NETWORKERS 2004

INTRODUCTION TO 802.11 WIRELESS NETWORKS

SESSION ACC-1N00

Agenda

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- **Introduction**
- Radio Considerations
- Basic Radio Elements
- WLAN Network Components
- Standards
- Beyond the Standards
- Reference Material and Other Technologies

WLAN Business Drivers

Wireless LANs Increase Productivity

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- Based on a survey of 300+ organizations with more than 100 employees:
- End users stayed connected an average of 3.5 hours more per day to their corporate network
- Average daily time savings: 90 minutes
- Productivity: +27%

Source: NOP World-Technology, Nov. 2003

http://www.cisco.com/application/pdf/en/us/guest/products/ps4570/c1031/cdccont_0900aecd800cf91f.pdf

Where Does Increased Productivity Come From?

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- Steal 5 minutes at the beginning of meetings
  - Often meetings don't start on time
  - Instead of wasting time with idle chit-chat, get work done
  - 3–4 meetings/day x 5 min./meeting = 15-20 min. productivity savings/day
- Eliminate "I'll do it when I get back to my desk" syndrome
  - Share files, PowerPoint presentations instantly
  - Arrange meetings using your online calendar
  - Saves 15–20 min./day for knowledge workers who don't sit at desks all day
- Use Instant Messaging as a corporate app
  - Great for quick communications; get answers without disturbing meeting
  - Only works if employees are connected to the network
- The "Connected Meeting"
  - Send presentations during meeting to all conf. call participants via email
    - Conf. calls are more productive when everyone is looking at same info
  - Follow presentations on your PC even if no projector in meeting room

Huge Number of 802.11-Enabled Devices and Growing

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HP iPAQ PDA

Cisco 7920

Epson Printer

Sharp M25X Projector

HHP Barcode Scanner

Compaq Tablet PC

- PDAs
- Printers
- Projectors
- Tablet PCs
- Barcode scanners
- Custom devices for vertical markets:
  - Healthcare
  - Manufacturing
  - Retail
  - Restaurants

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Wireless Technologies

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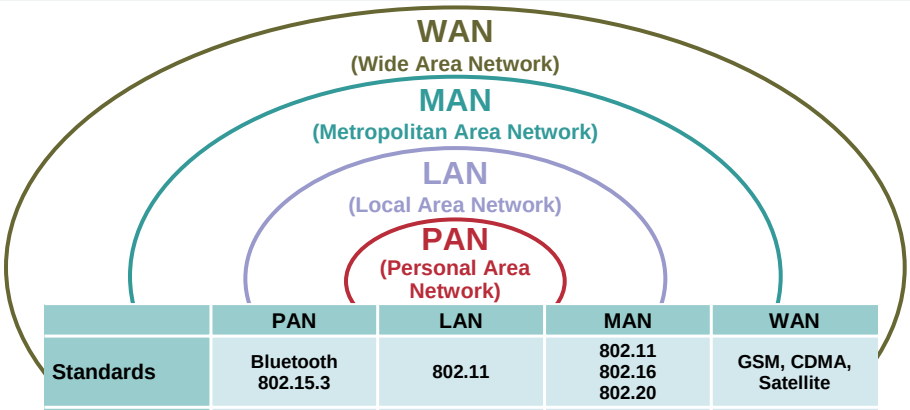

	PAN	LAN	MAN	WAN
Standards	Bluetooth 802.15.3	802.11	802.11 802.16 802.20	GSM, CDMA, Satellite
Speed	< 1 Mbps	11 to 54 Mbps	10-100+ Mbps	10 Kbps–2 Mbps
Range	Short	Medium	Medium-Long	Long
Applications	Peer-to-Peer Device-to-Device	Enterprise Networks	Last Mile Access	Mobile Data Devices

802.11 Radio Frequency Considerations

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- **Usage of unlicensed spectrum (most countries)**
  - Channels and radiated power limitations vary from country to country
- **Can be used indoor and outdoor**
  - Some frequencies have restrictions on outdoor usage
- **Works for point-to-point and point-to-multipoint environments**
  - Antennas help define coverage area and output power gain
  - It is important to have power gain in both directions for the system to work effectively

Not Only IEEE 802.11 Devices

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- **Many devices share the unlicensed spectrum**

  In the 2.4 and 5 Ghz we have video repeaters, phone systems and handsets, Bluetooth, microwave ovens, amateur video, etc.; some use direct sequence and others frequency hopping

- **Define a recommended policy for use multiple unshielded devices in office environment**
- **Educate users on potential problems of interference**

