~ 2.1x (80MHz)	4.2x (160MHz)
8 Spatial streams	Over max 4 spatial streams in 802.11n (but only just seeing 3SS 802.11n in the field)	~ 2x (4SS vs 2SS)	1x (4SS vs 4SS without MU-MIMO)
256-QAM 3/4 and 5/6 modulation	Over 64-QAM 5/6 in 802.11n	~ 1.2, 1.33x	~ 1.2, 1.33x
Beamforming (implementable BF)	No explicit BF in current 802.11n systems due to complexity	~1.5x	~2x
Multi-user downlink MIMO	Over single-user MIMO in 802.11n	~1.5x	~2x
Total improvement		~10x	~20x

(estimates only - performance depends on clients, traffic profiles, neighboring WLANs etc.)

WFA Industry Certification

- Wi-Fi Alliance – Work is underway for Draft 11ac Certification
  - Expected to be available 1H 2013
  - Based on IEEE 802.11ac draft
  - Followed by “Final ac”

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Summary: 11ac – 5GHz VHT

- What 802.11ac Offers:
  - Higher bandwidth, enable new applications
- Benefits:
  - New Usage Models & Application Environments
- Key Technical Components:
  - Significant improvements from wider channels, higher-rate modulation and higher-level MIMO
  - Together they offer a top speed that is >10x that of 802.11n
- Certification Status - 2013

802.11ac and the Enterprise

Craig J. Mathias • Principal

Farpoint Group

Topics for Discussion…

- Why demand for Wi-Fi *capacity* will continue to grow rapidly
- How 802.11ac will change the enterprise wireless LAN
  - Evolution, not revolution
- It's not just about the PHY…
  - The continuing importance of architecture and management
- Trends and timelines
- Alternatives for the enterprise now
- Conclusions and recommendations

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Wi-Fi Forever

- First a toy, then a tool, now part of the culture – *globally!*
- *No* competition from any other wireless technology
- Enterprise, personal, public-space (hotspot and metro-scale)
- Voice, data, video – the mobile Triple Play
- 802.11n removed the last barrier for enterprise installations
  - All other issues have been addressed for essentially all industries and applications
- Key differentiation in enterprise-class products is in *architecture* and *management*
  - But AP/radio implementations can still make a big difference!
- Next – gigabit-class WLANs
  - 802.11ac and ad
- Today's enterprise goal: *capacity*, not just coverage or throughput alone
  - And *reliability* and *scalability*

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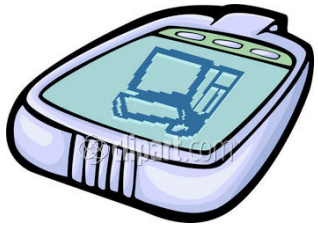
Wi-Fi as Default/Primary Access
Venues, Subscriber Units, Applications

Residential

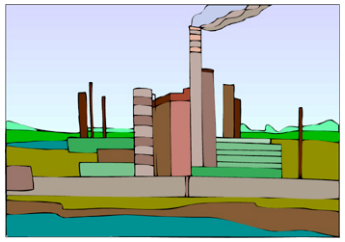
Public-Space

Enterprise

PC



Handset



Other Devices and Applications (e.g., M2M)

Voice

Data

Video

Source: Farpoint Group

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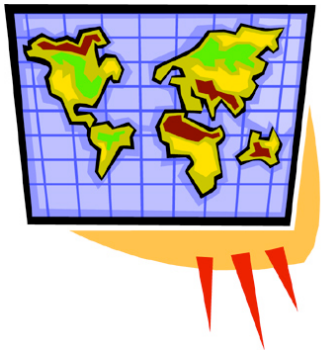
Wi-Fi: Key Trends

Device Proliferation

- Handsets
- Notebooks
- Tablets
- Users with *multiple* devices

Wireless as an *Expectation* and *Requirement*

- Default/primary access
- All venues
- All applications – *extreme* diversity
- Staff, customer, and guest use
- Social networks, media access
- Evolution to gigabit (802.11ac/ad)



Increasing *Dependence* on Wi-Fi

- Core driver: *convenience*
- *Capacity*, not just throughput
- Mobile Triple Play
- *Density*: users drive infrastructure
- *Coverage - everywhere*
- Complementary to cellular
    - *Cellular offload*

