

Computer Networking: Beyond Routing & Switching Series

Welcome Everyone!

- Session 1 was *Network Security & Cybersecurity*
- Session 2 was *Intro to Data Centers*
- **Session 3: *Going Wireless – Wireless Communications and Technologies***

All session recordings and presentations can be found [here](#)



Cisco Networking Academy

Beyond Routing & Switching

Internet of Everything Webinar Series

TOPIC

IoE & Smart Connected Industries

DATE

January 28th, 9:00 AM PST

[Register Here](#)

More IoE recordings can be found [here](#).





Career Advantage Webinars **Cloud Computing Series**



- Session 2: *Security in the Cloud*
10 December, 8:00 A.M. Pacific Standard Time , [Register Here](#)
- Session 3: *Open Stack—what is it? Connecting ACL to Open Stack*
26 January, 8:00 A.M. Pacific Standard Time, [Register Here](#)
- Session 1 – *What is the Cloud? How will it affect my network and I?* – recoding and presentation can be found [here](#).

Career Advantage Webinars

Mapping Your Path to Success Webinar Series



Upcoming Sessions

- Discovering the Magic of Teamwork
6 January, 2016 – 9:00 PM PST, [Register Here](#)
- How to Communicate Effectively With Body Language
3 February, 2016 – 9:00 PM PST, [Register Here](#)
- Browse all previous on-demand sessions [here](#)



Cisco Networking Academy
Mind Wide Open

Wireless Fundamental

Eric Kwok

Technical Manager, GC+JP

Networking Academy

Happy Birthday to 802.11 Wireless LAN 25th anniversary



IEEE 802.11™ WIRELESS LOCAL AREA NETWORKS

The Working Group for WLAN Standards

Agenda

1. Why is Wireless More and More important?
2. Wireless Technologies
3. Wireless Standards – 802.11 a/b/g/n
4. The new kid on the block – 802.11ac
5. NetAcad Courses

Why is Wireless More and More important?



John, 10 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, 2010



Multi Wi-Fi

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

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

More Applications

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

Sam, today in Barcelona

802.11ac
802.11n
Everything uses Wi-Fi...
Everything?

Far Reaching Wi-Fi

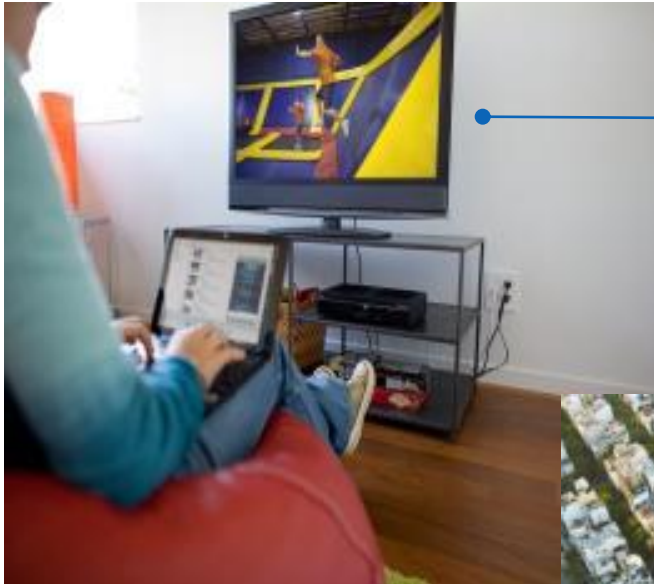
I get Wi-Fi from
almost everywhere



More Applications

Everyone uses Wi-Fi...
for almost everything

In 2017...



802.11ac -> 802.11ad

Your media server can stream to your TV, your laptop, your phone, your tablet... multiple streams everywhere in the house



802.11ah – Wireless for IoT

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

Explosive Mobile Device Growth

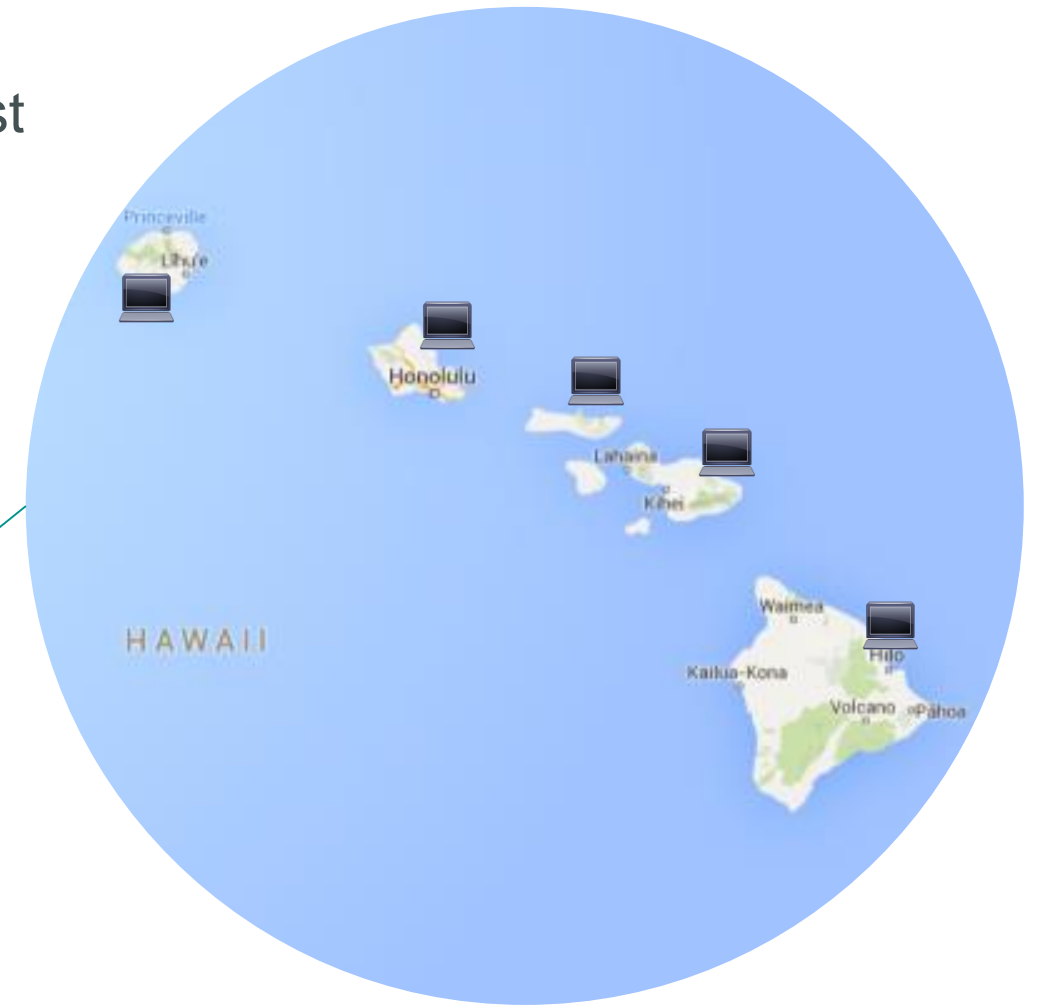
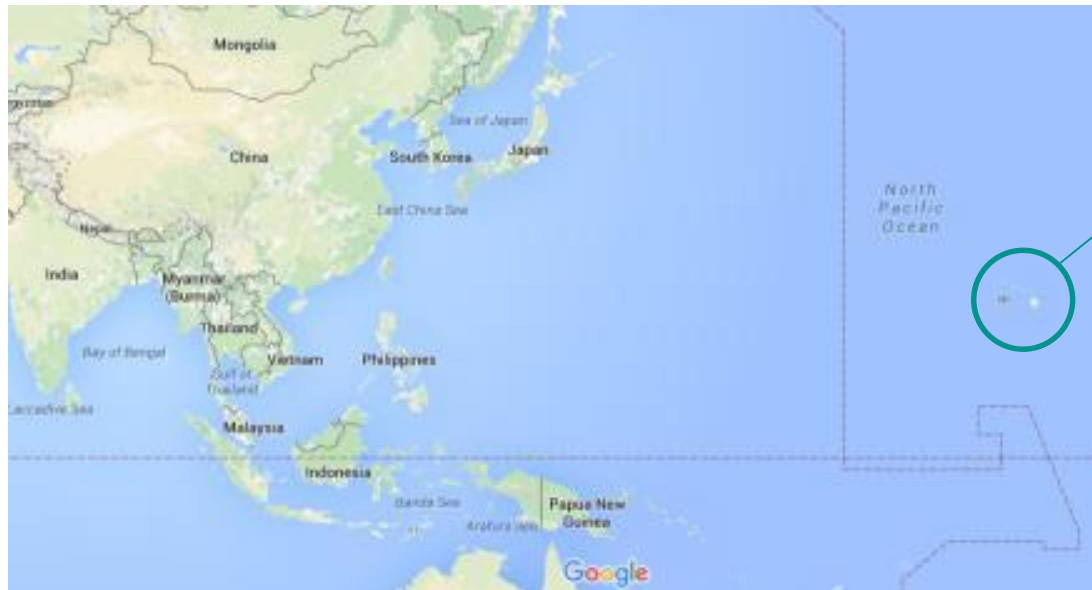
- In 2020 there will be **50 billion** connected devices
- Smartphone & Tablet adoption growing **70%+ annually**.**
- In 2014, more than **60%** of network devices shipped without a wired port.***



