

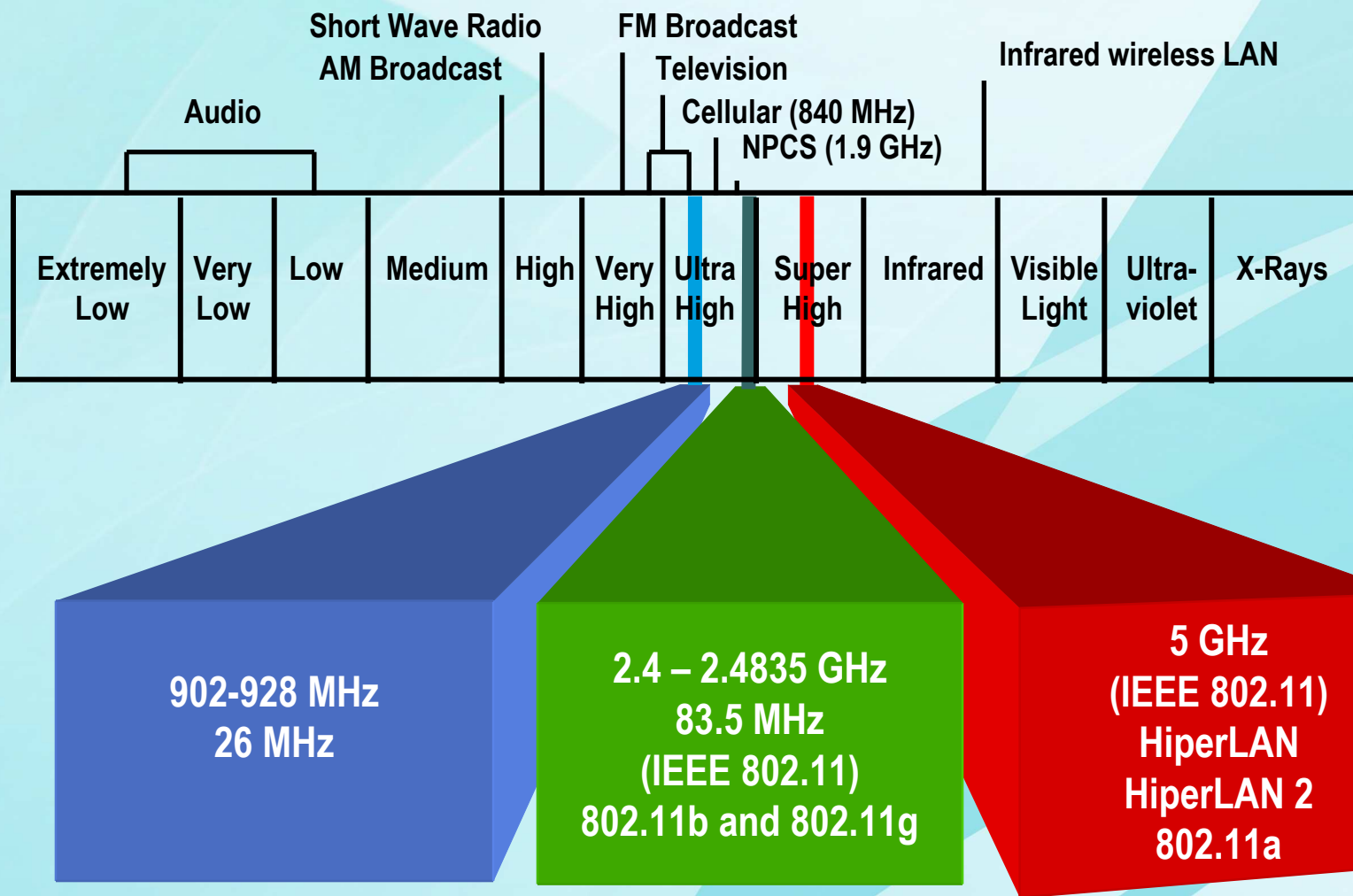
Radio Frequency Spread Spectrum Technology

Objectives

Upon completion of this module, you will be able to perform the following tasks:

- Define facts and characteristics of each spread spectrum technology.
- Identify facts on multipath distortion.
- Identify the process a wireless client adapter card undergoes while associating to an access point.
- Define multipath distortion and identify why diversity antennas are used on access points.
- Define basic facts on Orthogonal Frequency Division Multiplexing (OFDM).

Unlicensed Frequency Bands



Three Wireless Technologies

	802.11 b	802.11 a	802.11 g
Frequency Band	2.4 GHz	5 GHz	2.4 GHz
Availability	Worldwide	US/AP	Worldwide
Maximum Data rate	11 Mbps	54 Mbps	54 Mbps
Other Services (Interference)	Cordless Phones Microwave Ovens Wireless Video Bluetooth Devices	HyperLAN Devices	Cordless Phones Microwave Ovens Wireless Video Bluetooth Devices

The Laws of Radio Dynamics:

Higher Data Rates

= Shorter Transmission Range

Higher Power Output

= Increased Range, but Lower Battery Life

Higher Frequency Radios

= Higher Data Rates Shorter Ranges

Worldwide Availability



www.cisco.com/go/aironet/compliance

IEEE 802.11 Standard

IEEE 802.11 became a standard in July 1997

- 2.4 GHz at 2 Mbps Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS)

IEEE 802.11a and 802.11b became standards in September 1999

- 802.11a – 5 GHz at 54 Mbps OFDM
- 802.11b – 2.4 GHz at 11 Mbps DSSS

IEEE 802.11g is scheduled to be ratified in 2003

- 802.11g – 2.4 GHz at 54 Mbps OFDM

802.11 promises “true” vendor interoperability

What Is WLAN RF Technology?

Data sent over the air waves

Two-way radio communications (half duplex)

Same radio frequency for
sending & receiving (transceiver)

No licensing required for Cisco Aironet Wireless products (in most countries)

