Wireless LAN 101

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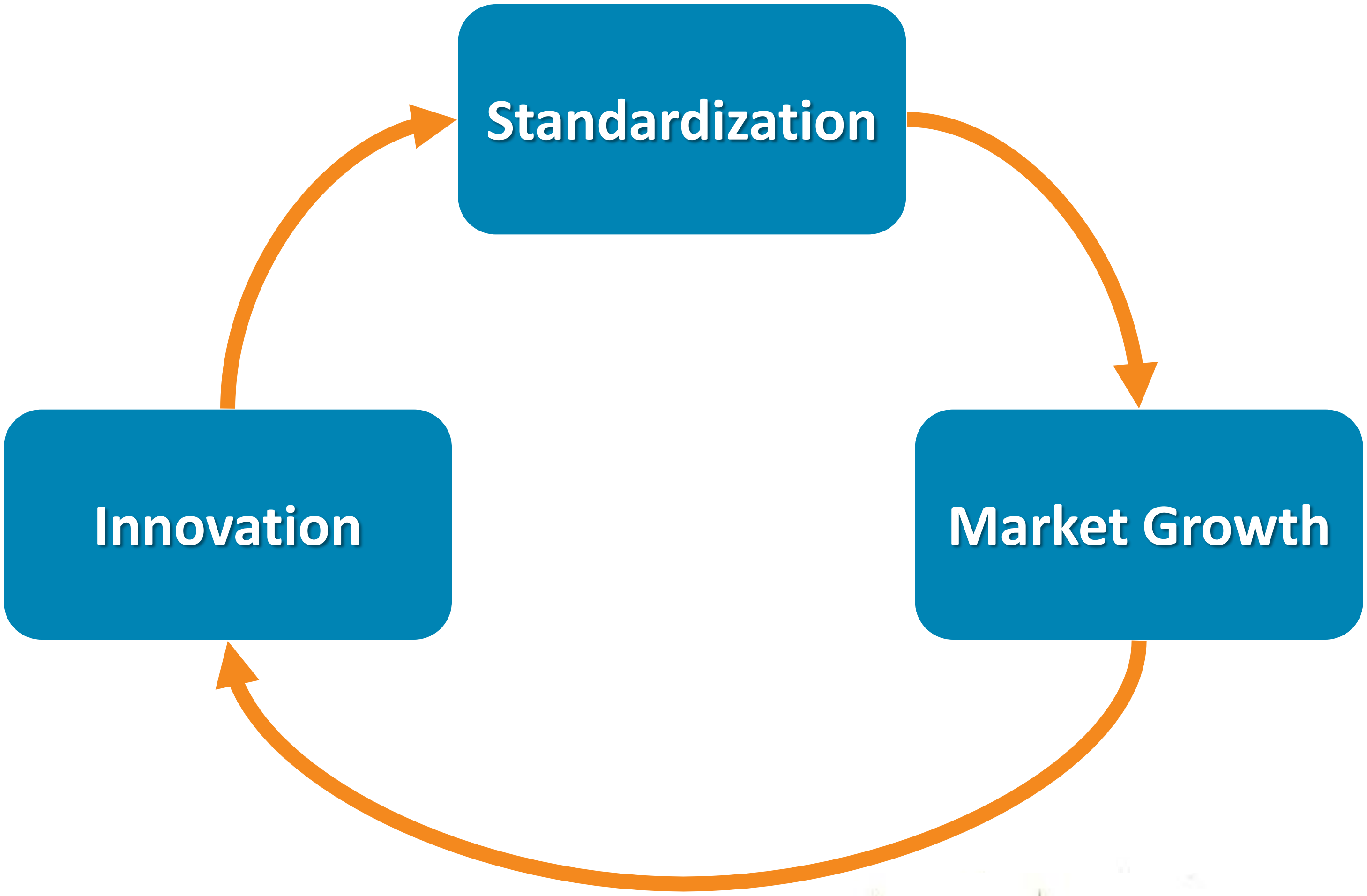
Agenda

- Wireless LAN Standards
- WLAN Technology and Design
- IEEE 802.11n
- CAPWAP and Centralized Wireless
- Wireless Mesh and AWPP (dot11s)

**Many of the slide source material from Cisco*

WIRELESS LAN STANDARDS

The Virtuous Standards Cycle



Types of Standards Bodies

Organization	Primary Activity
Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org	Development of Hardware Standards
Internet Engineering Task Force (IETF) www.ietf.org	Development of Software Standards
Wi-Fi Alliance www.wi-fi.org	‘Marketing’ of Technical Standards
FCC / ETSI / OFCOM / CITC etc. www.citc.gov.sa www.fcc.gov www.etsi.org www.ofcom.org.uk	Define and Enforce Regulatory Standards and Spectrum Allocation

‘Marketing’ Names for 802.11 Standards

Wi-Fi Alliance Interoperability Name	IEEE 802.11 Name
Wi-Fi Certified™	802.11 / a / b / g
Wi-Fi Protected Access™ (WPA v1 & v2)	802.11i
Wi-Fi MultiMedia™ (WMM)	802.11e

Standards Terminology

When is a Standard not a Standard?

- Does it have a completion date in the past?
- Does it use the word ‘Ratified’?

Look out for words like:

- Pre-standard
- Draft ‘x’
- Expected to be compliant
- De Facto Standard

Task Group

A group of interested technologists looking to develop a new standard.

Draft

A cut of the work-in-progress as of a specified date.

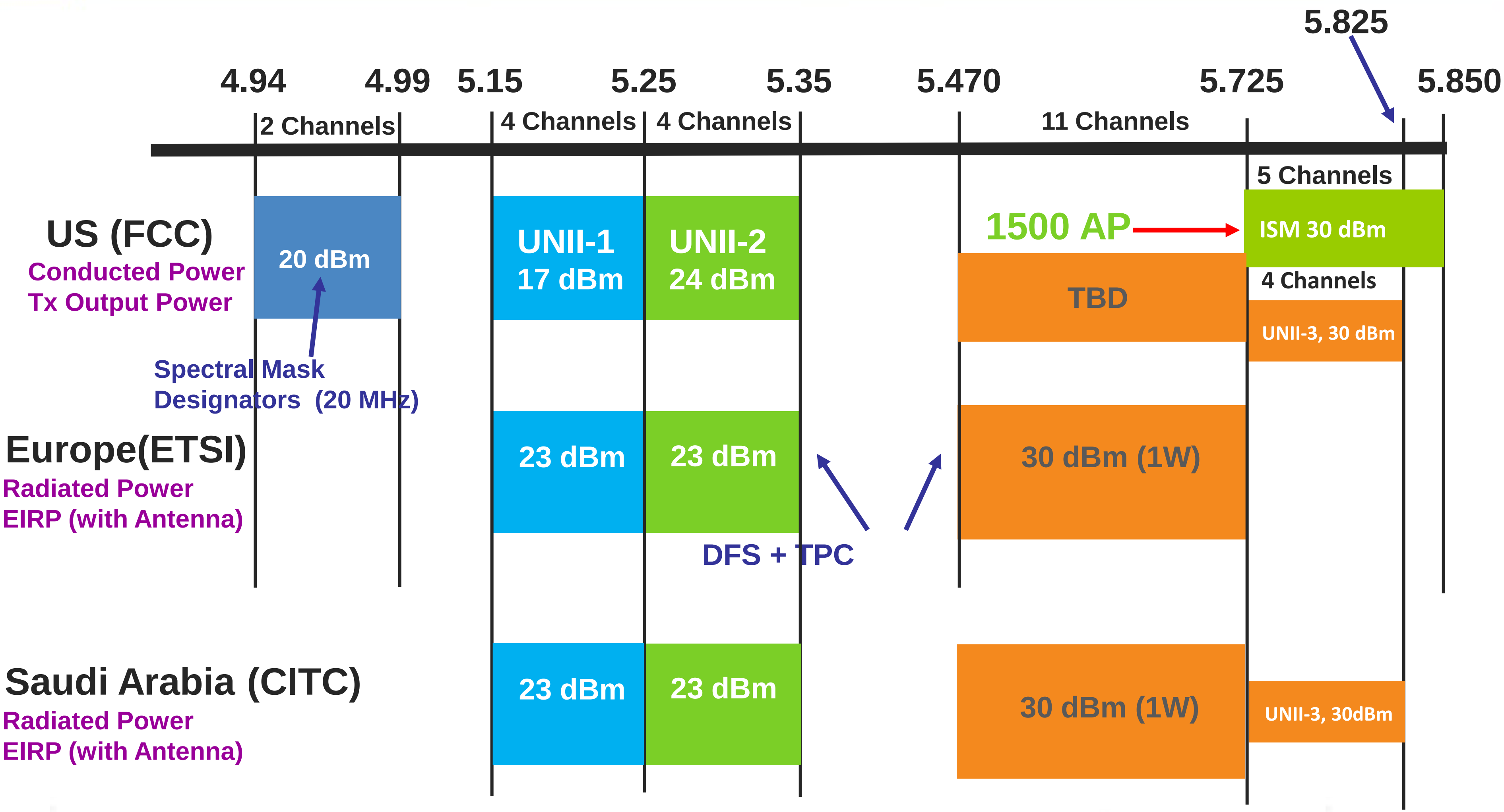
Standard

A ratified and final technical description of a technology, enabling vendors to unambiguously design and implement interoperable solutions.