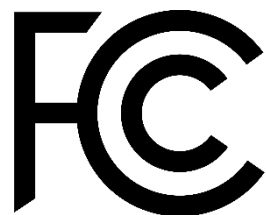
Source: *ABI Research, **IDC, *** Morgan Stanley Market Trends

History of Wireless LAN

- In 1970, the University of Hawaii developed the first wireless network, called ALOHAnet
- 400 MHz frequency range
- IEEE ratified the original 802.11 standard (1997) - 2Mbps



Standard Organization



- **The International Telecommunication Union Radiocommunication Sector (ITU-R) and Federal Communications Commission (FCC)** - regulate frequencies, power levels, and transmission methods



- **Institute of Electrical and Electronics Engineers (IEEE)** - Standard and compatibility between equipment



- **Wi-Fi Alliance** – Certification testing for wireless equipment



- **International Organization for Standardization (ISO)** – OSI 7 layers for data communication



- **Internet Engineering Task Force (IETF)** - creating Internet standards (RFC)

WiFi Certificate

- <http://www.wi-fi.org/product-finder>

The screenshot shows the Wi-Fi Certified Product Finder interface. At the top, there are social media icons and navigation links for 'Consumers & Retailers' and 'START HERE'. A search bar contains the text 'Certified products, news, etc.' with a 'SEARCH' button. Below the search bar, there's a section for 'View Wi-Fi CERTIFIED™ products by category' and a 'Download your results' button. The main content area is titled 'Your Search Results (20)' and includes a 'Sort By' dropdown set to 'Date Certified: Newest to Oldest'. On the left, there are filter sections for 'Keyword Search' (with '3702' entered), 'Brand' (with 'Cisco Systems' selected), and 'Categories' (with 'Routers (20)' selected). The search results are displayed in a grid of six product cards, each showing a product image, name, model number, brand, category, and last certified date.

Product Details



Certification ID: WFA52709

Date of Last Certification: 2014-07-10
Brand: Cisco Systems
Product: Cisco CTVM Virtual WLAN Controller and Cisco CAP3702 AP
Model Number: AIR-CTVM and AIR-CAP3702
Product Identifier(s): SKU: AIR-CTVM and AIR-CAP3702
Category: Enterprise/Service Provider Access Point, Switch/Controller or Router
Hardware Version: Version 1
Firmware Version: 8.0.72.195
Operating System: Proprietary / Other:AireOS and Cisco IOS, version:7.6.94.3
Frequency Band(s): 2.4 GHz, 5 GHz

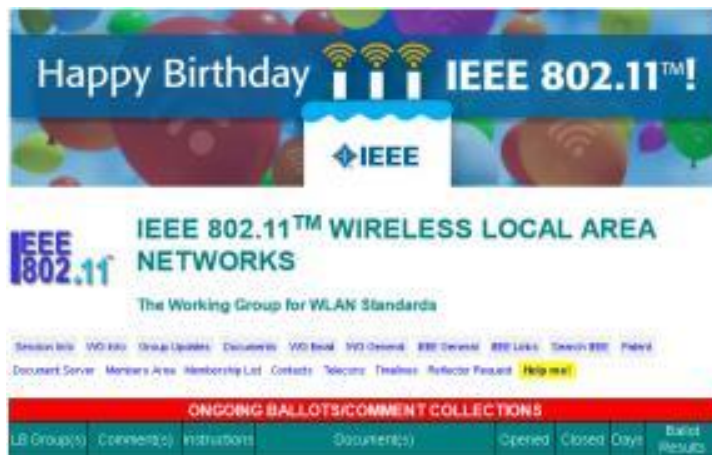
Summary of Certifications

CLASSIFICATION	PROGRAM
Connectivity	Wi-Fi CERTIFIED™ b
	Wi-Fi CERTIFIED™ a
	Wi-Fi CERTIFIED™ g
	WPA™ - Enterprise
	WPA™ - Personal
	WPA2™ - Enterprise
Optimization	WPA2™ - Personal
	Wi-Fi CERTIFIED™ n
Access	Wi-Fi CERTIFIED™ ac
	WMM®
	WMM®-Power Save
	Passpoint™ (Release 1)

IEEE and 802.11 Working Group



- <http://standards.ieee.org/about/get/802/802.11.html>
- Download the standard document (PDF)



- <http://www.ieee802.org/11/>



Wireless Technology

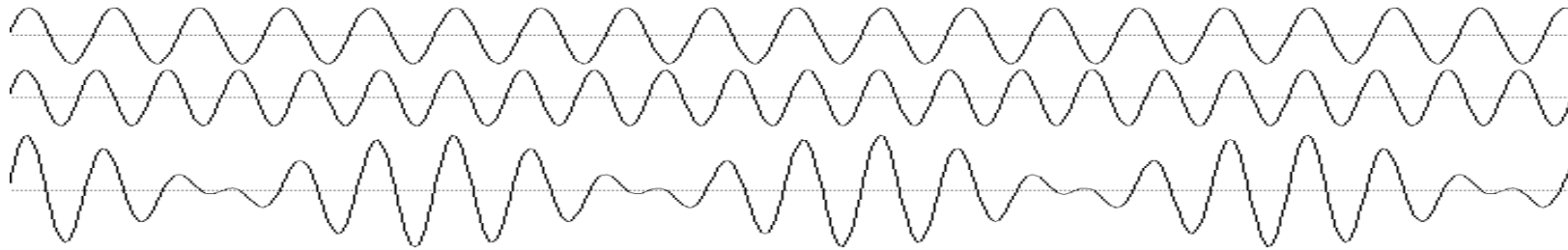


Wireless Technologies

- PAN/WPAN (Personal Area Network)
Bluetooth, IEEE 802.15.4
- **LAN (Local Area Network)**
IEEE 802.11
- MAN (Metropolitan Area Network)
IEEE 802.11, IEEE 802.16, IEEE 802.20
- WAN (Wide Area Network)
GSM, CDMA, Satellite
- <http://www.ieee.org/index.html>

Electromagnetic waves

- Wireless technologies use electromagnetic waves



- What types of communication mediums do we have in wired networks?

Copper, Fiber

- What communication medium do we have in wireless?

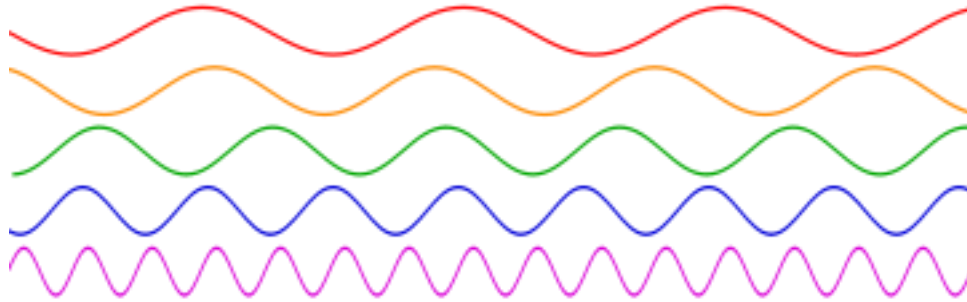
The Earth's Atmosphere



Where it starts

- Frequency (f - Hz)

Frequency is the number of occurrences of a repeating event per unit time.



- Higher frequency:

Greater speed

Shorter range

High reflection rate

Higher absorption in the Earth's atmosphere

Higher costs

Radio Fundamental

- Physical layer is radio frequency (RF) communications.
- Wired vs Wireless

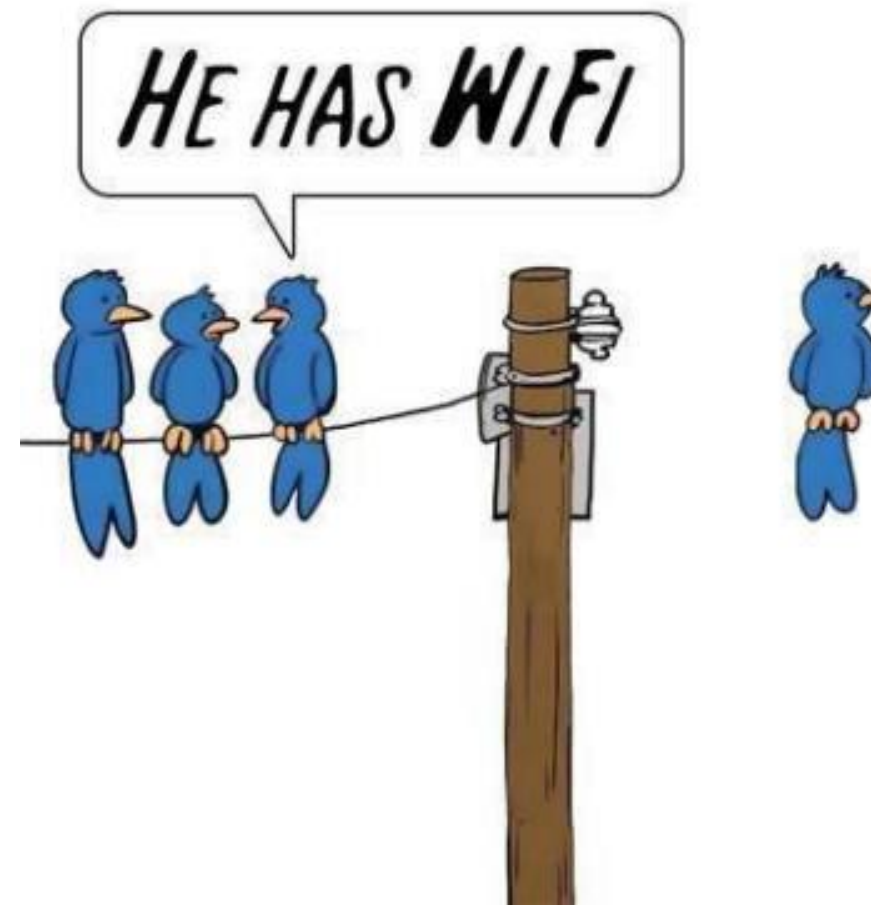


travel across the bounded medium contains or confines the signal.