Source: Farpoint Group

802.11ac – Breaking the Gigabit Barrier

Gratuitous clipart - Please ignore

Source: Farpoint Group

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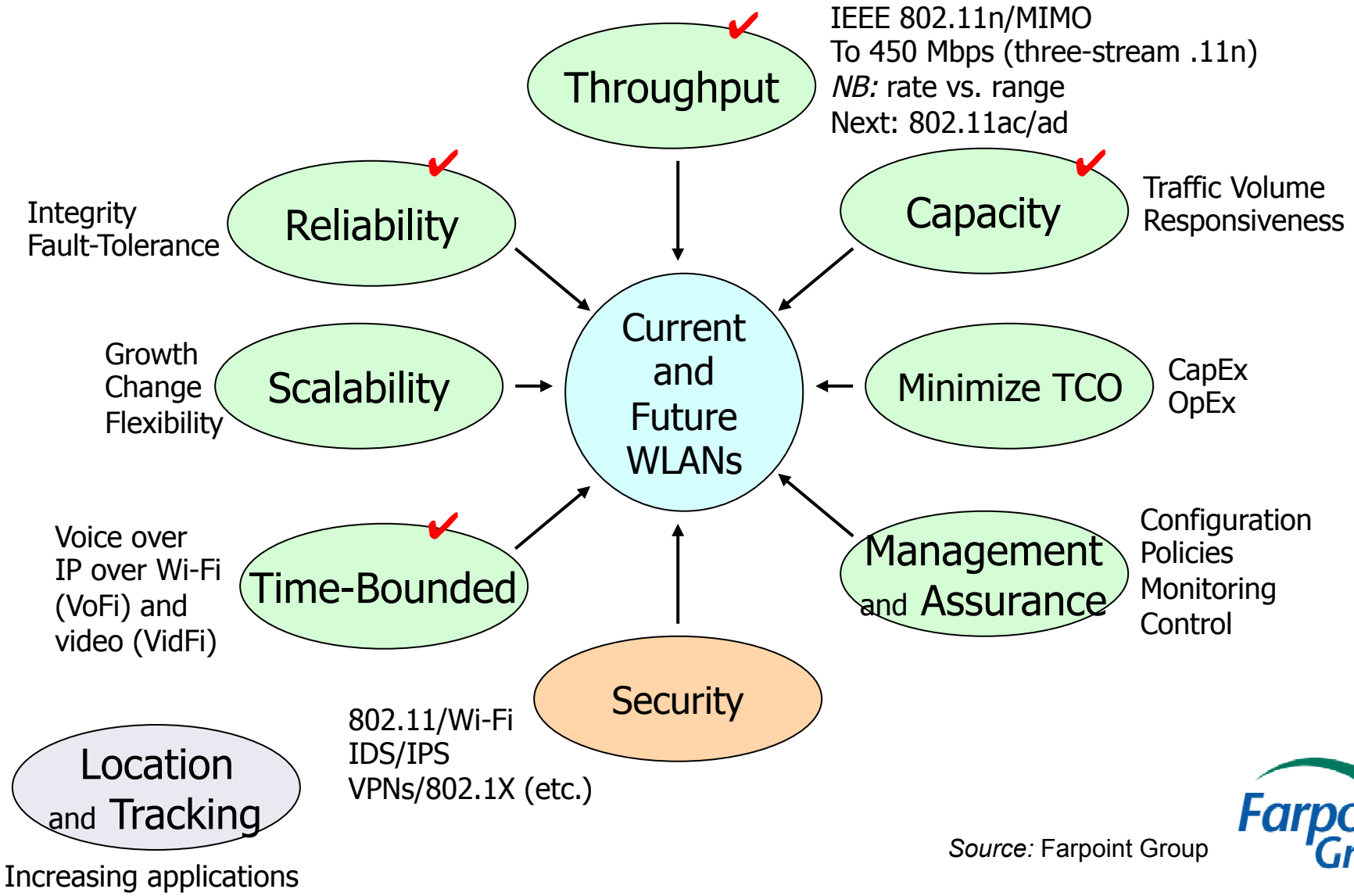
WLANs – Key Requirements



Source: Farpoint Group

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It's Not Really About Throughput – It's About *Capacity*

Solutions that also work with .11ac

Dense Deployments
- Maximize channel utilization
- Maximize throughput/reliability by minimizing range

RF Management Techniques
- Beamforming
- Beamsteering
- Bandsteering
- Auto channel/power selection
- Spectral analysis