802.11 Ratified Standards

Task Group	Description	Ratified
802.11	Base MAC and PHY Specifications	1999
802.11a	5GHz OFDM PHY (Radio)	1999
802.11b	2.4GHz DSSS PHY (Radio)	1999
802.11d	Additional Regulatory Domains (World Mode)	2001
802.11g	Data Rate Extension for 2.4GHz	2003
802.11h	Spectrum Management for 5GHz in Europe	2003
802.11i	Data Plane Security Extensions	2004
802.11j	4.9-5.0GHz Operation in Japan	2004
802.11e	QoS Extensions	2005
802.11k	Radio Resource Management	2008
802.11r	Fast Roaming	2008
802.11n	High Throughput	2009
802.11s	Mesh Networking	2011

Current State of 5GHz Bridging Spectrum



Dynamic Frequency Selection (DFS)
Target Power Control (TPC)

WLAN TECHNOLOGY AND DESIGN

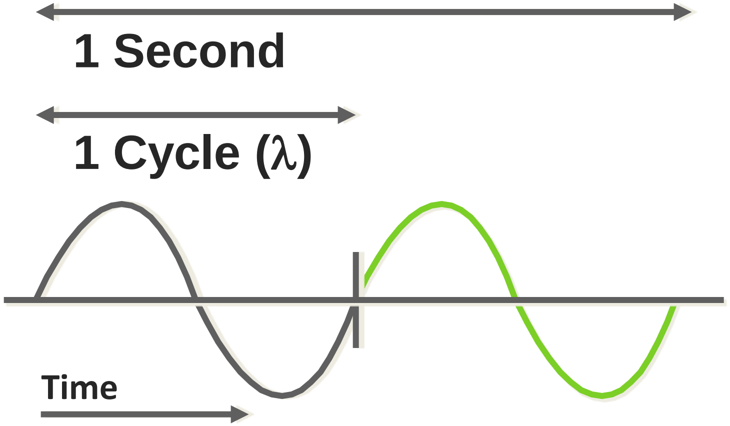
Radio Waves

- Waves attributes include frequency and wave-length
- Radio devices operate in bands or a designated frequency ranges

5GHz ~ 6 cm

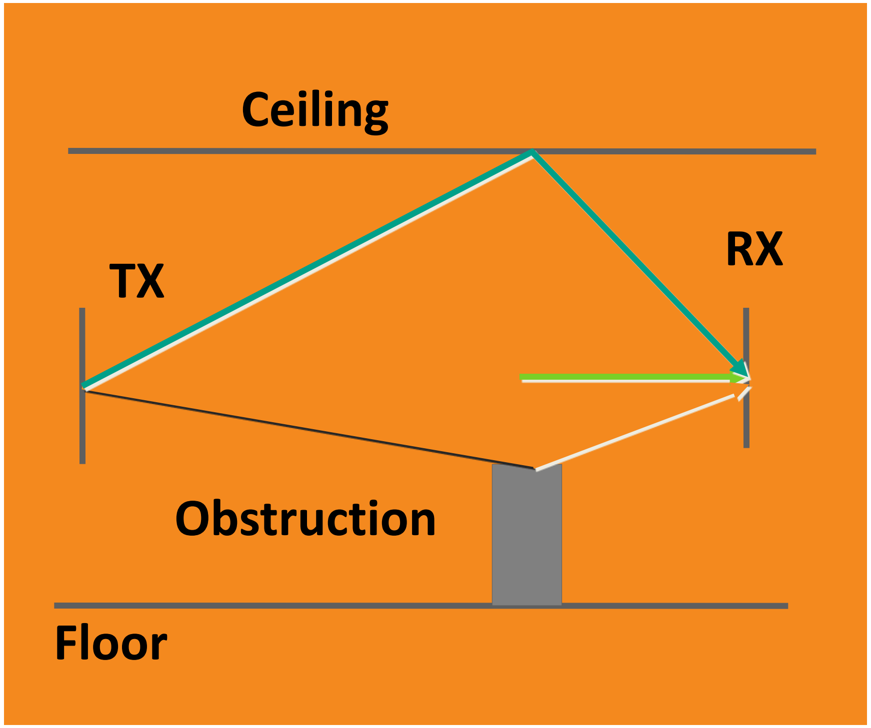
2.4 GHz ~ 12 cm

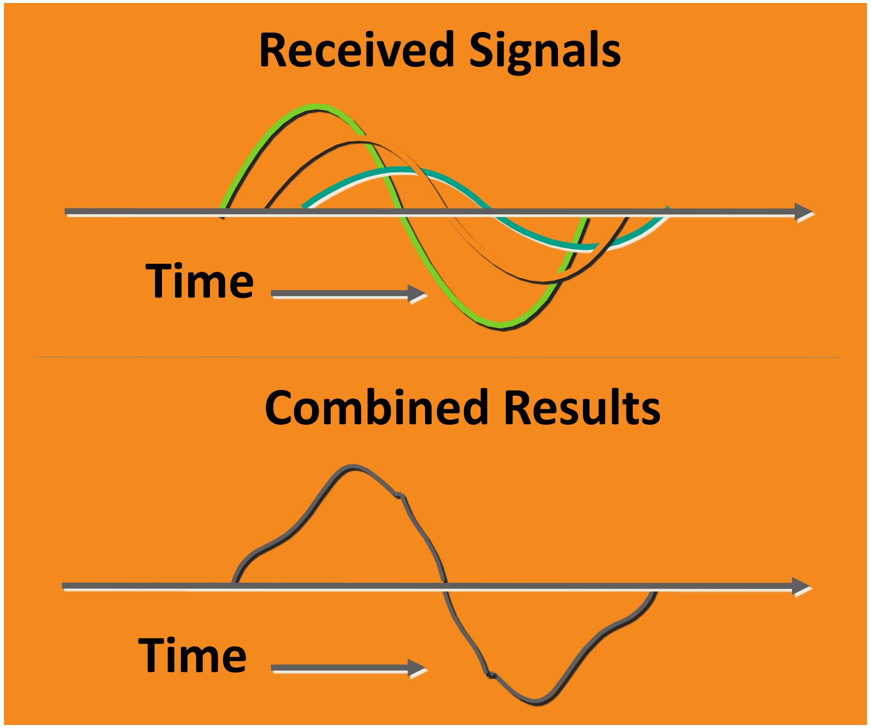
Frequency = *f* = V / λ (m/sec)