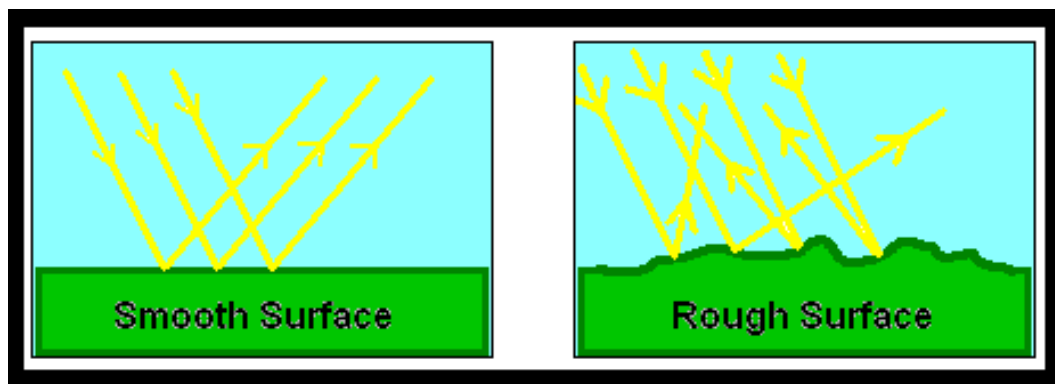


travel across the unbounded medium.

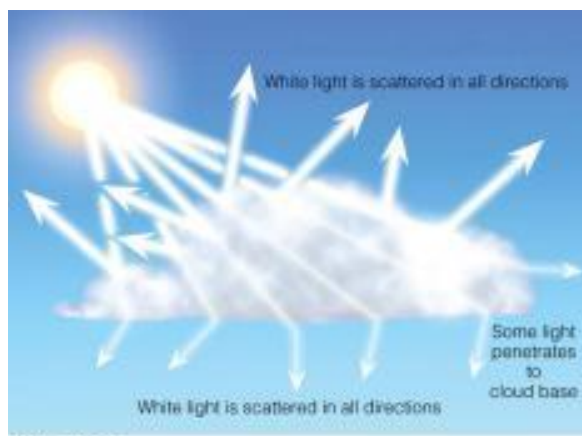
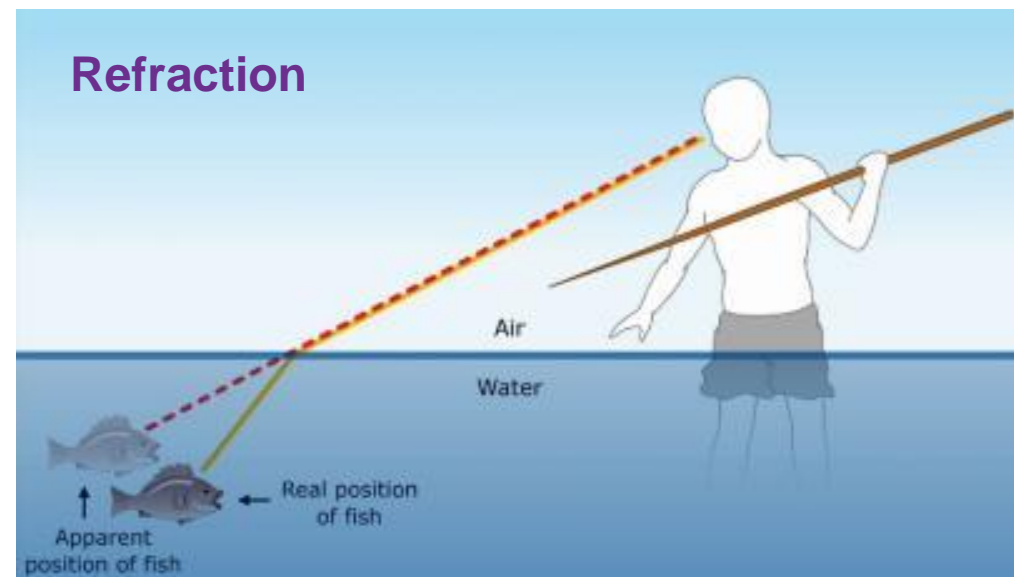
- Absorption
- Reflection
- Scattering
- Refraction
- Diffraction
- Loss (attenuation)
- Free space path loss
- Multipath



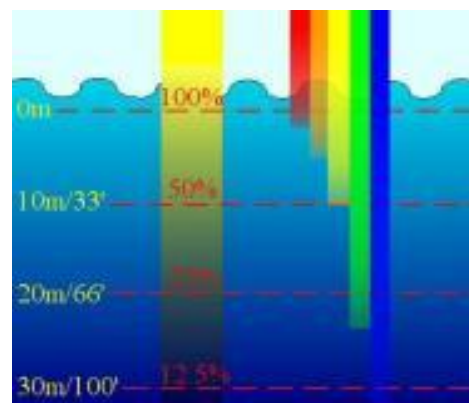
RF propagation behaviours



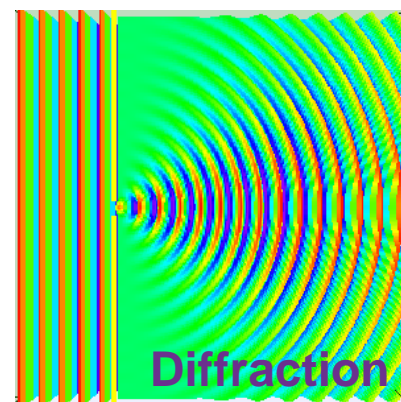
Reflection



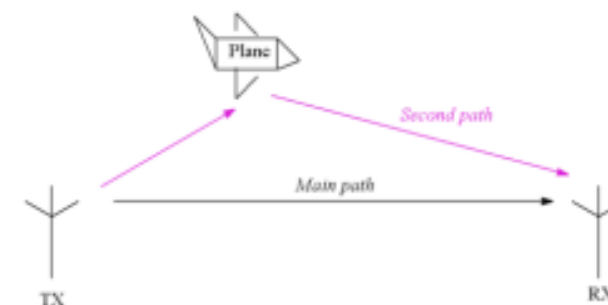
Scattering



Absorption



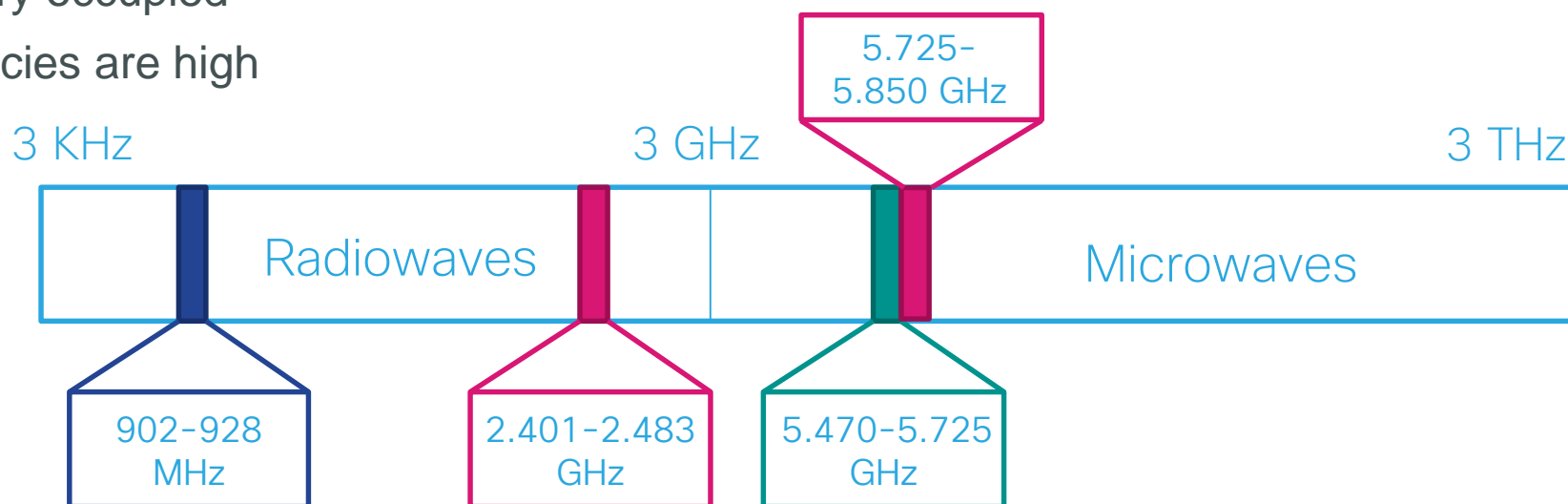
Diffraction



Multipath

Frequency in LAN?