WLAN Industry Standards

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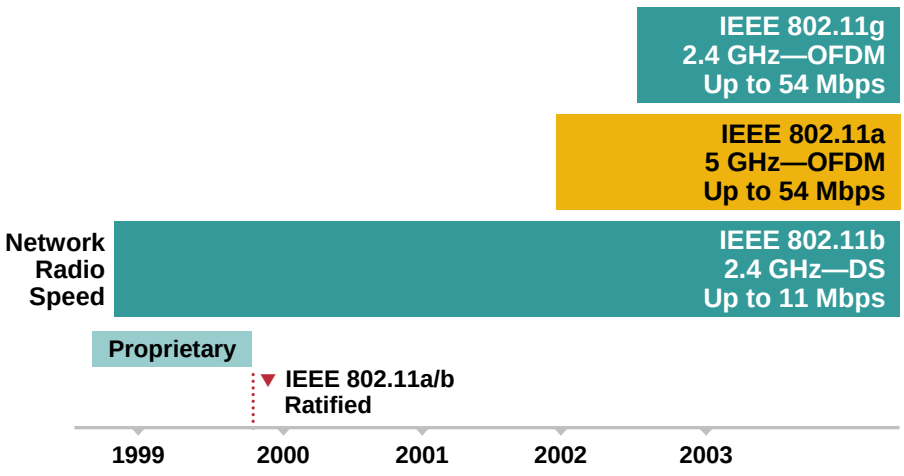

IEEE 802.11b

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- Ratified as standard in Sept, 1999
- Uses 2.4 GHz unlicensed spectrum
- Different physical access defined (PHY)

  Direct Sequence at 1, 2, 5.5 and 11 Mbps,
  Can "downshift" to lower data rates for longer range

  Frequency Hopping at 1, 2 Mbps for 2.4 Ghz (legacy)

  Infrared (obsolete)
- 11 US channels, 13 ETSI channels, 14 Japan channels
- Generally approved for world wide for use in many countries

Frequency Hopping

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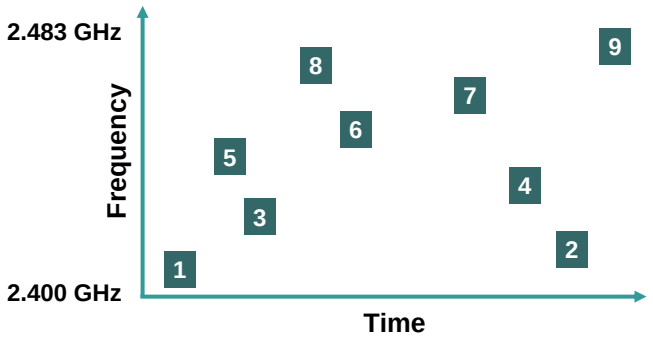

- 79 Channels, 1 MHz Each
- Changes frequency (Hops) at least every 0.4 seconds
- Synchronized hopping required

Frequency Hopping

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Pattern Number	Channel Numbers
1	1 8 4 9 *2* 6 *5* 3 7 0
4	4 6 8 3 *2* 7 1 *0* 9 *5*
3	*9* 7 2 1 3 8 4 6 0 *5*
4	*9* 3 6 8 4 1 *5* *0* 2 7

Time →

- Channel numbers (in N print are actually) interfering with other channels at the point in time
- In ANY multichannel scheme, there is the possibility of interference

IEEE 802.11b
Direct Sequence @ 2.4 GHz

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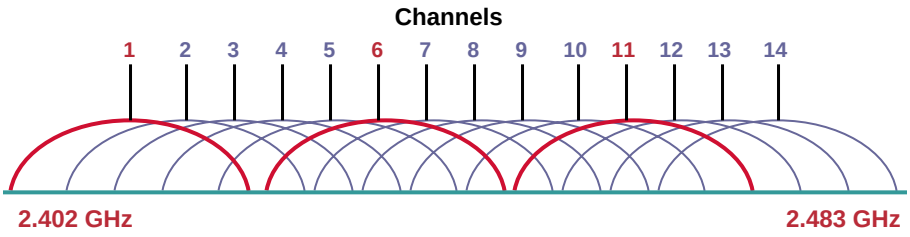

- Up to (14) 22 MHz wide channels
- 3 non-overlapping channels
  (1, 6,11 in US and 1,7,13 in Europe)
- Up to 11 Mbps data rate
- 3 Access Points can occupy the same space for a total of 33 Mbps aggregate throughput, but not on same radio card

Direct Sequence Modulation

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- Each data bit becomes a string of chips (chipping sequence) transmitted in parallel across a wide frequency range
- 11 chips used for 1 or 2 Mbps, 8 chips for 5.5 and 11 Mbps

If the data bit was: “1001” and the

Chipping code is : 1=00110011011 0=11001100100

The transmitted data would be:

00110011011	11001100100	11001100100	00110011011
1	0	0	1

Frequency Hopping vs. Direct Sequence: A Summary on Interference Handling

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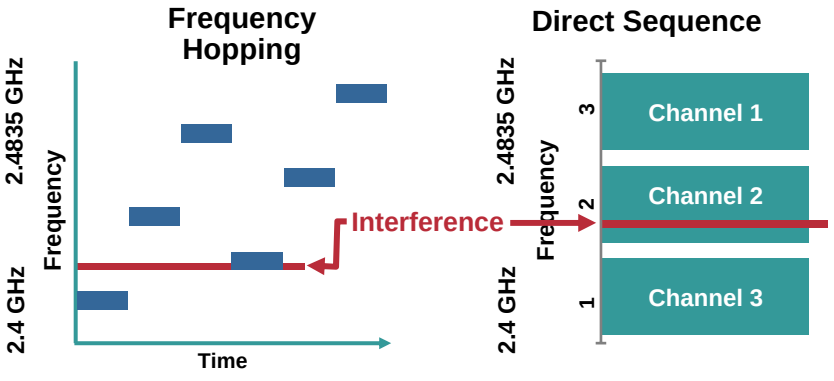

- FH system hops around interference
- Data may be decoded from redundant bits
- Can move to an alternate channel to avoid interference

Direct Sequence vs. Frequency Hopping (802.11b)

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	Direct Sequence	Frequency Hopping
Pros	**Faster—Up to 11 Mbps** **Greater Range**	**Multipath Resistant***
Cons		**Slower—2 Mbps max.** **Limited Range**

OFDM Is the Antidote for Inter-Symbol Interference

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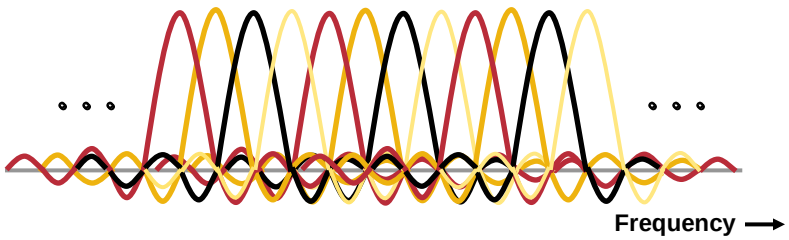
- **Ways to minimize inter-symbol interference:**
  - **Reduce the symbol rate, but data rate usually goes down too**
  - **Equalizers, but equalization is processor intensive**
- **Solution:**
  - **Transmit over multiple carrier frequencies in parallel (OFDM—Orthogonal Frequency Division Multiplexing)**



IEEE 802.11a

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- **Ratified as Standard in Sept, 1999**
- **Orthogonal Frequency Division Multiplexing (OFDM)**
  - **Data rates supported: 54, 48, 36, 24, 12, and 6 Mbps**
  - **Can "downshift" to lower data rates for longer range**
- **Compliant in some countries**
- **5 GHz band has more channels than 2.4 GHz band**
  - **UNII-1 + UNII-2 + UNI-3 = 12 non-overlapping channels**
  - **(vs. 3 channels for 2.4GHz) for greater scalability**
  - **Cisco's 1200 AP and cards 8 channels (UNII-1 + 2)**

Understanding the 5GHz Spectrum

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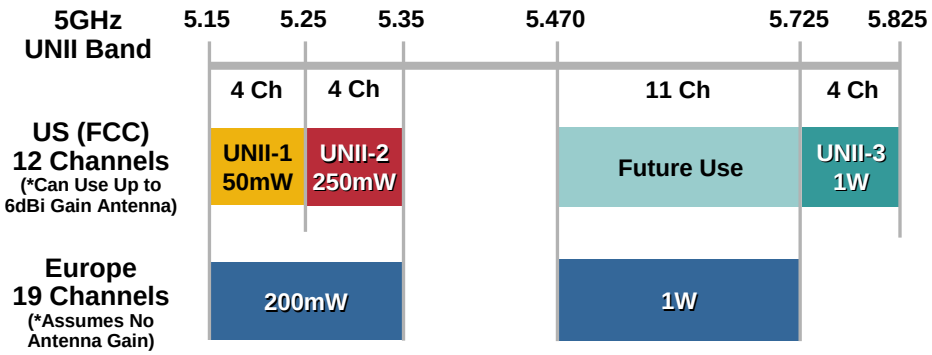

UNII-1: Indoor Use, Antenna Must Be Fixed to the Radio
UNII-2: Indoor/Outdoor Use, Fixed or Remote Antenna
UNII-3: Indoor/Outdoor; Fixed, Pt-to-Pt Can Employ Higher Gain Antenna