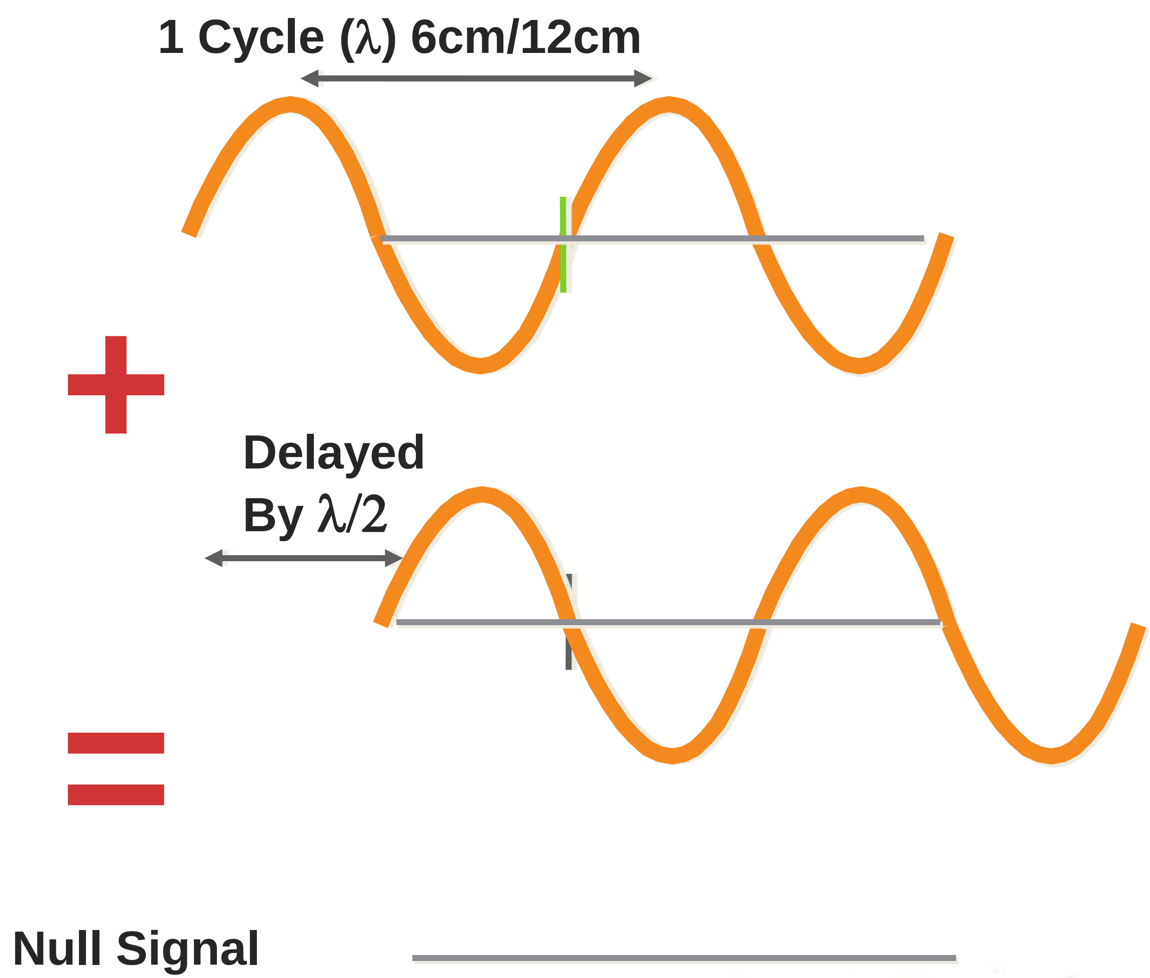
2 Cycles in 1 Second = 2 Hertz

Multipath


Ceiling
TX
RX
Obstruction
Floor


Received Signals
Time
Combined Results
Time

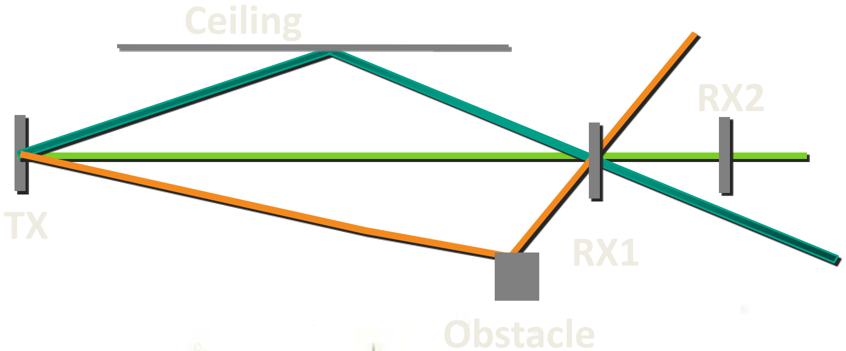
Null Signals



Diversity

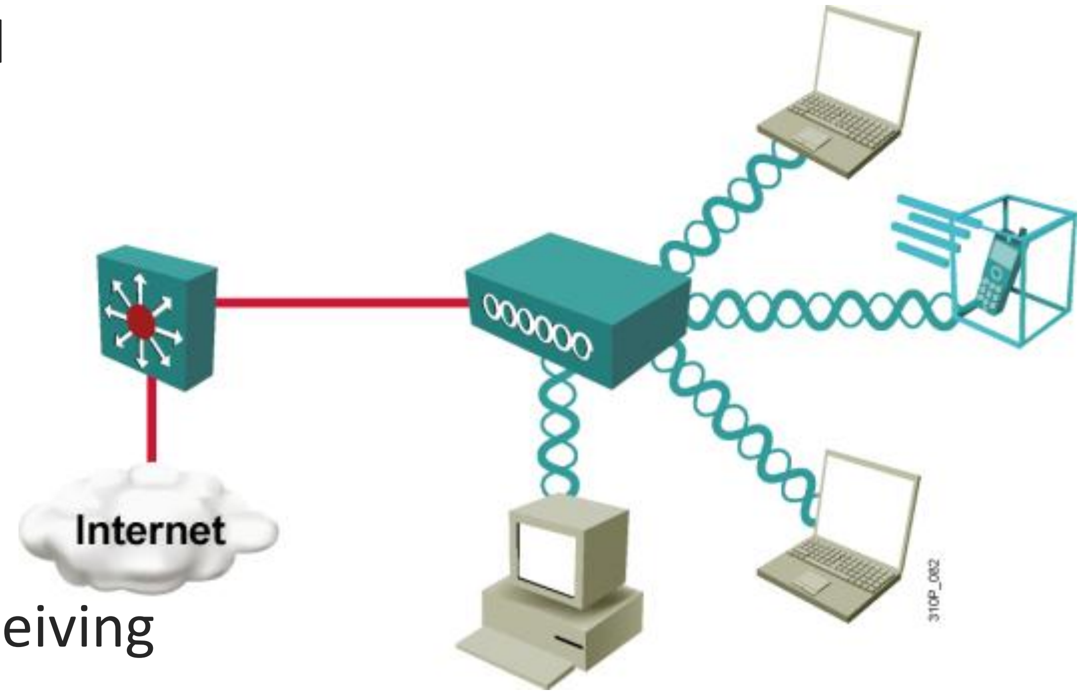
- In a multipath environment, signals null points are located throughout the area
- Moving the antenna slightly will allow you to move out of a null point and receive the signal correctly

Dual Antennas Typically Means if One Antenna Is in a Null, the Other One Will Not be, therefore Providing Better Performance in Multi-path Environments

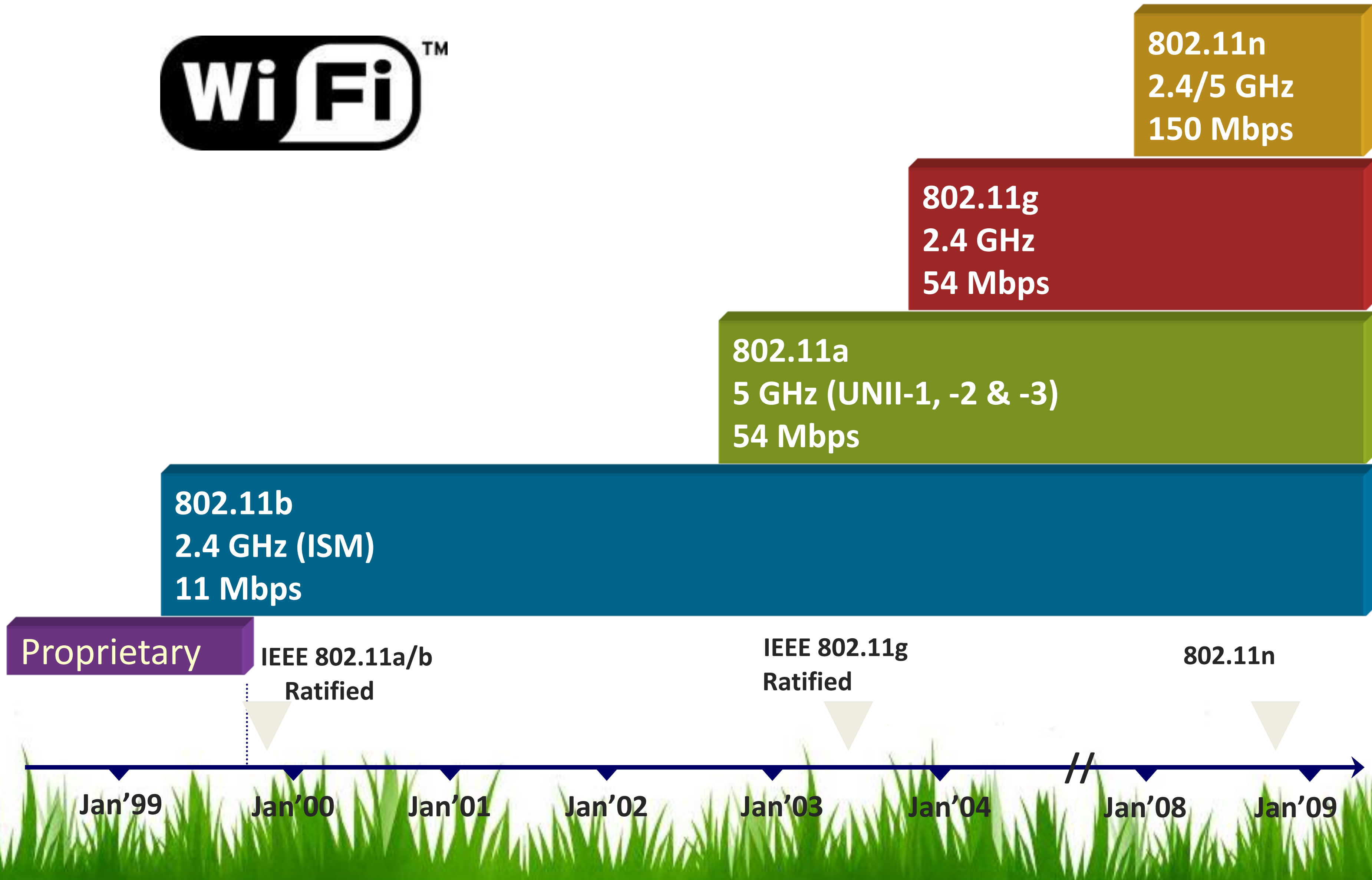


Wireless LAN (WLAN)

- A WLAN is a shared RF network
- An Access Point is a shared device and functions like a shared Ethernet hub.
- An AP typically has a wired Ethernet interface
- Uses CSMA/CA protocol
- The same radio frequency is used for sending and receiving (transceiver)