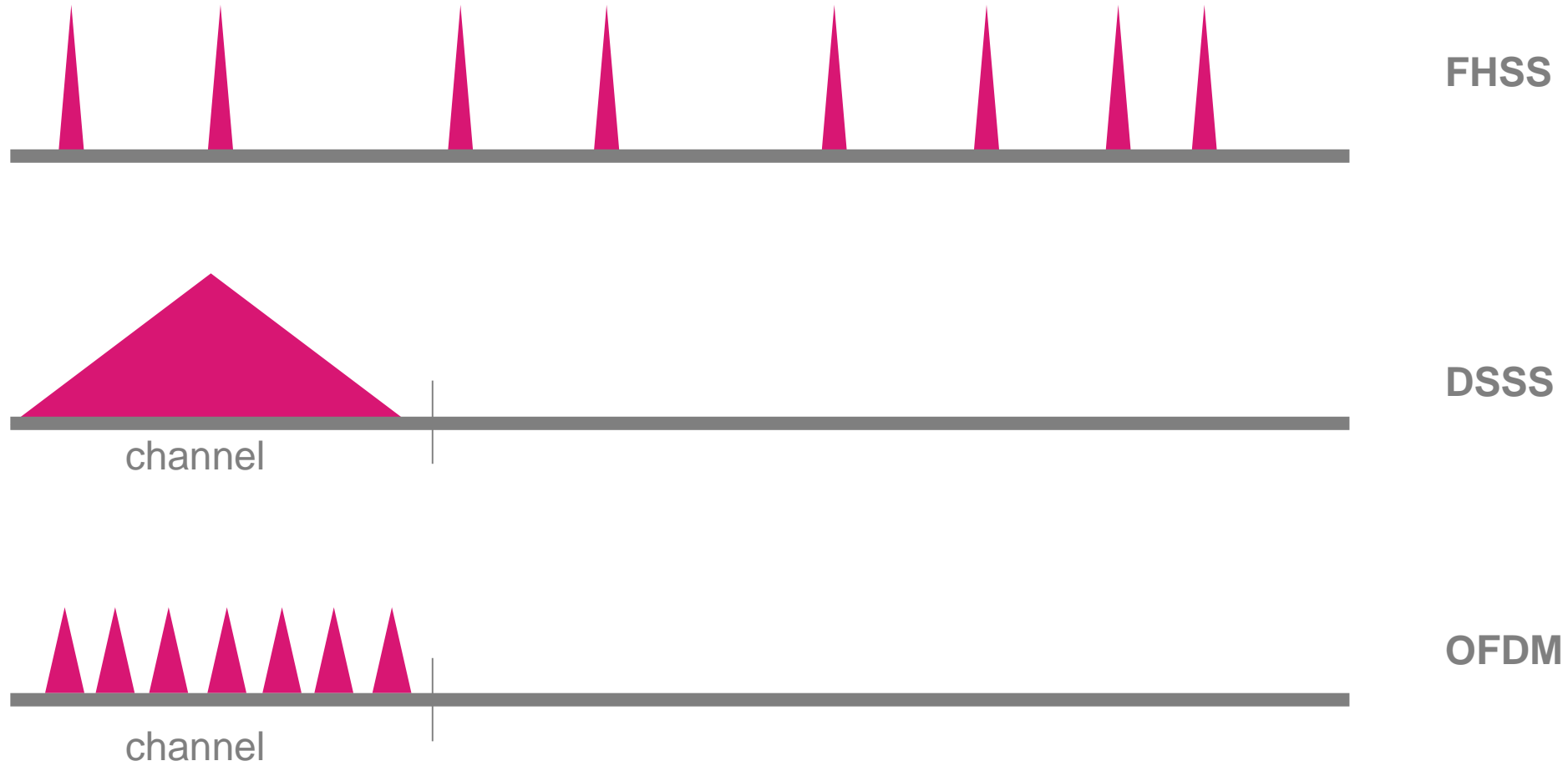
- ISM – Industrial Scientific Medical
Free to transmit
http://en.wikipedia.org/wiki/ISM_band
- 2.4GHz and 5 GHz bands
- Disadvantage:
They are very occupied
The frequencies are high



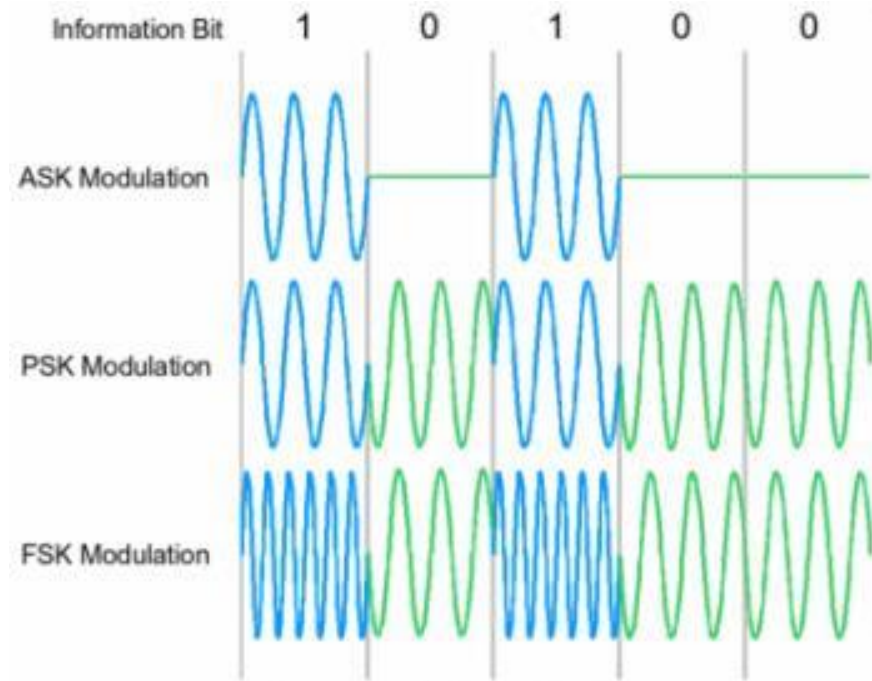
Encoding, Modulation and Multiplexing

- Analog modulation: AM, FM, PM etc
- Digital modulation: ASK, APSK, QAM-64 etc
- Encoding digital data into wireless signals (OFDM)
- Higher bandwidth requires higher modulation techniques
- Spread Spectrum: DSSS, FHSS, OFDM