*If You Use a Higher Gain Antenna, You Must Reduce the Transmit Power Accordingly

802.11a UNII-1 and UNII-2 ISM Channels

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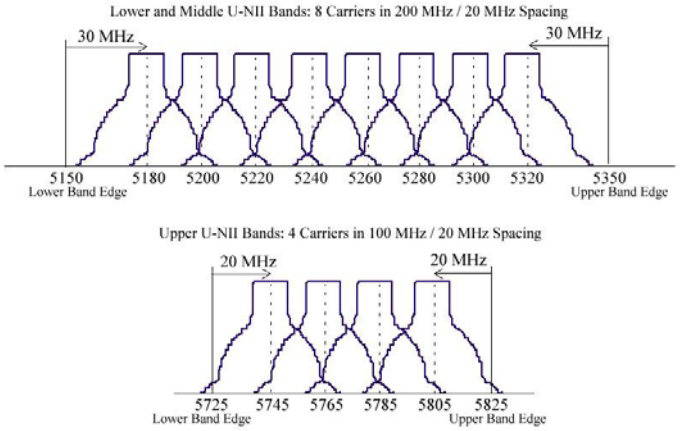
HIGH-SPEED PHYSICAL LAYER IN THE 5 GHz BAND

IEEE
Std 802.11a-1999



IEEE 802.11g

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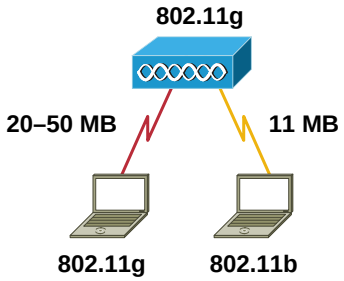
- **Ratified as standard in June, 2003**
- **Same frequencies as IEEE 802.11b (2.4 GHz)**
- **Backward compatible with 802.11b**
- **Orthogonal Frequency Division Multiplexing (OFDM)**
  - **Data rates supported: 54, 48, 36, 24, 12, and 6 Mbps**
- **Direct Sequence (802.11b backwards compatible)**
  - **Data rates: 1, 2, 5.5 and 11 Mbps**
- **Can "downshift" to lower data rates for longer range**



IEEE 802.11 Radio Summary

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	802.11b	802.11b	802.11g	802.11a
Ratified	1999	1999	2003	1999
Data Rates (Mbps)	1,2	1,2,5.5,11	1,2,5.5,11 and 6,9,12,18,24, 36,48,54	6,9,12,18,24, 36,48,54
Number of Non-overlapping Channels	Frequency Hopping	3	3	8 Indoors/ 4 Outdoors (Excluding Bridging)
Frequency Range (GHz)	2.402–2.483			5.15–5.35, 5.47–5.725*
Status	Obsolete	Worldwide Available		Limited Worldwide Availability

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Basic Radio Elements

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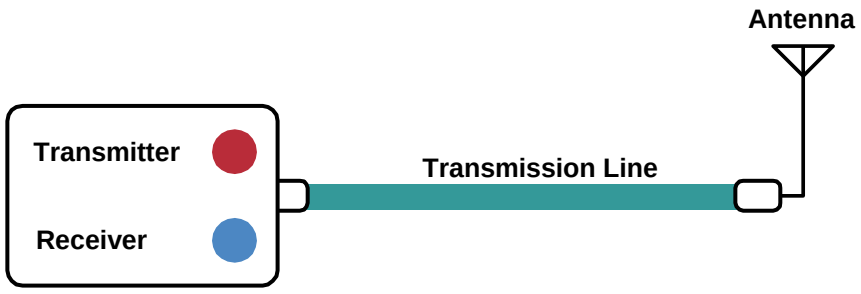

All Radio Devices
(Clients and Infrastructure)

dBx Definitions

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dB—deciBel, Used to Express the Ratio of Two Values, Usually Gain or Loss as the Ratio Between Two Powers:

$$dB = 10 \text{ Log}_{10} P2/P1$$

Power

- **dBm—deciBels referenced to 1 mW**
  - **0 dBm = 1 mW**
  - **P_{dBm} = 10 Log10 P_{dBm} /1mW)**
- **dBW—deciBels referenced to 1 W**
  - **P_{dBm} = 10 log10 (p_W/1W)**
  - **+ 30 dBm = 0 dBW**
  - **- 30 dBW = 0 dBm**

Gain

- **dBi—deciBels referenced to gain of an isotropic antenna**
- **dBd—deciBels referenced to gain of a dipole antenna**

Transmit Power

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- Power that the transmitter applies to the transmission line
- Also known as output power on some data sheets
- Typically expressed in mW for 802.11 devices
- Example: A wireless bridge has an output power of 30 mW; what power in dBm is applied to the transmission line?