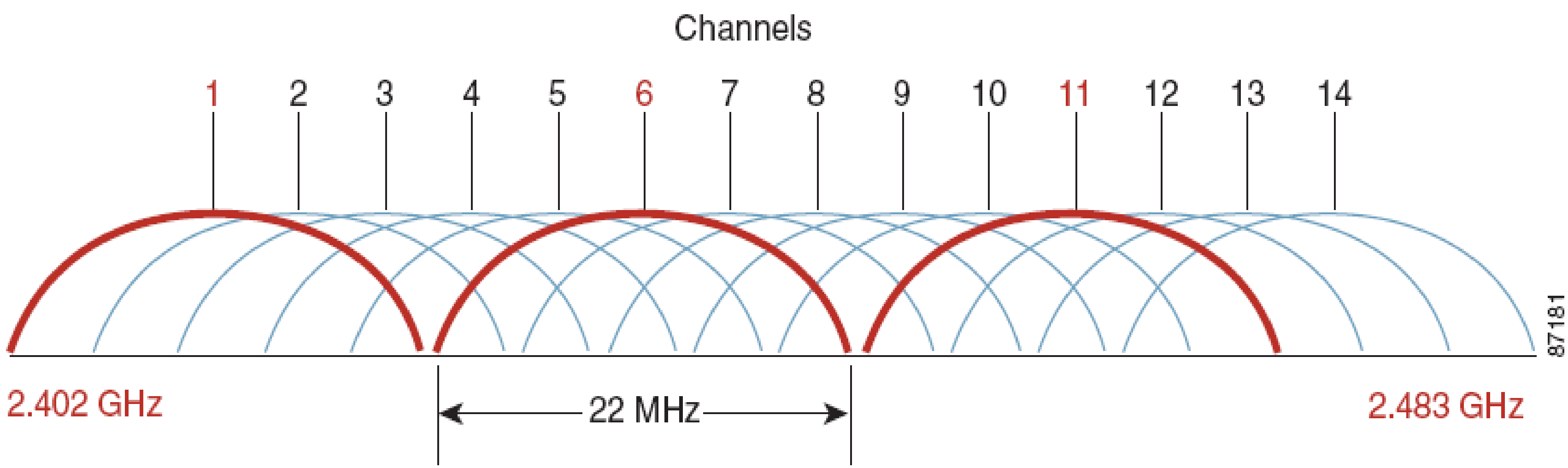


WLAN Speeds & Frequencies

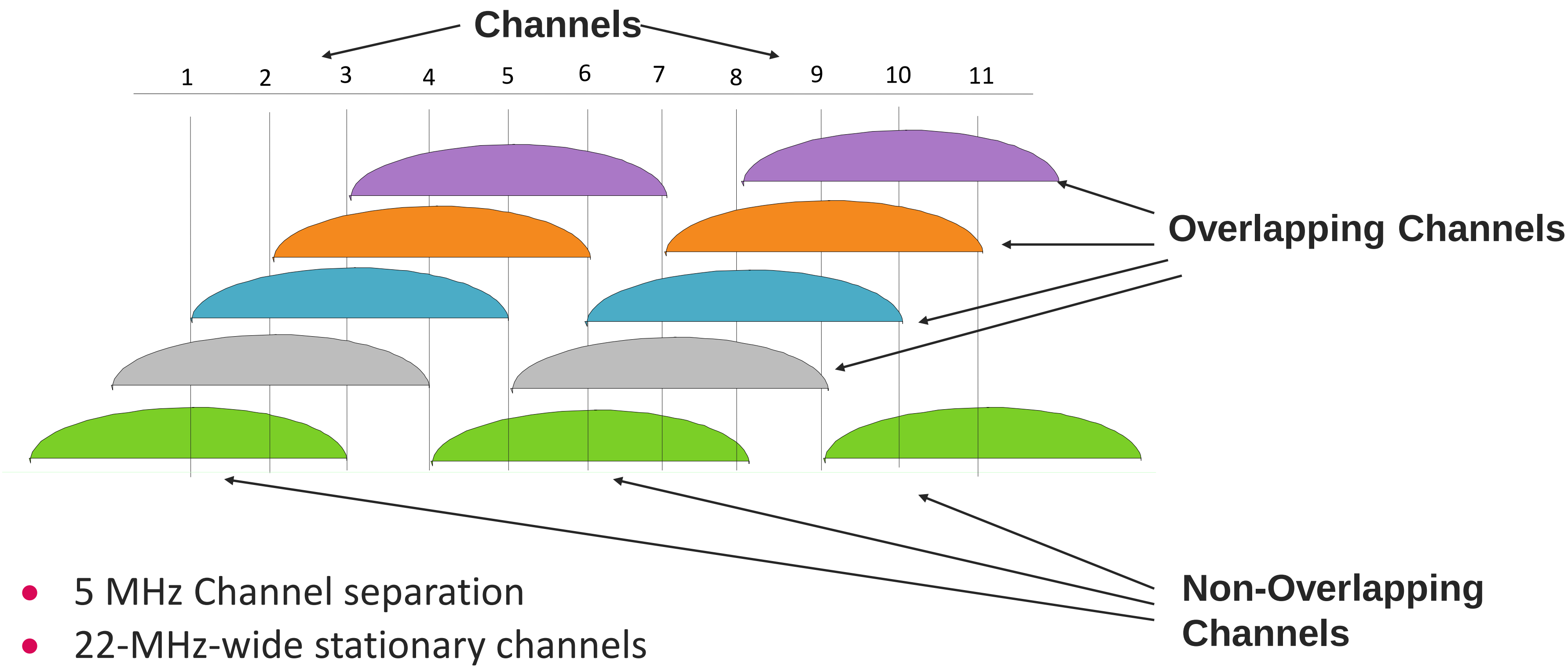


802.11b/g Channels (2.4 GHz ISM-ITU Range)

- Non-overlapping channels should be used when deploying WLAN
- Non-overlapping channels have 22 MHz of separation (at least 5 channels apart)
- There are 3 non-overlapping channels in the 2.4 GHz frequency range (channels 1,6,11)
  - –Channel 14 can be used as a fourth non-overlapping channel for Japan when using 802.11b access points

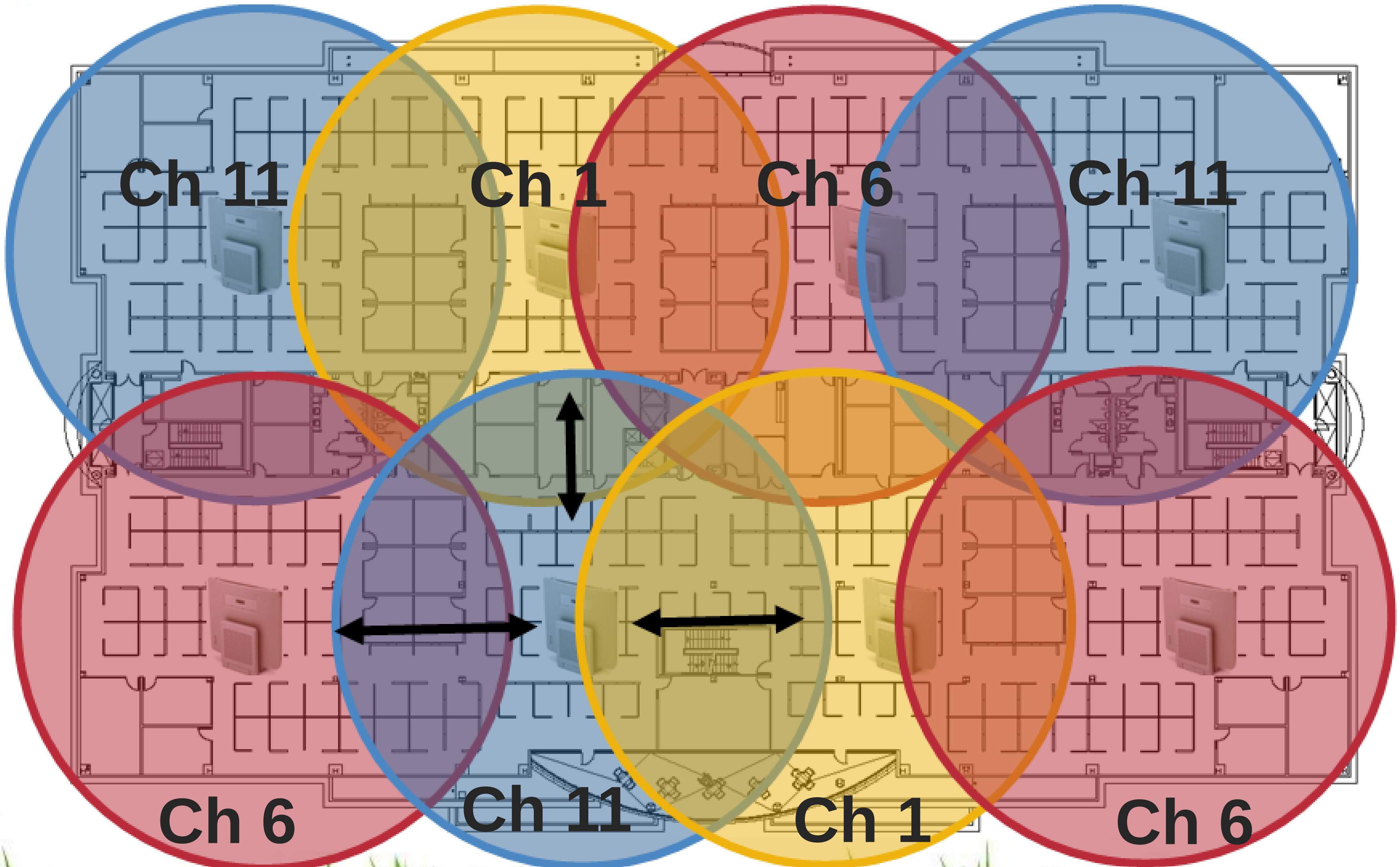


IEEE 802.11b/g Channel Allocations



- 5 MHz Channel separation
- 22-MHz-wide stationary channels
- 3 nonoverlapping channels (1, 6, and 11)
- 3 APs can occupy same area - set at different frequencies