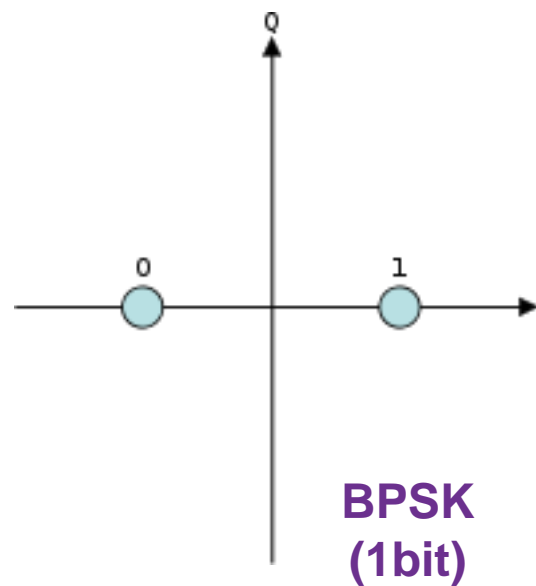
FHSS vs DSSS vs OFDM



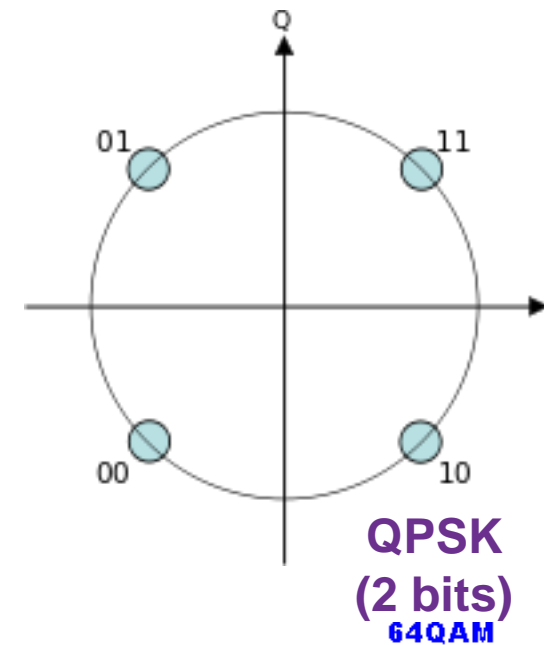
Digital Modulation



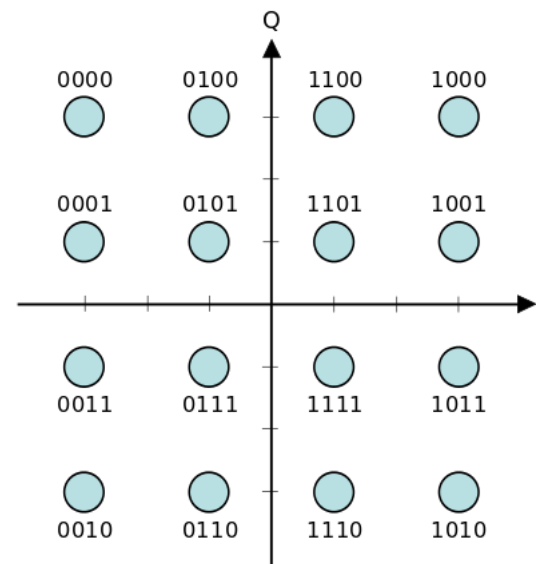
Amplitude, Frequency, Phase



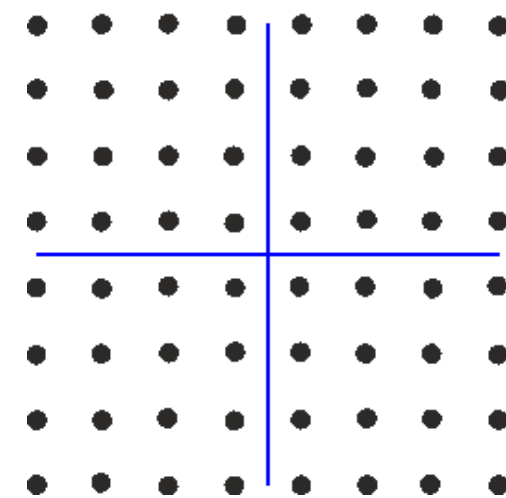
BPSK
(1bit)



QPSK
(2 bits)
64QAM

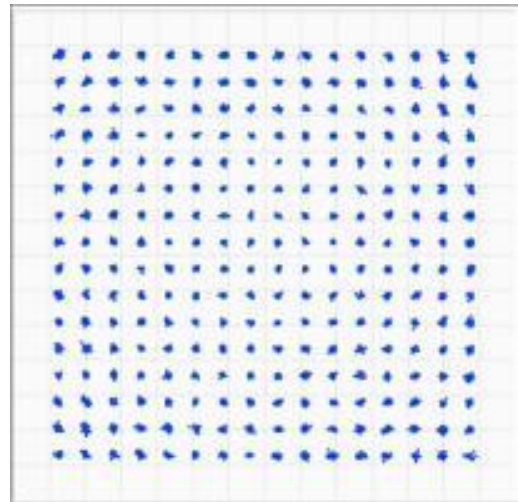
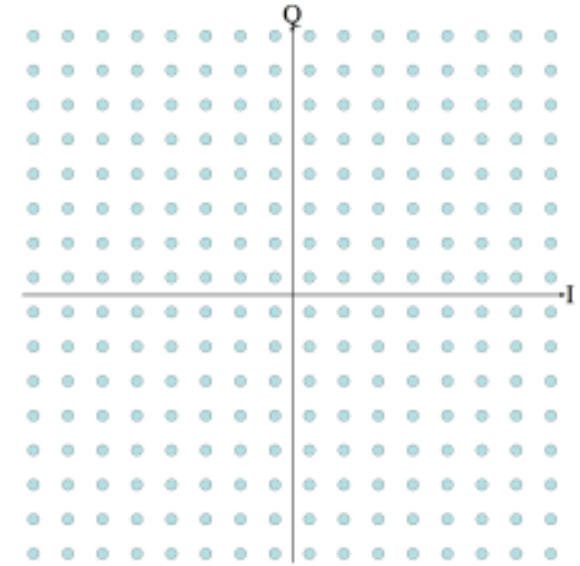
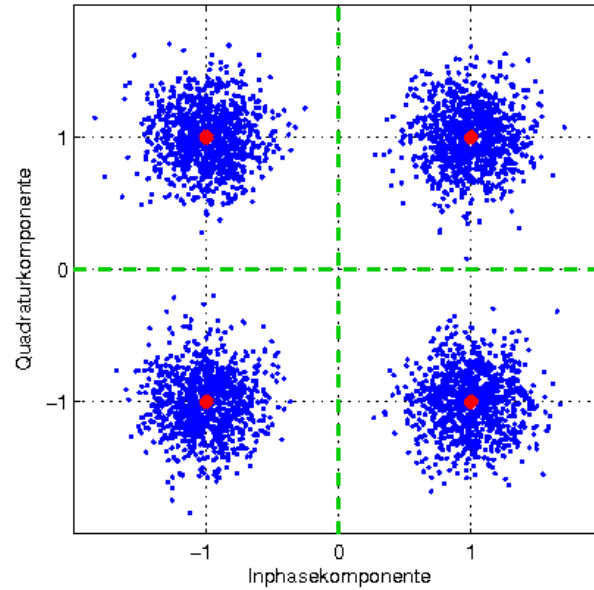


QAM-16
(4 bits)

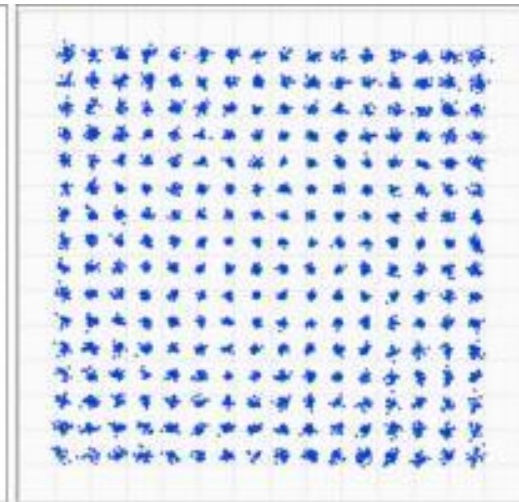


QAM-64
(6 bits)

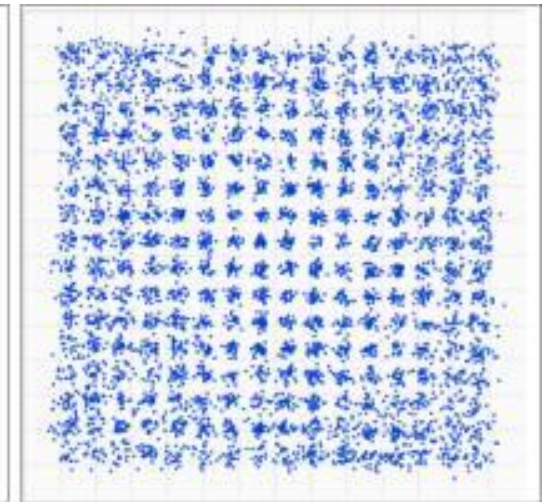
Higher QAM



SNR = 37 dB



SNR = 32 dB

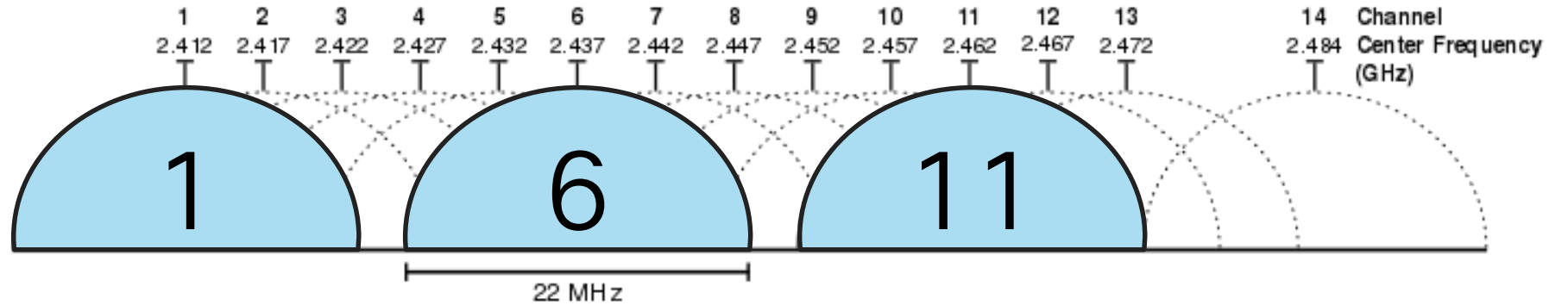


SNR = 27 dB

Communication channel

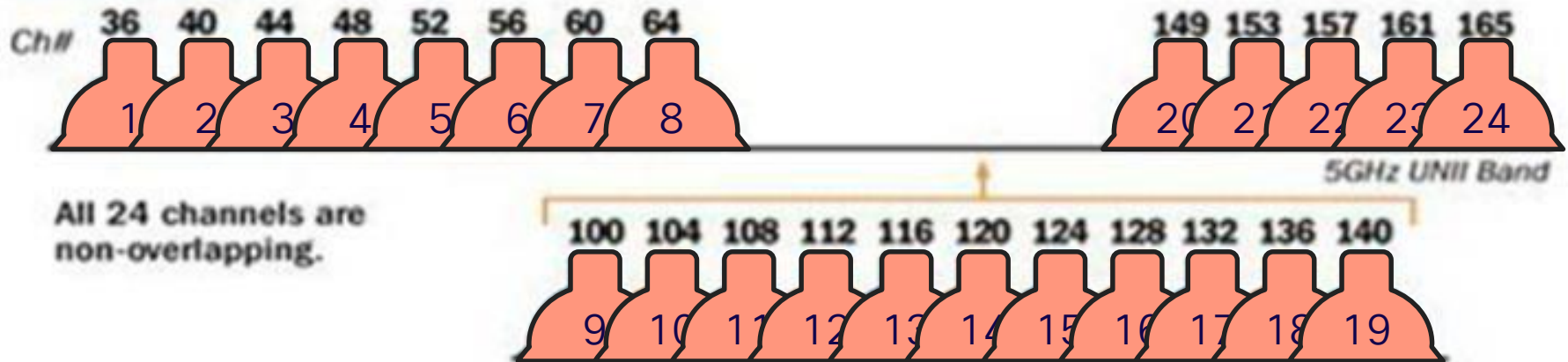
- The wireless transmission medium is shared
- It is not possible to transmit in the exact same frequency without collisions
- How many Hz do we need to transmit 54 Mbps in 802.11g?
Answer: **22 Mhz**
- Solution: we could split the ISM band into channels and map each WLAN/SSID on a single channel, thus having multiple networks in the same band