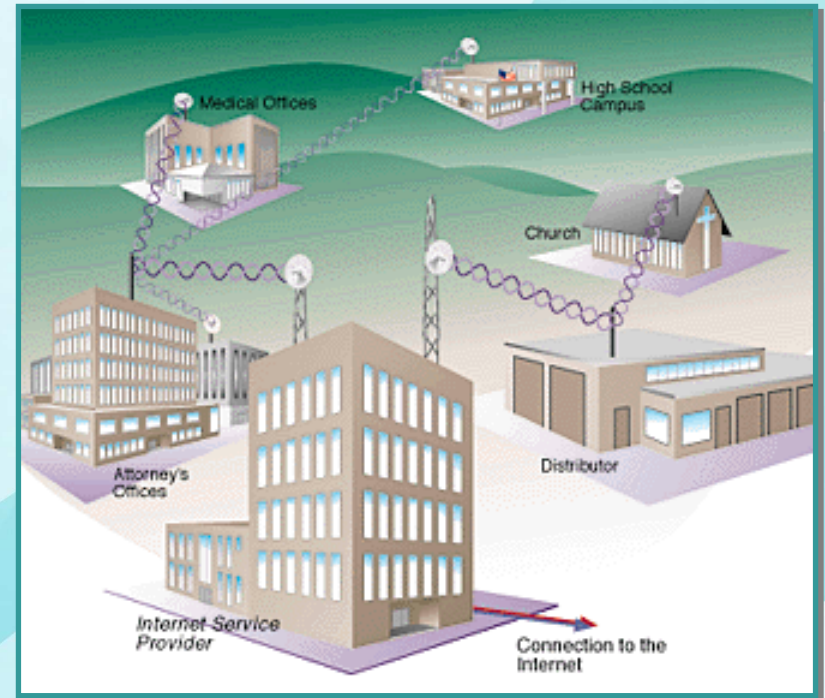
Transmitting a Signal

The goal of sending data over RF is to:

- Send as much data as far, and as fast as possible

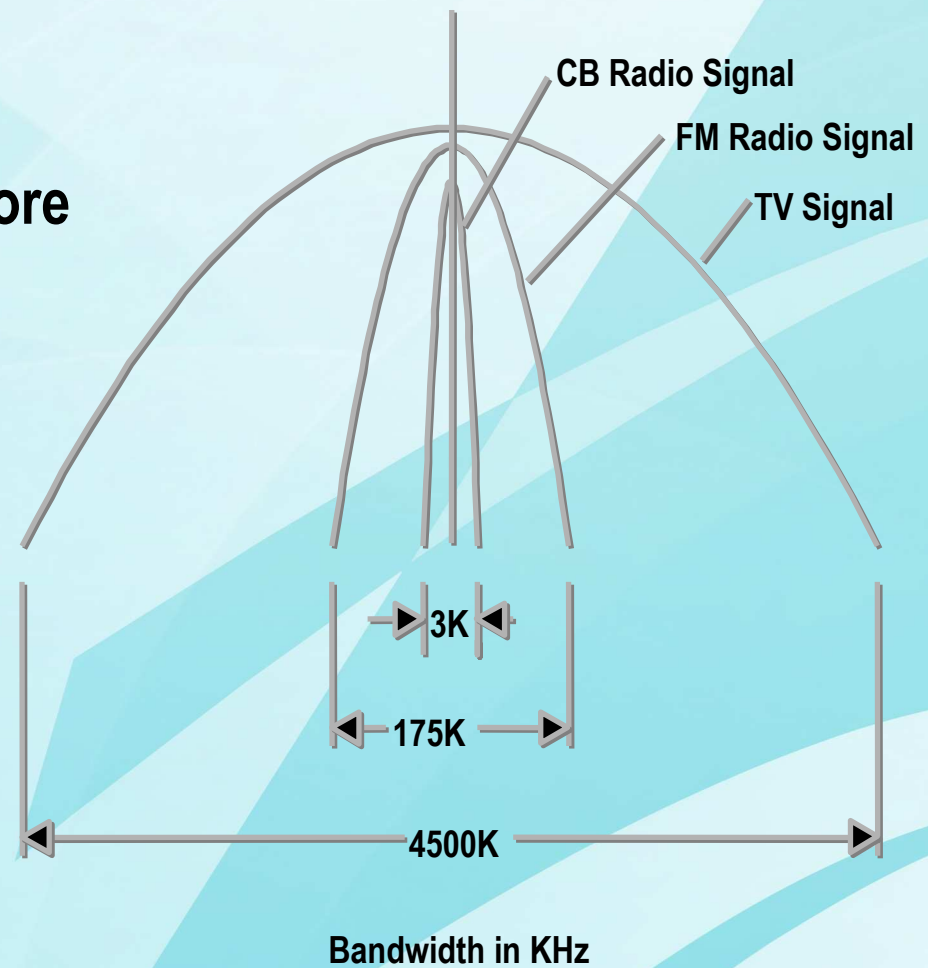
Transmitting more data across the airwaves on a signal