  Tx Pwr = 10 Log_{10} (30) = 14.8 dBm

Transmission Line/Cable Loss

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- Directly proportional to the square root of the length of the cable
- Inversely proportional to the diameter of the cable, assuming similar construction materials
- Proportional to frequency: for a given length of cable, a higher frequency signal will always experience more loss than a lower frequency signal
- Not depend upon which direction the signal travels through the cable (transmitted signals lose the same percentage of strength as received signals)
- Typically assume .25 dB of loss per connector

Cable Type	2.4 GHz	5.8 GHz
	Loss (dB/100 ft.)	Loss (dB/100 ft.)
LMR400	6.7	10.8
LMR600	4.4	7.3

Receiver Sensitivity

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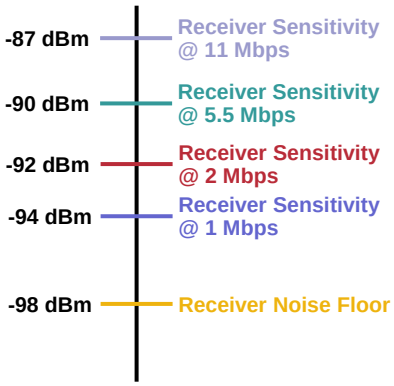
- Indication of the ability of the receiver to decode the desired signal
- The minimum received signal level, in the absence of interference, at which the desired signal can be decoded with a particular Bit Error Rate (BER)
- Typically expressed in dBm
- The more negative the value, the better
- Function of the data rate: the larger the data rate, the higher the receiver sensitivity



Antennas

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- Used to radiate transmitted signals and to capture received signals
- Types:
  - Directional antennas
    - Radiate/capture RF energy predominantly in one direction
    - Yagi, Parabolic Dish, Sector, Patch
  - Omnidirectional (or “Omni”) antennas
    - Radiate/capture RF energy equally in all horizontal directions, 360 degrees
- Characteristics:
  - Bandwidth
  - Beamwidth
  - Gain
  - Polarization
  - Cross polarization discrimination

Antenna Bandwidth

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- Band of frequencies over which the antenna is considered to perform acceptably
- The wider the range of frequencies → the wider the bandwidth of the antenna
- Antennas are provided pre-tuned by the manufacturer for use in a specified band segment
- Design trade-off: Wider bandwidths generally result in a poorer performing antenna relative to a similar antenna optimized for narrower bandwidth

Antenna Beamwidth

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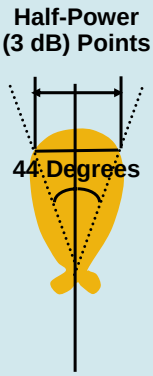
- Total width in degrees of the main radiation lobe at the angle where the radiated power has fallen by 3 dB (half-power) below that on the center line of the lobe
- In directional antennas the beamwidth is sometimes called half-power beamwidth
- Azimuth and elevation



Antenna Gain

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- Antenna gain is a fundamental parameter in radio link engineering
- Gain is an indication of the antenna's concentration of radiated power in a given direction
- Antenna gain is mostly expressed in dBi which is gain over an isotropic antenna
- Isotropic antenna is an ideal antenna which radiates in all directions and has a gain of 1 (0 dB) i.e. zero gain/zero loss

Linear Antenna Polarization

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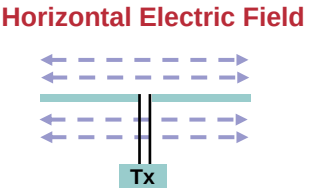
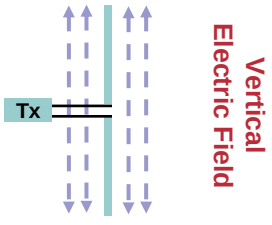
- Orientation of the electric field of the electromagnetic wave through space
- Horizontally polarized antenna → electric field in the horizontal plane
- Vertically polarized antenna → electric field in the vertical plane
- Both antennas in a link must have the same polarization to avoid additional unwanted signal loss



Horizontal Polarization



Vertical Polarization

Cross Polarization Discrimination

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- Defines how effectively an antenna discriminates between a signal with the correct polarization and the opposite polarization
- 20–25 dB isolation is typical
- Cross polarization can be used to great advantage when the two antennas belong to different links (such as at a hub), and you want to minimize any potential interference that one link might cause to the other