2.4GHz and 5GHz Frequency Band and Channel

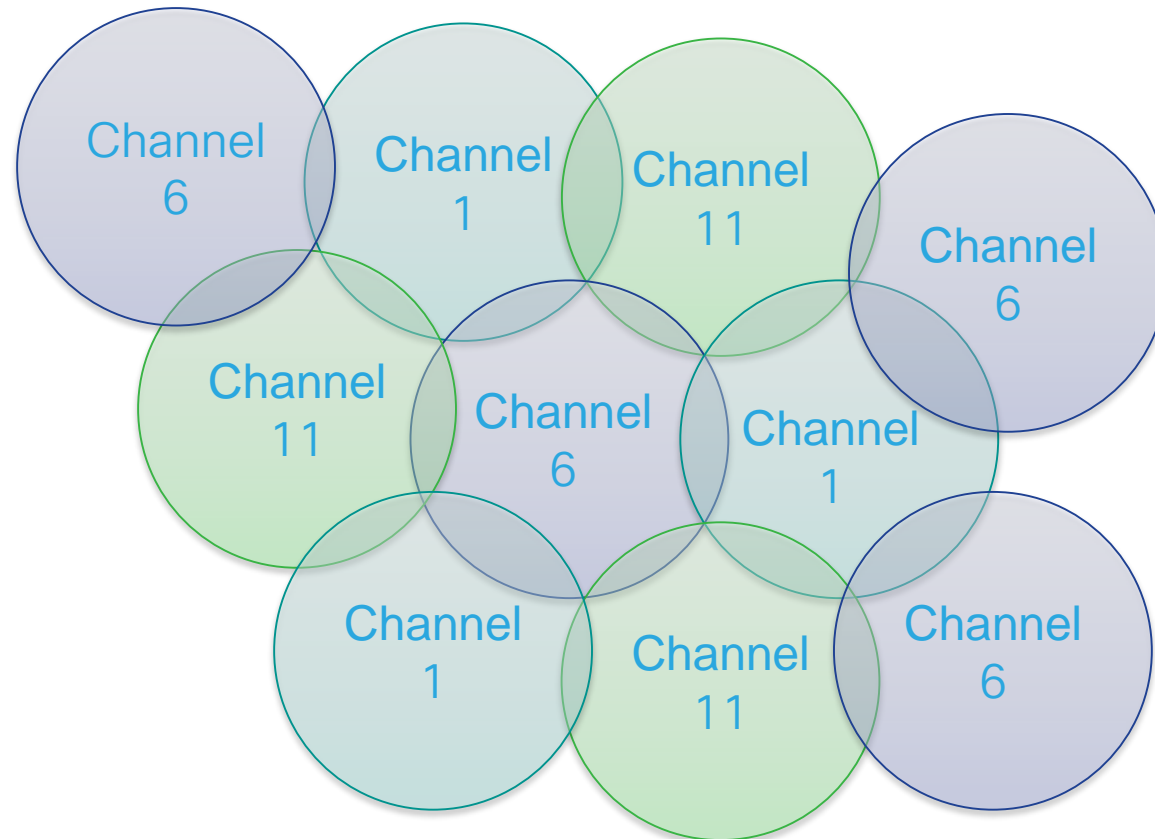


802.11a/n

24 channels are available in the U.S. for 802.11a/n

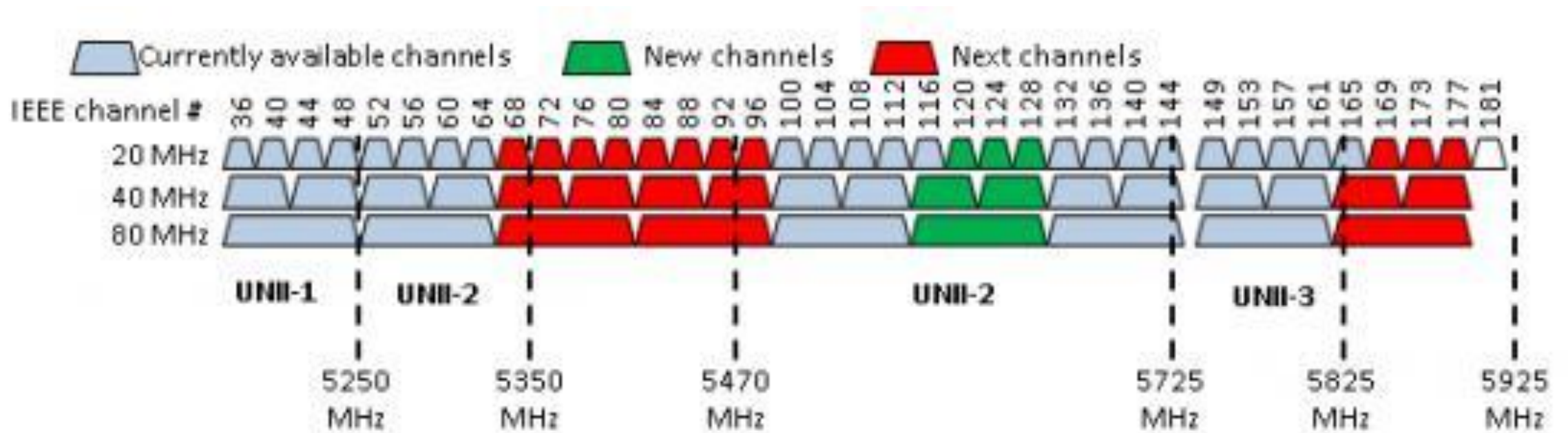


Multiple channels



It is possible to cover any surface using just 3 channels

WiFi Channel in 5Ghz



Wireless LAN Standards

802.11 a/b/g/n/ac



802.11

- Legacy – released in 1997
- Specified in infrared and wireless
- Spread Spectrum – FHSS/DSSS
- Speed: 1-2 Mbps
- Frequency: 2.4 Ghz and 900 Mhz

802.11 a&b

- Both standards appeared about the same time - 1999
- 802.11a
 - Introduces OFDM and takes speed up to 54 Mbps
 - Frequency band: 5 GHz
 - Distance to transmit signal: 25m
- 802.11b
 - Bandwidth: 11 Mbps
 - Frequency band: 2.4 GHz
 - Became very popular – called WiFi



802.11g

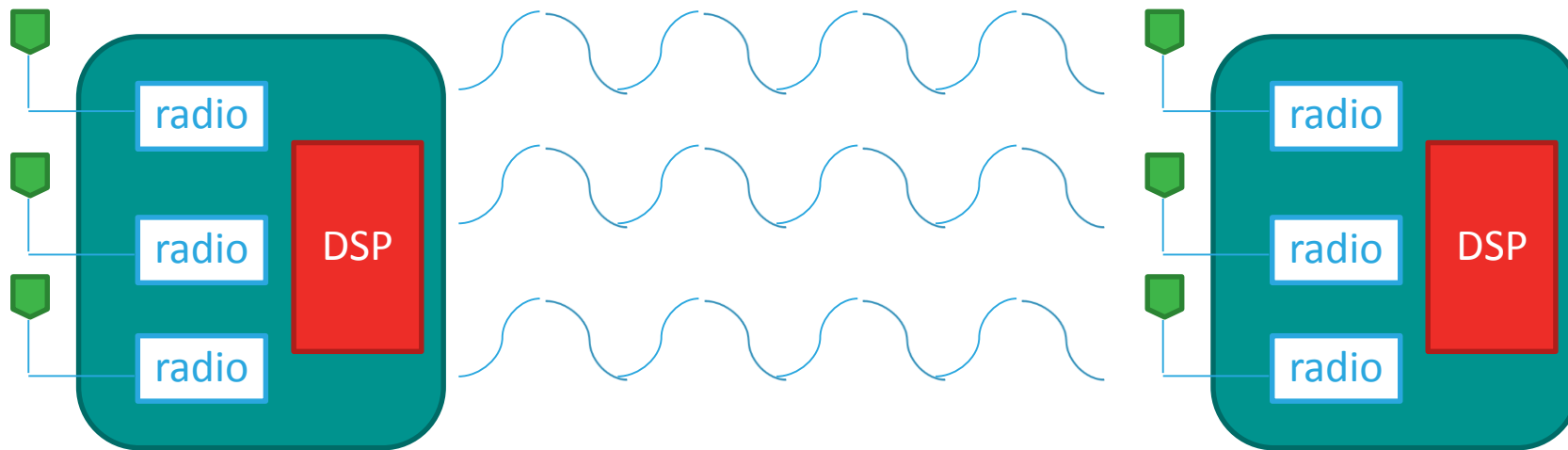
- Standardized in 2003
- Best of both worlds (a & b)
- Frequency band: 2.4 GHz
- Bandwidth: 54 Mbps
- Modulation: OFDM
- Used for a long time and can still be found in networks