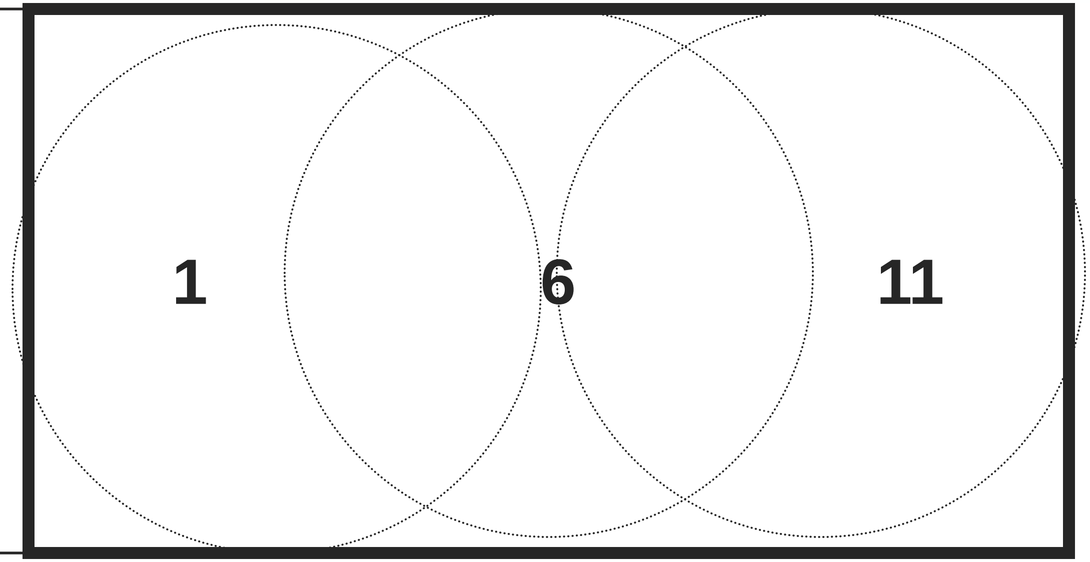
802.11b/g Channel Mapping Design



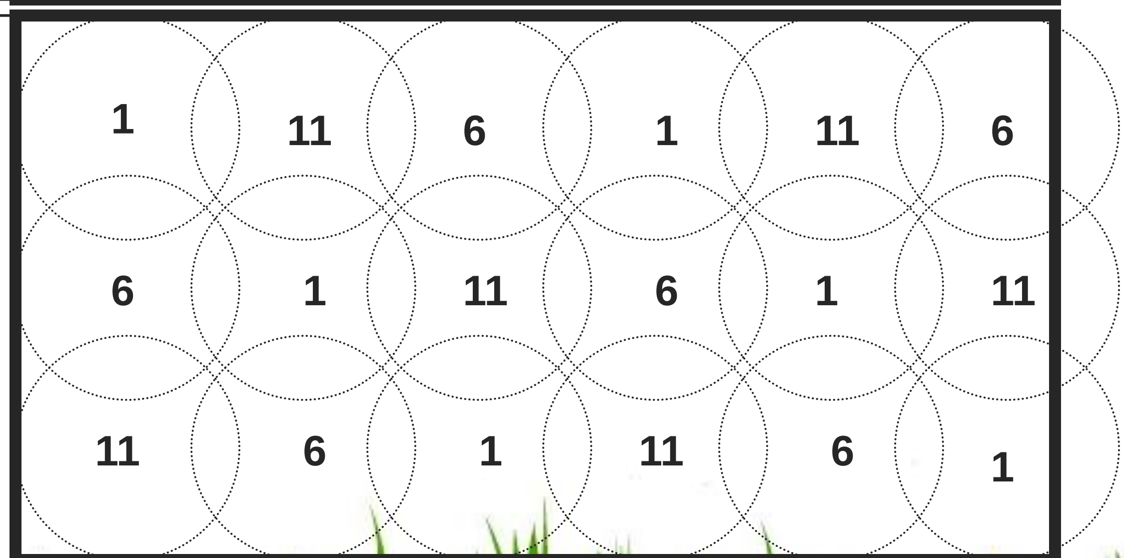
15-20% Overlap

Increasing Capacity by Design

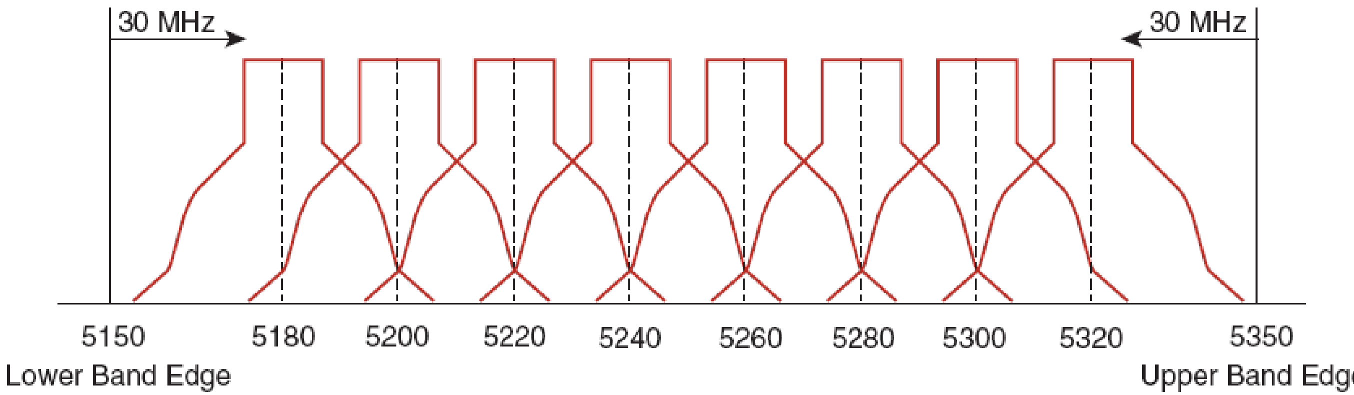
- **200 Users on the Floor**
- **Full Antenna Power: 30mW**
- **3 Access Points**
- **67 Users per AP of shared bandwidth**



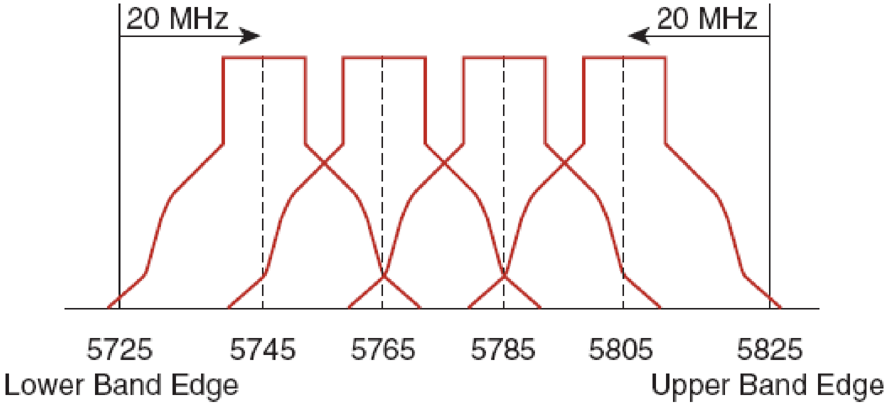
- **200 Users on the Floor**
- **Reduce Antenna power to 5mW**
- **18 Access Points**
- **11 Users per AP of shared bandwidth**



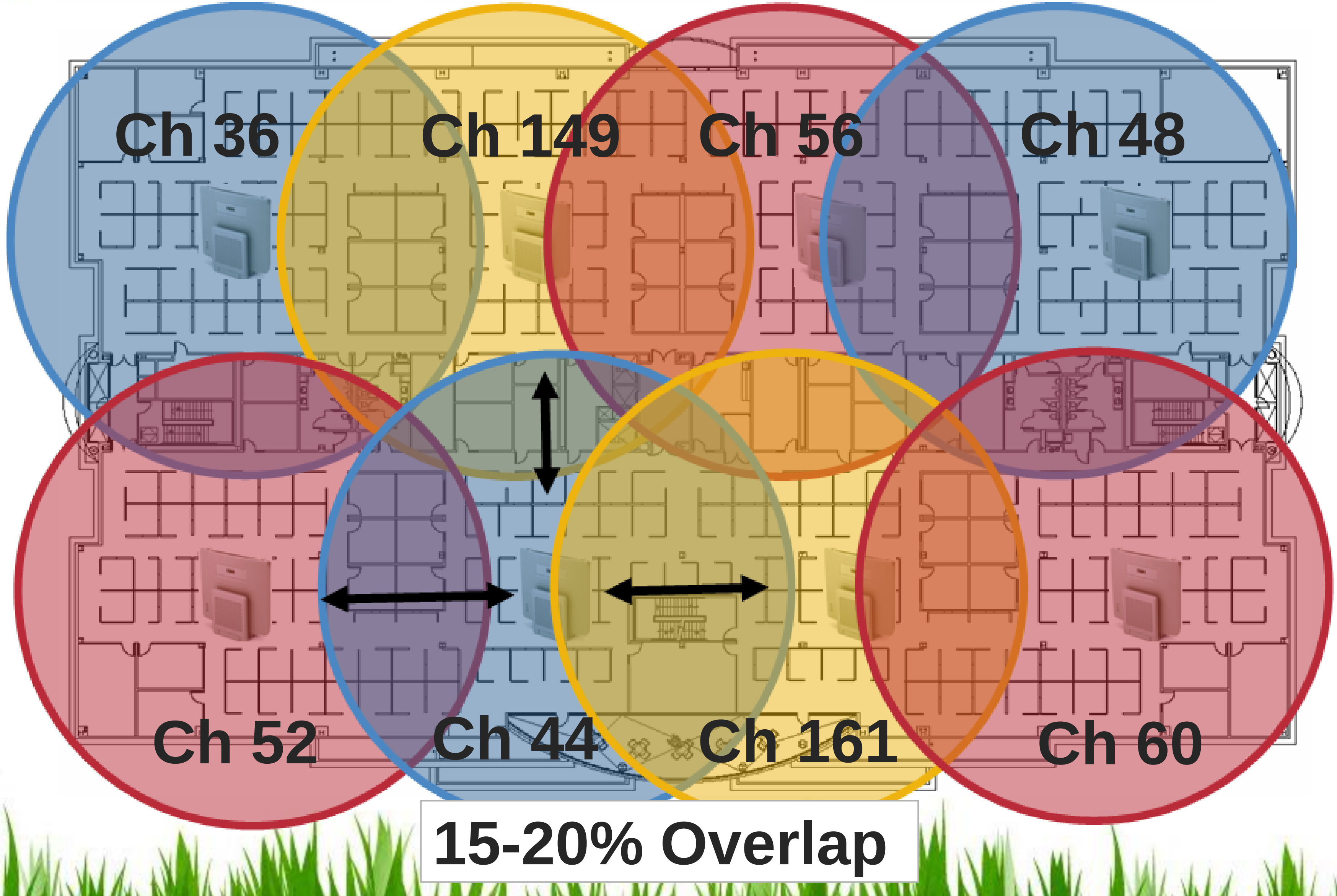
802.11a Channels – U-NII 1,2 & 3



- **12 non-overlapping channels: 8 indoor, 4 outdoor**
- **8 APs can occupy same area - set at different frequencies**
- **60-MHz-wide stationary channels**
- **20 MHz Channel separation**