- More frequency spectrum is used or
- Complex modulation techniques are used



Frequency Bandwidth

More information means more frequency spectrum is used



Modulation

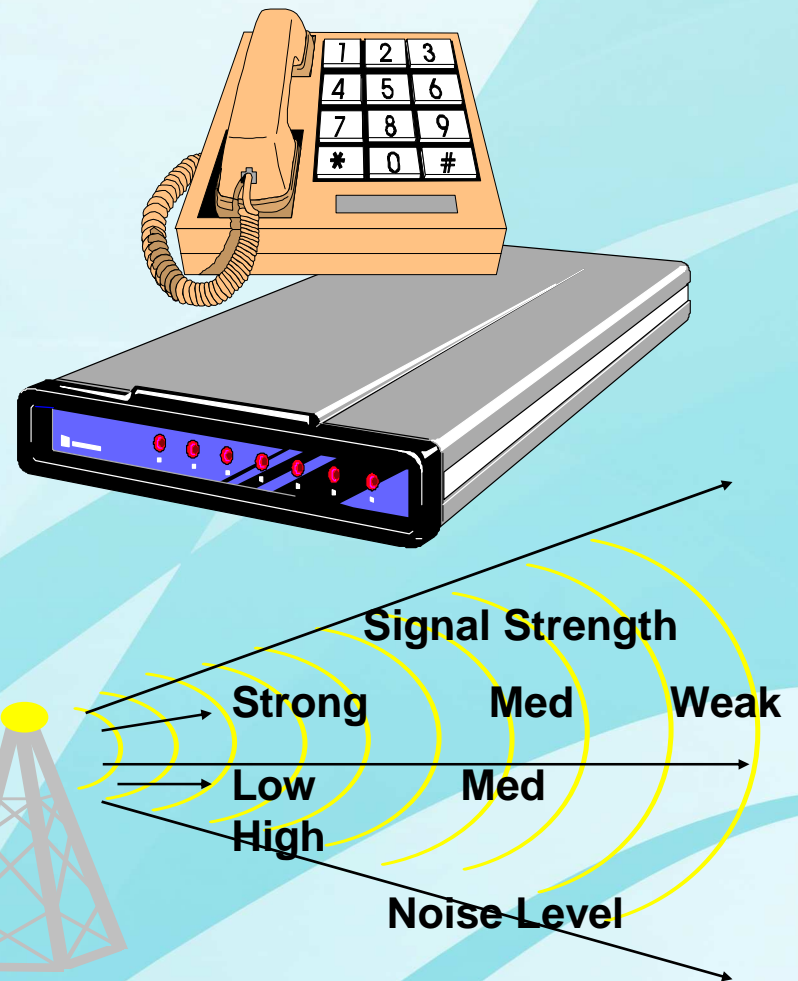
Complex modulation

- Better signal strength
- Less coverage area

Complex modulation schemes compress data

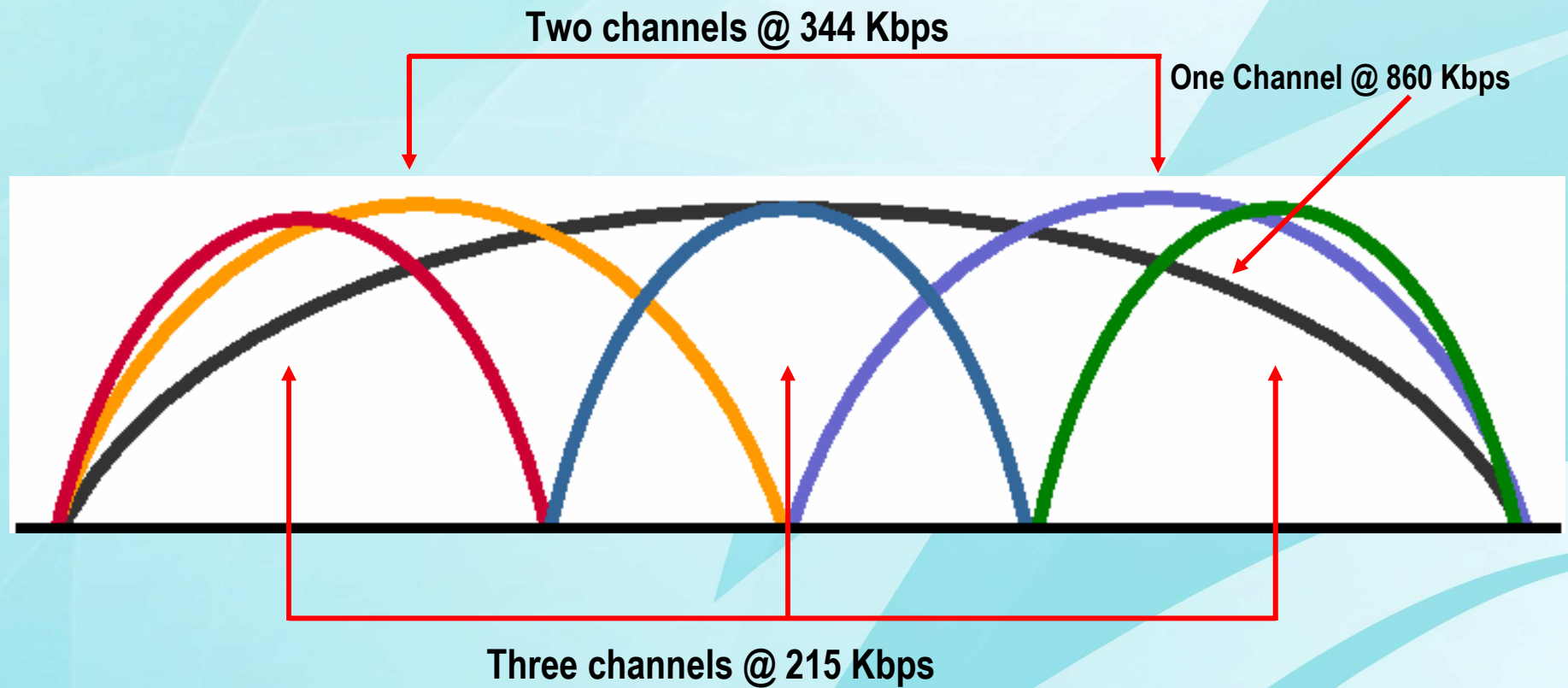
Better (quieter) phone line needed for higher speed

More noise, less speed



900 MHz DSSS Scheme

- More data rate, more frequency



802.11b Modulation

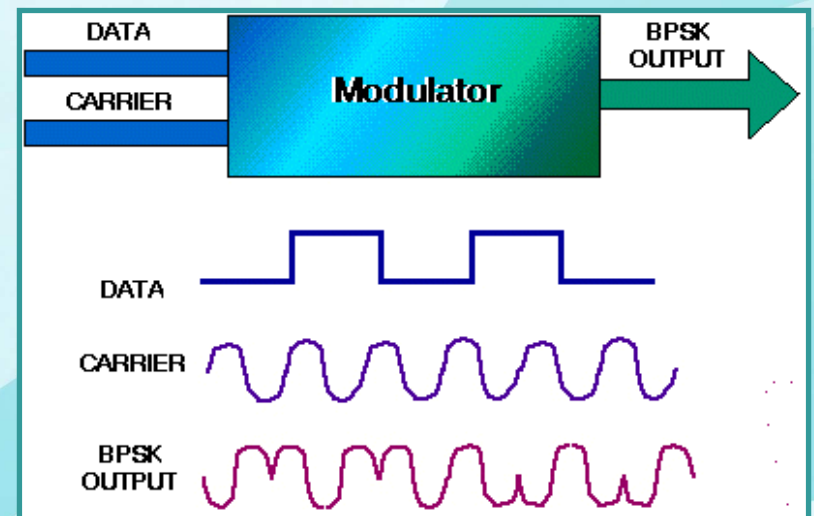
802.11b Radio Modulation

Cisco Aironet Access Points

Three different types of modulation

Depending upon the data rate:

- Binary Phase Shift Keyed (BPSK)
- Quadrature Phase Shift Keying (QPSK)
- Complementary Code Keying (CCK)



BPSK Modulation Example

802.11b Direct Sequence Modulation

Each data bit becomes a string of chips (chipping sequence) transmitted in parallel across a wide frequency range

Minimum chip rate per the FCC is 10 chips for 1 and 2 Mbps (BPSK/QPSK) and 8 chips for 11 Mbps (CCK) data rates

802.11b uses 11 chips

If the data bit was: 1001

Chipping code is : 1=00110011011 0=11001100100

Transmitted data would be:

00110011011	11001100100	11001100100	00110011011
1	0	0	1

2.4 GHz Channel Sets

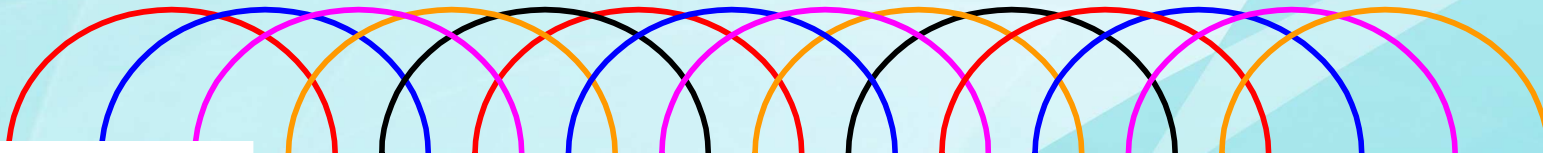
Channel Identifier	Center Frequency	Regulatory Domain			
		Americas	Europe, Middle East and Asia	Japan	Israel
1	2412 MHz	X	X	X	
2	2417 MHz	X	X	X	
3	2422 MHz	X	X	X	X
4	2427 MHz	X	X	X	X
5	2432 MHz	X	X	X	X
6	2437 MHz	X	X	X	X
7	2442 MHz	X	X	X	X
8	2447 MHz	X	X	X	X
9	2452 MHz	X	X	X	X
10	2457 MHz	X	X	X	
11	2462 MHz	X	X	X	
12	2467 MHz		X	X	
13	2472 MHz		X	X	
14	2484 MHz			X	

Channels- 2.4 GHz DSSS



11 Channels – each channel 22 MHz wide

1 set of 3 non-overlapping channels



14 Channels – each channel 22 MHz wide

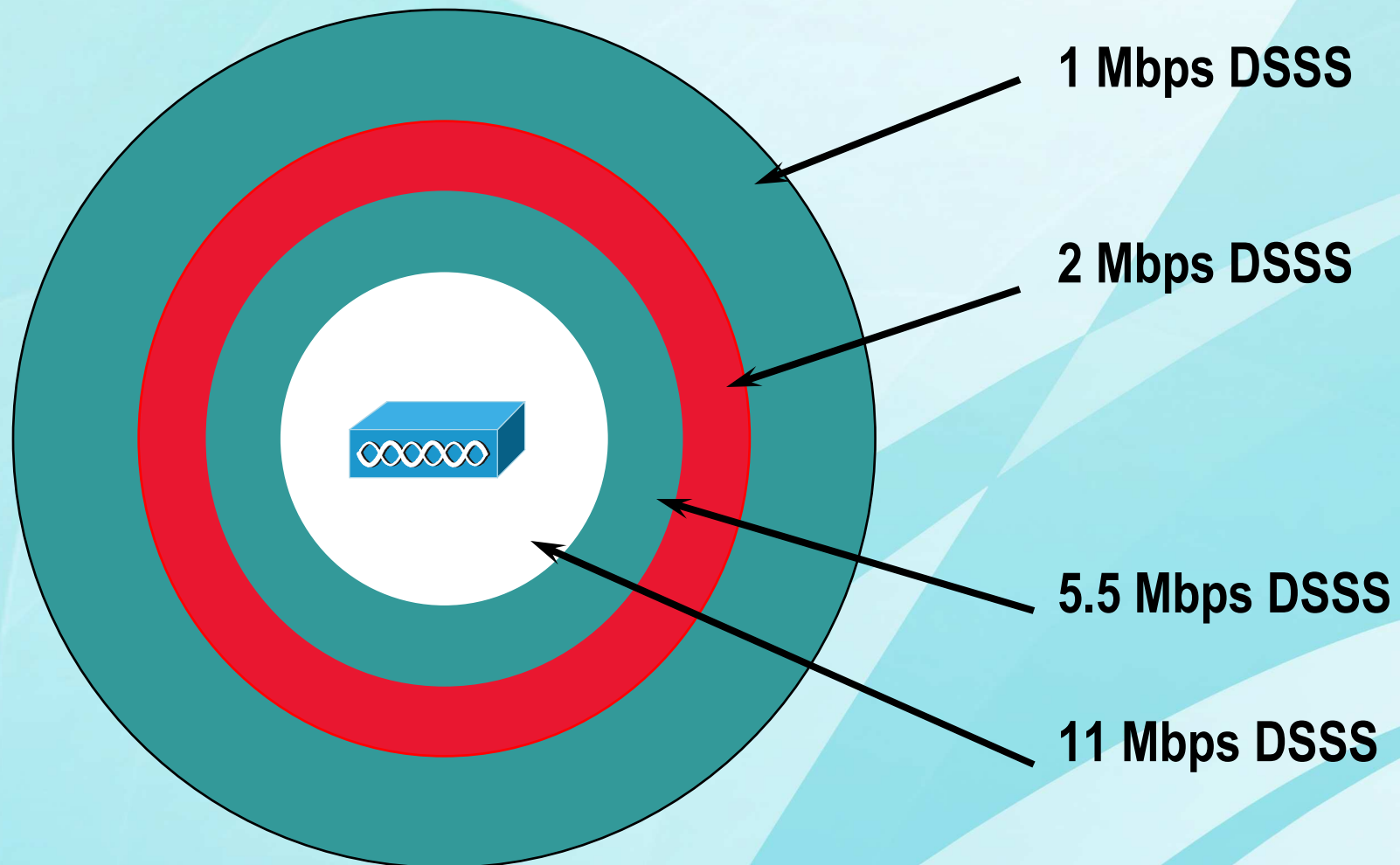
4 sets of 3 non-overlapping channels, only one set used at a time

11 “chips per bit” means each bit sent redundantly

11 Mbps data rate

3 access points can occupy same area

802.11b Access Point Coverage



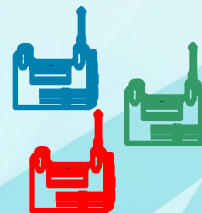
802.11b Scalability

Blue = 11 Mbps

Green = 11 Mbps

Red = 11 Mbps

Total Bandwidth = 33 Mbps!!!



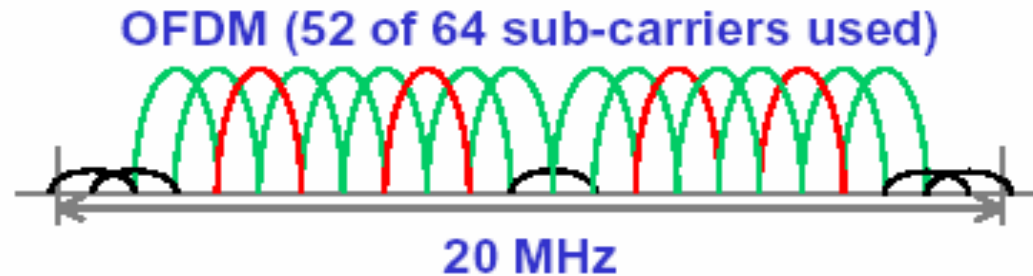
802.11a Modulation

802.11a Modulation

Comparing the Technologies 802.11a Data Rates

Modulation with Sub Channels	Data Rate Per Subchannel (Kbps)	Total Data Rate (Mbps)
BPSK	125	6
BPSK	187.5	9
QPSK	250	12
QPSK	375	18
16QAM	500	24
16QAM	750	36
64QAM	1000	48
64QAM	1125	54

