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July 10–14, 2016 · Las Vegas, NV
Your Time Is Now

BRKCRT-1100

CCNA Wireless, master the 802.11 protocols!

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Cisco live!

Agenda

- Introduction
- Time in Wi-Fi
- Modulations and Encoding Techniques
  - Modulations you take anywhere: BPSK, QPSK
  - Faster with CCK
  - Changing the game with OFDM
- 802.11n good ideas
- Even faster with 802.11ac
- How do all these coexist?
- Value of Certification
- Why Cisco Certifications Are Successful
- How We Build World Class Certifications
- Writing Exam Questions
- Exam Blueprints
- Summary – Become a Wireless SME – Q&A

John, 7 years ago

Wi-Fi laptop

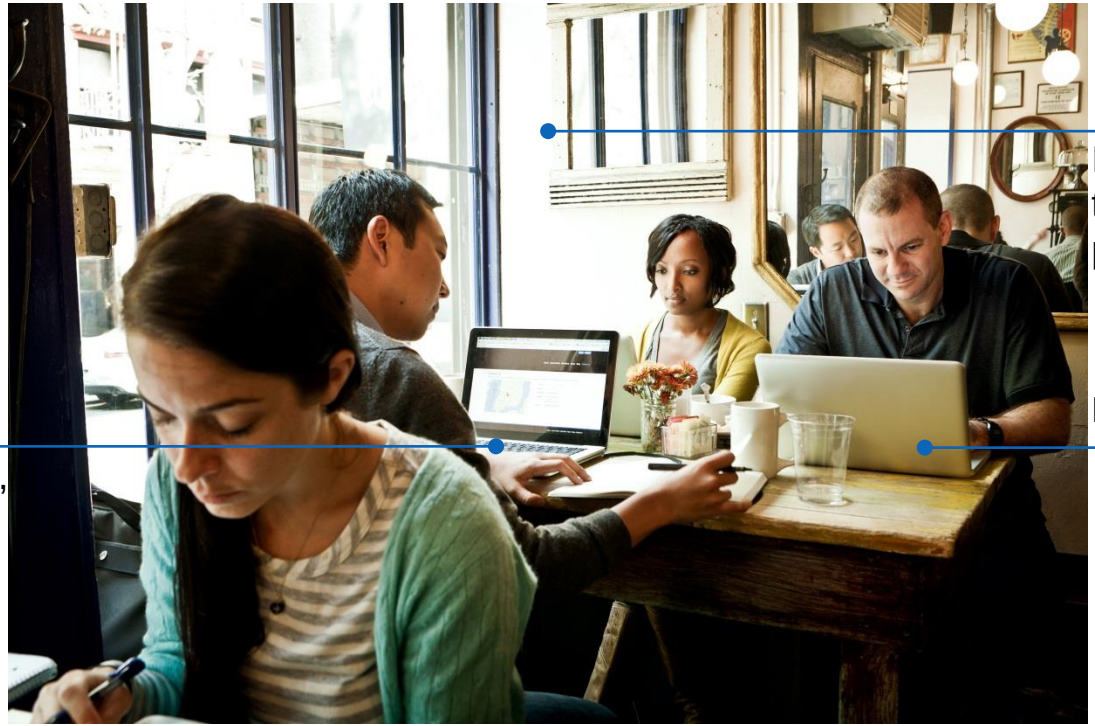
I can use Wi-Fi in the meeting room, but I lose signal if I move away

Everything else is wired

Wired Phone

I heard that some phones have Wi-Fi capabilities, but where would I use them?

Jim, today



I get Wi-Fi from home, the office, most public places, some streets

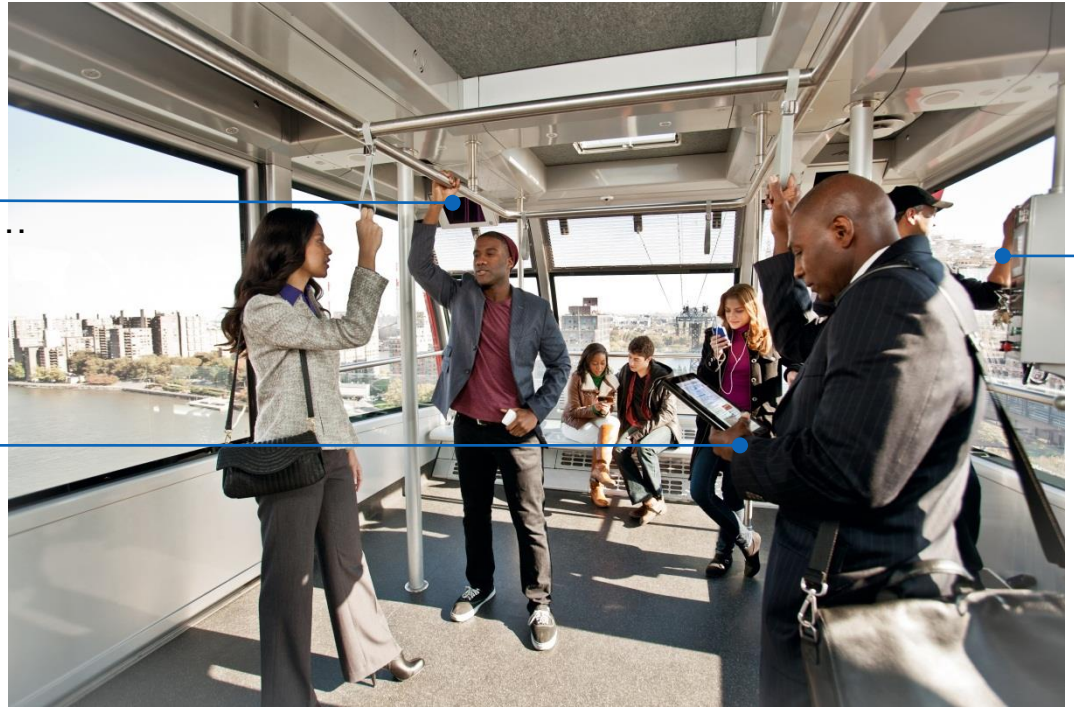
Multi Wi-Fi

Like most people, have 2 or 3 Wi-Fi devices

More Applications

I rely on Wi-Fi for critical applications… and do not see why video is so slow…

Sam, in 7 years…



Everything uses Wi-Fi…
Everything?

More Applications

Everyone uses Wi-Fi…
for almost everything

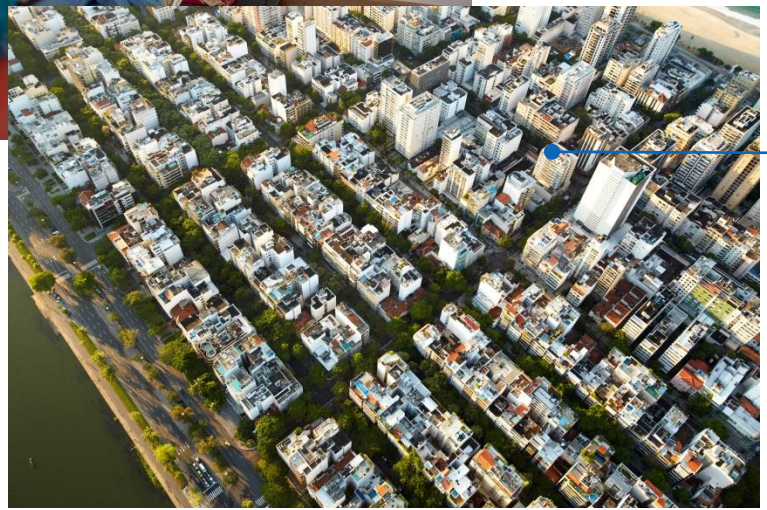
Far Reaching Wi-Fi

I get Wi-Fi from
almost everywhere

In 2020…

802.11ad – VHT 60 GHz

Your VCR can stream to your TV, your laptop, your phone, your tablet… multiple streams everywhere in the house



802.11ah – sub 1 GHz

Wi-Fi is used to monitor your electricity, gas meters, industrial sensors (wind-mills etc.), hospital remote patients vitals, etc.

In 2020…

802.11af – TV Whitespace

Your car is connected hundred of miles away

802.11aa – Video

Wi-Fi is optimized for high throughput applications, including video

Explosive Mobile Device Growth

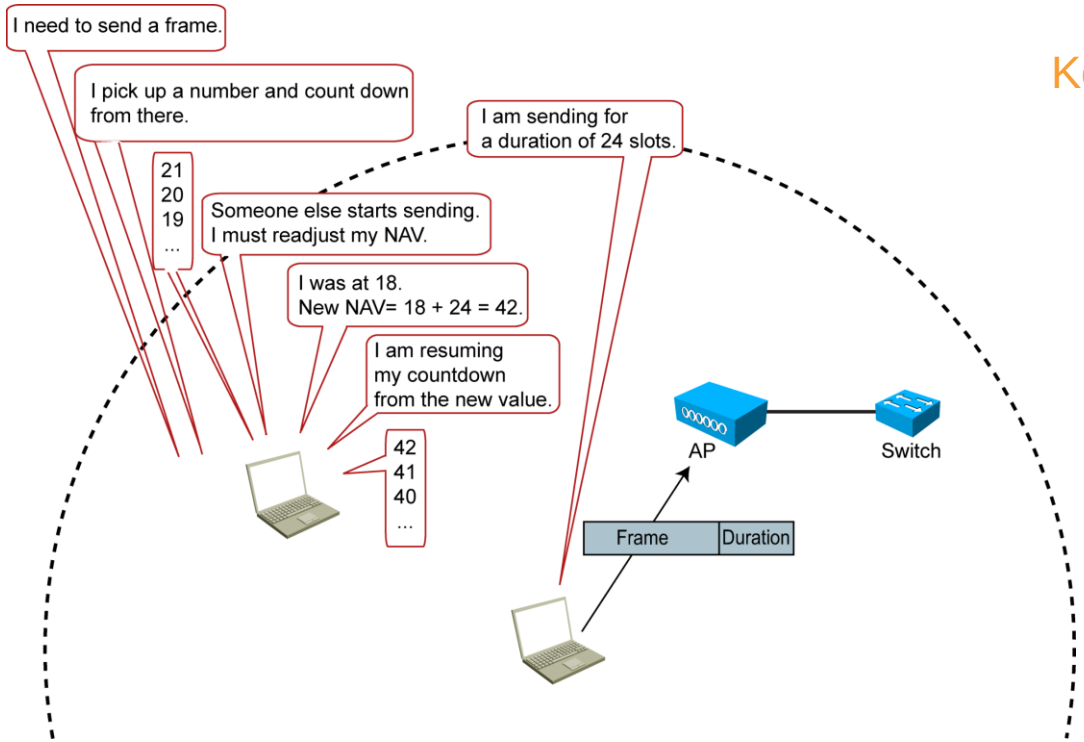
- Smartphone adoption growing **50%+ annually**.**
- In 2015, **48%** of mobile data diverted to Wi-Fi**.***
- **By 2019, 60% of voice calls will occur over Wi-Fi**
- In 2013, more than **50%** of network devices shipped without a wired port.***
- In 2019, there will be 3.75 billion wi-fi devices****

▪Source: *ABI Research, **IDC, *** Morgan Stanley Market Trends, ****MIC

Time in Wi-Fi

The Need for Speed

- Traditional 802.11 (DCF), CSMA/CA



Key terms:

- **Backoff timer**: the initial number you pick up and countdown from
- **Contention window**: the possible values for the backoff timer (at least CWMin, at most CWMax)
- **Network Allocation Vector**: the total time you wait before sending.

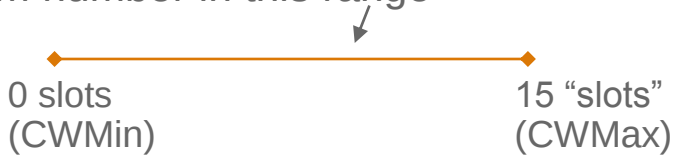
The Need for Speed

- Traditional 802.11 (DCF), CSMA/CA

I need to send a frame… listen for a DIFS

- Then, pick up a random timer and wait:

Pick a random number in this range



Count down from there

Key terms:

- **Backoff timer**: the initial number you pick up and countdown from
- **Contention window**: the possible values for the backoff timer (at least CWMin, at most CWMax)
- **Network Allocation Vector**: the total time you wait before sending.

The Need for Speed

- Traditional 802.11 (DCF), CSMA/CA

Listen as you count down

- Air is free? Count down (12, 11, 10 …)
- Air is busy? Readjust your NAV

Frame	Duration = 18

The sender tells the duration of the frame; add this duration to your NAV and restart from there: e.g. 10+18=28. 28, 27, 26…

Key terms:

- **Backoff timer**: the initial number you pick up and countdown from
- **Contention window**: the possible values for the backoff timer (at least CWMin, at most CWMax)
- **Network Allocation Vector**: the total time you wait before sending.

The Need for Speed

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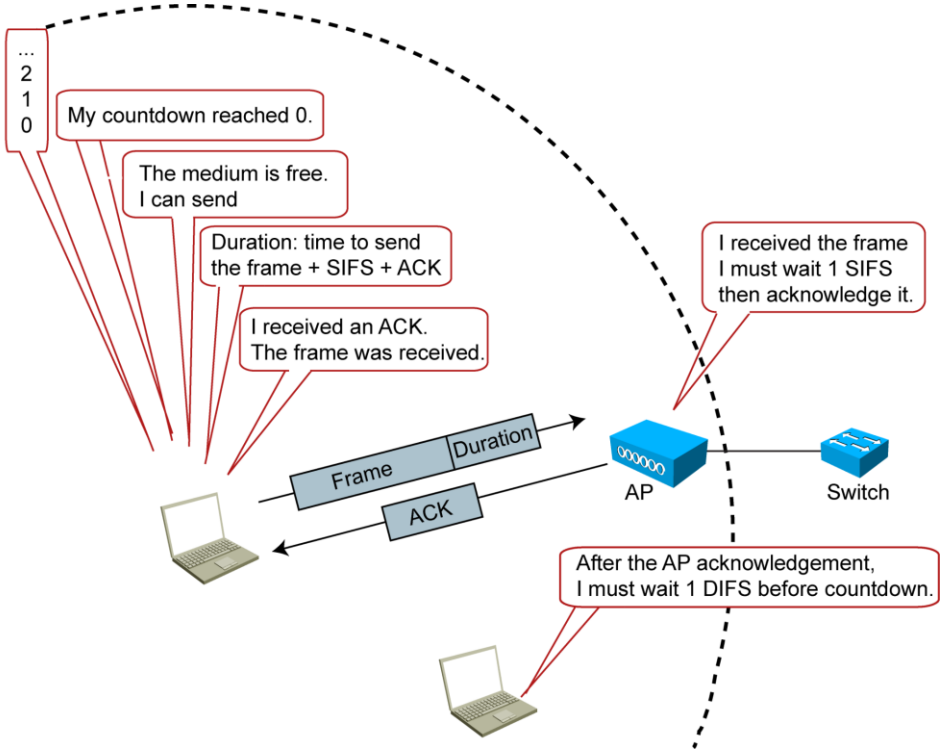
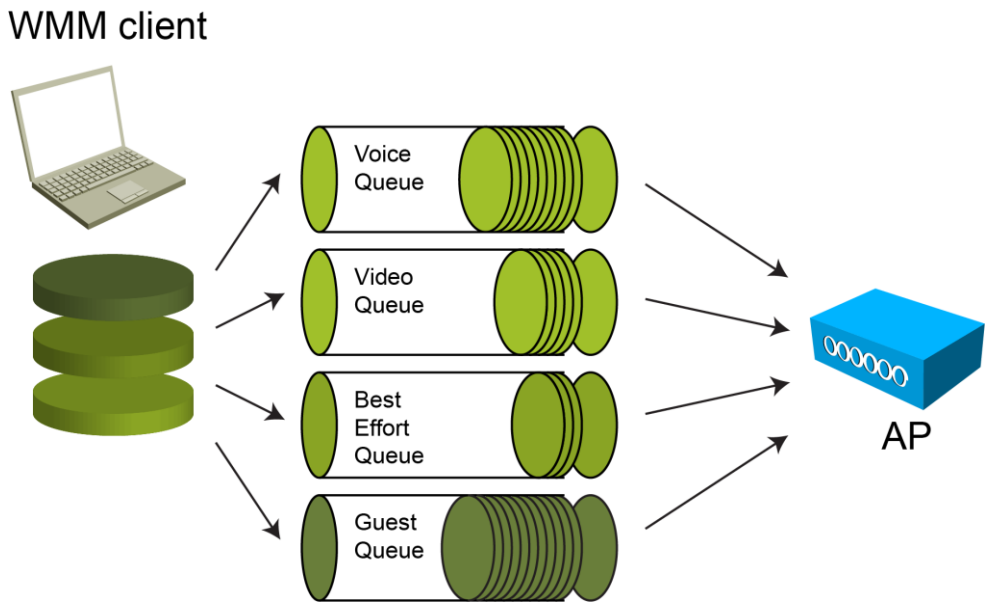


Key terms:

- **SIFS**: Short Interframe Space (silence between unicast frame and its ACK)
- **ACK**: Acknowledgement
- **DIFS**: Distributed Interframe Space (silence between one transmission and the next)

Improving 802.11: 802.11e

- Better Countdown Mechanism



Key terms:

- **AC**: Access Category – Platinum (Voice), Gold (Video), Silver (Best Effort), Bronze (Background)
- **AIFS**: Arbitration Interfame Space (DIFS equivalent, when QoS is used)

How Much Do We Save With 802.11e?

