Voice Over Wi-Fi

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- A brief history of VoWi-Fi
- Voice RF Design
- QoS
- VoIP signaling and encoding
- Let's make some calls

A Brief History

The Early Years

- The first VoIP company establishes in 1995
- The first Wi-Fi standard 802.11 is publish in 1997
- 802.11b and 802.11a are published in 1999

A Brief History

- 2002 - 802.11b Wi-Fi handsets become available
- 2003 - IEEE ratifies 802.11g
- 2005 - IEEE ratifies 802.11e
- 2006 - 802.11g Wi-Fi handsets become available
- 2007 - 802.11a Wi-Fi handsets become available
- 2008 - IEEE ratifies 802.11r
- 2009 - IEEE ratifies 802.11n
- 2010 - 802.11n Wi-Fi handsets become available
- 2013 - IEEE ratifies 802.11ac

VoWi-Fi WLAN Design

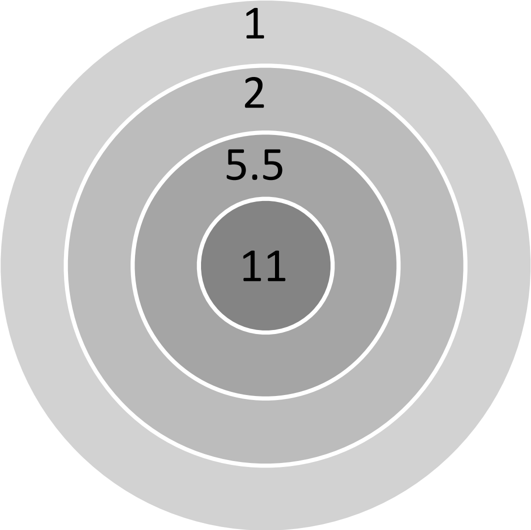
Different challenges for different spectrum

Challenges	2.4 GHz	5 GHz
Coverage	Easy	Not So easy
Interference	Not so easy	Easy
Roaming	Easy	Not so easy
Device Support	Easy	Easy

Voice RF Design

#1 Coverage

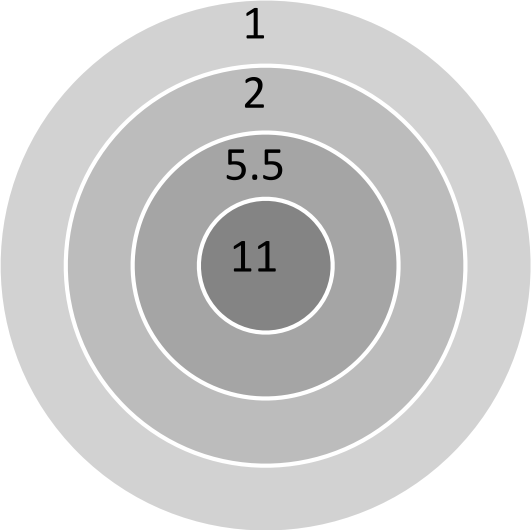
- How much? Typically -67dBm
  - SNR & Retries
- Biggest challenges
  - Stairwells
  - Elevators
  - Metal Mesh
  - Heavy Metals



Voice RF Design

#1 Coverage

- Stairwells are off limits to AP installation
- Elevators are challenging too
  - AP in the elevator car
  - Antennas at the top and bottom
  - Elevator regulation
  - Cars travel 5-10 ft/s



Voice RF Design

#1 Coverage

- Metal mesh can attenuate and scatter the signal
- Lead lined walls in hospitals will require more AP’s
- Manufacturing facilities have a lot of metal beams, large metal molds and presses that reflect signals and create RF shadows

Voice RF Design

#1 Coverage

- Surveying for Voice
  - Again -67dBm target but…
  - Reference the client receive sensitivity
  - Take measurements with the handset in survey mode
  - Look for retries and observe the RSSI

Voice RF Design

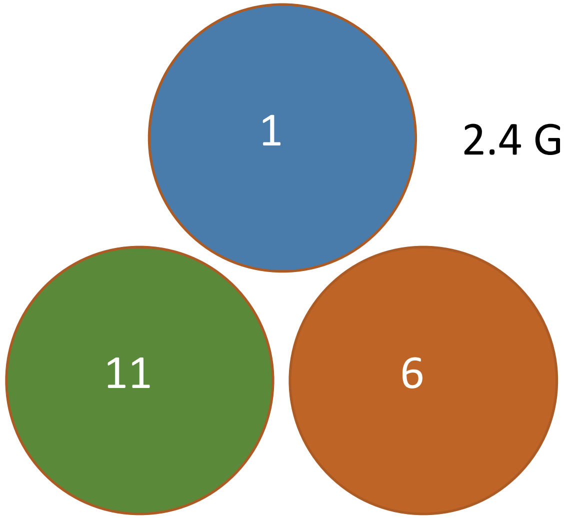
#2 Interference

- Create a static channel plan to avoid CCI
- Which channels? 2.4 or 5 GHz
  - UNII-1 36-48
  - UNII-2 52-64
  - UNII-2 ext 100-136
  - UNII-3 149-161
  - ISM 165
  - ISM 1-11