802.11a Uses Orthogonal Frequency Division Multiplexing (OFDM) Modulation



Channel sampled at 20 MHz

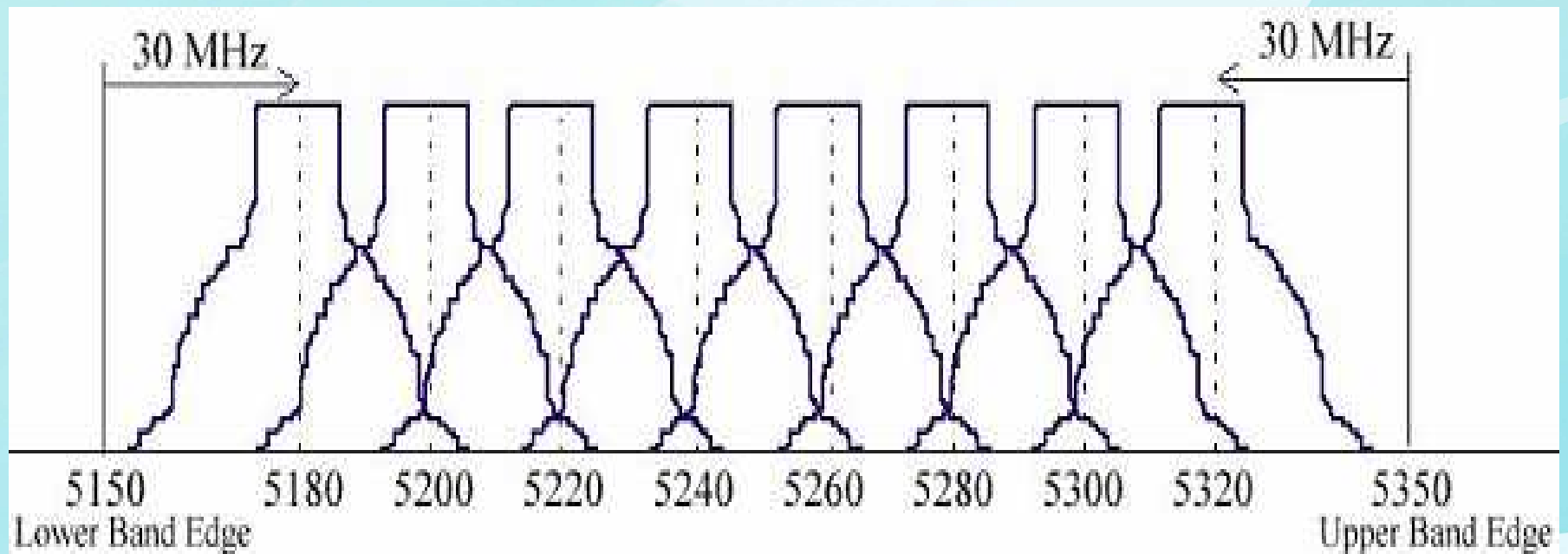
- 64-sample (3.2us) symbols
- 16-sample (0.8us) cyclic prefix/guard interval
- 250 symbols per second

Of 64 sub-carriers:

- 12 zero sub-carriers (In black) on sides and center
 - Side is frequency guard band leaving 16.5 MHz occupied BW
 - Center sub-carrier is zero for DC offset/carrier leak rejection
- 48 data sub-carriers (In green) per symbol
- 4 pilots sub-carriers (In red) per symbol for synchronization/tracking

802.11a 5GHz Frequency Bands

Lower and Middle UNII Bands: 8 Carriers in 200 MHz / 20 MHz Spacing



The figure above shows the center frequency of the channels. The frequency of the channel is 10 MHz either side of the dotted line. There is 5 MHz of separation between channels.