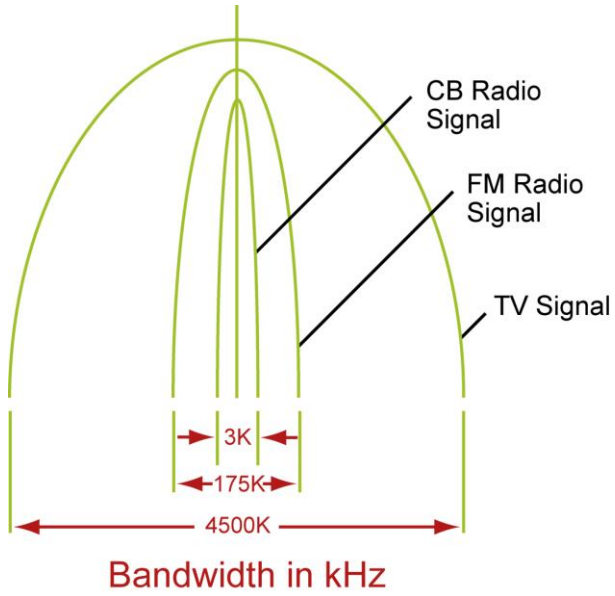
- Smaller CW, Same or Larger IFS

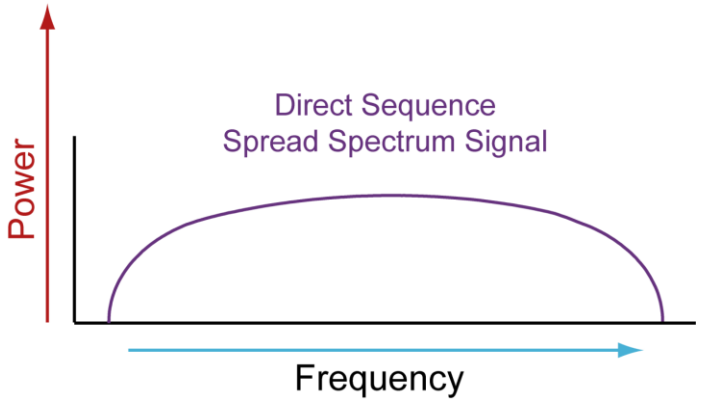
Access Category	CWMin	CWMax	AIFS
DCF	15 or 31	1023	2 (DIFS)
Voice	3	7	2
Video	7	15	2
Best Effort	15	1023	3
Background	15	1023	7

Modulations and Encoding Techniques

“Higher Speed”: 802.11, 802.11b

- Working on the Wave Shape vs. Speed Problem
  - Bandwidth depends on the amount of information to send

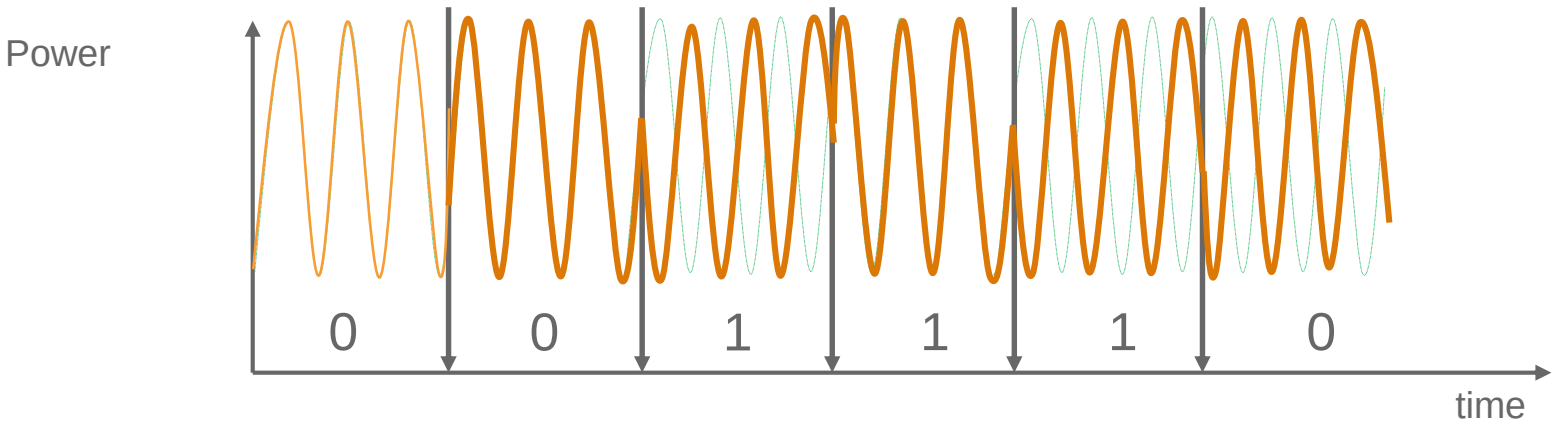




  - 802.11, in the 2.4 GHz band, used 22 MHz-wide signals

“Higher Speed”: 802.11 Techniques

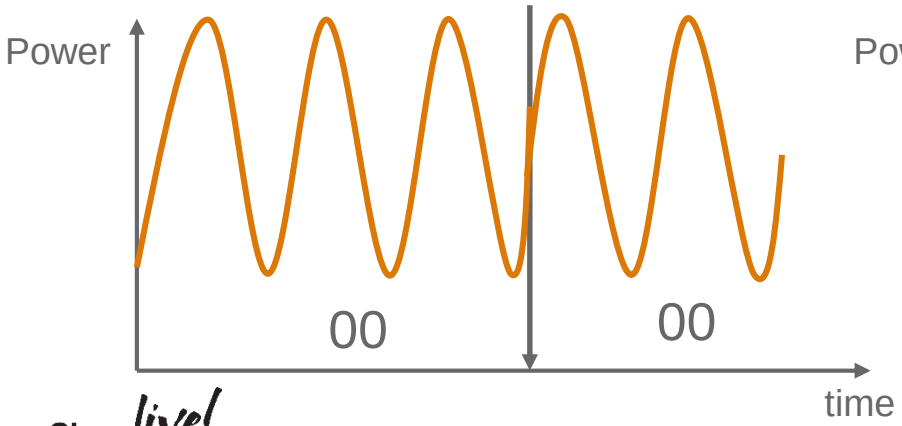
- Modulations: BPSK, QPSK
  - When using Binary Phase Shift Keying (BPSK), the phase shifts with 180° angles; each shift represents 1 bit. BPSK allows 1 Mb/s.



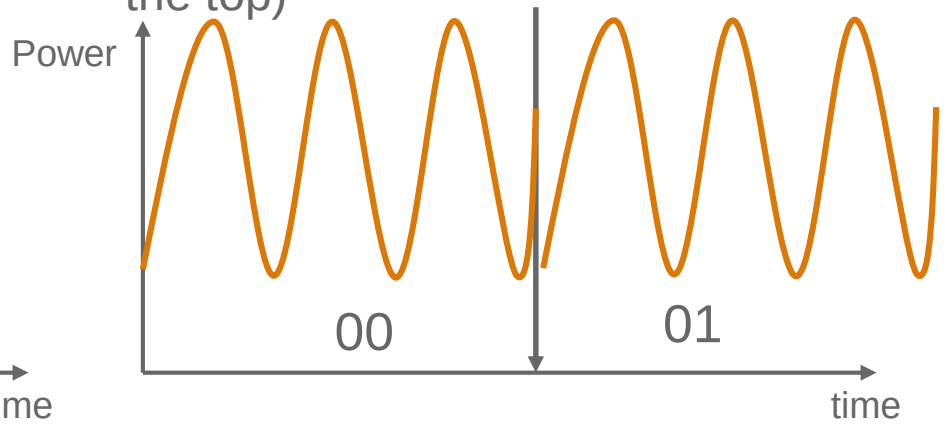
“Higher Speed”: 802.11 Techniques

- Modulations: BPSK, QPSK
  - When using Quadrature Phase Shift Keying (QPSK), shifts are 90°; each shift represents 2 bits. QPSK allows 2 Mb/s

If next sequence is 00, do not change the wave



If next sequence is 01, and you were going up, restart from the bottom (if you were going down, restart from the top)

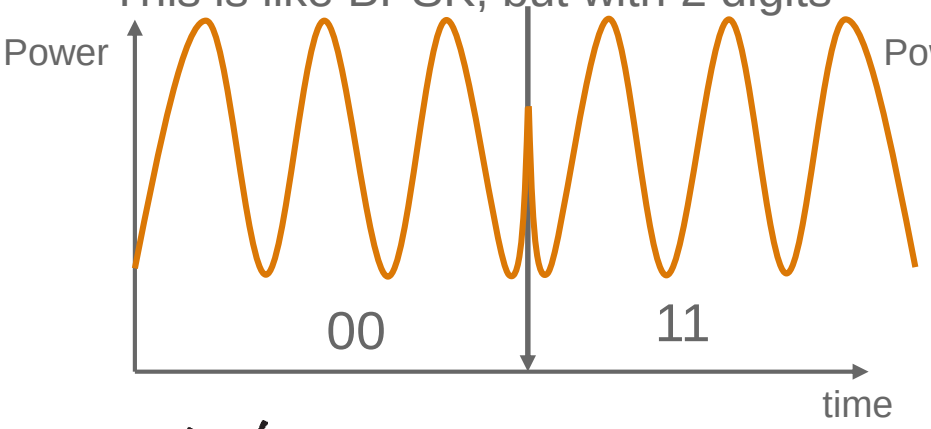


“Higher Speed”: 802.11 Techniques

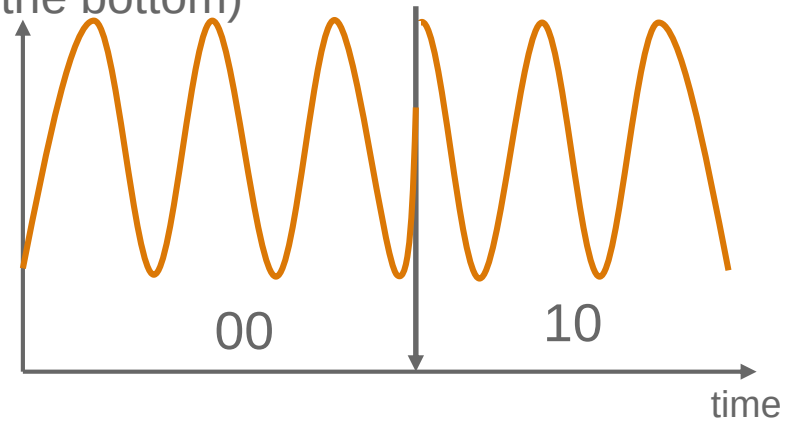
- Modulations: BPSK, QPSK
  - When using Quadrature Phase Shift Keying (QPSK), shifts are 90°; each shift represents 2 bits. QPSK allows 2 Mb/s

If next sequence is 11, reverse the direction of the wave

This is like BPSK, but with 2 digits

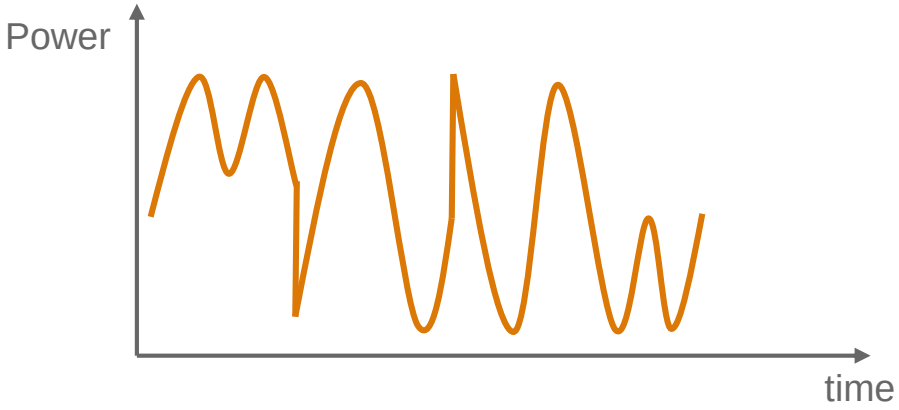


If next sequence is 10, and you are going up, continue from the top
(if you were going down, continue from the bottom)

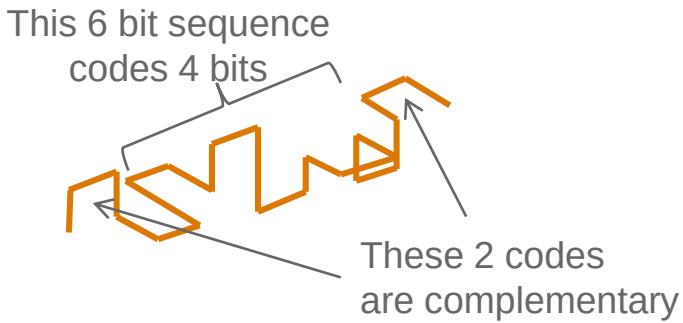


Higher Speed: 802.11b Improvements

- Modulations: CCK
  - With CCK, bits are grouped by 4, or by 8, and represented as a 6 bit unique code sequence; 2 more complementary bits are used
  - Coding 4 bits per symbol allows 5.5 Mb/s; coding 8 bits per symbol allows 11 Mb/s.

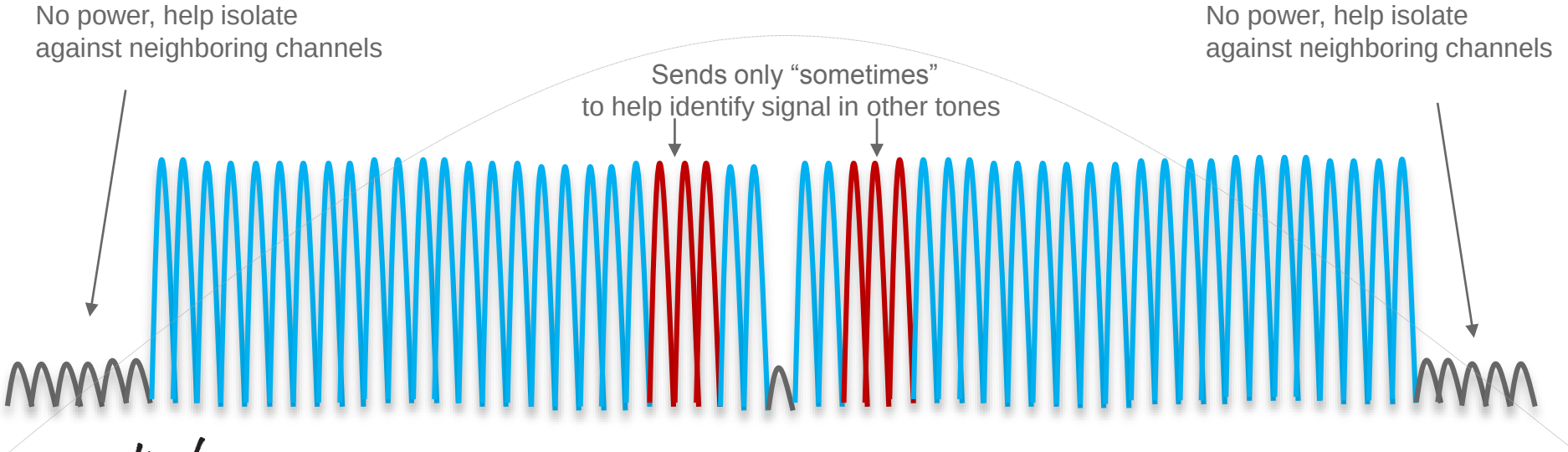


The 8 bit result is sent using QPSK



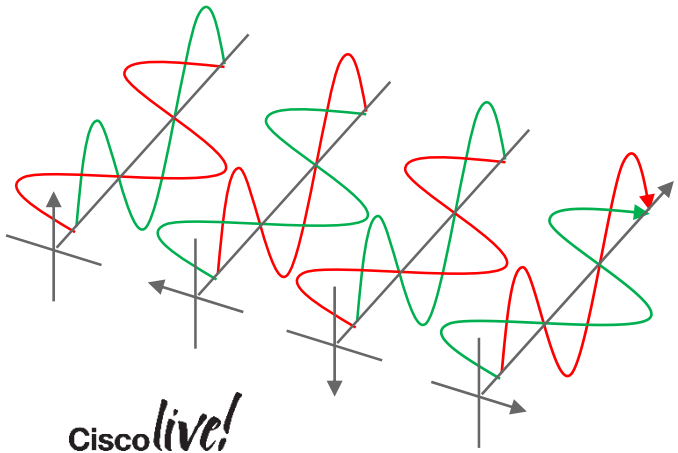
Higher Speed: 802.11g, 802.11a Improvements