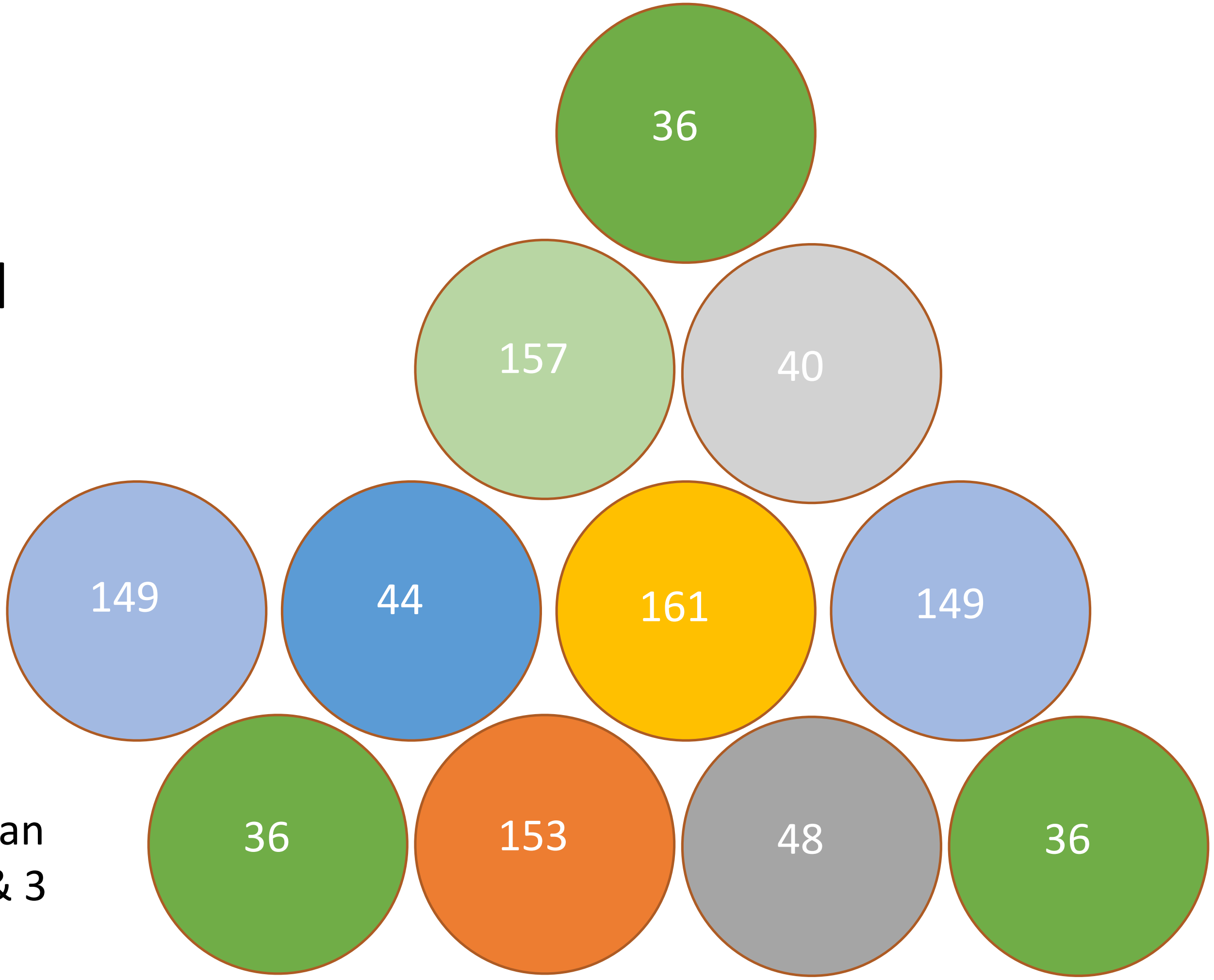
Voice RF Design

#2 Interference

Typical static channel plan for 2.4 and 5 GHz to avoid CCI and ACI



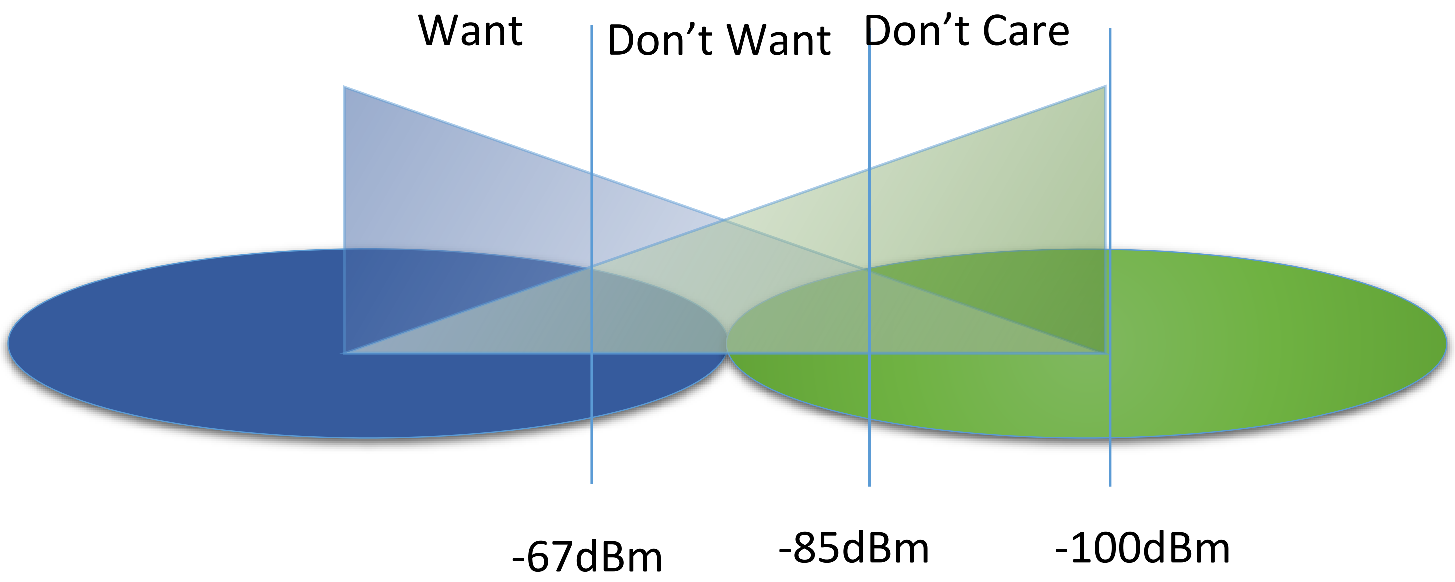
2.4 GHz Channel Plan



5 GHz 8 Channel Plan
Using only UNII-1 & 3

Voice RF Design

- Three types of signal
  - want