Traffic prioritization/Airtime fairness

Load balancing

Source: Farpoint Group

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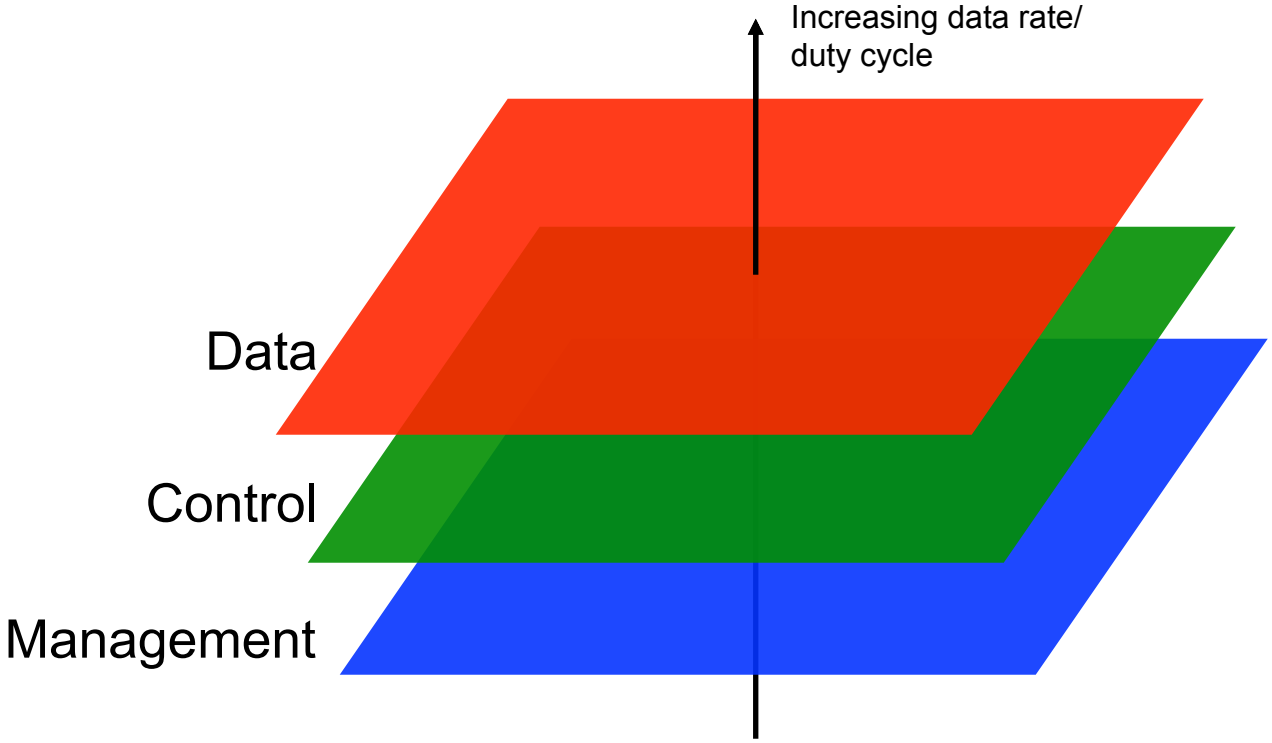
Architecture Matters: The "Planes" Model of Enterprise WLAN Systems



- ***Distributed***
- ***Centralized***
- *Capacity*

- ***Distributed***
- ***Centralized***
- ***Hybrid/Adaptive***
- "OS" – traffic flow
- Resource management
- Policy Implementation

- ***Centralized***
- Planning
- Configuration
- Deployment
- Administration
- Security
- Integrity
- Monitoring
- Logging, Reporting, Compliance
- Troubleshooting
- Alerts, Alarms, Exceptions
- Assurance

Source: Farpoint Group

Farpoint Group

802.11ac Unknowns

5 GHz. Bands
- Relatively uncrowded today…
- But tomorrow?

80- and 80x2/160-MHz. Channels
- Range, rate vs. range; effective throughput
- Increasing interference?
- Re-farming current channel plans

Evolution
- 802.11n backwards-compatible performance
- Vendor coexistence/migration strategies
- Varying quality of PHY and MAC implementations