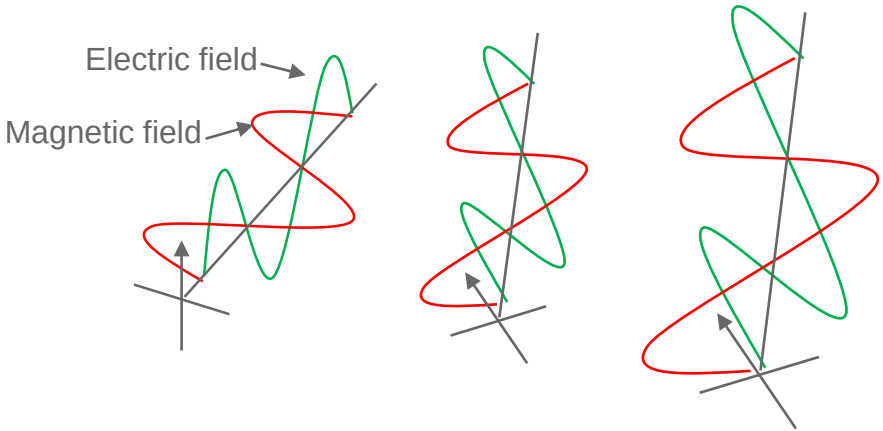
- Modulations: OFDM
  - 64 small waves (called Carriers, or Tones), using BPSK, QPSK… or QAM (Quadrature)
  - Some carriers are not used for data



Higher Speed: 802.11g, 802.11a Improvements

- Modulations: OFDM
  - To avoid overlap between waves, they are orthogonal (at 90 degree angle of one another)
  - This technique is called Orthogonal Frequency Division Multiplexing (OFDM)
  - Inside OFDM, each tone can use … BPSK, or QPSK!... Or QAM



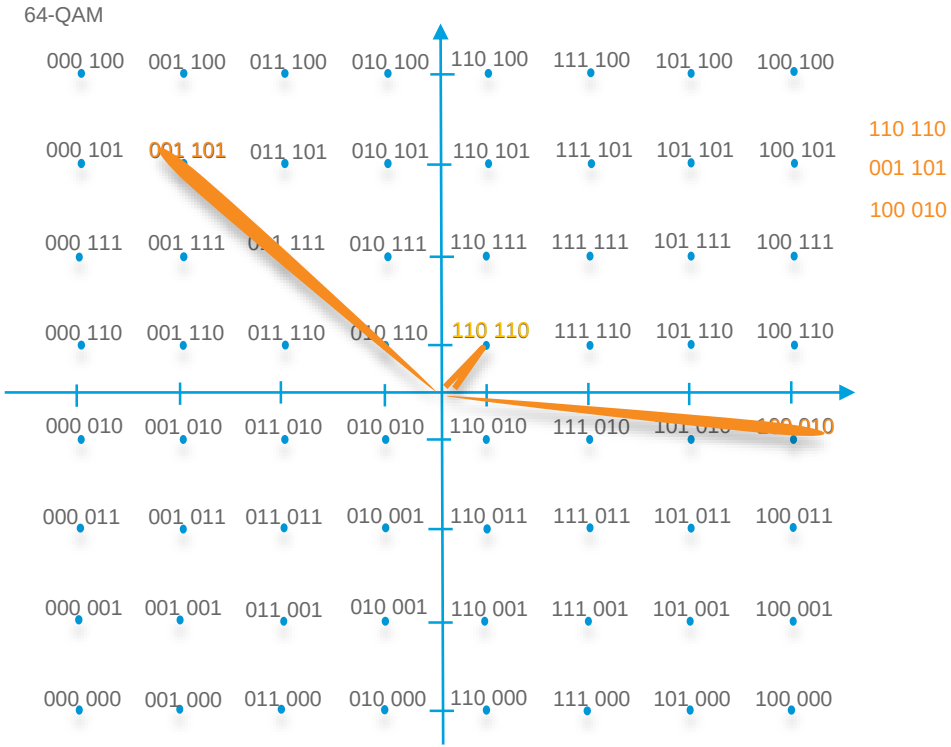


Higher Speed: 802.11g, 802.11a Improvements

- Modulations: OFDM

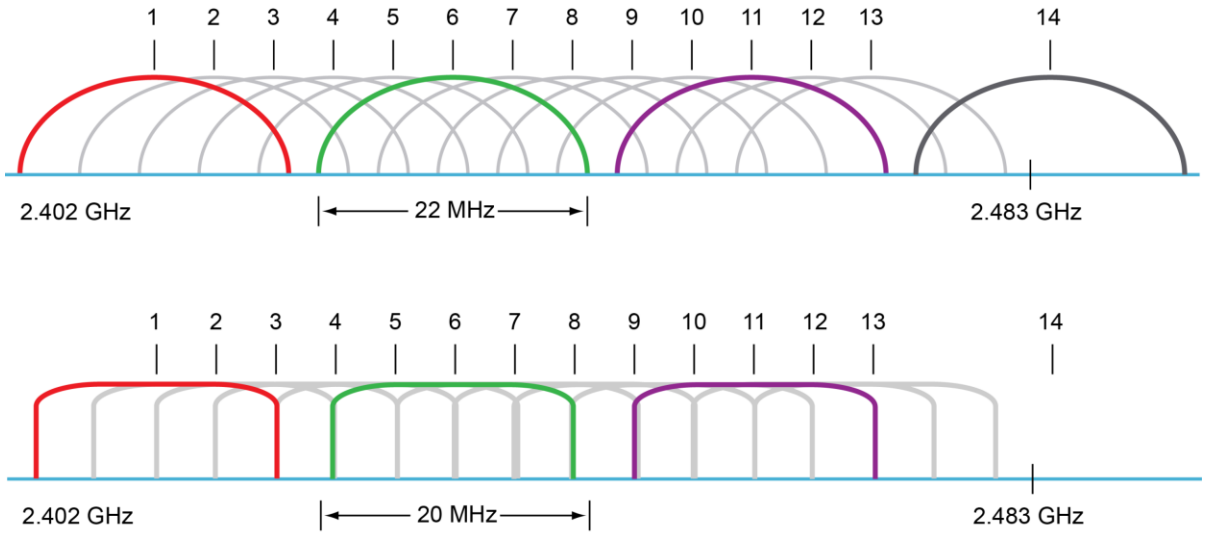
- For each modulation, some information is repeated to avoid losses.
- Less repeats means higher data rate

BPSK	QPSK	QAM 16	QAM 64
6 Mb/s	12 Mb/s	24 Mb/s	48 Mb/s
9 Mb/s	18 Mb/s	36 Mb/s	54 Mb/s



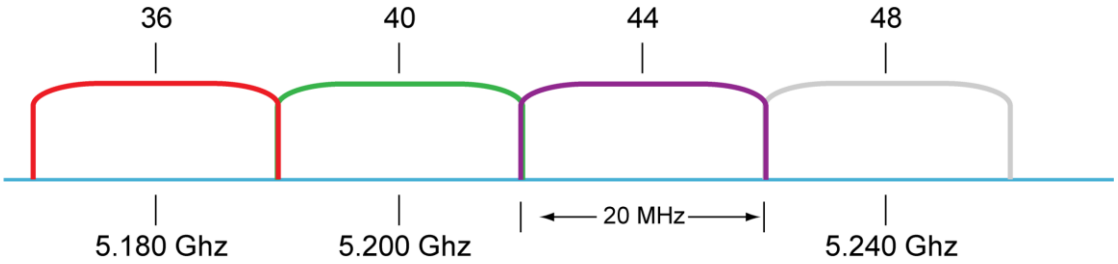
802.11g vs. 802.11a

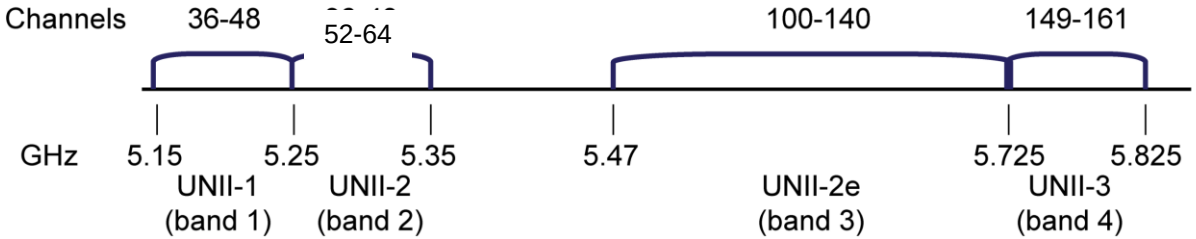
- 802.11g Band of Operation
  - Up to 13 (OFDM) or 14 (DSSS) channels
  - 3 to 4 non-overlapping channels



802.11g vs. 802.11a

- 802.11a Band of Operation
  - Up to 23 channels
  - All are non-overlapping channels

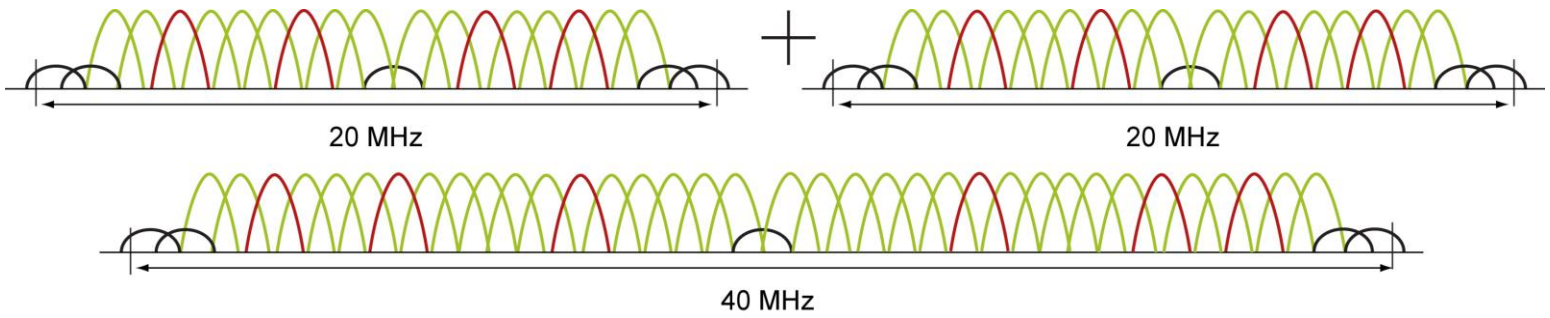




802.11n Good Ideas

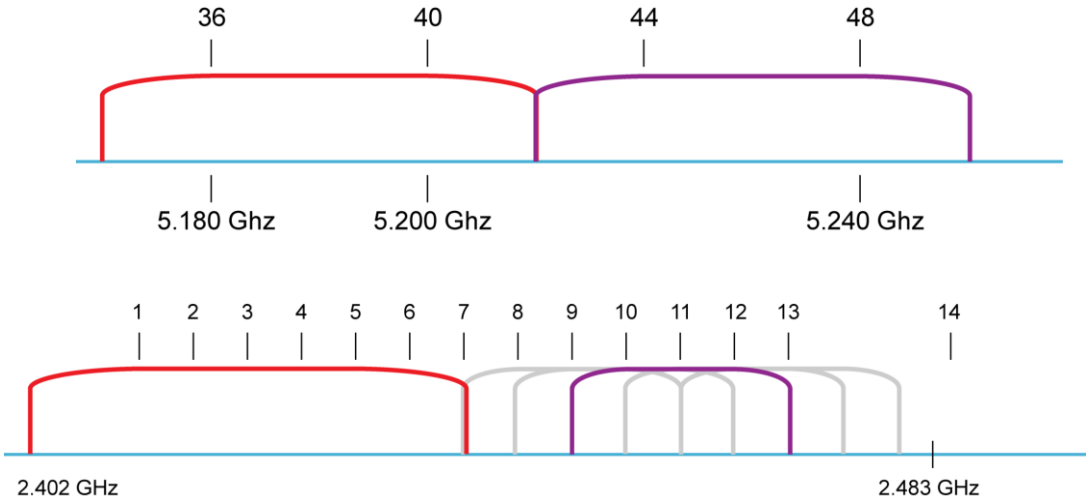
Going Faster with 802.11n

- Channel Aggregation
  - 802.11n aggregates two carriers to more than double the speed:
    - 128 subcarriers (vs. 64)
    - 14 (vs. 12) zero subcarriers for calibration on sides (6;5) and center (3)
    - 6 pilot subcarriers (vs. 4) for synchronization and tracking
    - 108 data subcarriers (vs. 48)
    - 54 Mb/s to 108+11 = 119 Mb/s



Going Faster with 802.11n

- Channel Aggregation
  - Great in 5GHz, not so good in 2.4 GHz
    - 9 to 11 non-overlapping 40 MHz channels in 5 GHz
    - 1.5 non-overlapping channel in 2.4 GHz



Going Faster with 802.11n

- MIMO
  - Instead of one radio per band, 802.11n allows for multiple radios per band
  - Each radio typically connects to an antenna, and become a **radio chain**
  - Up to 4 radios per band in the 802.11n amendment
  - All radios on a band are on the same channel (20 MHz or 40 MHz)
  - Radios on a band can be combined to send a signal from multiple radios, or receive a signal through multiple radios
  - Multiple Input, Multiple Output (MIMO)*
  - Older (non-802.11) system used Single Input, Single Output (SISO)

  * Useless fact: seen from the antenna standpoint: input is what you inject into the antenna, output is what you received from the antenna

Going Faster with 802.11n

- MIMO
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    - Multiple In, Multiple Out (MIMO)
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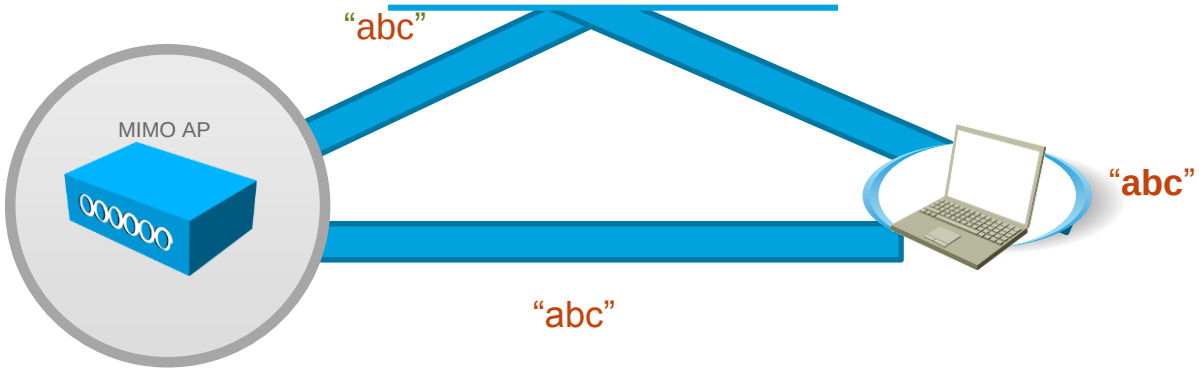
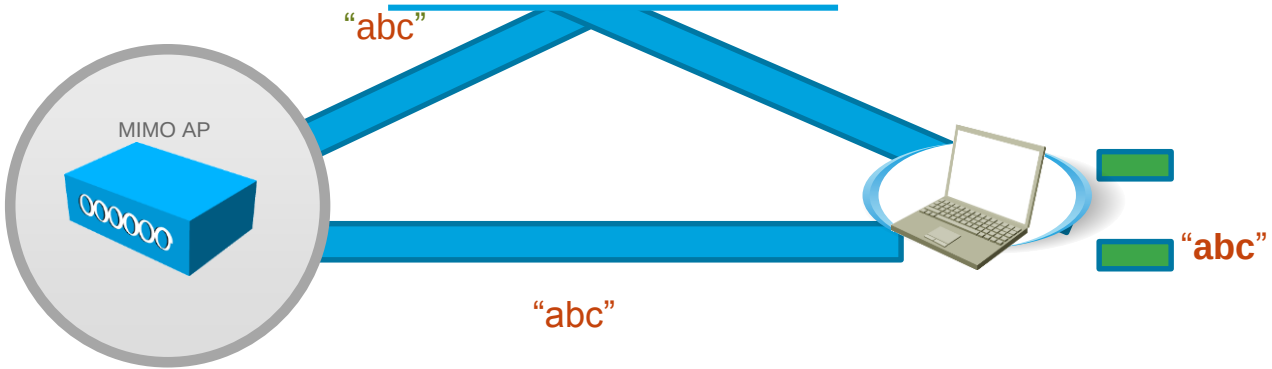
Going Faster with 802.11n

- MIMO: Transmit Beam Forming (TxBF) – Cisco ClientLink
  - The emitter coordinates the signal sent on different radios so that they reach the receiver at the same time
  - Objective: achieve extreme reliance
    - Longer range or Better speed at same range