802.11a Channel Mapping Design



802.11a/b/g Comparison

Range

Data Rates	802.11g	802.11a
54 Mbps	32 m	26 m
48 Mbps	55 m	46 m
36 Mbps	79 m	64 m
24 Mbps	87 m	70 m
18 Mbps	100 m	79 m
12 Mbps	108 m	85 m
11 Mbps	111 m	
9 Mbps	116 m	94 m
6 Mbps	125 m	100 m
5.5 Mbps	130 m	
2 Mbps	136 m	
1 Mbps	140 m	

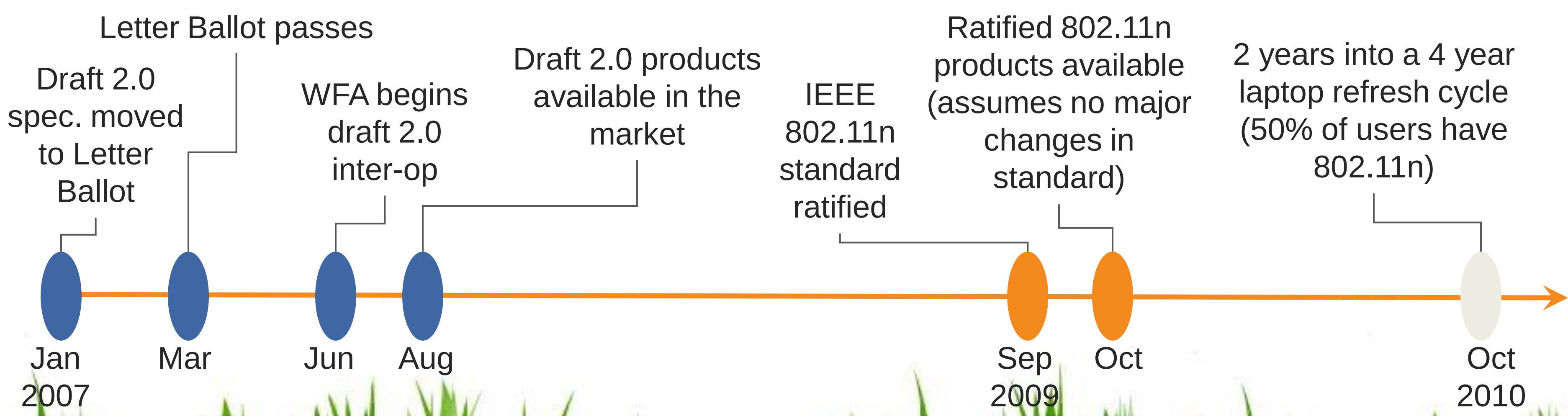
Typical indoor ranges measured using an AP1242AG with 2.2-dBi dipole antenna for 2.4 GHz, and 3.5-dBi omnidirectional antenna for 5 GHz.

IEEE 802.11N

High Throughput

802.11n Standard

- Official amendment name: “high throughput”
- IEEE 802.11n standard officially ratified September 2009
- Had a lot of pre-standard activity
- WFA created a certification of 802.11n draft 2.0 products mid-2007



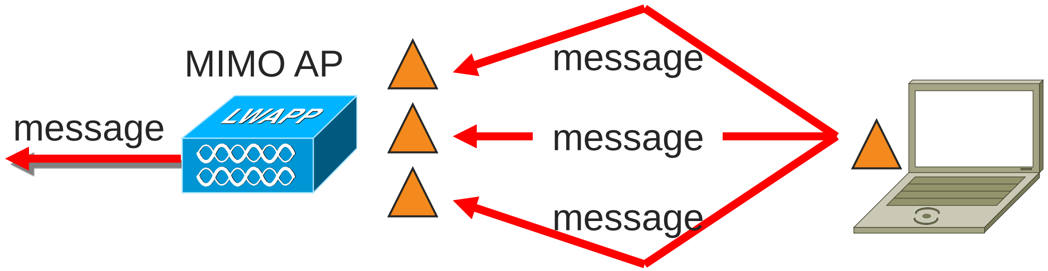
802.11n Throughput Improvements

MIMO	Dual Channel	MAC Efficiency
• Maximal Ration Combining • Beam Forming • Spatial Multiplexing	• Two Adjacent 20MHz Channels for a Single a 40MHz Channel	• Packet Aggregation • Block Ack

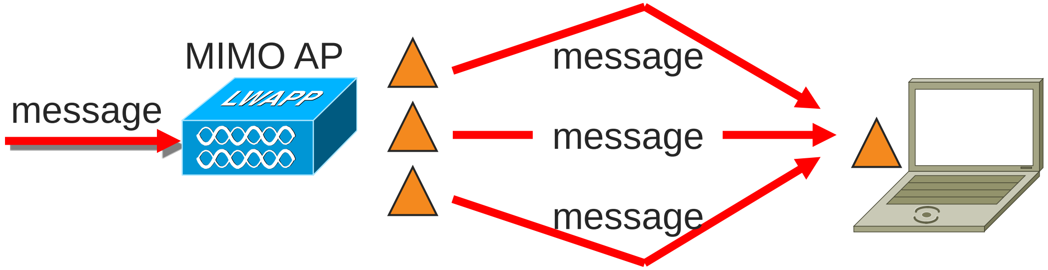
- 5x higher throughput
- More reliable and predictable coverage
- Backwards compatibility with 802.11a/b/g clients

MIMO Overview

Maximal Ratio Combining
- Performed by receiver
- Combines multiple received signals
- Increases receive sensitivity
- Works with non-MIMO and MIMO clients



Transmit beam forming
- Performed by transmitter
- Ensures signal received in phase
- Increases receive sensitivity
- Works with non-MIMO and MIMO clients

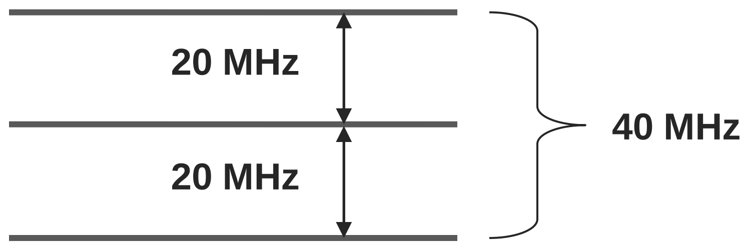


Spatial Multiplexing
- Transmitter and receiver participate
- Multiple antennas txmt concurrently on same channel
- Increases bandwidth
- Requires MIMO client

40-MHz Channels and Packet Aggregation

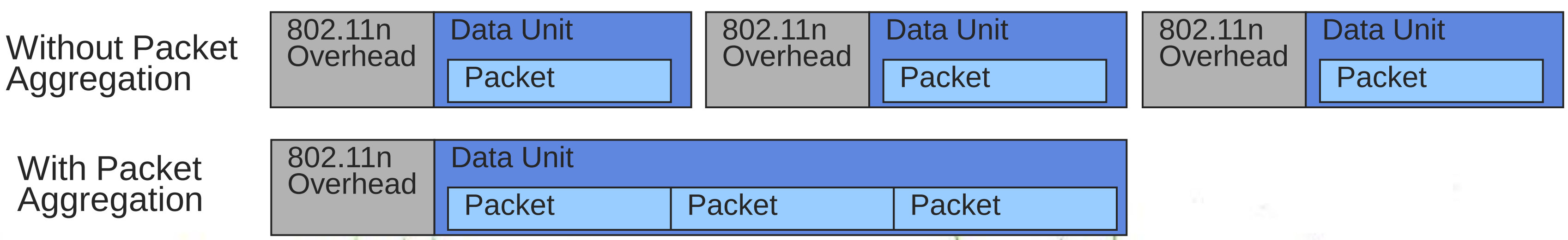
40-MHz Channels:
802.11n supports both 20- and 40-MHz wide channels
Wider channels means more BW per AP
(not per physical location)

Auto Analogy:
Twice the traffic lanes, twice the cars



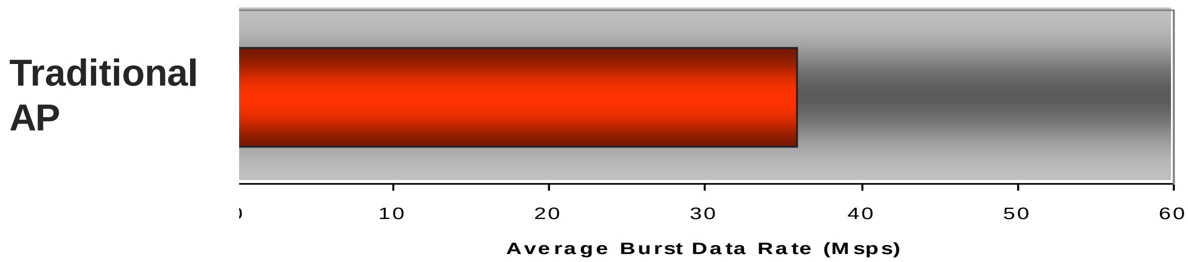
Packet Aggregation:
Combine multiple data units into one frame
Saves on 802.11n and MAC overhead