Source: Farpoint Group

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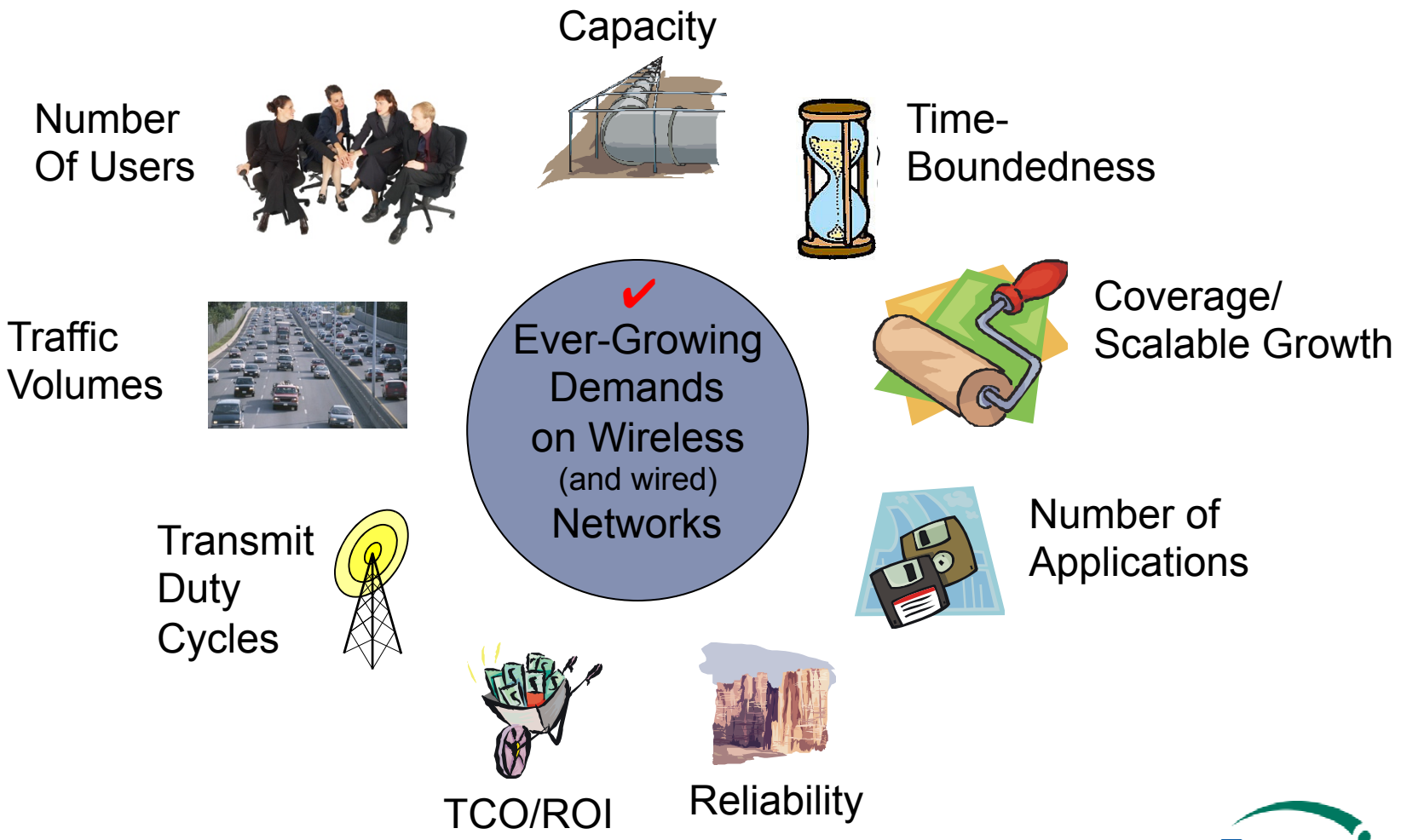
Scalability: Networks *(of any form)* Only Grow…