Antenna Gain vs. Frequency

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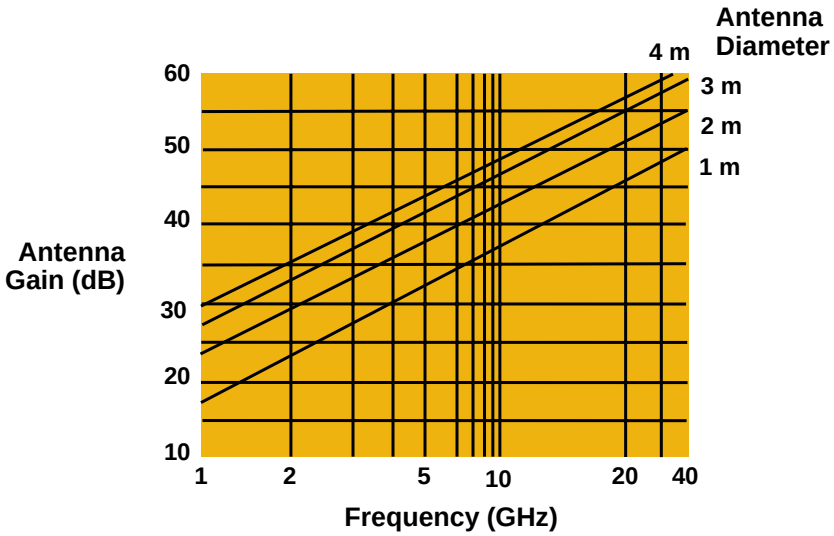

Effective Isotropic Radiated Power (EIRP)

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- EIRP—the energy radiated out of the antenna
- EIRPdBm = P_t + Gant - L_L

  P_t: output power of the transmitter in dBm

  G_{ant}: antenna gain in dBi

  L_L: transmission line loss in dB
- Example: A wireless bridge has an output power of 100mW; the cable connecting this transmitter to its antenna has a loss of 4.6 dB and the antenna has a 13.5 dBi gain; What is the EIRP in dBm? (100 mW = +20 dBm)

  $EIRP_{dBm}$ = +20 dBm + 13.5 dBi - 4.6 dB = +28.9 dBm

Effective Isotropic Radiated Power (EIRP)

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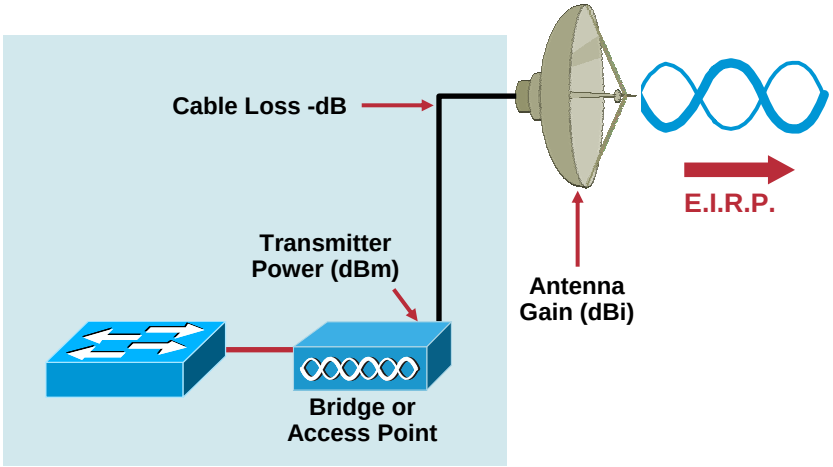

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Wireless LAN Active Network Components

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- **Stations (STA)—client devices**
  - **Mobile devices**
  - **Workgroup bridges* (proprietary client with Ethernet jack)**
- **Access Points (AP)—interconnects wireless clients and usually the wired network**
- **Bridges*—links 2 or more wired LANs**
  - **Can act as a superset of functions (Bridge, AP or repeater)**

Access Points and Bridges Are Layer 2 Ethernet Devices

***Proprietary Functionality**

Basic Service Sets (BSS)

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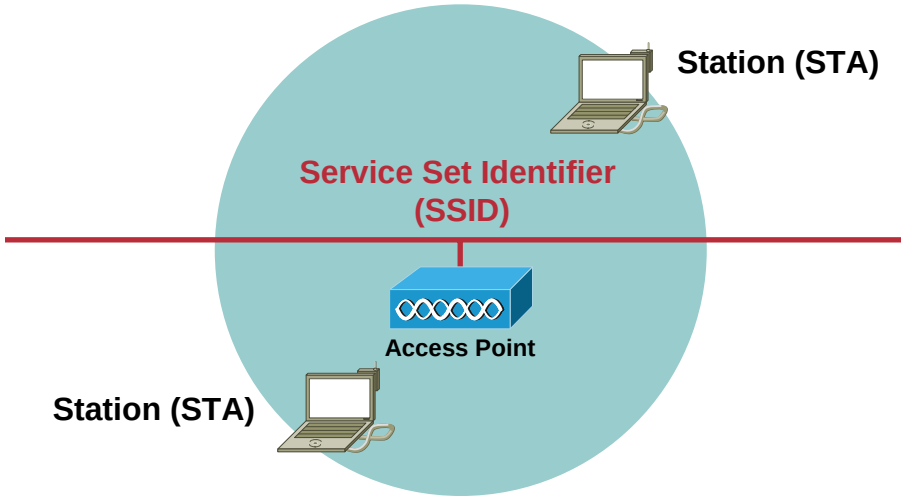