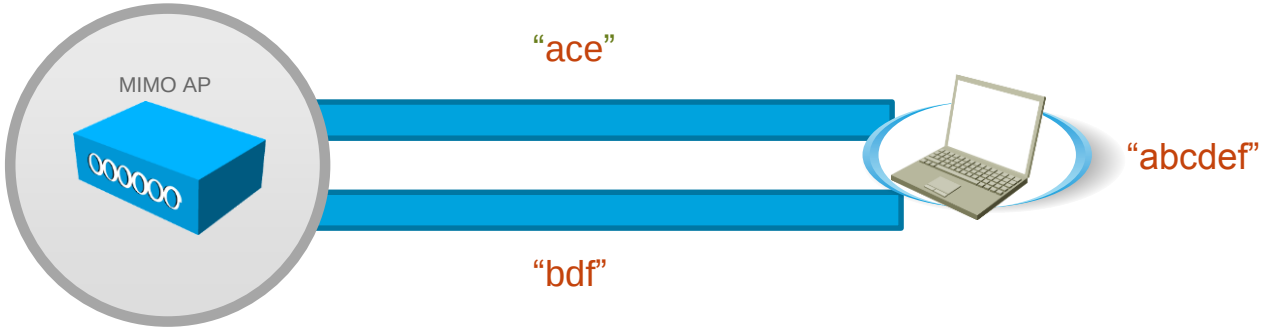
Going Faster with 802.11n

- MIMO: Maximal Ratio-Combining (MRC)
  - The receivers aligns a signal received on different radios
  - Objective: achieve extreme reliance
    - Longer range or Better speed at same range



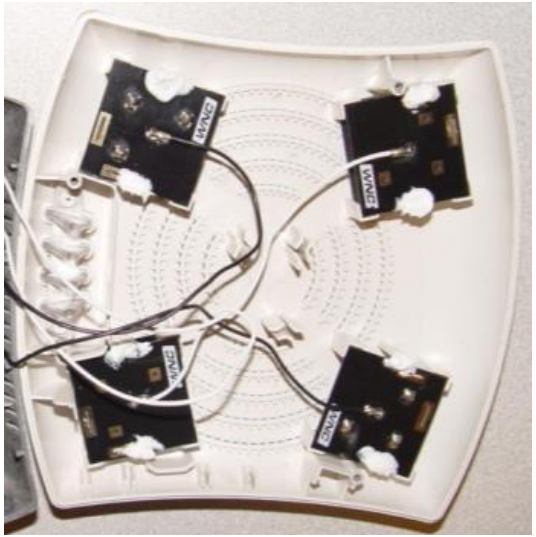
Going Faster with 802.11n

- MIMO: Spatial Multiplexing
  - Each emitter radio sends different information, combined in 802.11n receiver
  - Objective: achieve extreme throughput gain



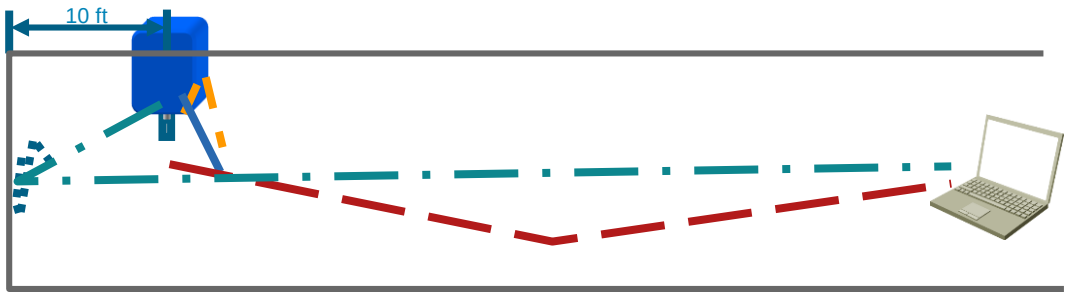
Going Faster with 802.11n

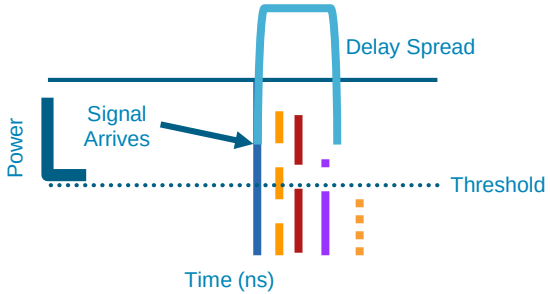
- MIMO
  - With MIMO, each antenna connects to a radio circuit
  - Typically, not all radio chains are used at the same time when sending or receiving
  - Combination of the best chains based on client location
  - AP specs mention the number of radios used to transmit (Tx), to receive (Rx), and the number of parallel streams. E.g.: 4x4:3, 2x3:2



Going Faster with 802.11n

- Short Guard Interval (SGI)
  - With 802.11a and 802.11g, there are small silences between two signals on the same radio wave
  - Objective is to let reflections occur before the next useful part of the wave hits the receiver
  - 802.11n can reduce this silence from 800 ns to 400 ns
    - 11% increase in throughput, but possible increased collisions





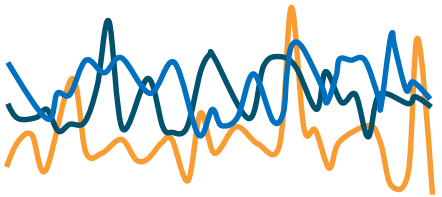
Going Faster with 802.11n

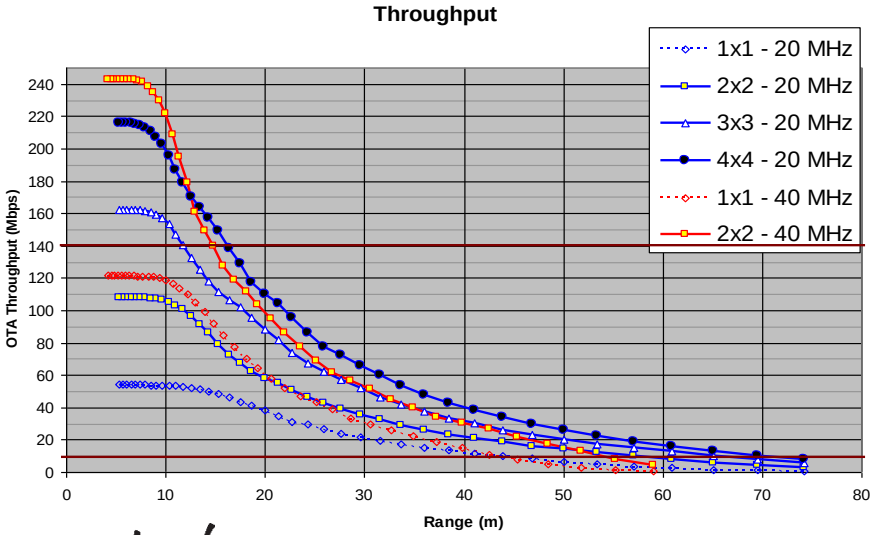
- 802.11n Max Speeds (Modulations Coding Schemes – MCS), Mbps

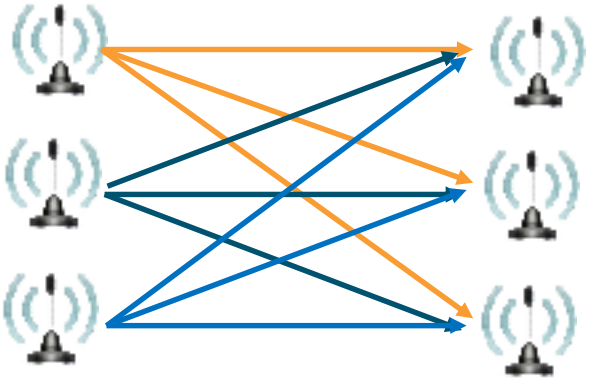
Spatial Streams	Data rate (20 MHz channel, 800 ns GI)	Data rate (20 MHz channel, 400 ns GI)	Data rate (40 MHz channel, 800 ns GI)	Data rate (40 MHz channel, 400 ns GI)
1	65.5	72.2	135	150
2	130	144.4	270	300
3	195	216.7	405	450
4	260	288.8	540	600

Why Not 802.11n With 10 or 100 Streams?

- What Can We Do, What Do We Gain?
  - Multiple streams reach multiple receiving circuits
  - Distinguishing one from the other is difficult
  - Larger channel is easier than more streams







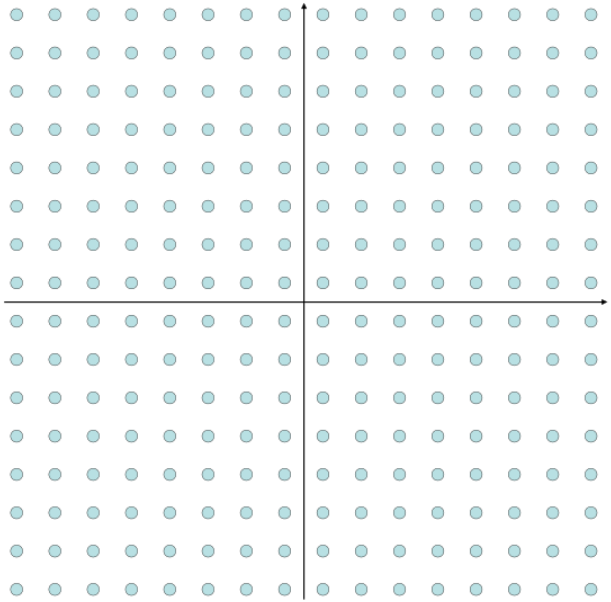
Faster with 802.11ac

Faster Than 802.11n

- How to Increase Speed Without Making it Impossibly Difficult?
  - Increase channel width… beyond 40 MHz
  - Increase number of spatial streams… more than 4
  - Improve the modulation? Is 64-QAM the best we can do?
  - Better manage the cell
    - Why would only one device send at a time?
      - If we can have one device send 3 streams at the same time on the same frequency, why not have 3 devices send 1 stream at the same time on the same frequency instead?
    - Why would all devices be on the same frequency?
      - If we can send one 40 MHz signal, why not send two 20 MHz signals instead?

Faster Than 802.11n: 802.11ac

- Beyond the 1 Gbps Bar
  - 160 MHz-wide channel width…
    - Up to 160 MHz for APs
    - 80 MHz for stations, 160 MHz optional
  - More spatial streams
    - Up to 8 spatial streams
    - 8 radio circuits sending or receiving
  - Better modulation
    - QAM-256
      (8 bits per symbol vs. 6 bits for QAM-64)
      Up to 4 times faster



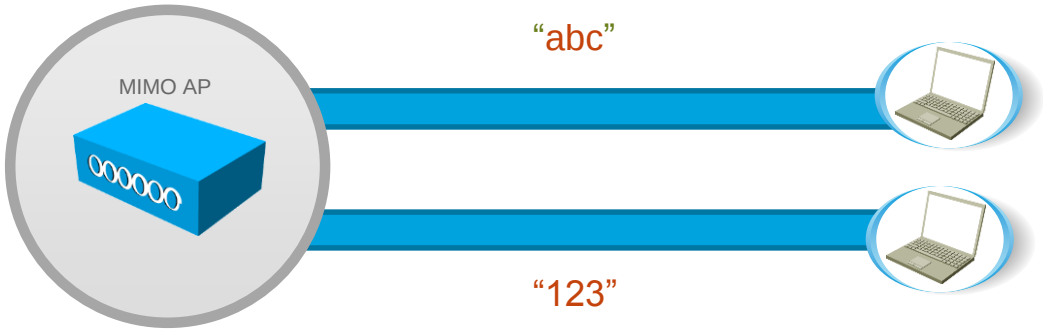
802.11ac Max Speeds

(Modulations Coding Schemes – MCS), Mbps, 1 SS

MCS	Modulation	Ratio	20 MHz channel		40 MHz channel		80 MHz channel		160 MHz channel	
			800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI
0	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	QPSK	1/2	13	14.4	27.	30	58.5	65	117	130
2	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
8	256-QAM	3/4	78	86.7	162	180	351	390	702	780
9	256-QAM	5/6	N/A	N/A	180	200	390	433.3	780	866.7

Faster Than 802.11n: 802.11ac

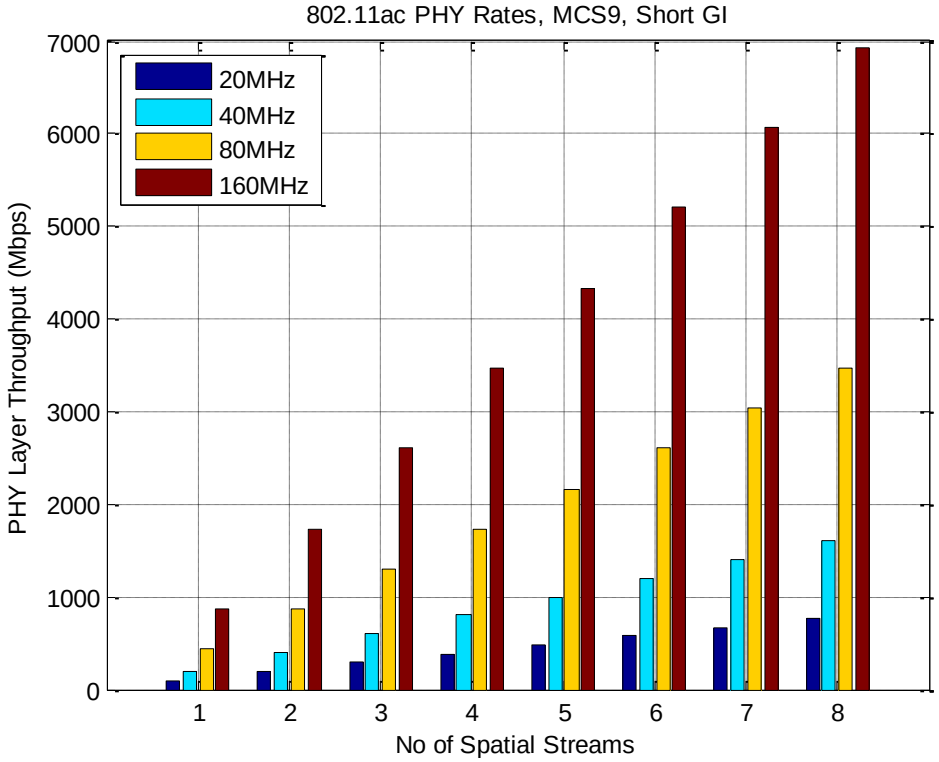
- MU-MIMO
  - 2 clients can receive signals at the same time, on the same frequency
    - Each client has dedicated spatial stream(s)
    - No wasted streams anymore
    - Only works downstream



Faster Than 802.11n: 802.11ac

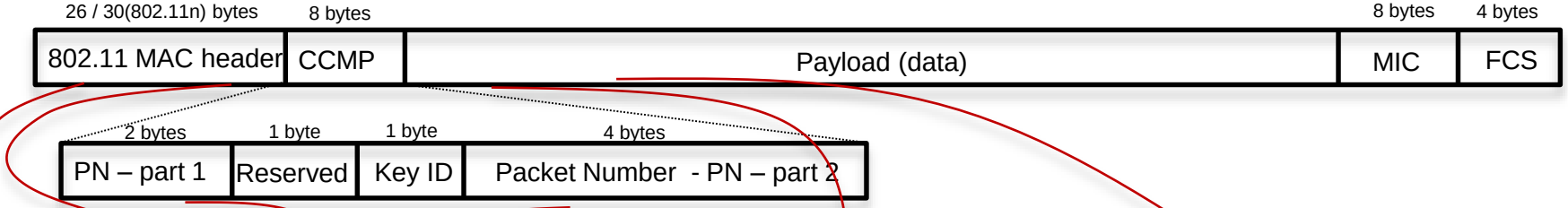
- How Fast Can 802.11ac Go?

- Throughput will all depend on stations!
- Example best case:
  - 160 MHz-wide channel, 8 antenna AP with MU-MIMO support
  - One 4-SS 160 MHz client, 3.47 Gbps data rate to this client
  - One 2-SS 160 MHz client, 1.73 Gbps data rate to this client
  - Two 1-SS 160 Mhz clients, 867 Mbps data rate to each client
  - **Total cell throughput, 6.93 Gbps!**
- However, few clients will go beyond 80 MHz

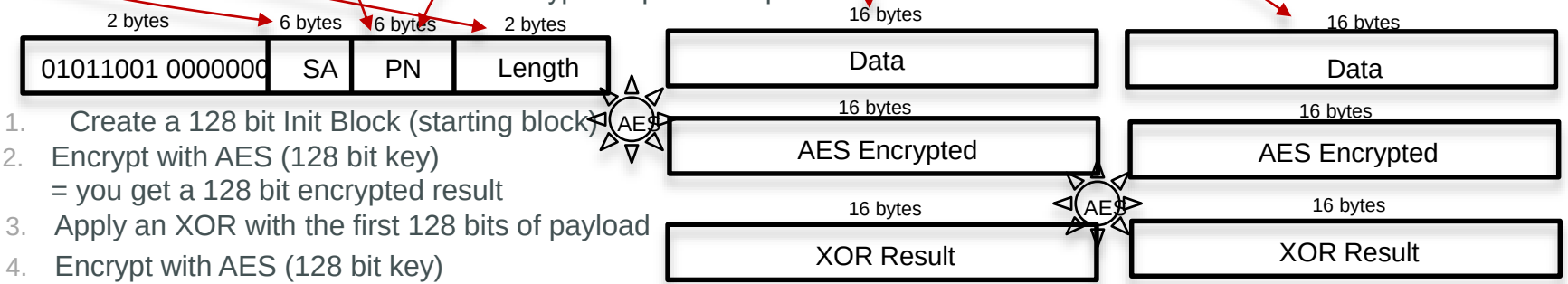


WPA2/AES-CCMP?