Source: Farpoint Group

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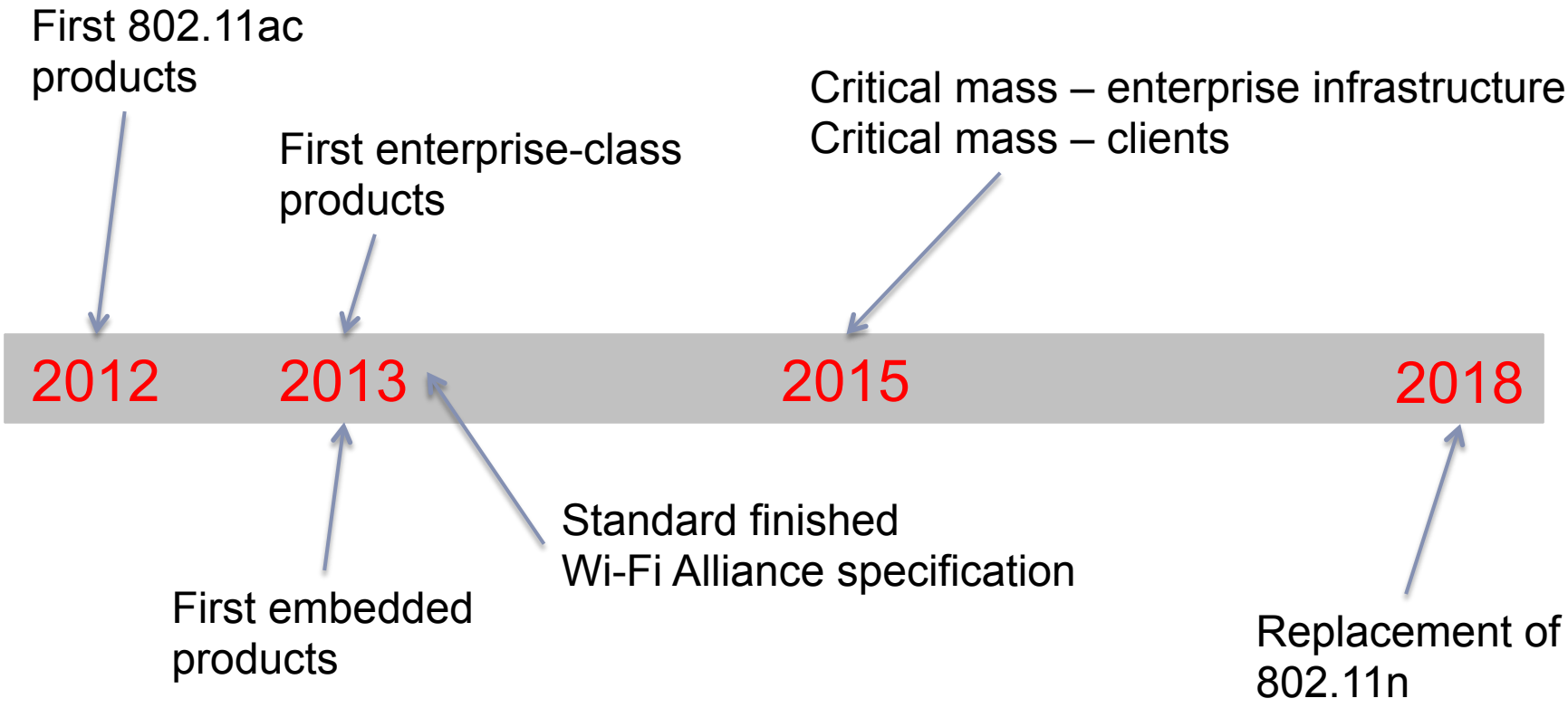
802.11ac Adoption Timeline



Source: Farpoint Group

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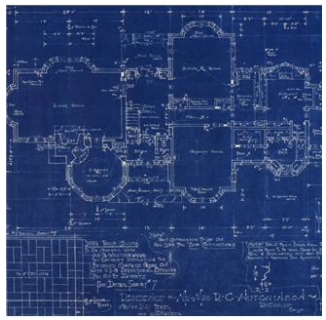
What Should the Enterprise Do Now?

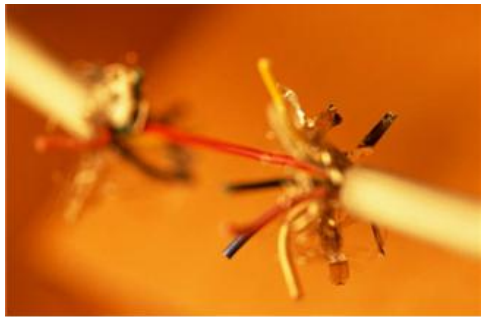
Coexistence/migration planning with vendor

Begin the operations planning process



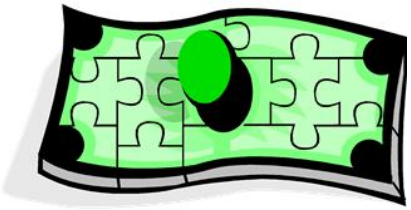
Wi Fi CERTIFIED

Continue to deploy 802.11n



Wired network - audit

Budgetary analysis



Non-disruptive, gradual upgrade strategy

Source: Farpoint Group

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Conclusions (for now…)

- ***802.11ac will replace 802.11n*** – but not for many years
- **802.11n projects should continue to be evaluated (and deployed)** based on current ROI
- **Talk with your vendor** about coexistence/ migration plans
- And remember: ***there's more to successful WLAN deployments than radios!***

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Questions

For more information contact

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