  - don’t want
  - don’t care
- Goldilocks approach
  - -45dBm = 54Mbps
  - -65dBm = 54Mbps
  - No benefit from more power



These AP's go to eleven!

Voice RF Design

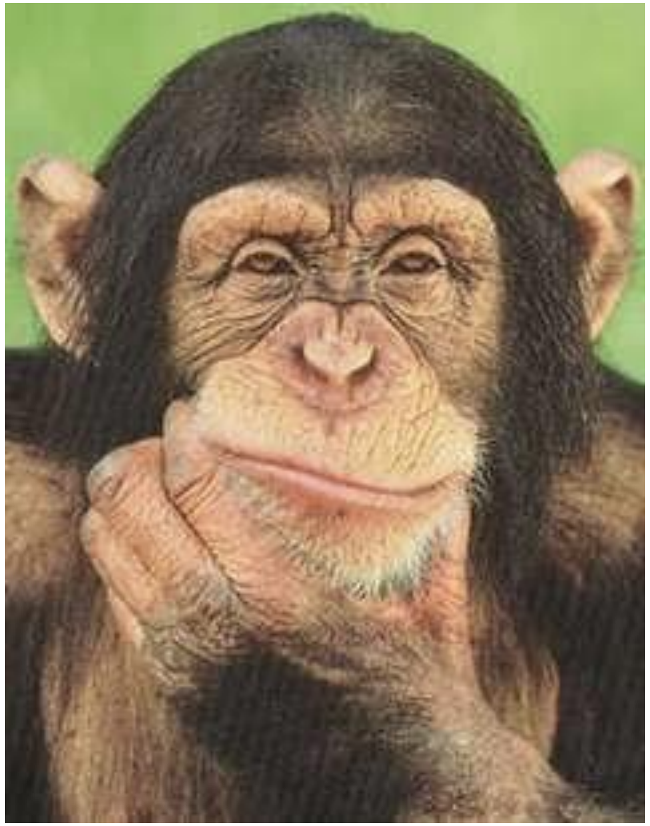
#3 Roaming

- 2.4 GHz vs 5 GHz
  - Number of channels
  - Security Suite
  - Active vs Passive Scann