- With current WPA2, blocks of 128 bits are encrypted with 128 bit AES/CCMP:



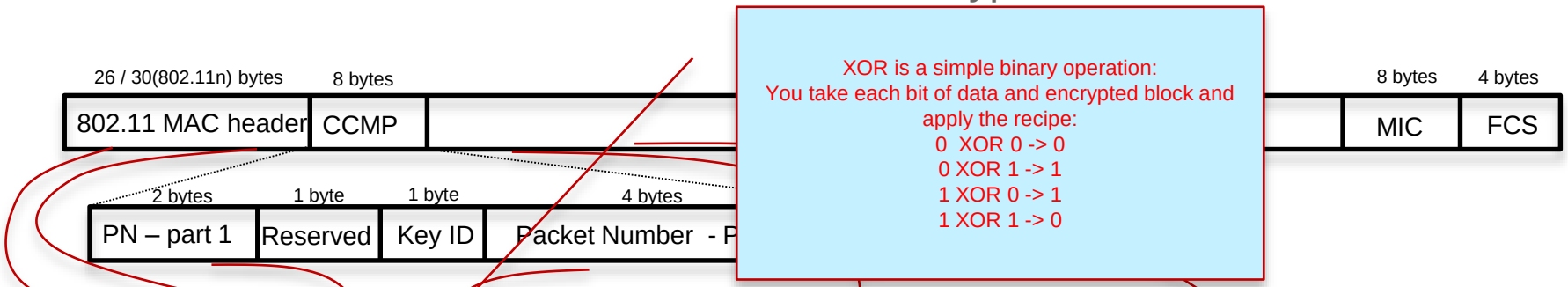
- You need to calculate the MIC and encrypt the packet in parallel. let's look at the MIC:



1. Create a 128 bit Init Block (starting block)
2. Encrypt with AES (128 bit key)
   = you get a 128 bit encrypted result
3. Apply an XOR with the first 128 bits of payload
4. Encrypt with AES (128 bit key)
5. Apply an XOR with the next128 bits of payload
6. Repeat 4 and 5 as you go through the frame

WPA2/AES-CCMP?

- With current WPA2, blocks of 128 bits are encrypted with 128 bit AES/CCMP:



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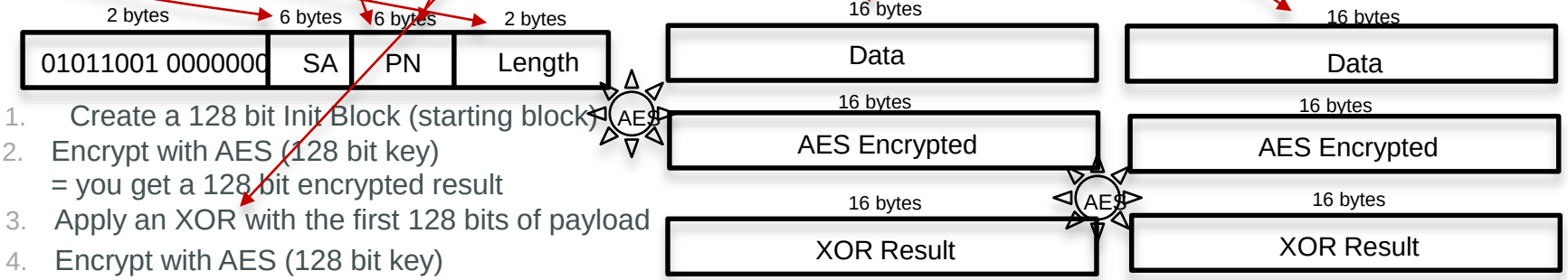

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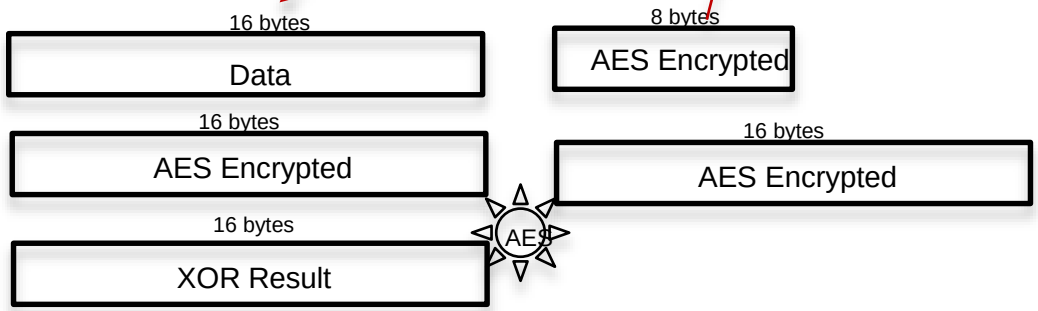
4. Encrypt with AES (128 bit key)
5. Apply an XOR with the next128 bits of payload
6. Repeat 4 and 5 as you go through the frame

WPA2/AES-CCMP?

- With current WPA2, blocks of 128 bits are encrypted with 128 bit AES/CCMP:

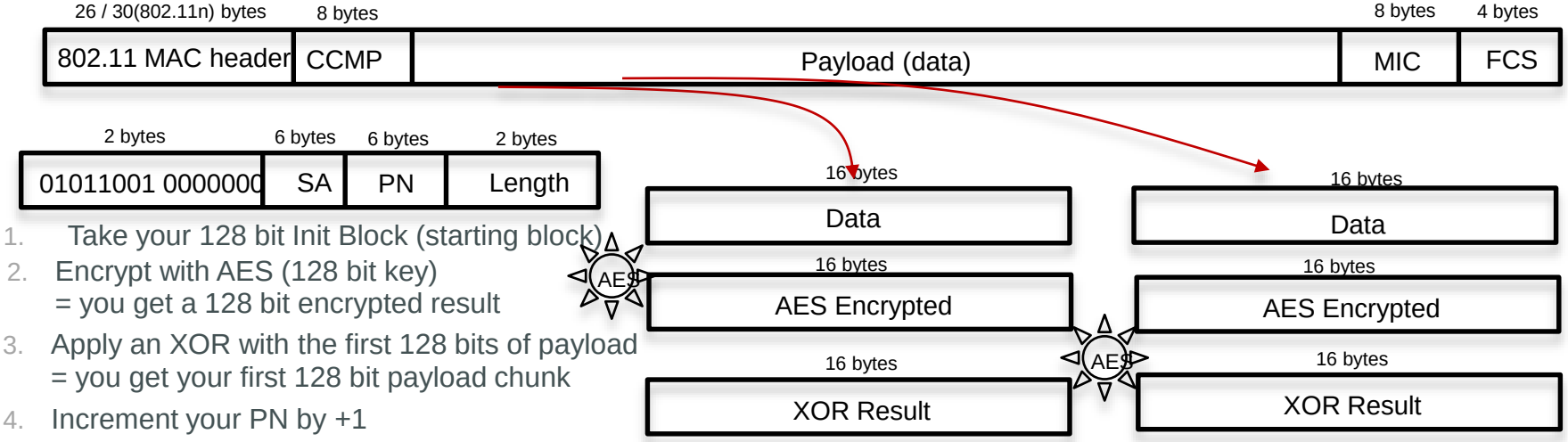
- Once you get to the last 128 bits of the payload (with padding if needed):

7. Take the 64 most significant bits:
   that's your unencrypted MIC (TBC…)



WPA2/AES-CCMP?

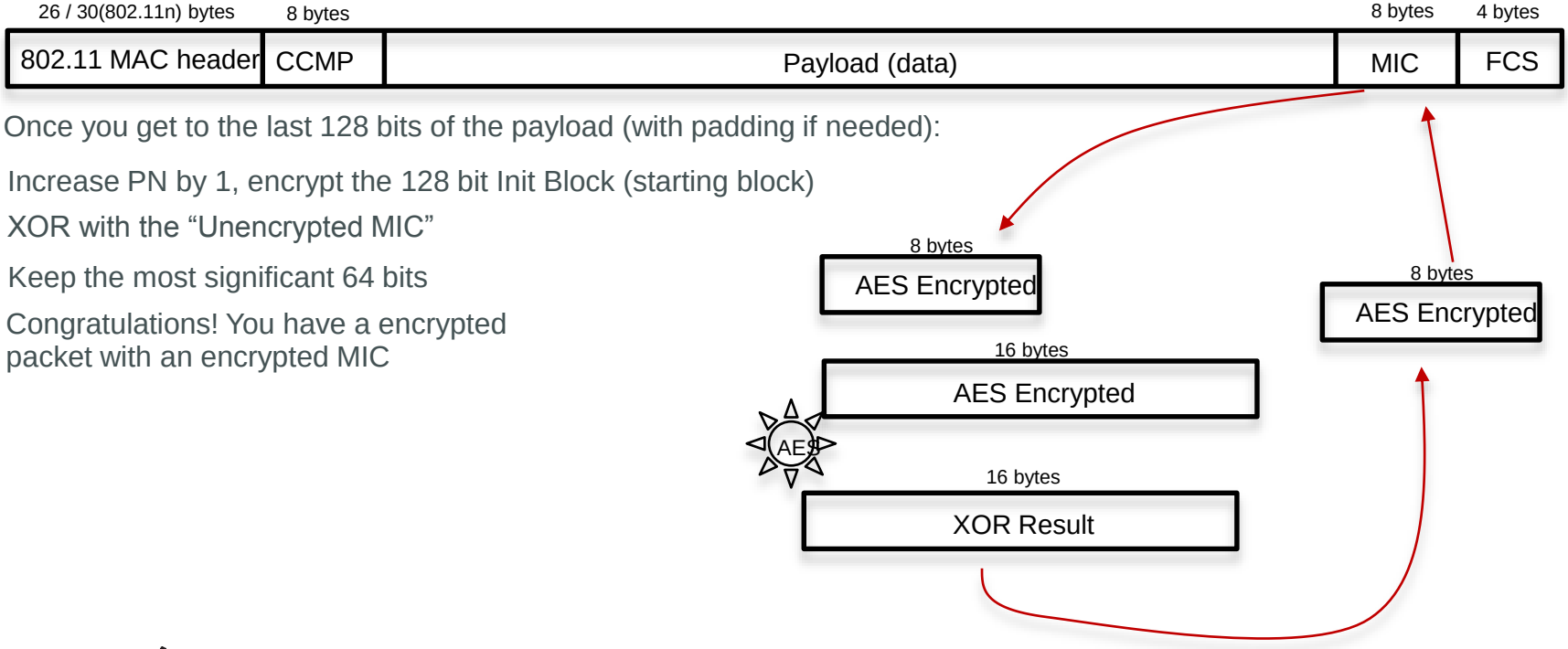
- Congratulation, you have your MIC. Now, let's encrypt the payload:



1. Take your 128 bit Init Block (starting block)
2. Encrypt with AES (128 bit key)
   = you get a 128 bit encrypted result
3. Apply an XOR with the first 128 bits of payload
   = you get your first 128 bit payload chunk
4. Increment your PN by +1
5. Encrypt this new block with AES
6. Apply an XOR with the next 128 bits of payload
7. Repeat 4 to 6 as you go through the frame

WPA2/AES-CCMP?

- Congratulation, you have your MIC. Now, let's encrypt the payload:



- Once you get to the last 128 bits of the payload (with padding if needed):

1. Increase PN by 1, encrypt the 128 bit Init Block (starting block)
2. XOR with the "Unencrypted MIC"
3. Keep the most significant 64 bits
4. Congratulations! You have a encrypted packet with an encrypted MIC

What's wrong with WPA2/CCMP?

- AES CCMP uses blocks of 128 bits, with a 128 bit key:
  - 128 bit key is getting a bit light, especially if you want FIPS certification (you will require 256 bit keys at some point)
  - Blocks of 128 bits: with 802.11n A-MPDU max length of 65,535 octets, you may need more than 24 580 calculations to encrypt a frame
  - If your throughput is about 270 Mbps (3SS 450 Mbps), this represents more than 13 million calculations per second (just to encrypt)
  - Imagine 6.93 Gbps… close to 350 million calculations per second…
- In their wisdom, the 802.11ac members decided that more efficiency would soon be needed:
- A first change is that 802.11ac allows for 256 bit keys, even with WPA2/CCMP and 128-bit blocks
  - Packet format and process would stay the same, except that MIC would change from 64 bits (8 bytes) to 128 bits (16 bytes)

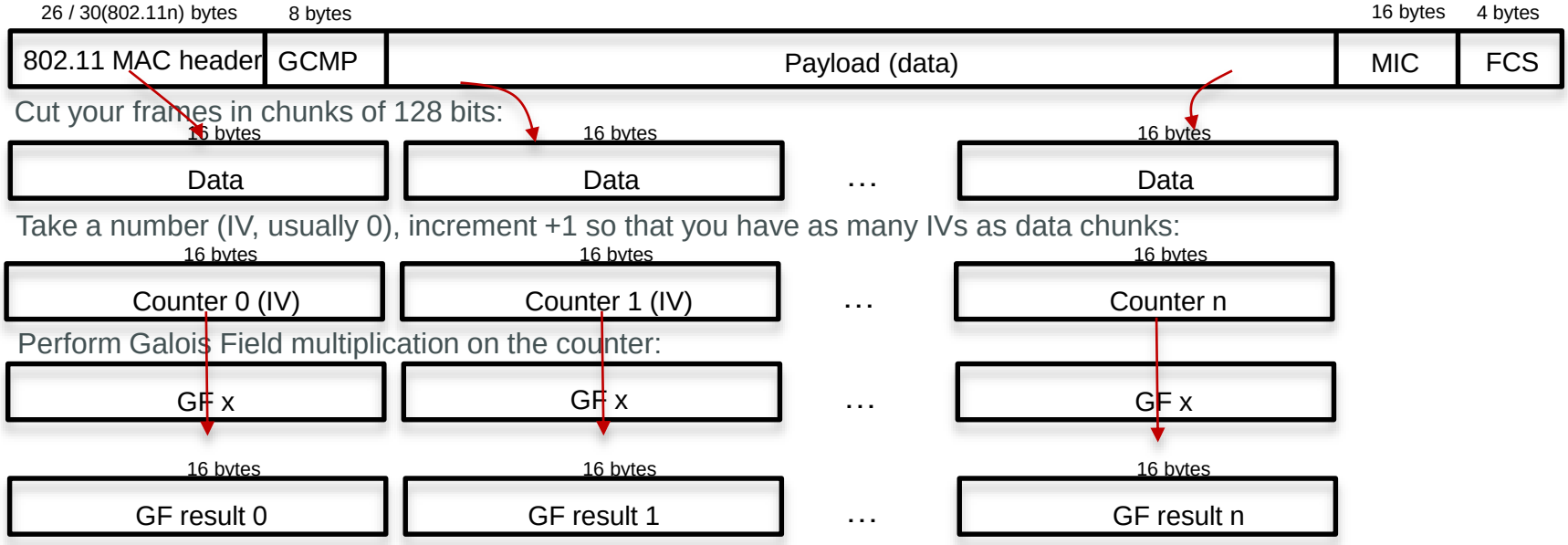
What's wrong with WPA2/CCMP?

- A second change is that AES with Counter Cipher Mode (CCM) with Block Chaining Message Authentication Code (CMAC) Protocol (CCMP) is not the only possible mechanism anymore
  - A new mechanism, AES with GCM with Galois Message Authentication Code (GMAC) Protocol (GCMP) is allowed
  - Key is 128 or 256 bits
  - Block can be 128, 192, 256, 384, 512 or 704 bit long
  - A great strength of this mechanism is that you can calculate (still using AES) the different elements needed for the MIC determination in parallel, saving an enormous amount of time
  - GCMP was recently allowed in 802.11ac, experiments are being made so see how much time is saved
  - GCMP (with 128 bit blocks and key) was already allowed by 802.11ad

GCMP, Why is it Faster?