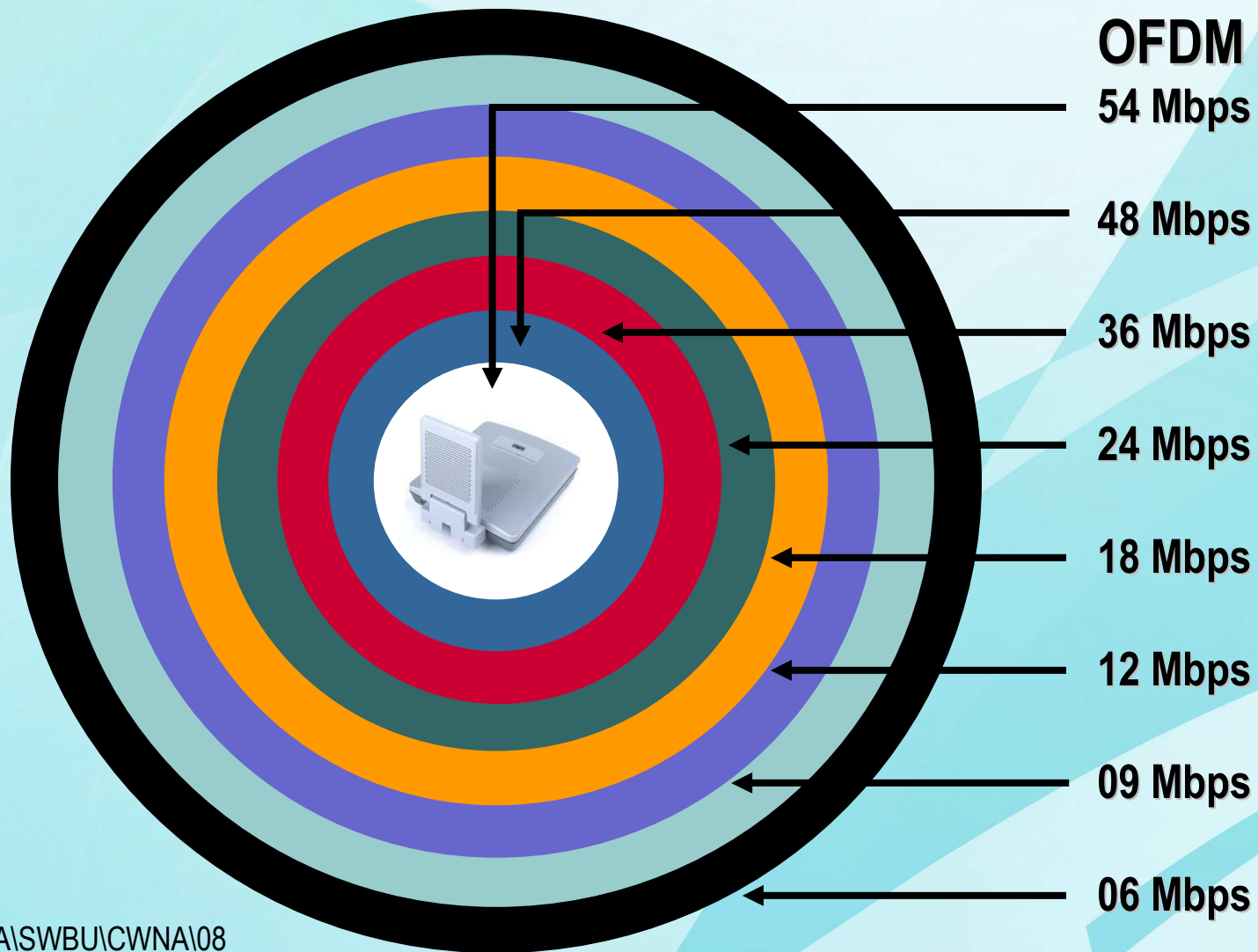
802.11a Channel Sets

Americas include:

Argentina	Mexico
Australia	New Zealand
Austria	Panama
Brazil	Peru
Canada	Sweden
Chile	United Kingdom
Columbia	United States
Denmark	Venezuela
France	

Channel ID	Frequency (MHz)	Channel Set			
		Americas (-A)	Japan (-J)	Singapore (-S)	Taiwan (-T)
34	5170		x		
36	5180	x		x	
38	5190		x		
40	5200	x		x	
42	5210		x		
44	5220	x		x	
46	5230		x		
48	5240	x		x	
52	5260	x			x
56	5280	x			x
60	5300	x			x
64	5320	x			x
Cisco Maximum Peak Power (mW)*		40	40	20	40

802.11a Access Point Coverage



802.11a Scalability (Indoor UNII-1 and 2)

Total Bandwidth = 432 Mbps!!!