Voice RF Design

#3 Roaming 2.4 vs 5 GHz

- 2.4 GHz has 3 non-overlapping channels
- 5 GHz has 24 non-overlapping channels
- Clients must scan channels in order to roam
- Fewer channels are better for roaming



Voice RF Design

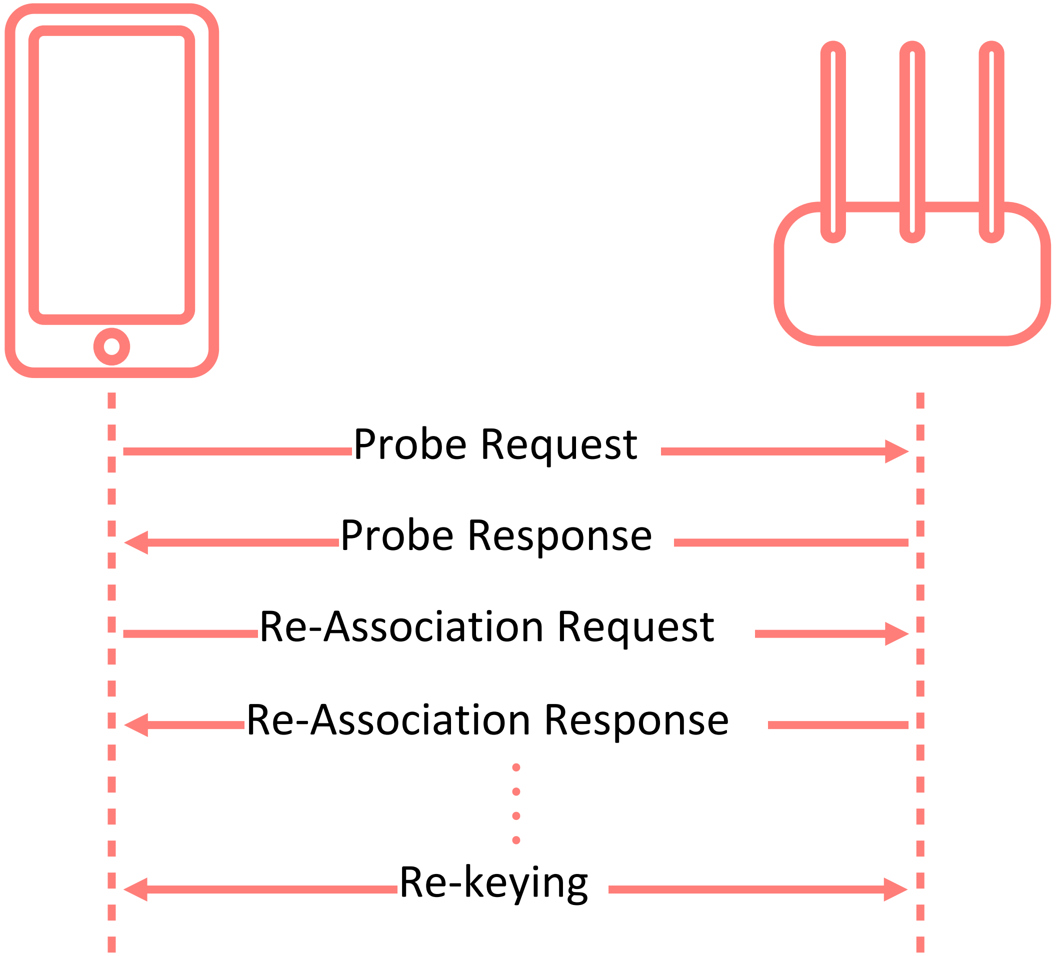
#3 Roaming 2.4 vs 5 GHz

- Passive scanning requires a client to listen to beacons from nearby AP’s
- Active Scanning is quicker but requires transmitting a probe request on every channel in use
- Either can take a lot of time