WARNING: simplified scheme for educational purpose

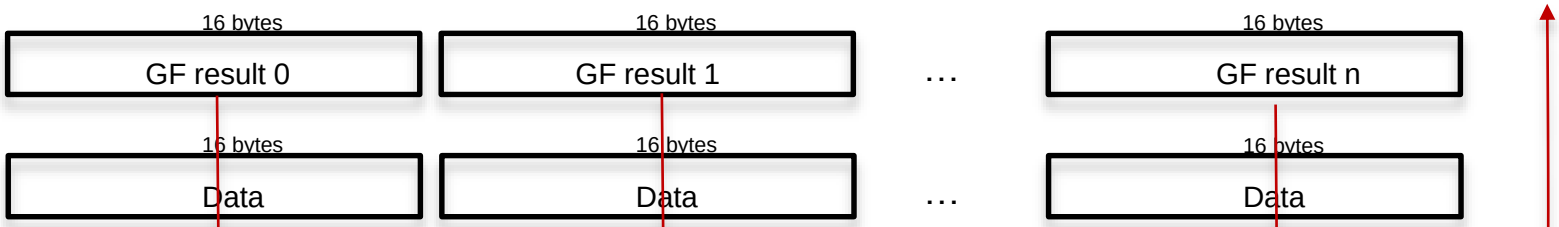
- You can process some phases of the encryption/authentication in parallel:



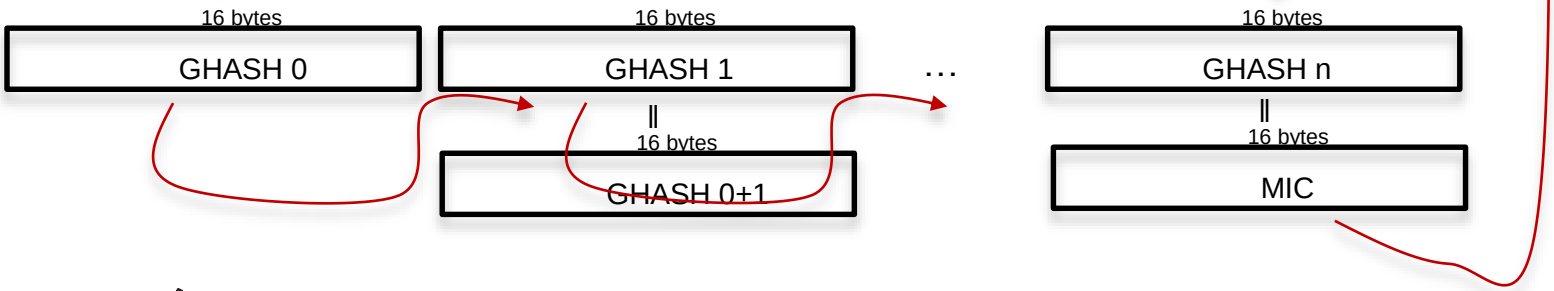
GCMP, Why is it Faster?

- The last phase is serial:

5. Apply your result to the data chunks:

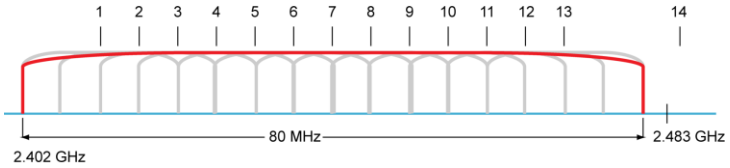


6. Concatenate the results to get your 16 byte MIC:

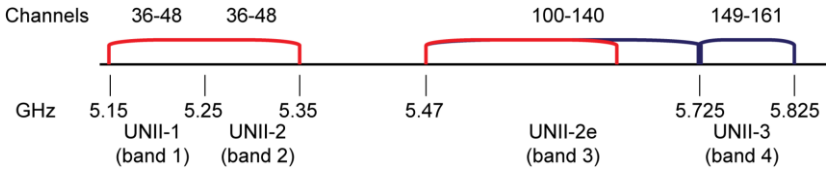


Faster Than 802.11n: 802.11ac

- What Are We Waiting For?
  - Where do I find 160 MHz?
    - One 80 MHz channel in 2.4GHz
    - Two 160 MHz channels in 5 GHz (with DFS; one without DFS band)

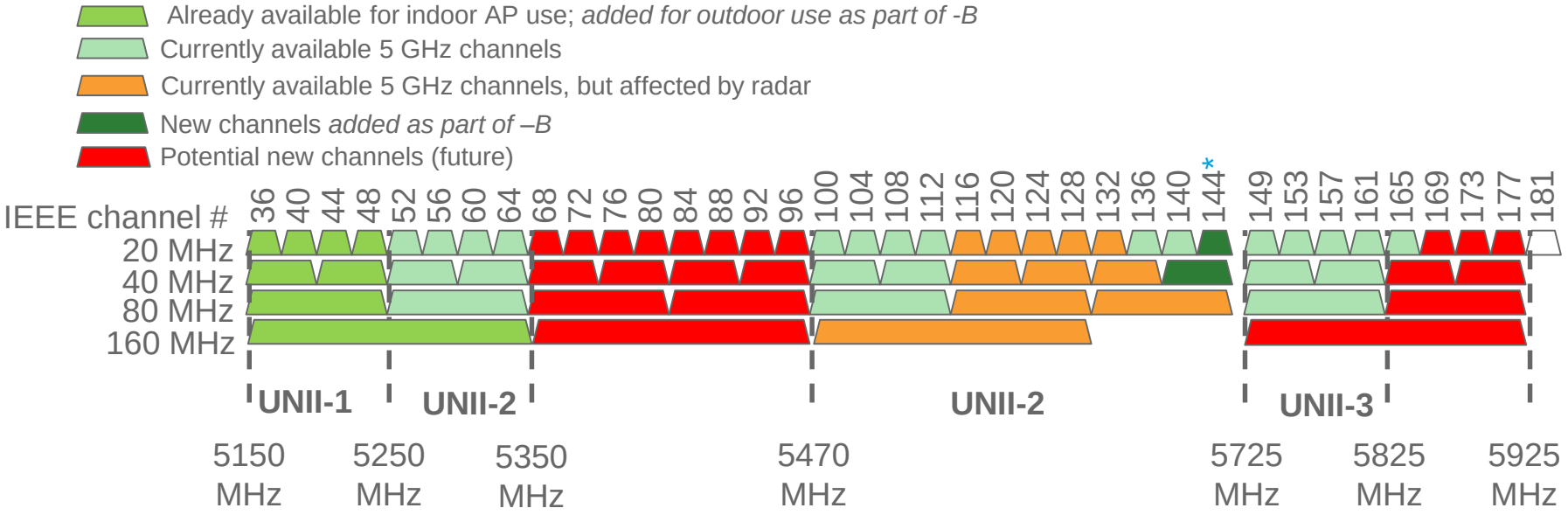


  - 802.11ac focuses on 5 GHz
  - Even in 5 GHz, a new protocol does not make the spectrum wider



  - One great advantage of 802.11ac will be to increase the 5 GHz adoption
    - But multiple 802.11ac cell coexistence will be a challenge
    - And can you afford 8 radios in your mobile device?

802.11ac – Wider Channels

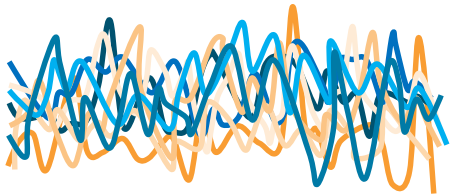


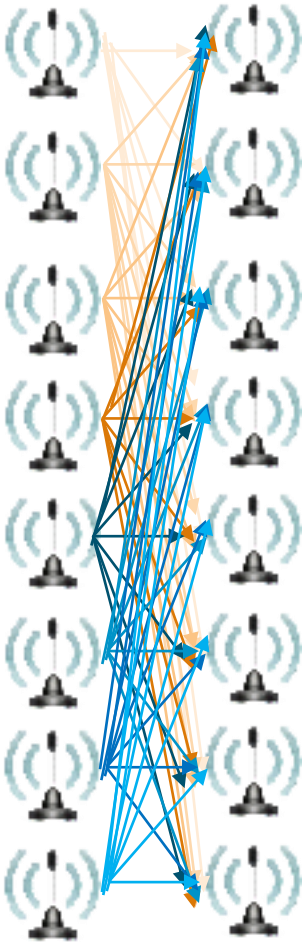
Channel 144 was allowed for use prior to the FCC 14-30 order but not supported until –B introduced

- The number of channels with 20/40/80/160MHz bandwidth in other countries (as of Nov 2015):
  EU: 17/8/4/2, China: 5/2/1/0 (about to expand number of channels), India: 13/6/3/1, Japan: 19/9/4/2, Russia: 16/8/4/1
- Efforts are underway globally to expand the availability of 5Ghz, including for use by wide 802.11ac channels

Is 802.11ac a Good Idea?

- "802.11n Will Never Take-off" (Computers magazine, 2007)
  - 160 MHz is an obvious choice for SOHO
    - 8 streams… will take a while
  - Adoption in corporate environments may take longer
    - Great opportunity for wireless professionals
    - 802.11ac wave will follow 802.11n wave
  - New ideas are yet to be found to go even faster
    - 802.11ax (HEW) Task group was created in 2013
      - Should complete in 2019





What are These Waves?

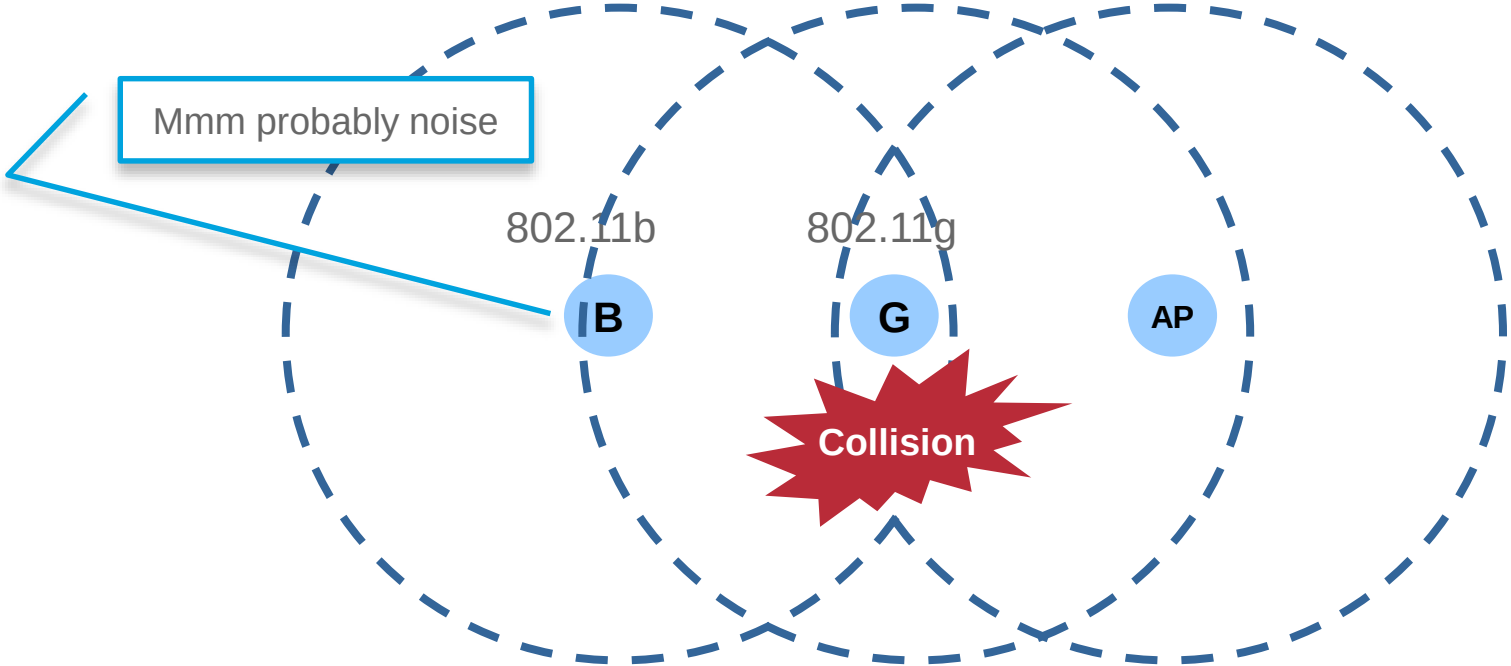
- Wi-Fi Alliance releases 802.11ac certifications in phases (“waves”)
  - Can’t wait for the industry to be 100% 82.11ac spec ready

Feature	Wave 1	Wave 2
Channel	80 MHz	160 MHz
Spatial Streams	3	4
MU-MIMO	No	Yes
256-QAM	Optional	Yes

Peaceful Coexistence?

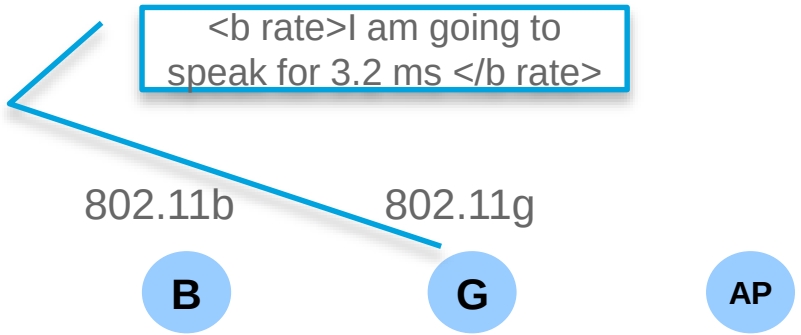
802.11b - 802.11g Coexistence

- 802.11g EXTENDS 802.11b by providing OFDM rates
- When 802.11g communicate, 802.11b do not understand…



802.11b - 802.11g Coexistence

- To limit issues, 802.11g devices first send messages at 802.11b speed
  - Can be a Request to Send (RTS), to which destination replies with a Clear To Send (CTS) – both show the intended duration of the exchange
  - Can be a CTS to self



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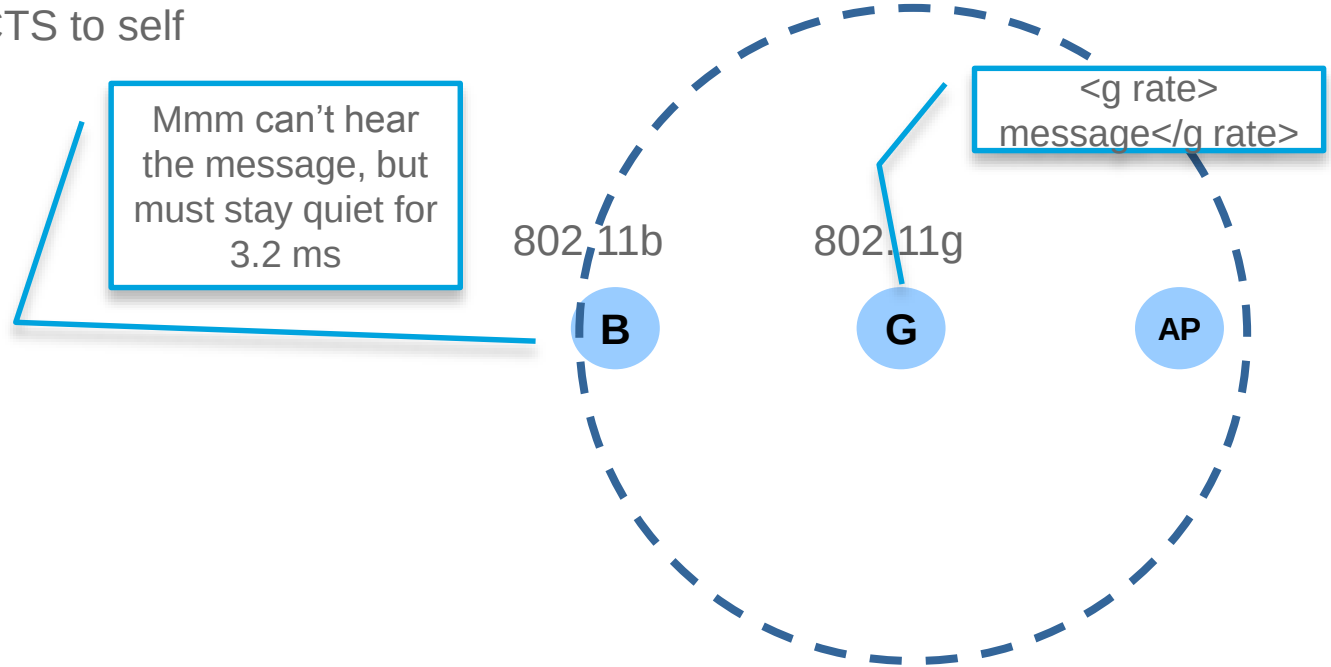
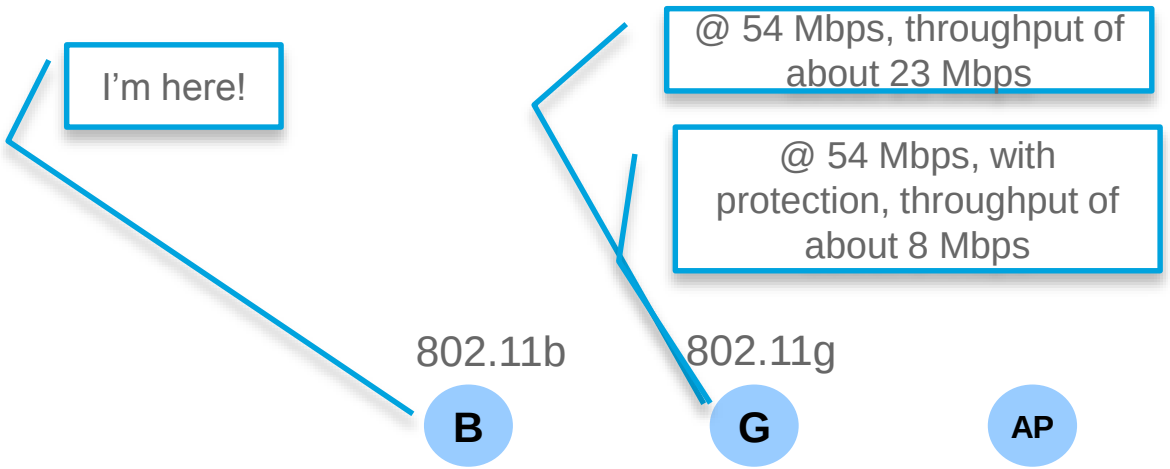