8 non-overlapping channels

54 Mbps

54 Mbps

54 Mbps

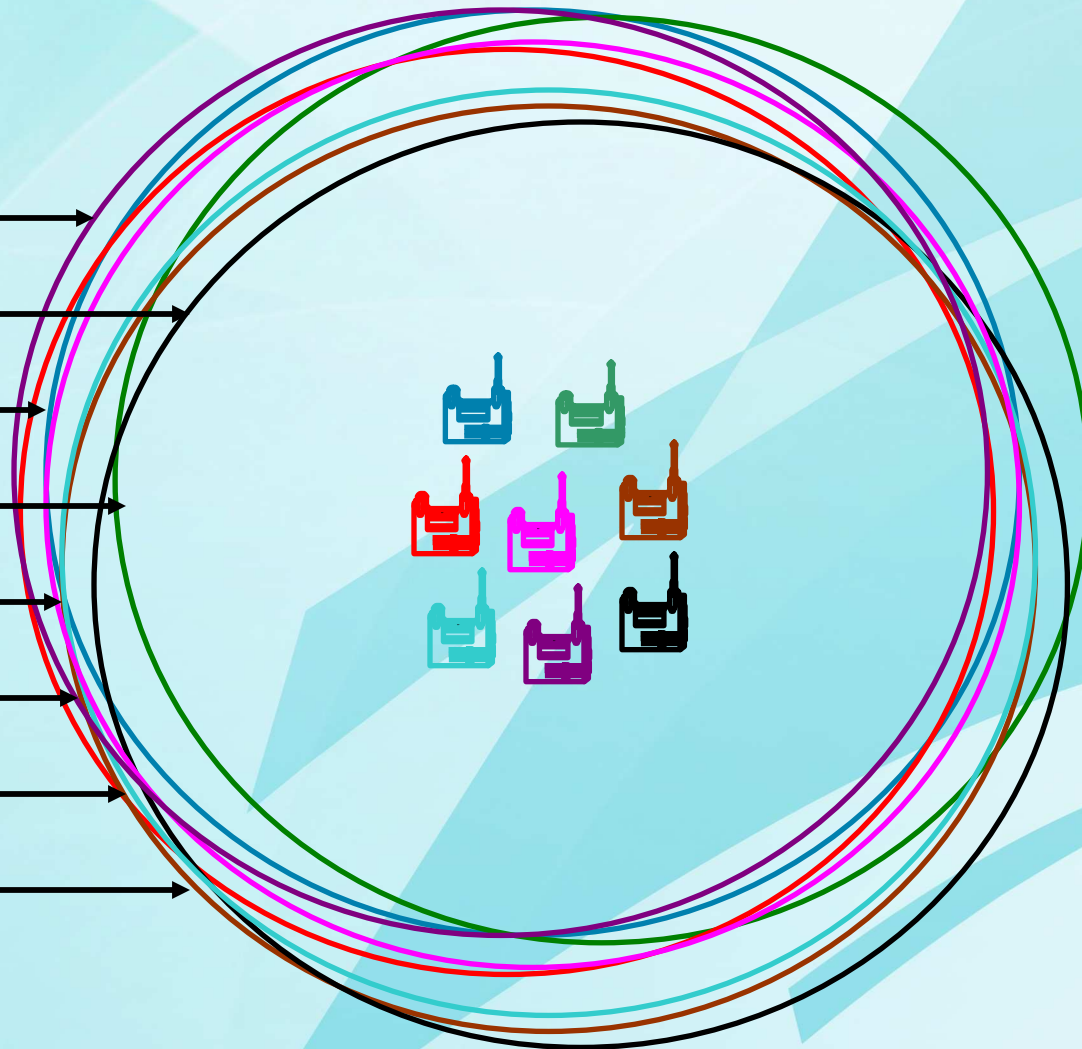
54 Mbps

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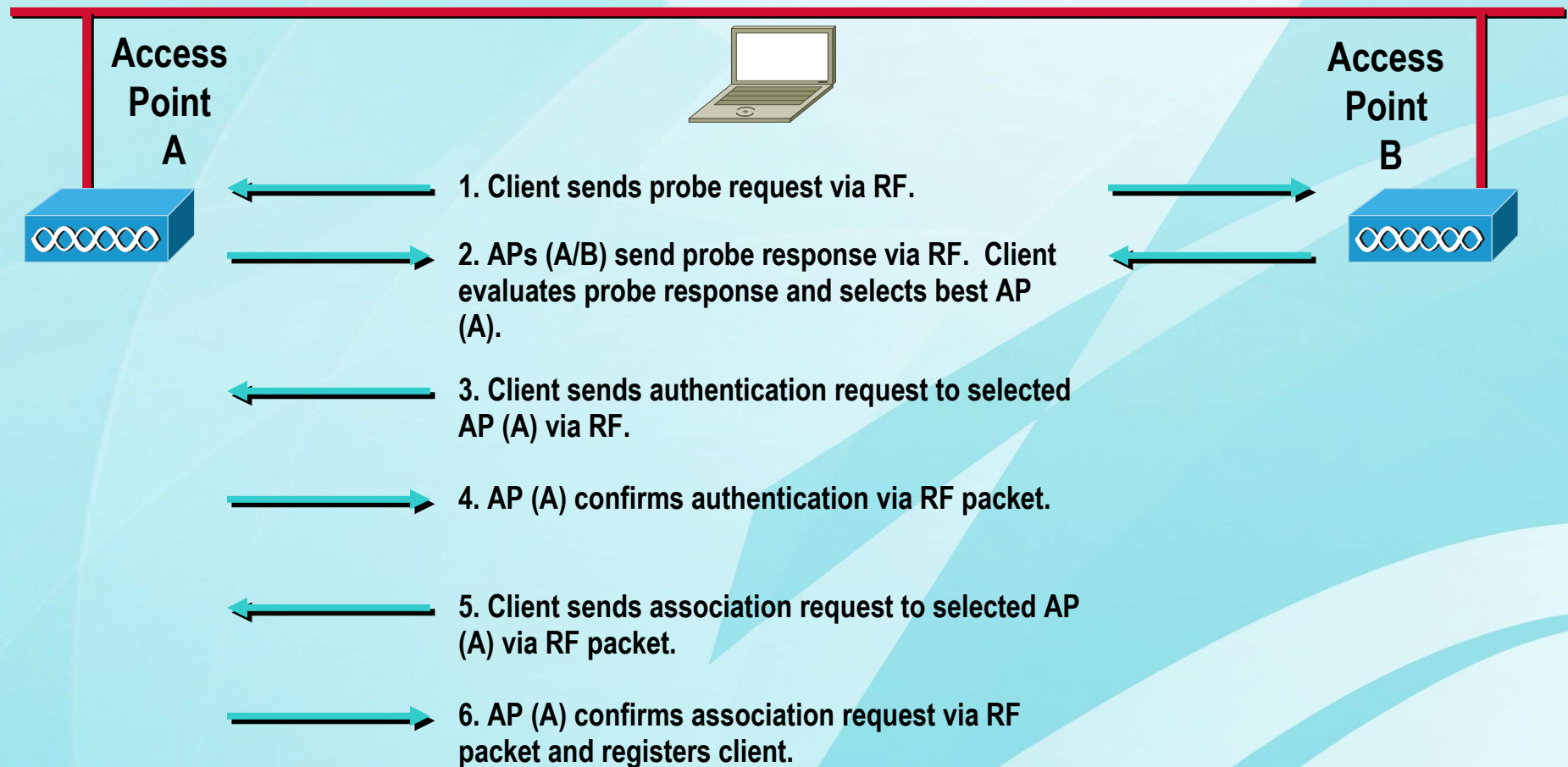
54 Mbps