Voice RF Design

#3 Roaming 2.4 vs 5 GHz

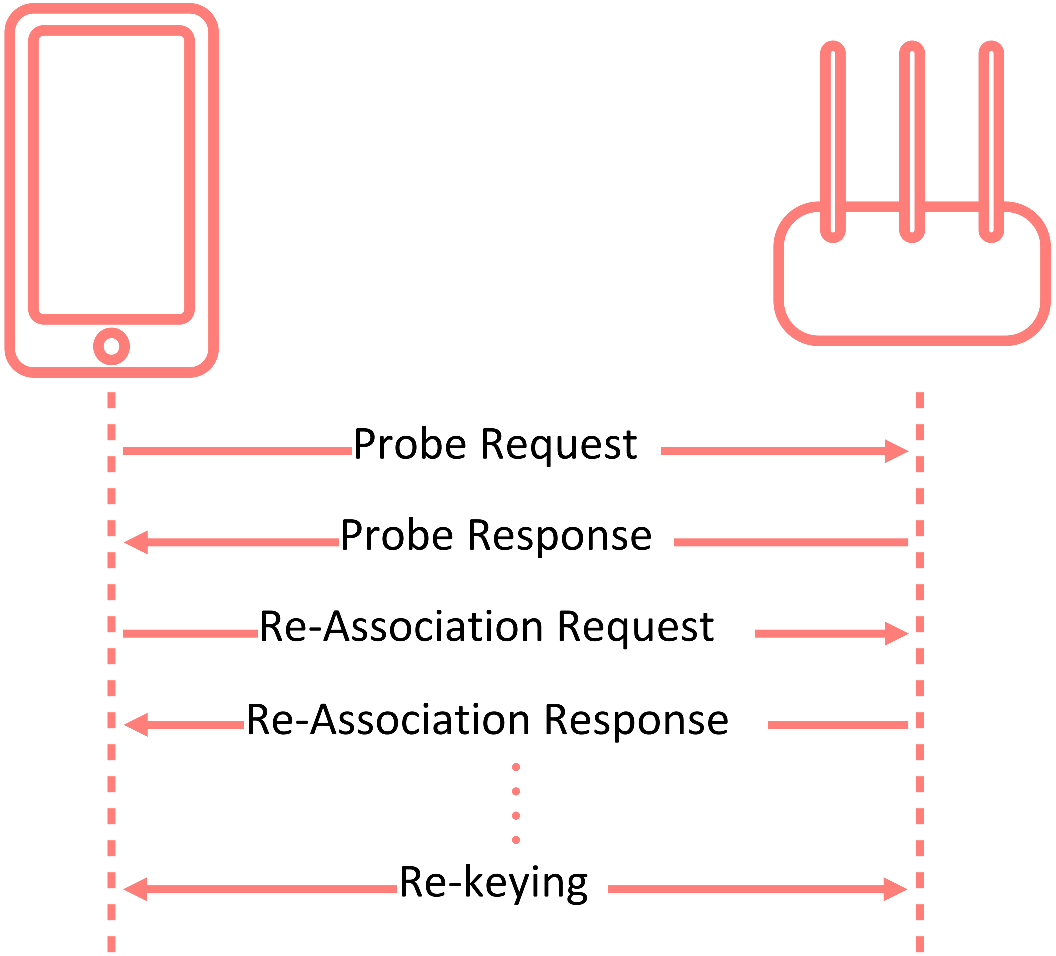
- 2.4 GHz roam times should be better than 5 GHz
- 5 GHz roam times should be under 50ms nonetheless
- WPA2-PSK will be quicker than WPA2-Enterprise
- 802.11k can improve scanning intelligence



Voice RF Design

#3 Roaming with WPA-Enterprise

- WPA-Enterprise EAP requires additional frame exchanges for username and password
- 802.11r reduces those frame exchanges by combining frames
- 802.11r&k are not implemented in dedicated voice handsets to date



Voice RF Design

#4 Device Support

- What component of a WLAN is the biggest challenge?
- The client devices have the biggest constraints
  - Power use
  - Size
  - Durability

Voice RF Design

#4 Device Support

- What are the target VoWi-Fi clients today?
  - Voice Dedicated Handsets
  - Smartphones
  - Tablets
  - Laptops
  - VoWiFi is being used much more broadly

Voice RF Design

#4 Device Support

- Traditional VoWiFi used dedicated SSID’s on single purpose devices
- QoS was less difficult
- Current VoWiFi uses multipurpose devices on shared SSID’s
- Video uses VoWiFi

Voice RF Design

#4 Device Support

- Lower PHY rate demand
  - 64Mbps for dedicated handsets
  - 130Mbps for smart phones
- No MIMO
  - Added cost/complexity with little benefit to the client device

Quality of Service

Making it End to End

- Wi-Fi QoS
  - WMM
  - 802.11e
- Wired QoS
  - 802.1D
  - Diffserv

Quality of Service

Wi-Fi QoS

- IEEE creates standards
- Wi-Fi Alliance certifies them
- IEEE created 802.11e
- The WFA created WMM