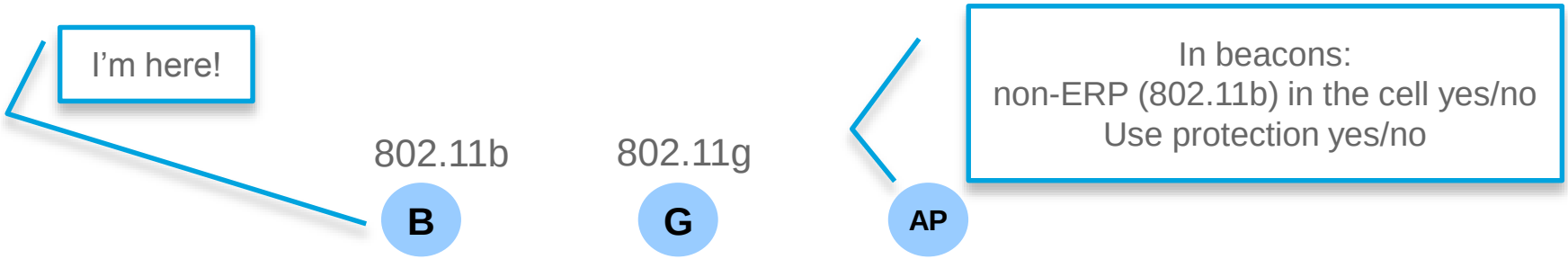
802.11b - 802.11g Coexistence

- This protection mechanism is great for 802.11b clients, not so much for 802.11g clients



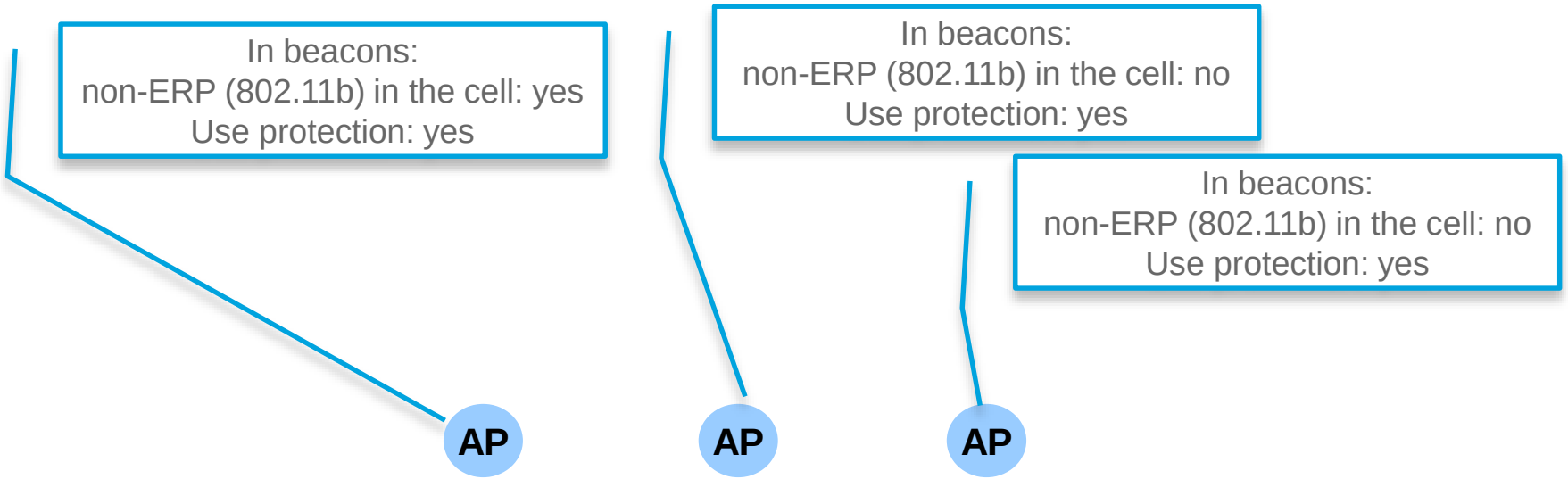
802.11b - 802.11g Coexistence

- Protection occurs when a “802.11b client is associated to the BSA”
- Most vendors understand this as “detected by the AP”
- AP has 2 ways of informing the 802.11g clients
- AP beacons info about the network at regular intervals, mentions 802.11b presence and protection requirements



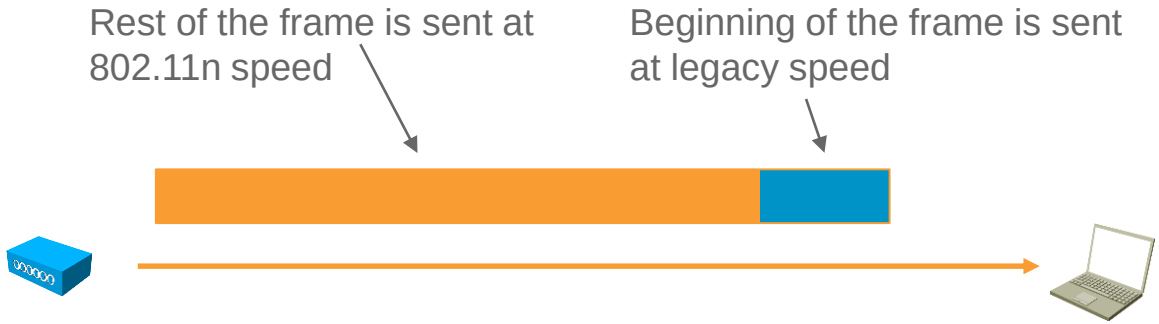
802.11b - 802.11g Coexistence

- Protection messages tend to spread from APs to APs



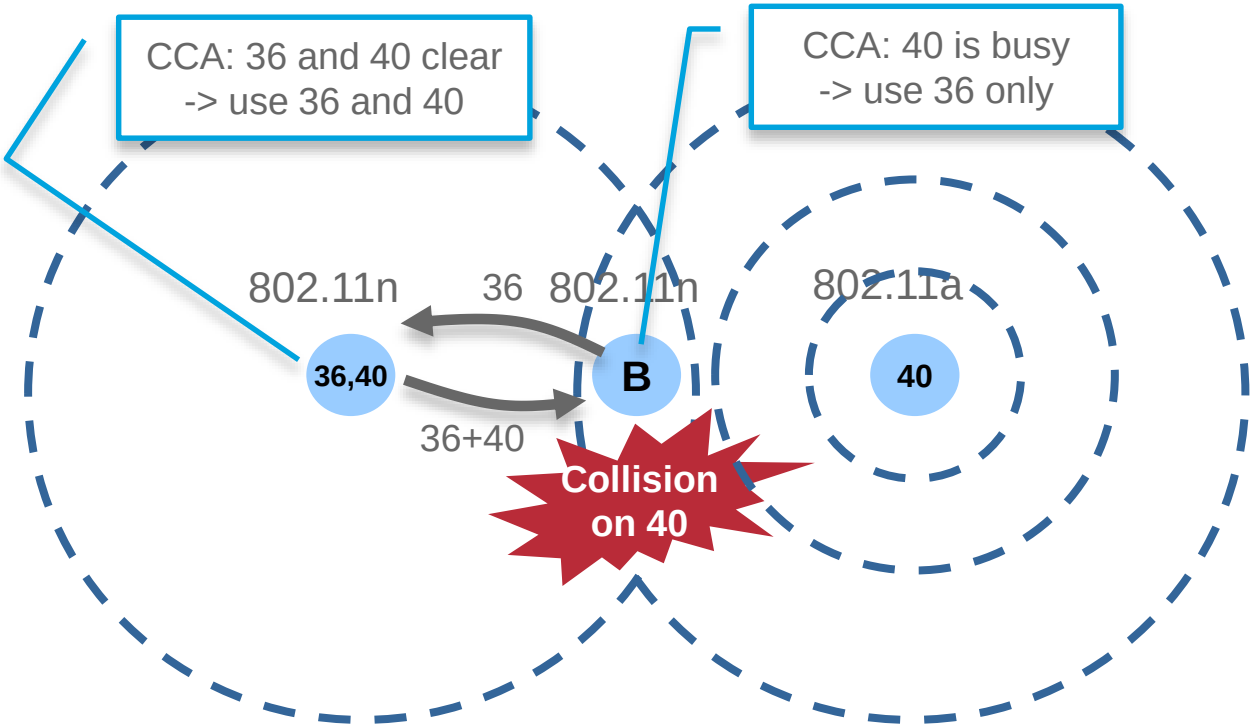
802.11n - Protection

- 802.11n does not repeat the weakness of 802.11g protection



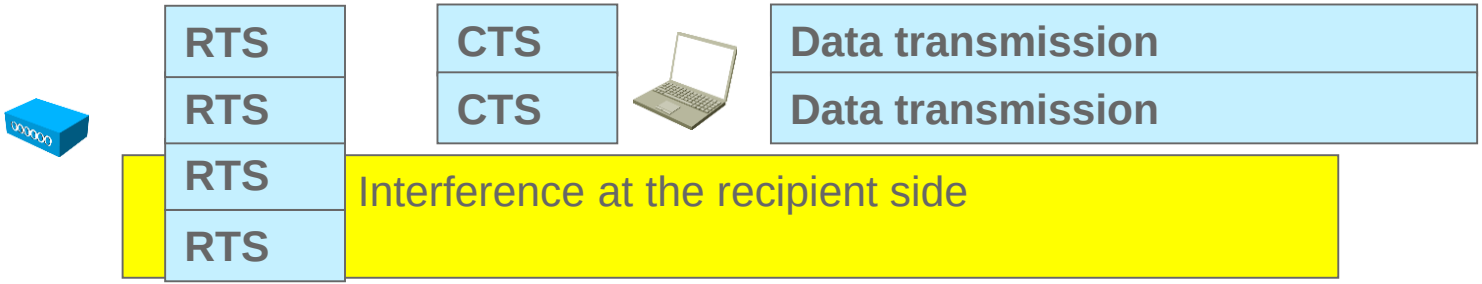
802.11n - Protection

- 802.11n Protection issue is limited to channel width



802.11ac - Protection

- 802.11ac uses the same protection logic as 802.11n (beginning of frame sent slow)
- 802.11ac also protects against channel width



RTS is in 20MHz format, but indicates 80MHz BW

CTS is in 20MHz format, but indicates 40MHz BW

Conclusion

So… Should You Work in 802.11?

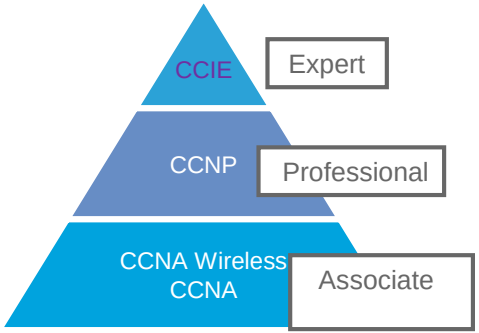
- For Most Managers, Wireless is Just an Access Method, but Wireless is Complex
  - Design depends on applications, user behaviors, density, roaming paths, cloud/no cloud, environment, other RF devices, etc...
  - Troubleshooting implies knowledge of RF, and detailed knowledge of the 802.11 30+ amendments and new features (close to 100 new features in Cisco controllers every year)
  - Wireless is just not about plugging APs anymore, and requires expertise
  - Wireless skills become more and more valuable, and become a differentiator

Where to Start

- Professional Course, or Certification?
  - Professional courses: WLE, WDBWL, WDAWL, WICXS, CMX
  - Certification: WIFUND, then CUWSS, IUWVN, IAUWS, IUWMS,

    Or WIDESIGN, WIDEPLOY, WITSHOOT, WISECURE
    Then CCIE W

Professional Level Recognition in Wireless



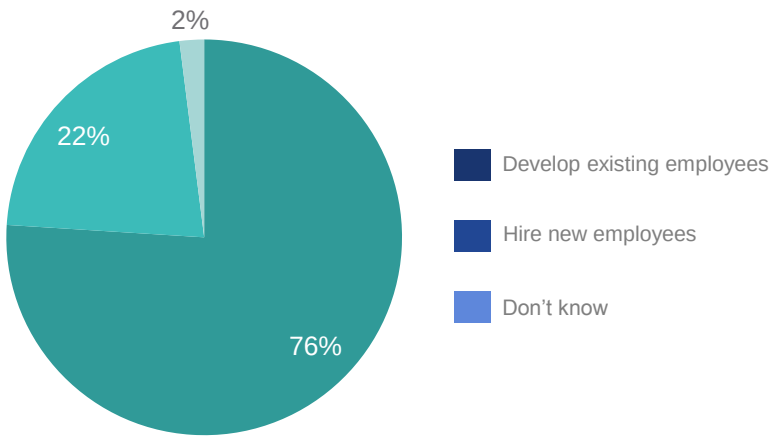
Wireless LAN Certification

www.cisco.com/go/certifications

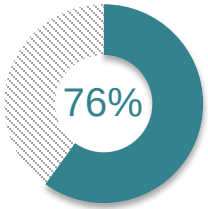
Value of Certification

Organizations are focused on developing internal resources

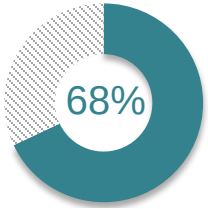
Organizations tend to favor developing existing employees over hiring new employees in order to fill technical skill/ talent gaps



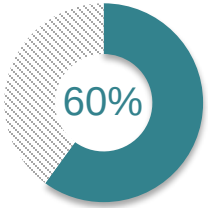
They prefer to develop existing employees because the market for professionals with the skillsets they desire is limited and extremely competitive



favor employees attaining a technical certification when they do formal training



think its at least somewhat difficult to find or develop individuals with the skillsets they need



believe there is a shortage of critical IT skills in their area

"The pool of highly qualified candidates familiar with current and advanced technologies seems to be shrinking."