Independent BSS: Ad Hoc

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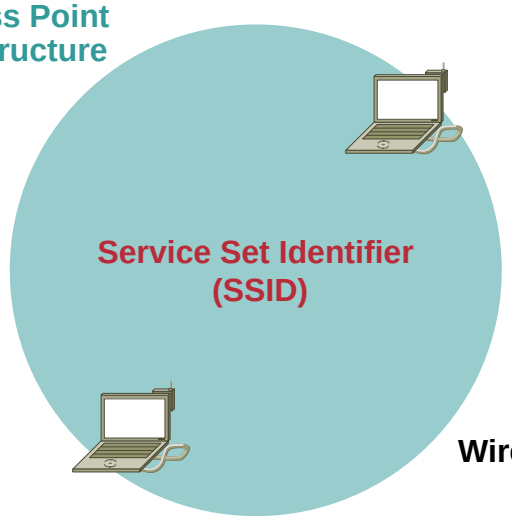
No Access Point
or infrastructure



Wireless Clients
ONLY

Distribution System (Multiple BSS) and Extended Service Set (ESS)

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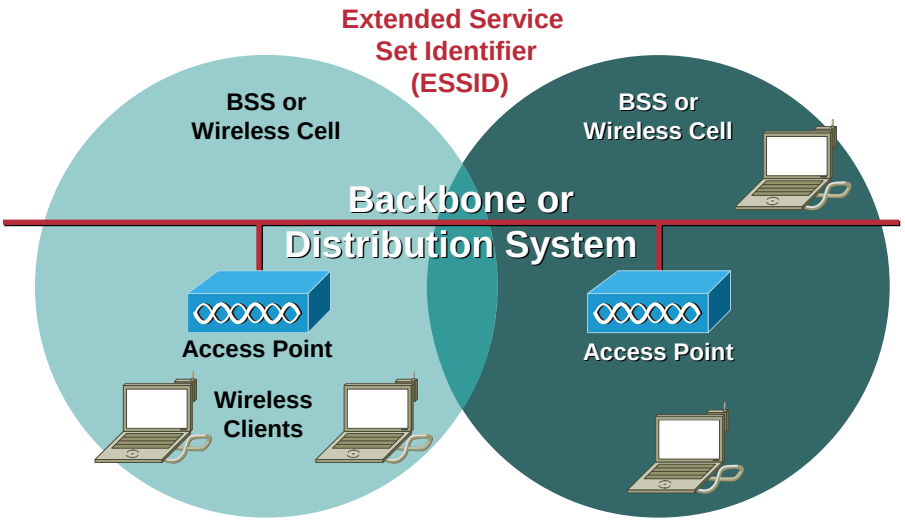

Association Process

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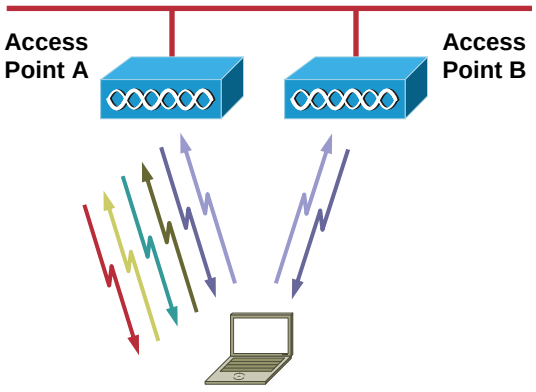

Initial Connection to an Access Point

Steps to Association:

- Stations associate with the infrastructure (AP, Bridge or repeaters)
- Which is chosen depends on various factors (algorithm that can use standard or extensions information)
- Roaming is typically done when the first association drops below certain levels

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Standards and Implementation Process