Quality of Service

Wireless Arbitration

- DCF
  - Everyone basically has equal access
- EDCA
- Proprietary

Quality of Service

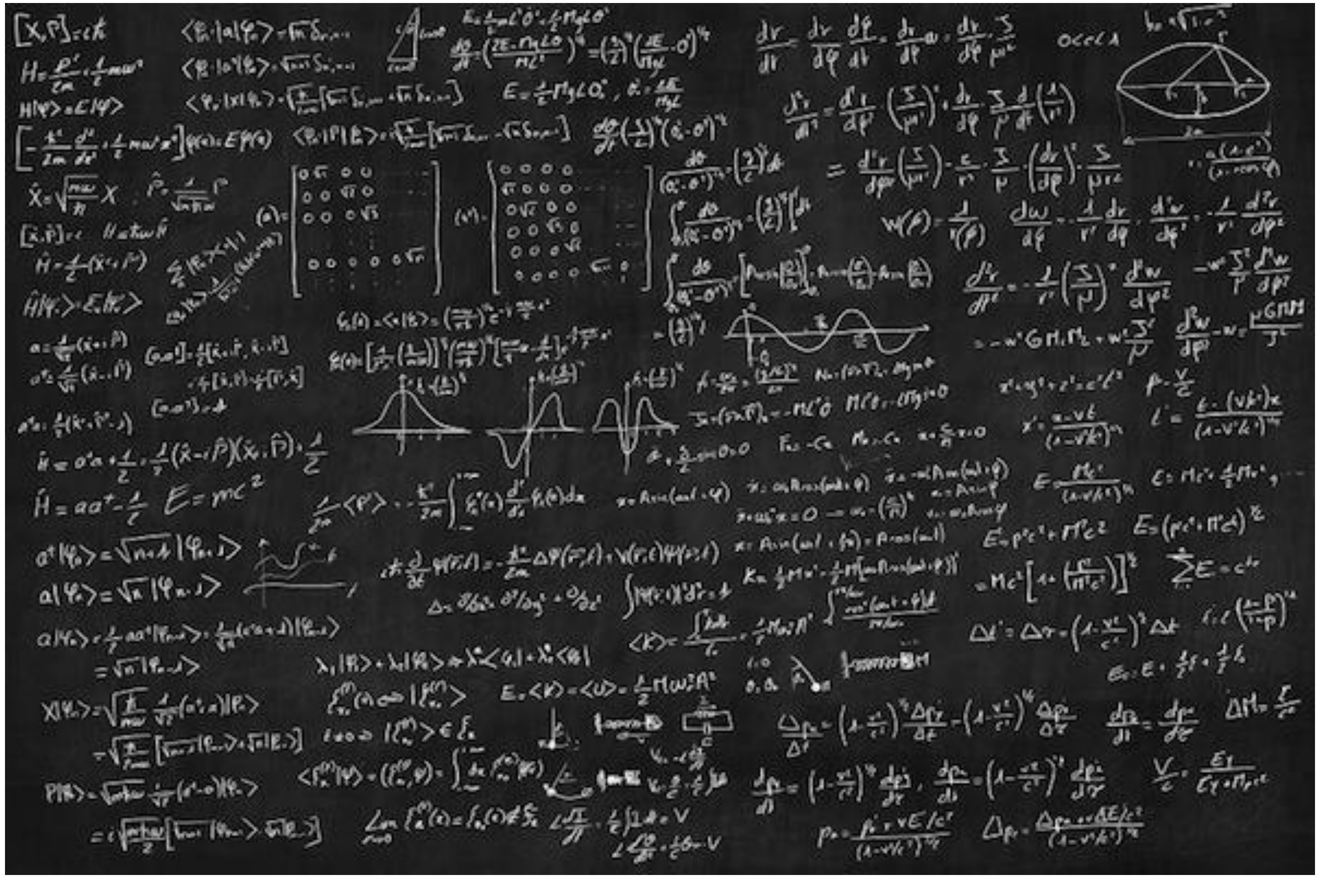
Wireless Arbitration

- Why do we need QoS
  - Wi-Fi is half-duplex
  - DCF does not guarantee the ability to transmit
  - Need a mechanism to improve the odds

Quality of Service

Wireless Arbitration

- DCF
  - Random number selection determines who speaks
- EDCA
  - It’s complicated…
  - but we have 4 different QoS Queues



Quality of Service

Wireless Queues (AC's)

- Voice AC_VO
- Video AC_VI
- Best Effort AC_BE
- Background AC_BK
- 4 AC map to 8 UP's
- UP numbers are not sequ