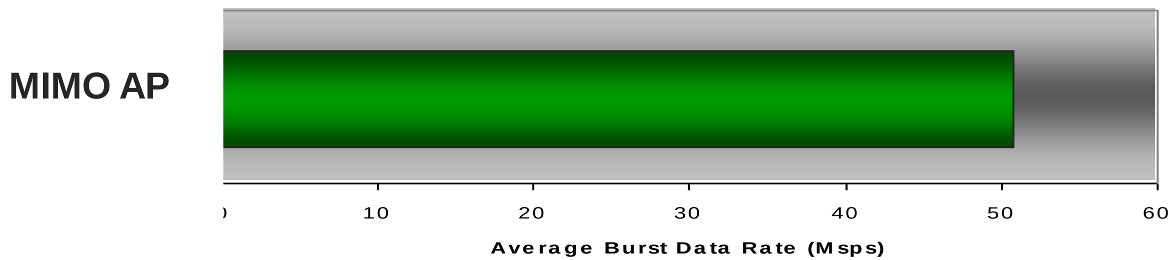
Auto Analogy:
Car pooling is more efficient than driving by yourself



More consistent, reliable coverage

- Higher mean throughput, more reliable connections for each client
  - –Consistent throughput and coverage
  - –Better reliability, better user experience
  - –Fewer help desk calls





CONTROL AND PROVISIONING OF WIRELESS ACCESS POINTS CAPWAP

- *CAPWAP Protocol*
- *Business Class Reliability*
- *Radio Resource Management*

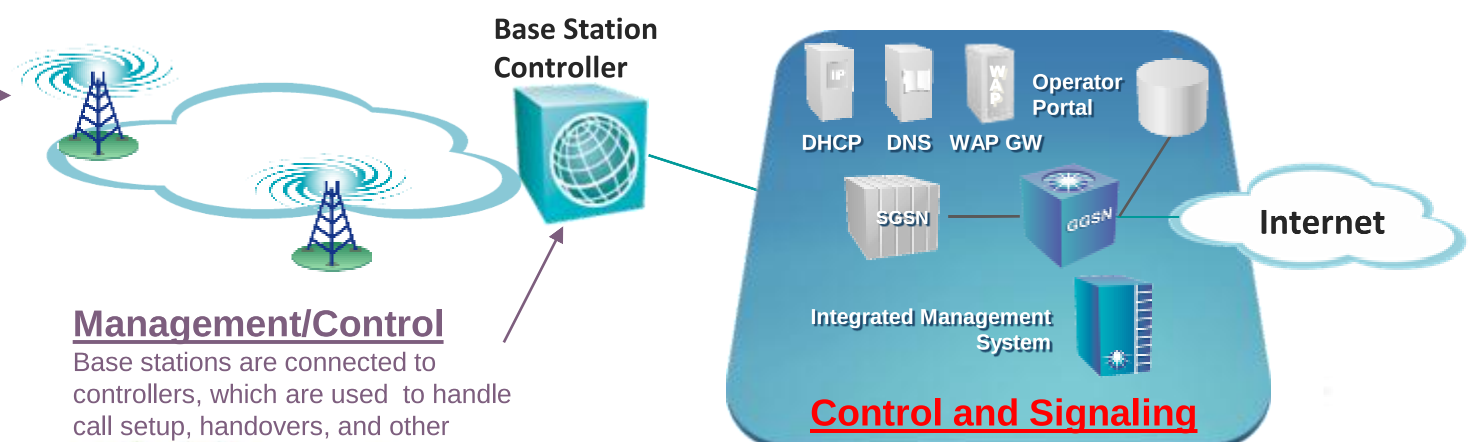
Lessons From Cellular Networks…

- CAPWAP is an IETF standard ratified July 2007
- Was originally called LWAPP before standardized (or Light Weight Access Point Protocol)

Access, Control, and Traffic Forwarding must be separated from one another to build scalable, reliable wireless networks

Access

Cell sites are made up of base stations that contain numerous pieces of radio equipment (e.g., antennas) for communicating with mobile devices.



Management/Control

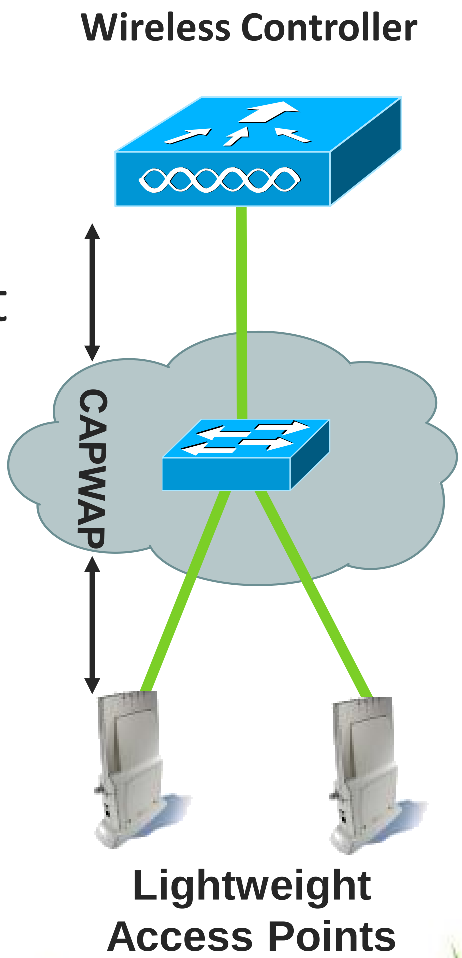
Base stations are connected to controllers, which are used to handle call setup, handovers, and other functions across an entire cellular network.

CAPWAP Architecture

- Security policies
- QoS policies
- RF management
- Mobility management

Division of Labor
Split MAC

- Remote RF interface
- MAC layer encryption



Controller MAC Functions

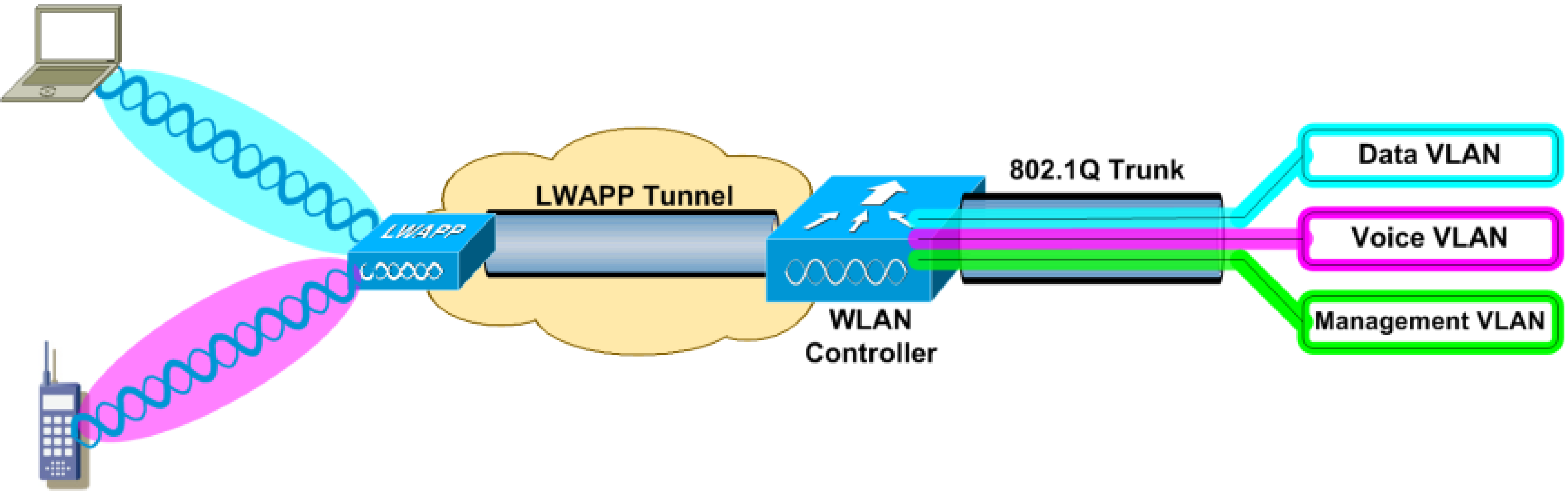
- 802.11 MAC mgmt: (Re)association requests and action frames
- 802.11 Data: Encapsulate and sent to AP
- 802.11e resource reservation: Control protocol carried to AP in 802.11 mgmt frames—signaling done in the controller
- 802.11i authentication and key exchange

AP MAC Functions

- 802.11: Beacons, probe response, auth (if open)
- 802.11 control: Packet ack and retransmission (latency)
- 802.11e: Frame queuing and pkt prioritization (access to RF)
- 802.11i: Encryption in AP