802.11 Authentication

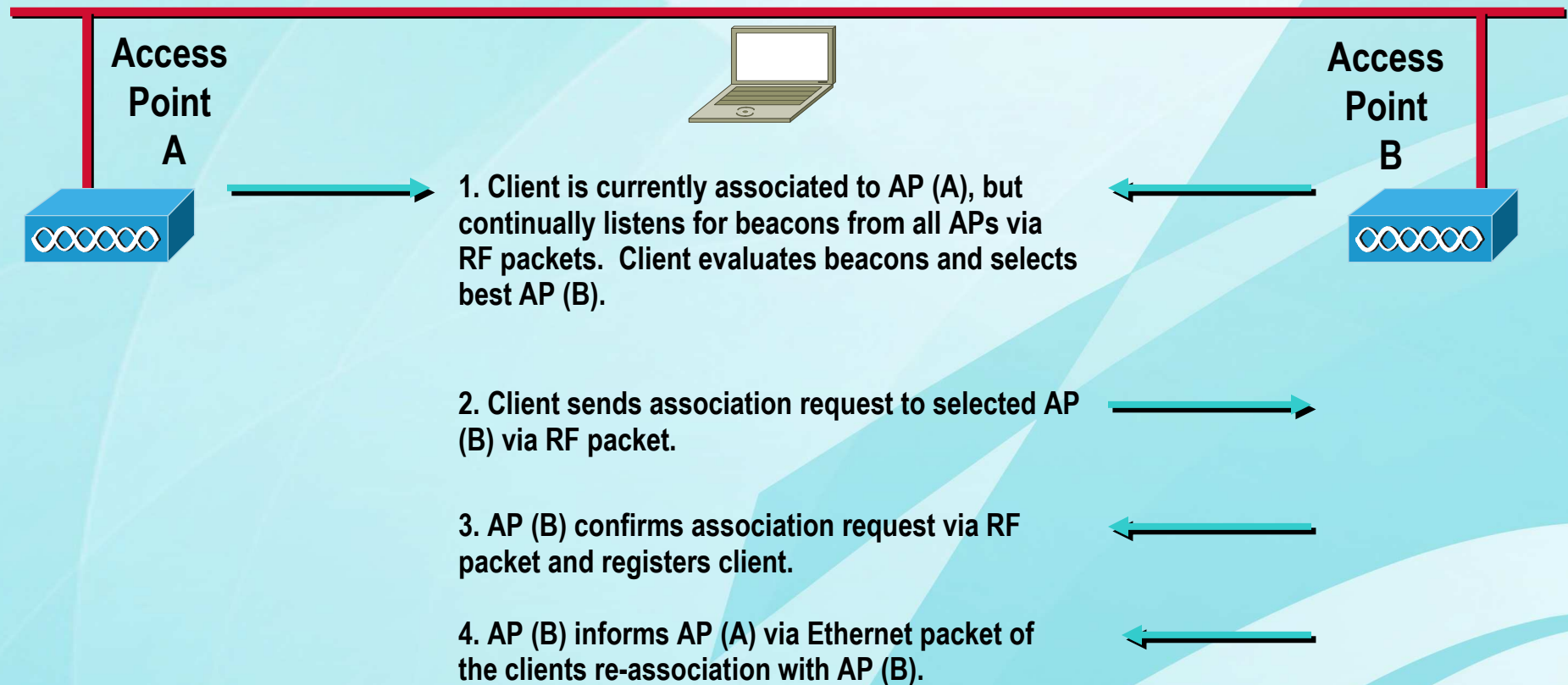
802.11 Protocol Association Process

Initial Connection to an Access Point



802.11 Protocol Roaming/Re-association Process

Initial Connection to an Access Point



Multipath

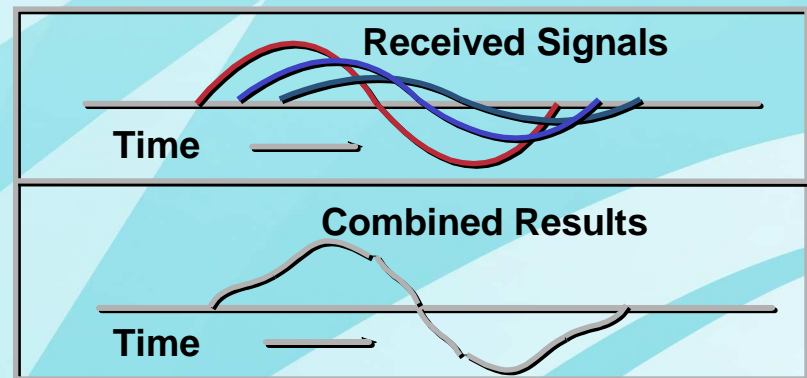
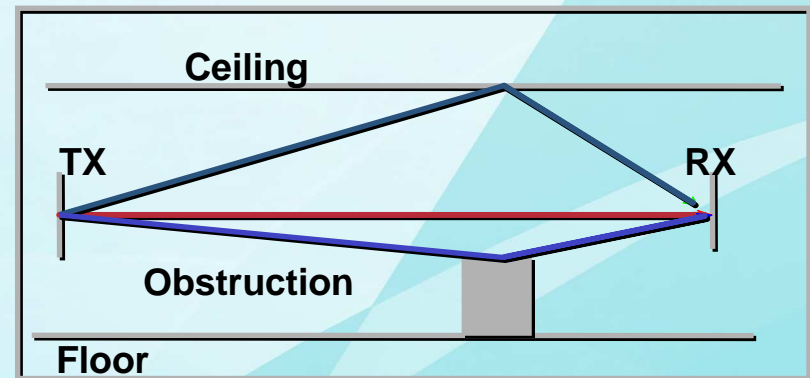
Multipath Distortion

Occurs when an RF signal has more than one path between a receiver and a transmitter

RF take more than one path

Multiple signals cause distortion of the signal

Can cause high signal strength yet low signal quality

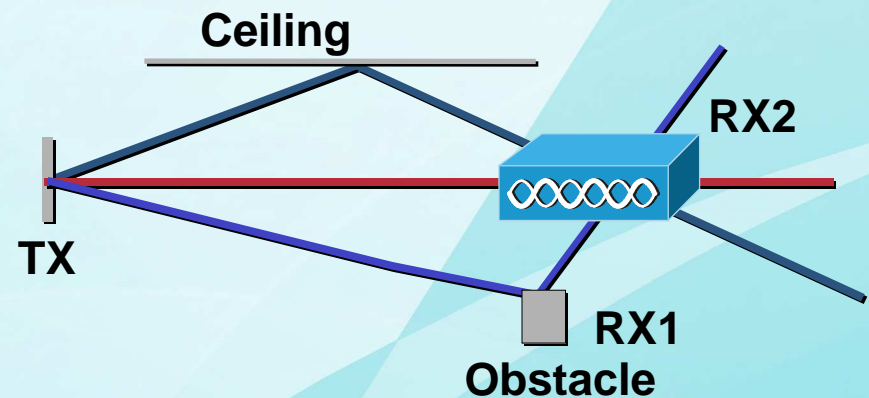


Diversity and Multipath

In a multipath environment, signal null points are located throughout the area

Moving the antenna slightly will allow you to

- Move out of a null point
- Receive the signal correctly



Dual diversity antennas typically mean if one antenna is in a null, the other one will not be, therefore providing better performance in multipath environments

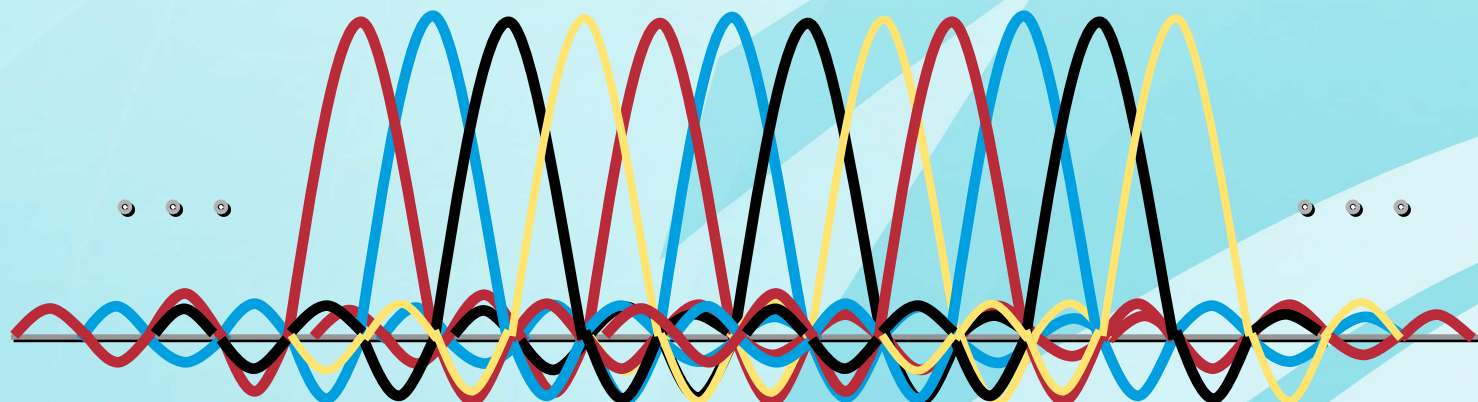
OFDM Is the Antidote for Inter-Symbol Interference

Ways to minimize inter-symbol interference:

- Reduce the symbol rate, but data rate usually goes down too
- Equalizers, but equalization is processor intensive

Solution:

- Transmit over multiple carrier frequencies in parallel (Orthogonal Frequency Division Multiplexing)



Summary

Upon completion of this module, you will be able to perform the following tasks:

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Review Questions

What does ISM stand for?

What are the unlicensed frequency bands?

What causes multipath distortion?

What are the three modulations techniques that are utilized in all 802.11b radios?

Why is it important to choose a single vendor's access point for the wireless backbone?

What is achieved by co-locating access points and how many access points can you co-locate in an 802.11b environment?

Review Questions (cont.)

Why are diversity antennas used on the Cisco Aironet Access Points?

How does OFDM encoding scheme work?

Why is OFDM signal not affected by inter-symbol interference?

802.11a has how many non-overlapping channels?

What is the highest aggregate data rate for an 802.11a system?