Priority	UP (Same as 802.1D user priority)	802.1D designation	AC	Designation (informative)
Lowest	1	BK	AC_BK	Background
	2	—	AC_BK	Background
	0	BE	AC_BE	Best Effort
	3	EE	AC_BE	Best Effort
	4	CL	AC_VI	Video
	5	VI	AC_VI	Video
	6	VO	AC_VO	Voice
Highest	7	NC	AC_VO	Voice

Quality of Service

Wired QoS

- Layer 2 QoS
  - 8 802.1D User Priorities
- Layer 3 QoS
  - 8 IP Precedences
  - 21 defined DSCP markings
  - Differentiated Service Code Points

PHB	DSCP	TOS field	CS (PHB)	Drop Prec
Default	0	000000	000 (0)	000 (0)
AF11	10	001010	001 (1)	010 (2)
AF12	12	001100	001 (1)	100 (4)
AF13	14	001110	001 (1)	110 (6)
AF21	18	010010	010 (2)	010 (2)
AF22	20	010100	010 (2)	100 (4)
AF23	22	010110	010 (2)	110 (6)
AF31	26	011010	011 (3)	010 (2)
AF32	28	011100	011 (3)	100 (4)
AF33	30	011110	011 (3)	110 (6)
AF41	34	100010	100 (4)	010 (2)
AF42	36	100100	100 (4)	100 (4)
AF43	38	100110	100 (4)	110 (6)
EF	46	101110	101 (5)	110 (6)
CS0	0	000000	000 (0)	000 (0)
CS1	8	001000	001 (1)	000 (0)
CS2	16	010000	010 (2)	000 (0)
CS3	24	011000	011 (3)	000 (0)
CS4	32	100000	100 (4)	000 (0)
CS5	40	101000	101 (5)	000 (0)
CS6	48	110000	110 (6)	000 (0)
CS7	56	111000	111 (7)	000 (0)

Quality of Service

End To End

- Default behavior of many switches is to remove QoS markings before forwarding
- Switch process QoS 3 ways:
  - Strip and forward
  - Honor and forward
  - Process and forward

Signaling and Encoding

IP Voice consists of:

- Call Signaling
- Call Encoding

Signaling and Encoding

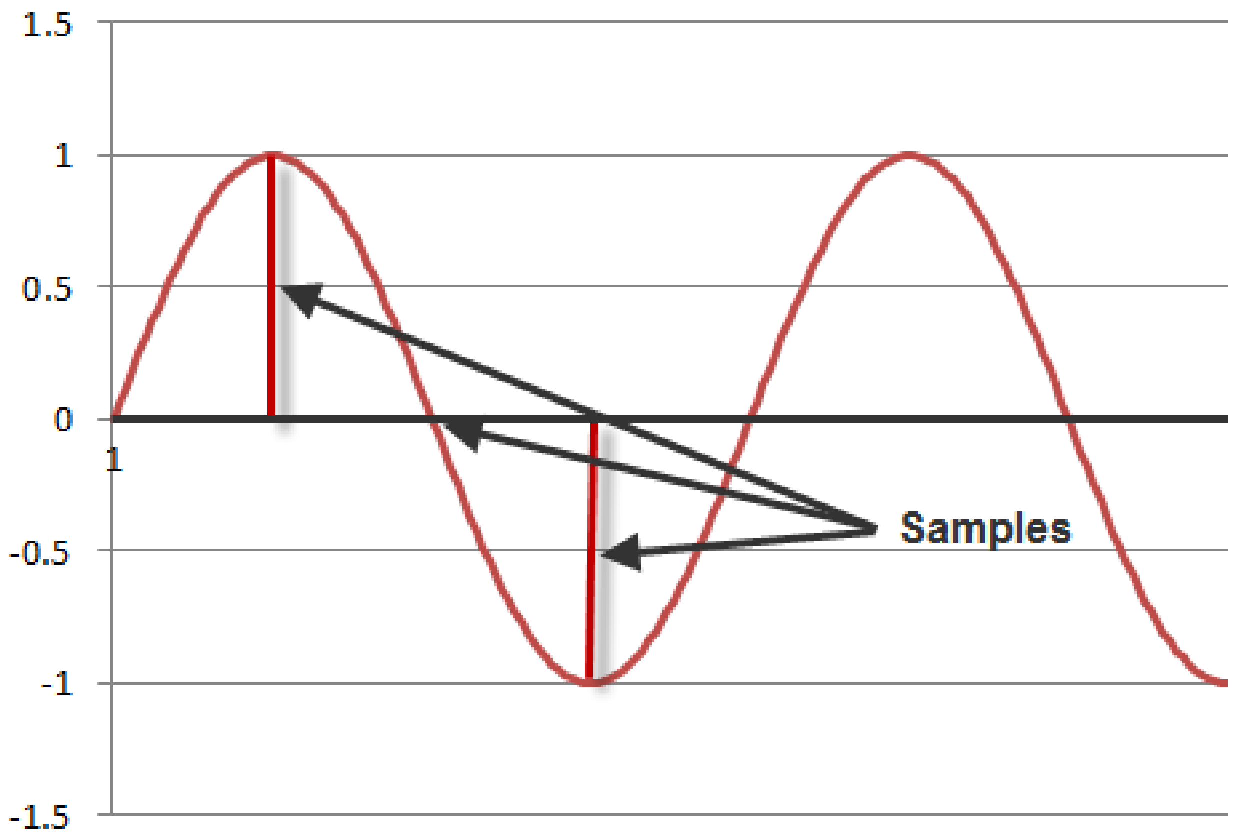
Encoding examples:

	Bit Rate (Kbps)	Sample Size (Bytes)	Sample Rate (kHz)	Sample Interval	MOS	Voice Payload (Bytes)	Voice Payload (ms)	Packets Per Second
G.711	64	80	8	10 ms	4.1	160	20 ms	50
G.729	8	10	8	10 ms	3.92	20	20 ms	50
G.723.1	6.3	24	8	30 ms	3.9	24	30 ms	33.3
G.723.1	5.3	20	8	30 ms	3.8	20	30 ms	33.3
G.726	32	20	8	5 ms	3.85	80	20 ms	50
G.726	24	15	8	5 ms	3.85	60	20 ms	50
G.728	16	10	8	5 ms	3.61	60	30 ms	33.3
G.722	64	80	16	10 ms	4.13	160	20 ms	50

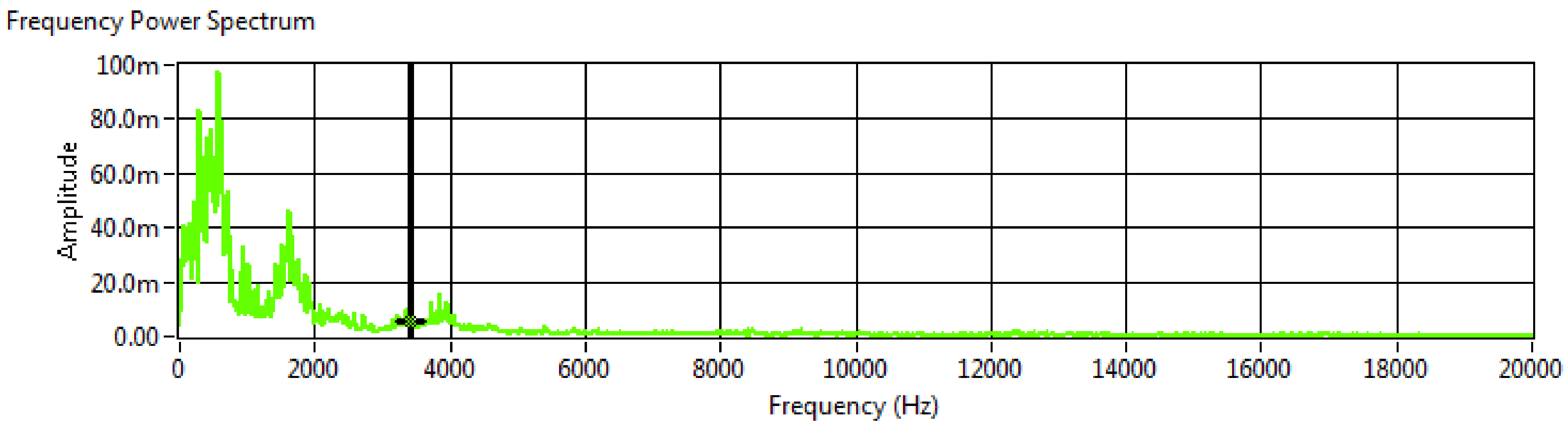
Signaling and Encoding

Encoding:

- Most codecs use 8K samples
- Human ear can hear 20Hz-20KHz
- The human voice range is 300Hz-3400Hz
- Can you guess what range codecs sample?



Signaling and Encoding



Signaling and Encoding

Types of Signaling:

- H.323
- SCCP “Skinny”
- SIP
- SVP

Signaling protocols are create by:

- ITU, IETF, IEEE and others

VoWi-Fi Demonstration

Let's Make some calls

Sip Server:192.168.2.10

Codec:G.711u

Use Phone #:100 to 120