Understanding WLAN Controllers

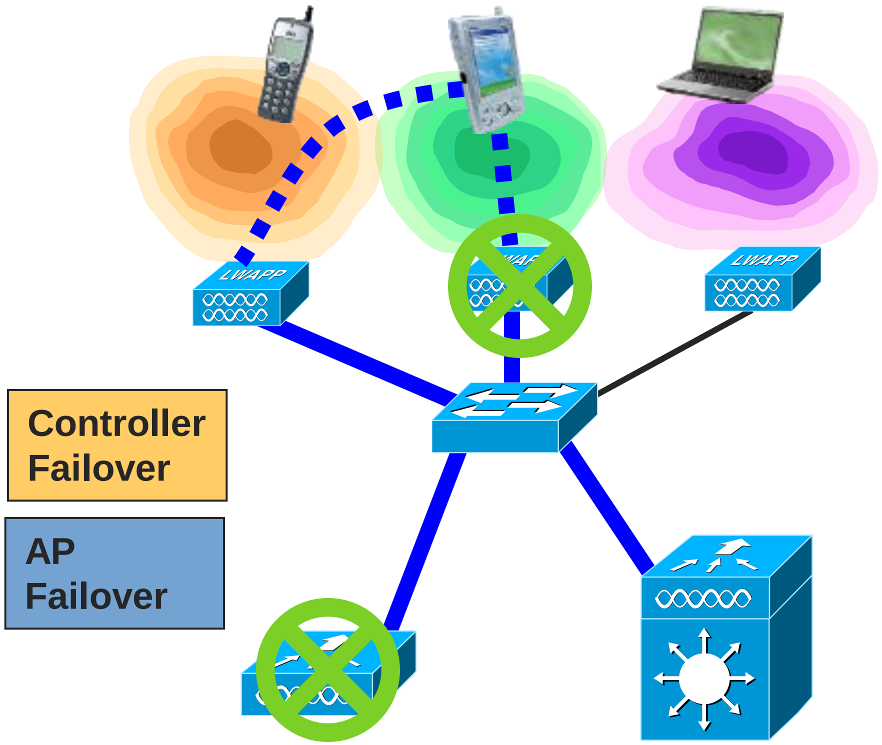
The WLAN Controller as a Network Device



- WLAN Controller
  - For wireless end-user devices, the controller is a 802.1Q bridge that takes traffic of the air and puts it on a VLAN
  - From the perspective of the AP, the controller is an CAPWAP Tunnel end-point with an IP address
  - From the perspective of the network, it's a Layer-2 device connected via one or more 802.1Q trunk interfaces
- The AP connects to an access port—no concept of VLANs at the AP

CAPWAP Adds AP Redundancy
for Mission Critical Mobility

- **Maximized system availability**
  - **Controller redundancy**
  - **Access point failover**
- **System level management automates failover to guarantee availability**



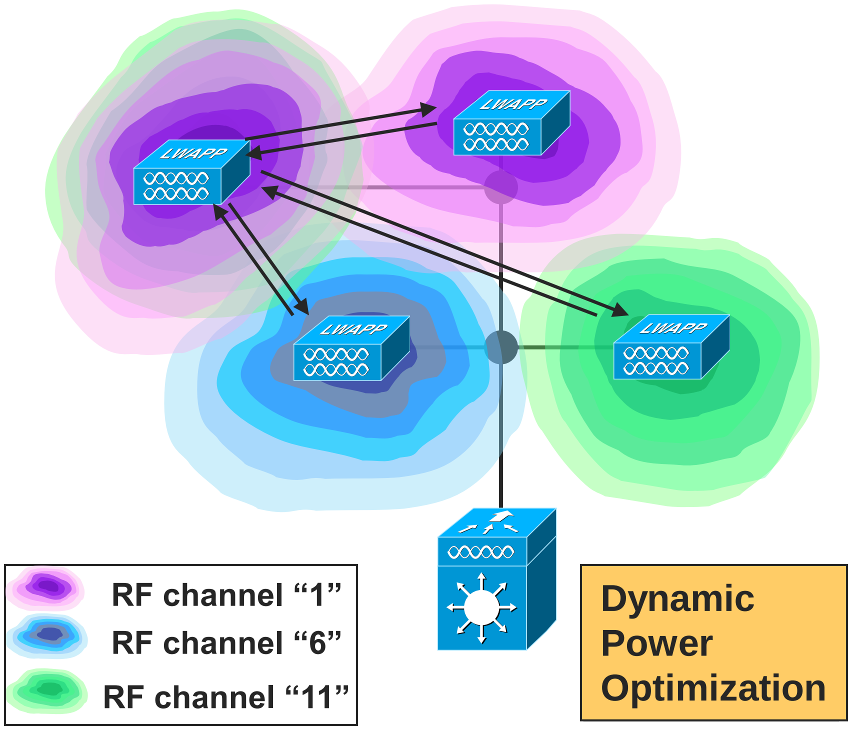
Benefits

- **No single point of failure**
- **Automated network failover decreases support and downtime costs**
- **Wireless network reliability on par with wired**

CAPWAP Radio Resource Management

Real-Time RF Management

- The RF domain is an ever changing environment
  - Users are mobile
  - Interference prone
- The controller has a system level view of the RF domain and adjusts individual access points to optimize coverage and network availability



Benefits

- An optimized RF environment allows for superior application performance and higher network availability
- Complete RF management without specialized RF skills
- No RF recalibration required – decreased support costs

IEEE 802.11S WIRELESS MESH

Adaptive Wireless Path Protocol (AWPP)

AWPP Path Selection

Solution Components

Radio Roles

Roof Top Access Point (RAP) mode-

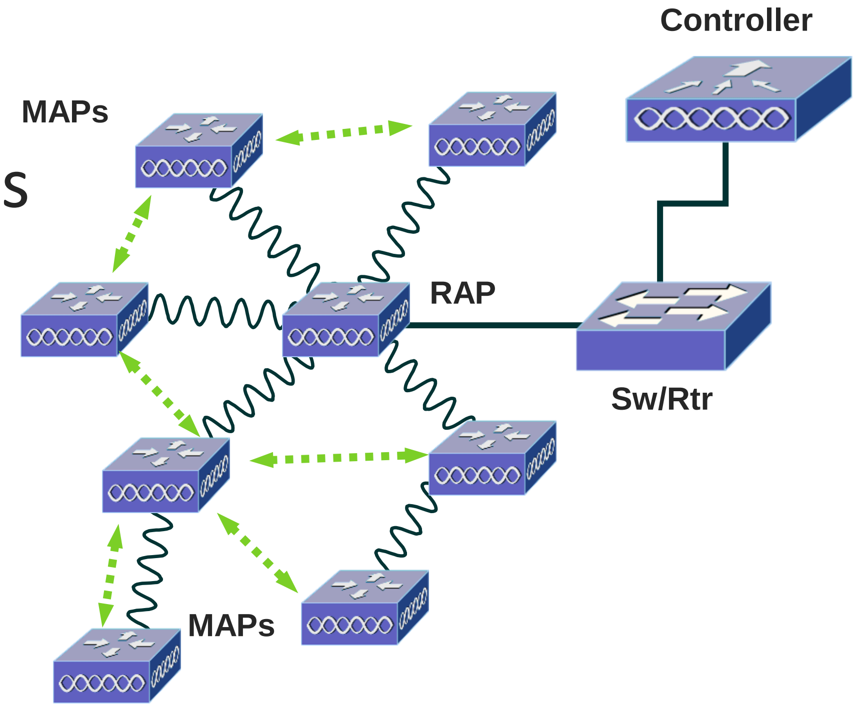
- –Wired LWAPP connection to the Controller
- –RAP has only backhaul interface, and we do not recommend RAP to have local client access
- –More than one RAP for the same Mesh for Redundancy

Pole Top Access Point (MAP) mode-

- – No wired connection for Mesh
- – Wired connection for Bridging (P2P or P2MP)
- – Communicating directly to RAP, or to other MAPs and eventually to RAP
- – Support wireless clients

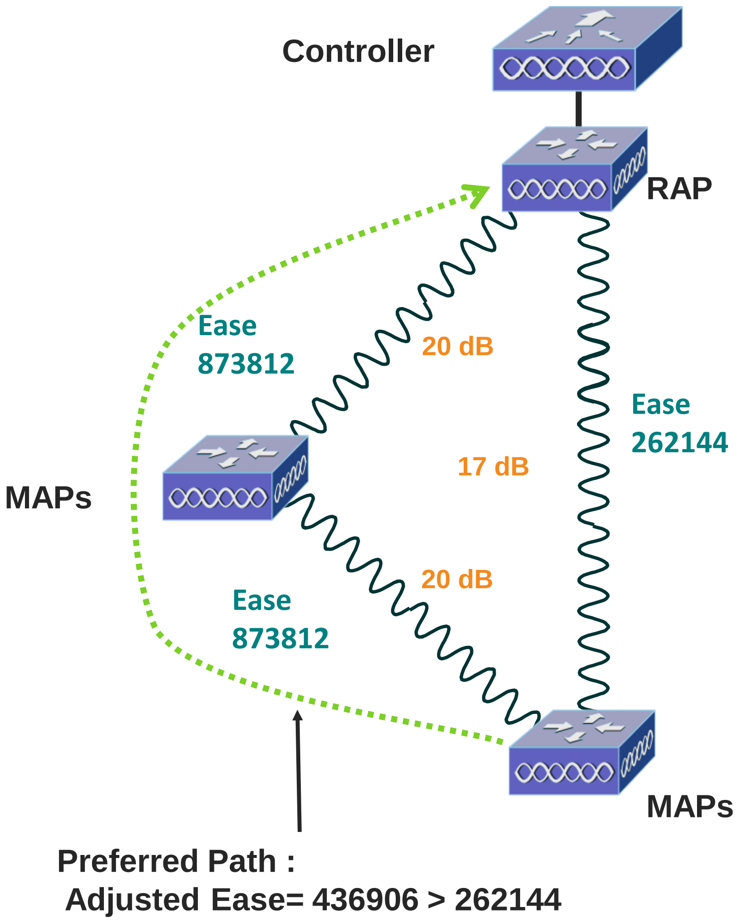
Adaptive Wireless Path Protocol (AWPP)
IEEE 802.11s

- Self-configuring, Self-healing
- Dynamic, Intelligent Path Selection
- AWP establishes and maintains an optimal path to RAP
- Each MAP carries possible successors if topology or link health changes
- Cisco AWP is part of the IEEE 802.11s committee (SEE Mesh)



AWPP Path Selection

- Routing uses a concept of ‘Ease’ (preferred path is highest ‘Ease’)
- Combination of
  - –SNR
  - –Hop Value
  - –And coefficient, based on various SNR thresholds
- Adjusted Ease = $\dfrac{\text{Min Ease at Each hop}}{\text{Hop Count}}$
- 20% premium to selected parent to prevent flopping (SNR smoothing)
- Loop detection and prevention mechanism



Questions