Source: 2015 Learning@Cisco IT Manager Survey

Why Cisco Certifications Are Successful

Digitization Is Changing The World

Bookstore

Taxi

Music

Hotel

Print Advertising

Car

Point-of-Sale

Pace of Change is Accelerating

50B Connected Devices by 2020

80% of enterprise apps were deployed in the Cloud in 2014

300K apps available in 2010–>2M+ in 2014

More data created in 2012 than the past 5000 years

Connected devices outnumbered people in 2014

Mobile

DC, Cloud, SDx, NFV

DevOps , NP Apps

Big Data, Analytics

IoT, IoE, Fog

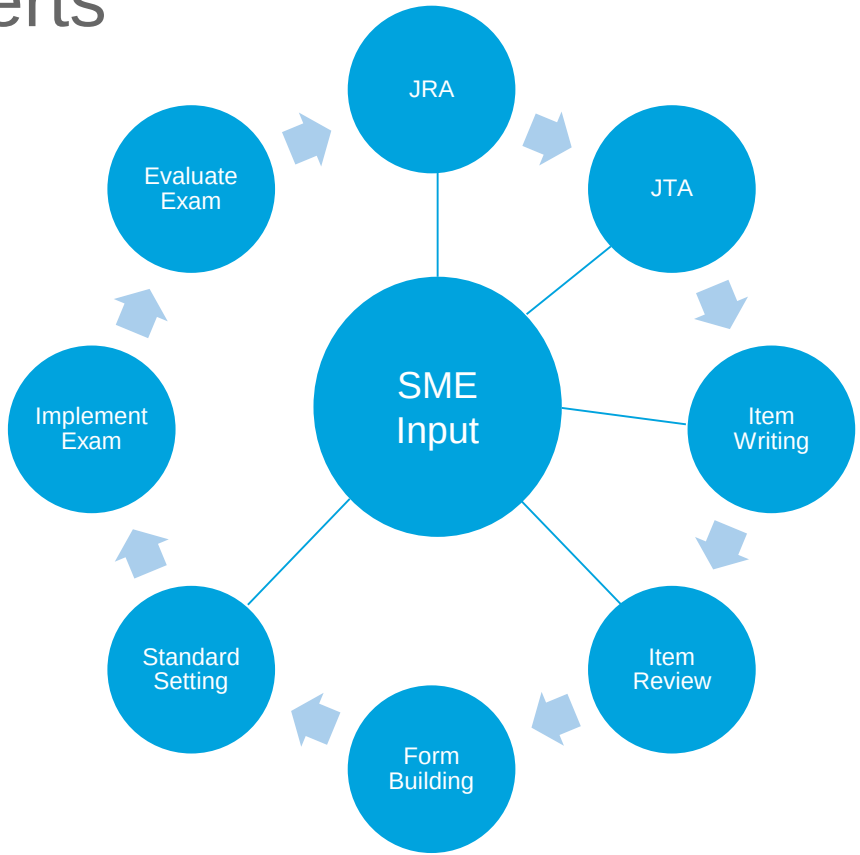
Keys to Success

- Keeping up with pace of change in technology industry
- Staying on cutting edge of testing industry
- Rigor and integrity of exam design and development processes

How We Build World Class Certifications

Global Subject Matter Experts

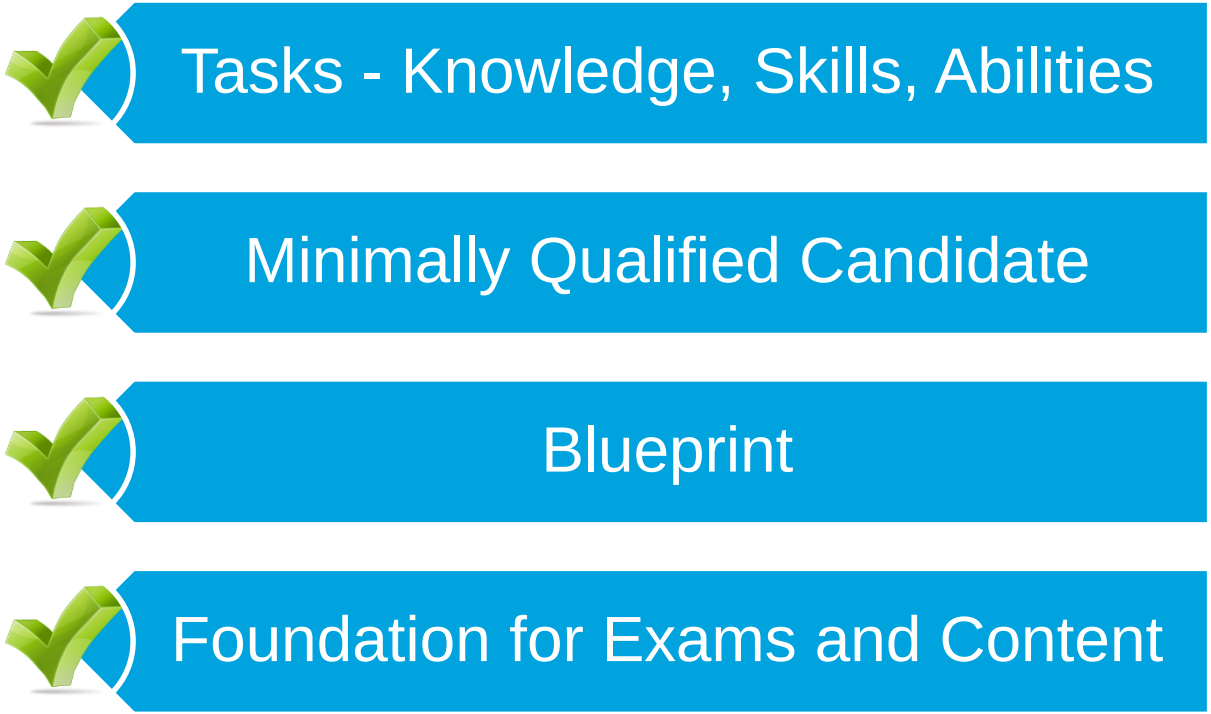
Subject Matter Experts (SMEs) are critical to exam design and development



Job Role Analysis

- Research job role, technology market analysis
- Subject matter experts (SMEs) define job at high level
- Foundation for certification and minimally qualified candidate (MQC) definition

Job Task Analysis

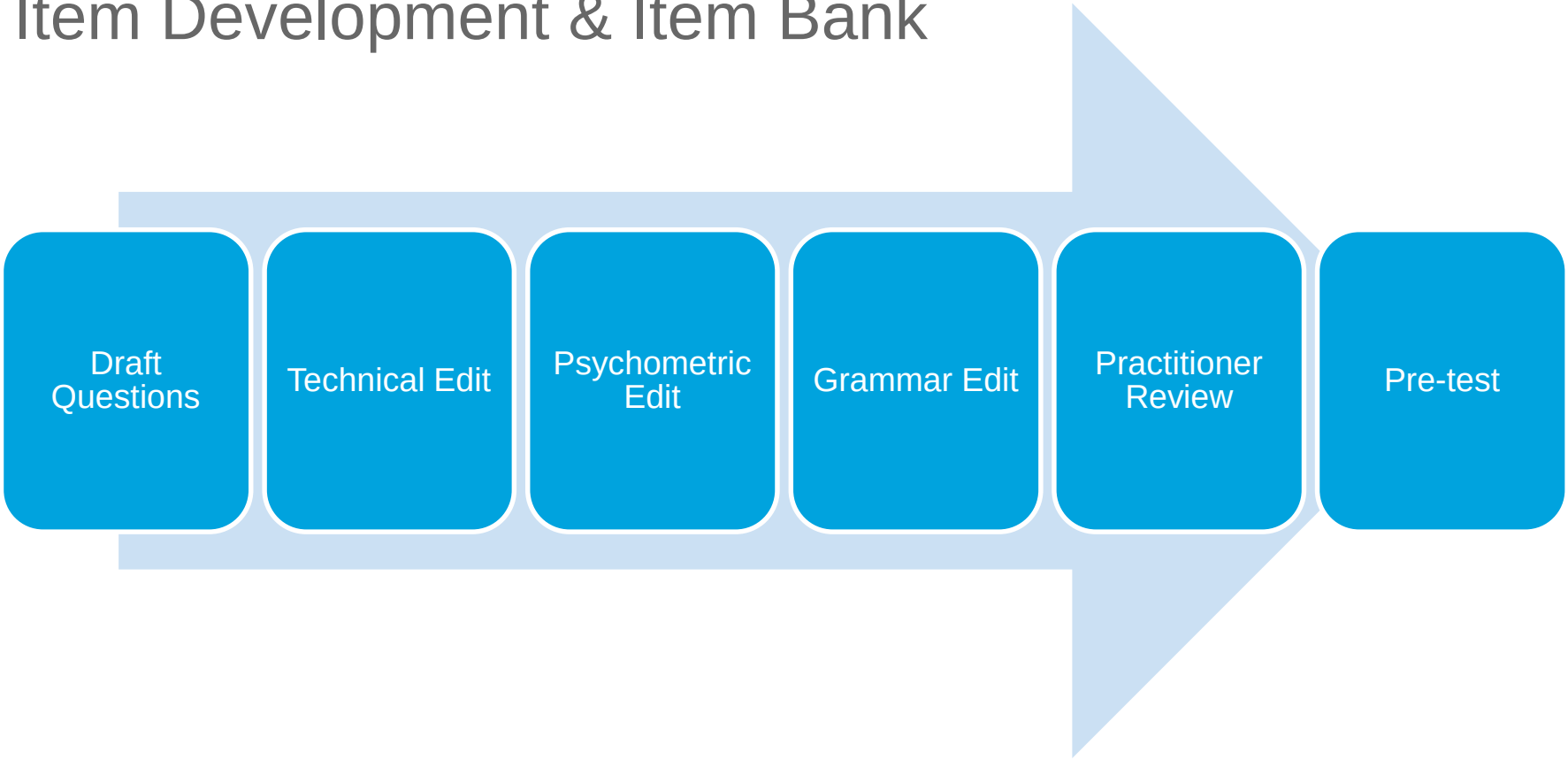


Exam Blueprint

- Based on Job Role Analysis and Minimally Qualified Candidate definition
- Result of completed Job Task Analysis
- Purpose:
  - Build exams
  - Build curriculum
  - Prepare candidates

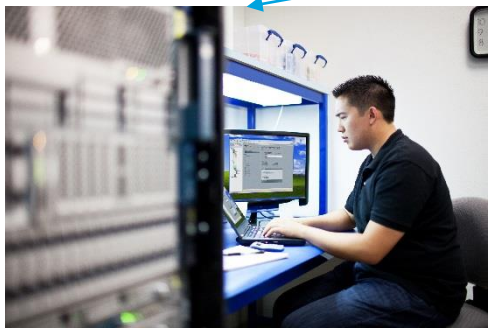
Writing Exam Questions

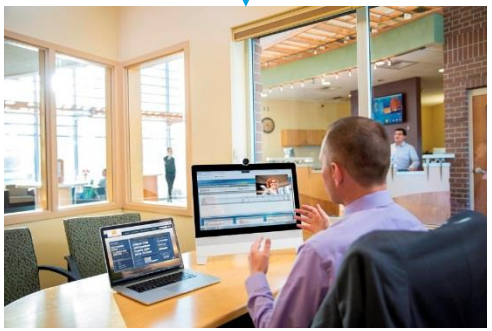
Item Development & Item Bank



Item Review

Exam Item



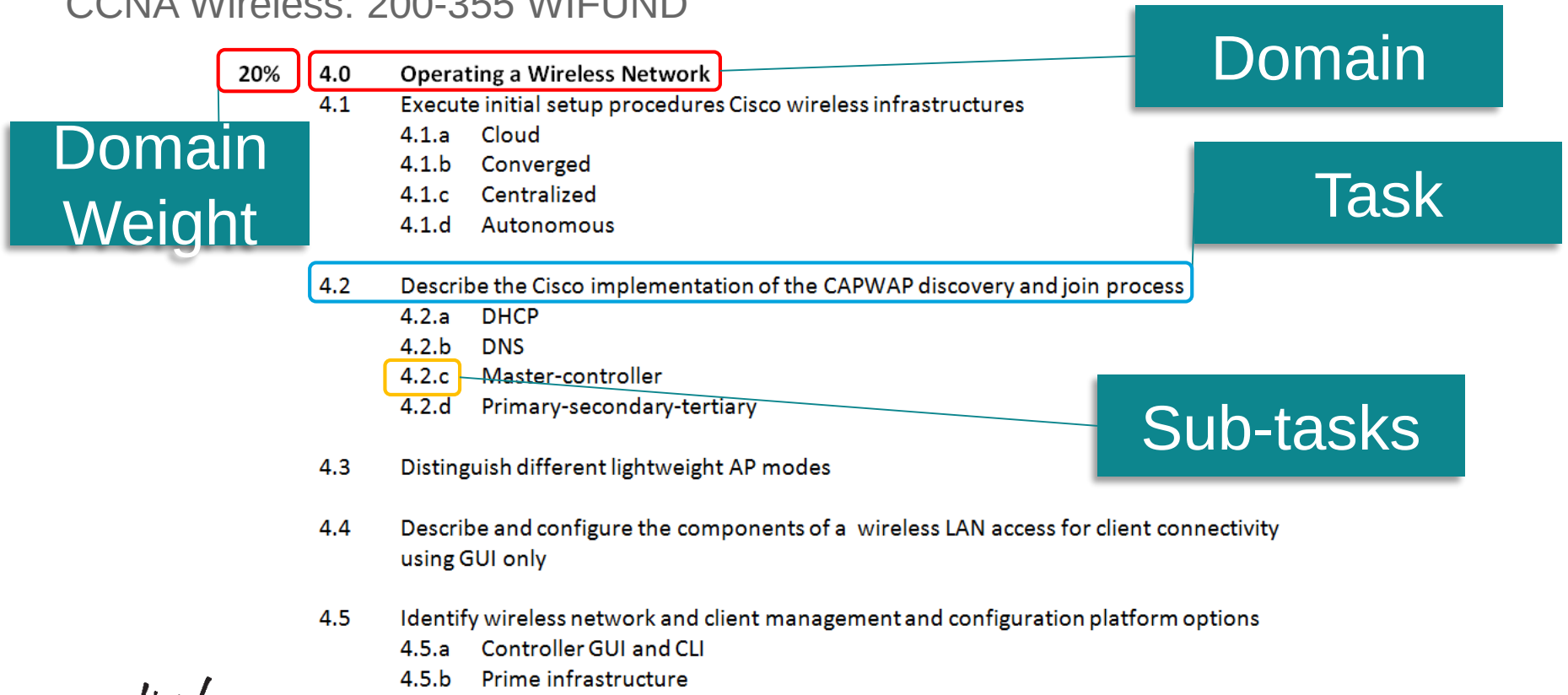


Reviewed by minimum 3 SMEs

Exam Blueprints

Let's Look at a Blueprint

CCNA Wireless: 200-355 WIFUND



Item Writing Exercise

20%	4.0	**Operating a Wireless Network**
	4.1	Execute initial setup procedures Cisco wireless infrastructures
		4.1.a Cloud
		4.1.b Converged
		4.1.c Centralized
		4.1.d Autonomous
	4.2	Describe the Cisco implementation of the CAPWAP discovery and join process
		4.2.a DHCP
		4.2.b DNS
		4.2.c Master-controller
		4.2.d Primary-secondary-tertiary
	4.3	Distinguish different lightweight AP modes
	4.4	Describe and configure the components of a wireless LAN access for client connectivity using GUI only
	4.5	Identify wireless network and client management and configuration platform options
		4.5.a Controller GUI and CLI
		4.5.b Prime infrastructure

Exam Question

On which DNS name does a Cisco lightweight access point tries to find the WLC during discovery process?

A. CISCO-CONTROLLER.*localdomain*

B. CISCO-CAPWAP-CONTROLLER.*localdomain*

C. CAPWAP-CONTROLLER.*localdomain*

D. CISCO-CAPWAP.*localdomain*

Summary

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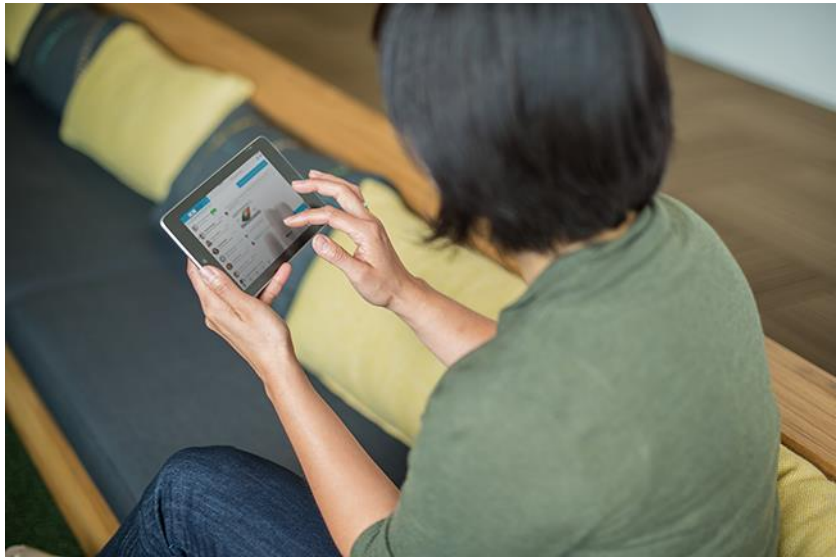

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Course	Description	Cisco Certification
• Designing Cisco Wireless Enterprise Networks • Deploying Cisco Wireless Enterprise Networks • Troubleshooting Cisco Wireless Enterprise Networks • Securing Cisco Wireless Enterprise Networks	Professional level instructor led trainings to prepare candidates to conduct site surveys, implement, configure and support APs and controllers in converged Enterprise networks. Focused on 802.11 and related technologies to design, deploy, troubleshoot as well as secure Wireless infrastructure. Course also provide details around Cisco mobility services Engine, Prime Infrastructure and wireless security.	CCNP® Wireless Version 3.0 (Available March 22nd, 2016)
Implementing Cisco Unified Wireless Network Essential	Prepares candidates to design, install, configure, monitor and conduct basic troubleshooting tasks of a Cisco WLAN in Enterprise installations.	CCNA® Wireless (Available Now)
Deploying Basic Cisco Wireless LANs (WDBWL)	Understanding of the Cisco Unified Wireless Networking for enterprise deployment scenarios. In this course, you will learn the basics of how to install, configure, operate, and maintain a wireless network, both as an add-on to an existing wireless LAN (WLAN) and as a new Cisco Unified Wireless Networking solution.	1.2
Deploying Advanced Cisco Wireless LANs (WDAWL)	The WDAWL advanced course is designed with the goal of providing learners with the knowledge and skills to successfully plan, install, configure, troubleshoot, monitor, and maintain advanced Cisco wireless LAN solutions such as QoS, “salt and pepper” mobility, high density deployments, and outdoor mesh deployments in an enterprise customer environment.	1.2
Deploying Cisco Connected Mobile Experiences (WCMX)	WCMX will prepare professionals to use the Cisco Unified Wireless Network to configure, administer, manage, troubleshoot, and optimize utilization of mobile content while gaining meaningful client analytics.	2.0

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