802.11n

- 802.11n – standardized 29 October 2009
- Far greater speeds: theoretical maximum 600 Mbps
- Better coverage and density of the signal
- Backwards compatible with 802.11 a/b/g
- Uses multiple antennae and MIMO technology
- Increased channel width to 40 Mhz
- Improved immunity to noise using complex modulation techniques
- Support packet aggregation (one header for multiple data packets)

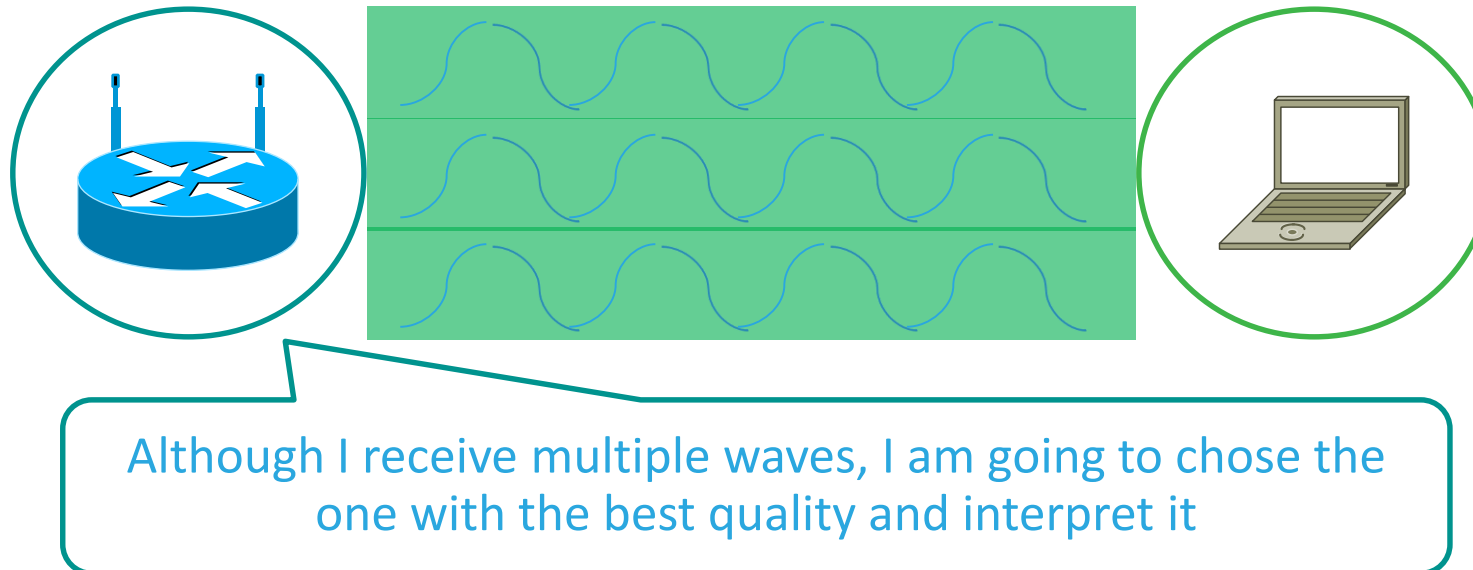
802.11n - MIMO

- MIMO uses DSP processors to multiplex and demultiplex the signal



802.11n – Maximum Ratio Combining

- The multipath effect = the process in which many waves carrying the same information are reflected differently from surfaces and with varying clarity
- In 802.11g, the DSP chose the wave with the best signal to noise ratio



802.11n – Maximum Ratio Combining

- Problem description: some weaker SNR waves are ignored even if there is the possibility that they contain relevant information
- In 802.11n, MRC is implemented in the NIC's DSP so that it takes all the waves and composes just one high-quality wave, thus increasing throughput
- Concluding:
 - MRC is a client-side technology
 - If you have an 802.11n board in a 802.11g network, you will have higher-than-ordinary through
 - It's like having a cat with multiple ears



Faster than 802.11n – 802.11ac



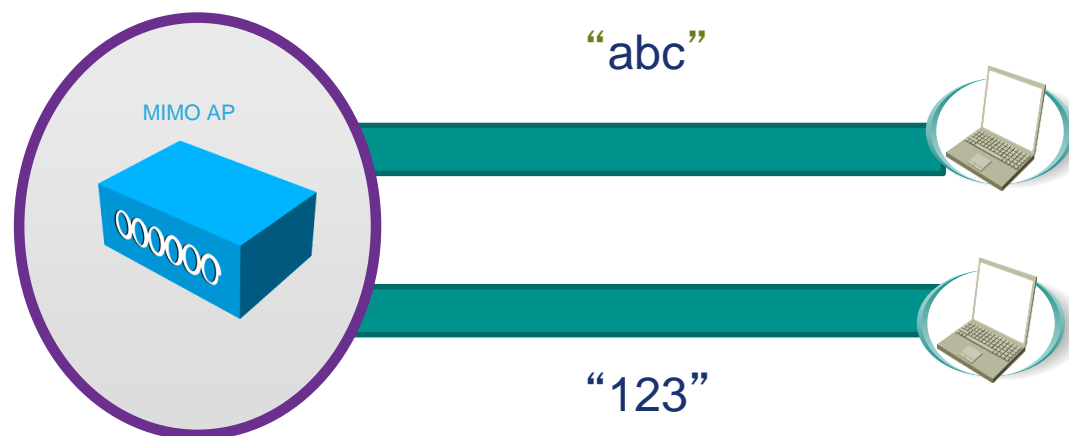
Faster Than 802.11n

- 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
 - 5 Ghz band – in 2015 it's the perfect thing to have
 - Cost does not vary with freq anymore
 - It's not as populated as 2.4
 - It's a bigger space
 - 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?

Faster Than 802.11n: 802.11ac

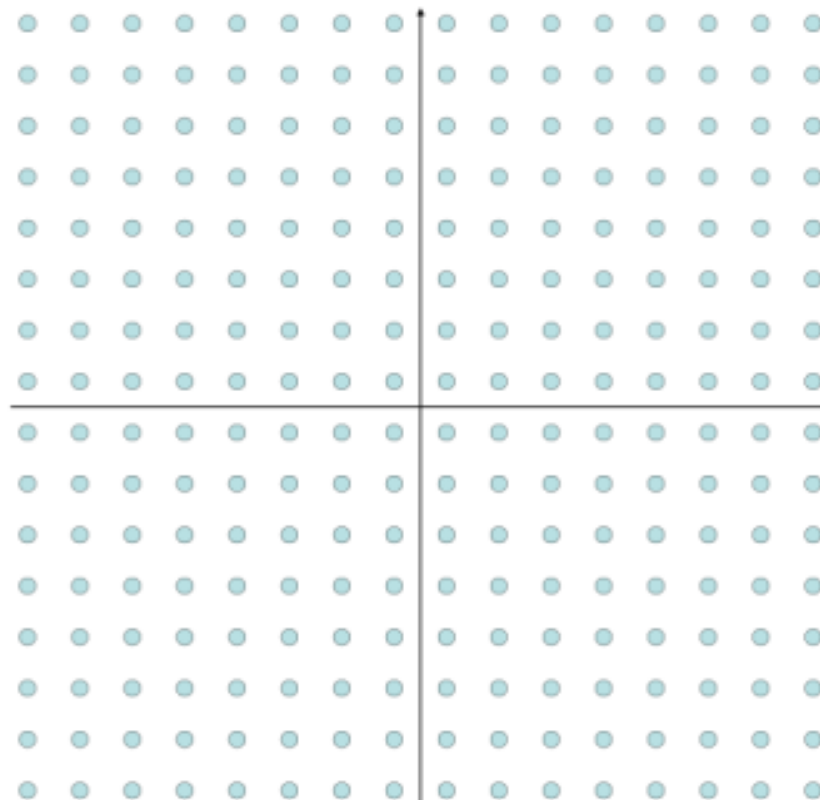
- MU-MIMO

- 2 clients can receive signals at the same time, on the same frequency
 - Each client has a dedicated spatial stream
 - No collisions anymore
 - “Full-duplex” becomes possible

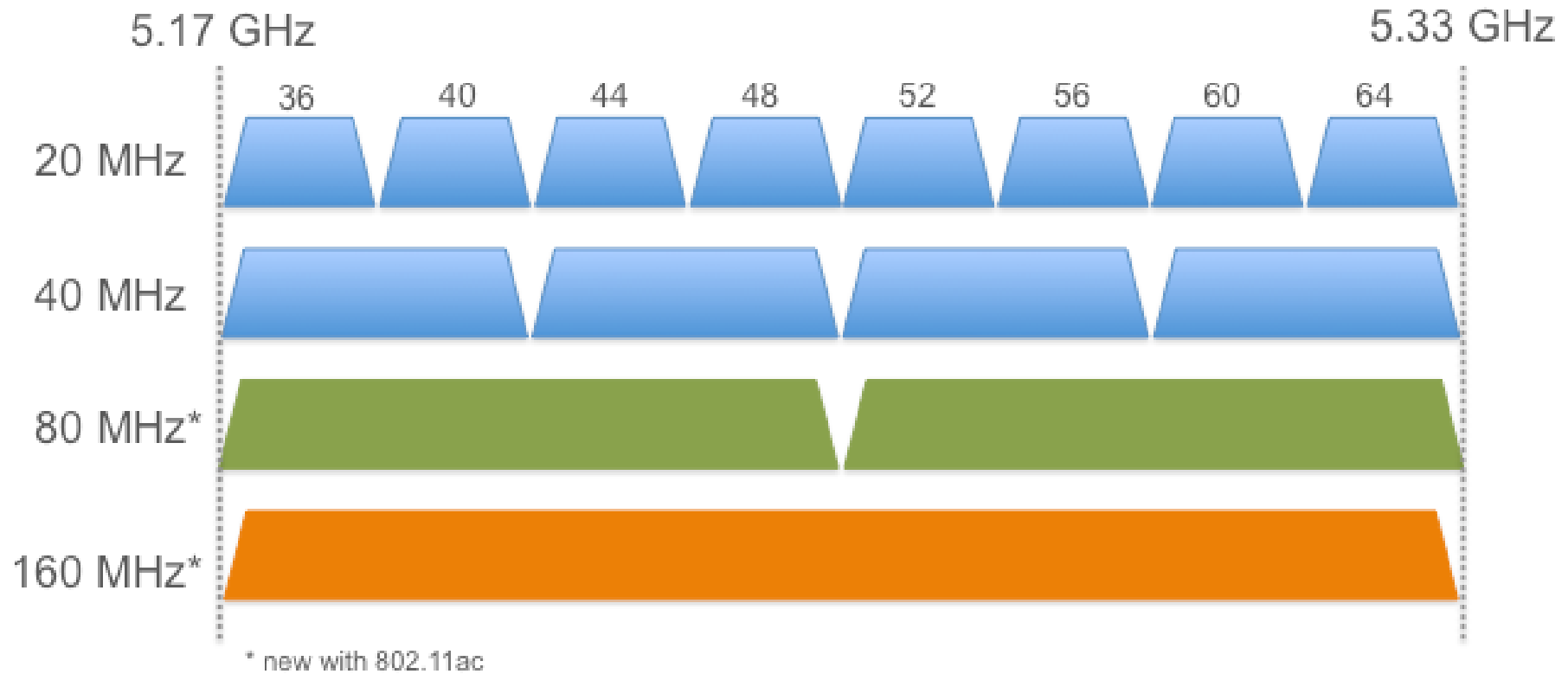


Faster Than 802.11n: 802.11ac

- 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



5 GHz Channelization



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

866.7

Summary

- Better Modulation - DSSS > QFDM
- Better Modulation Coding – BPSK > QPSK > 16QAM > 64QAM > 256QAM
- Wider Channel – 20 > 40 > 80 > 160MHz
- More Spatial Stream (more radio chains) – MIMO (1SS, 2SS, 4SS, 8SS)
- Optimization - MRC, BeamForming, Short GI, Frame Aggregation

Mobility Fundamentals Series

Series Overview

Starting with Wireless Technology Standards, the Mobility Fundamentals series teaches students about wireless and mobility technologies in the Internet of Everything.

Topics covered in these instructor-developed courses include wireless LAN design and mobility applications.

Career Prep

Builds foundational wireless and mobility technology career skills for current IT Essentials or CCNA R&S students interested in learning more about the Internet of Everything.

Prerequisites: IT Essentials or CCNA R&S 1-2

Languages: English

Course Delivery: Self paced

Estimated Time to Complete: 1.5 hour (each course)

Recommended Next Course: Mobility Fundamentals Series: Wireless LAN Networks (next in the Mobility Series *coming in October*)



Learning Components

- Several modules of multimedia content
- Video recordings featuring NetAcad instructors
- Activities that reinforce learning, including Cisco Packet Tracer activities
- Assessments, including module quizzes
- Certificates of completion for each module

Wireless Technology Standards

In this module, Bogdan Doinea brings the audience through the evolution of the wireless communications; and explains the technologies and standards that have enabled the mobile phenomenon that tremendously impacted on the way we work, learn and play today.

- Learning Outcome
 - Understand Wireless Technologies
 - Understand Wireless LAN Standards
- 1.5 hour content / video recording
- Quiz



Explosive Mobile Device Growth

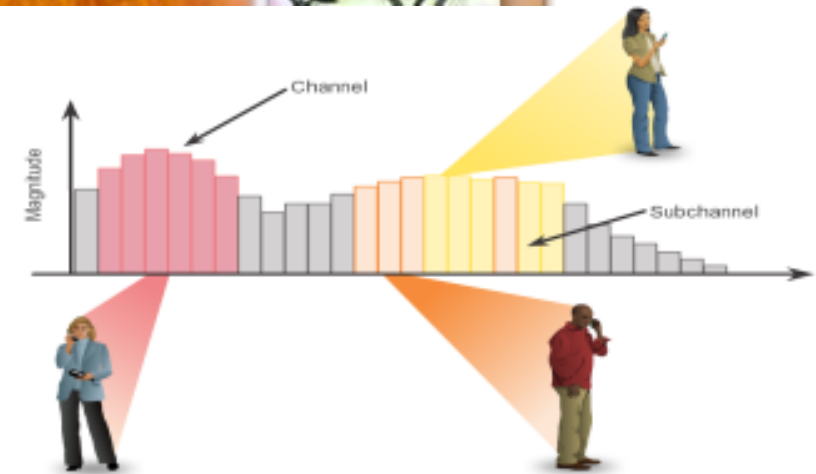
- In 2020 there will be 50 billion connected devices
- Smartphone & Tablet adoption growing 70%+ annually.**
- In 2014, more than 60% of network devices shipped without a wired port.***



Wireless LAN Networks

In this module, we look at the most important, popular and commonly used Wireless network today: the Wireless LAN. Vinh Ho and Eric Kwok explains the essential components in a Wireless LAN infrastructure, the operation of a Wireless LAN and how to plan a Wireless LAN.

- Learning Outcome
 - Understand Wireless LAN components
 - Understand how Wireless LAN works
 - Understand how to plan a Wireless LAN deployment
- 1 hour content / video recording
- Quiz



Self-paced course enrollment

The screenshot shows the top navigation bar with the Cisco logo and 'Cisco Networking Academy'. Below it, there are links for 'Courses', 'Careers', 'Get Started', and 'About Us'. A search bar is also present. The main content area features a blue header with the course title 'Mobility Fundamentals' and a sub-header 'Learn about wireless concepts, technology, and standards as a foundation for networking careers.' An 'Enroll Now' button is visible. Below the header, there are three colored squares representing course levels: 'Intermediate' (selected), 'Beginner', and 'Advanced'. The course duration is listed as 'Duration: 1.5 hours' and the format is 'Self-paced'.

Course Summary

Created by the Networking Academy community, **Mobility Fundamentals** is a series of modules created for students who have taken IT Fundamentals and CCNA Routing and Switching course 1 and course 2. Course modules are 1.5 hours long and cover different technical aspects of wireless networking and applications.

Module 1: Wireless Technologies and Standards

Engel Torres, Cisco Systems Engineer, guides you through the evolution of wireless communications and explains the standards and technologies enabling the mobile environment that impacts the way we work, learn and play.

- Understand wireless technology concepts
- Learn about wireless LAN design, configuration and troubleshooting

Languages: English

A blue button with the text 'Enroll Now'.

About Series

Cisco Networking Academy module-based series are designed to take at your own pace, at any point in your career journey. Cisco Networking Academy is an IT skills and career building development program for learning institutions and individuals worldwide. We've helped more than 5.5 million people prepare for the IT workforce since 1997.

Next Steps

- [Enroll Now](#)
- [Become an Academy](#)
- [Enroll As](#)

Mobility Fundamentals

Learn about wireless concepts, technology, and standards as a foundation for networking careers.

[Enroll Now](#)

Module 1: Wireless Technologies and Standards - English

Module 2: Wireless LAN Standards - English

The screenshot shows the user dashboard with the Cisco logo and 'Cisco Networking Academy' text. The top right corner has links for 'NetSpace Home', 'Inbox 11', and 'Settings'. Below the navigation bar, there are three main menu items: 'Courses & Groups' (with a dropdown arrow), 'Grades', and 'Calendar'. The user's initials 'M' are visible in the top right corner.

Enroll in Mobility Fundamentals Series : Wireless Technology and Standards - 29June

You are already enrolled in **Mobility Fundamentals Series : Wireless Technology and Standards - 29June**.

- [Go to your Dashboard](#)
- [Go to the Course](#)

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- Go to netacad.com
- Click *Learn with Us*
- karsulli@cisco.com

Build your skills today

Cisco Networking Academy is an IT skills and career building program for learning institutions and individuals worldwide.

About Us

Learn with us

Prepare for a rewarding career in a connected world.

Courses

Get hired

Learn what you need to know to do the work you love.

Careers

Teach with us

Help us build the workforce of tomorrow.

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