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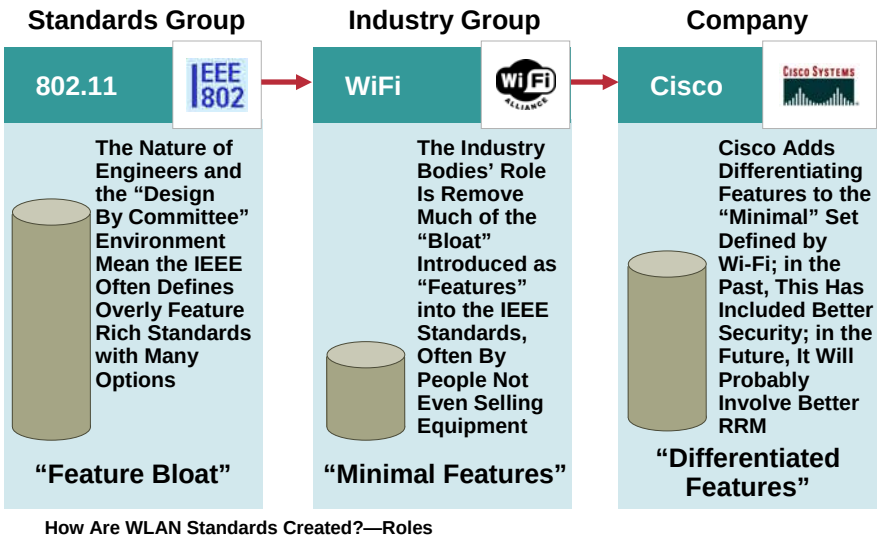

How Are WLAN Standards Created?—Roles

IEEE 802.11 Standard

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- 802.11 incorporates some basic features
  - Power management
  - Active scanning
  - Registration (association) with AP
  - Roaming
  - Link layer security

802.11 Media Access Control (MAC) Is Like Other IEEE 802 MAC

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- Carrier Sense Media Access/Collision Avoidance (CSMA/CA) with some retransmission capabilities
- Standard IEEE 802.3 Ethernet 48 bit address
- Common architecture for different 802.11 physical radio interfaces
- IEEE 802.11 appear to higher layers (Link Layer Control—LLC) like other IEEE 802 networks
- To meet some reliability assumptions, features are added to the Media Access Control (MAC) sublayers

Initial 802.11 Standards

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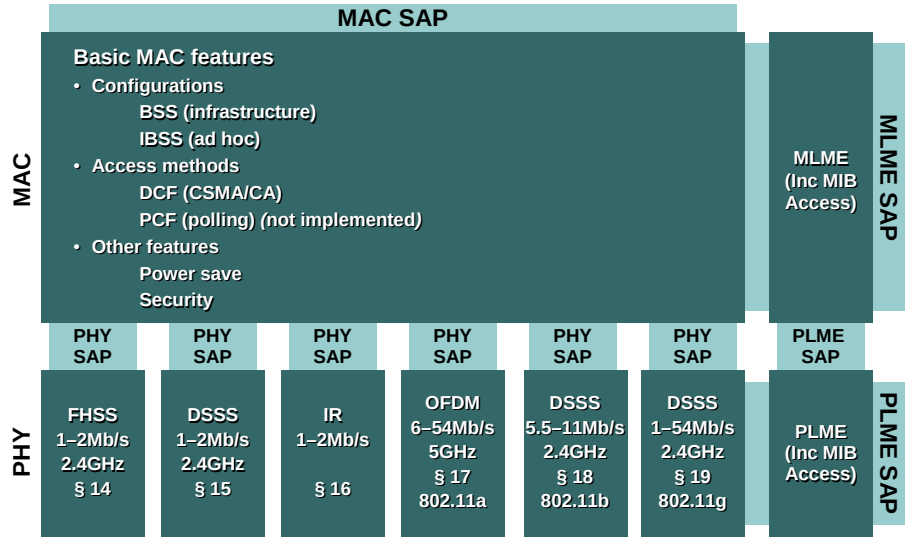

Physical Considerations

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- Supports different radio interfaces (a, b and g)
- A single channel is shared for transmission and reception
- Each radio interface can support different modulation techniques and data rates
- Can operate with many data rate users on the same frequency (for Direct Sequence); this impacts performance, but provides backwards compatibility or longer distances from the AP

Radio Robustness
Unicast vs. Multicast/Broadcast

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- Wireless medium is unprotected and less reliable than wired PHY
- Unicast packets
  - Stored and forward (retransmitted in case of radio errors, collisions and power saving)
  - Forwarded when roaming to another AP supporting Inter Access Point Protocol
  - Only unicast receivers can be fragmented
- Multicast/broadcast packets
  - Not retransmitted

WLAN "Alphabet Soup":
IEEE 802.11 Standards and Activities

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Standards

802.11-1999	Wireless LAN MAC and PHY Specifications
802.11a:	5GHz, up to 54Mbps
802.11b:	2.4GHz, up to 11Mbps
802.11d:	Multiple Regulatory Domains
802.11g:	2.4GHz, up to 54Mbps
802.11F:	Inter-Access Point Protocol (IAPP) (Best Practices Recommendation)
802.11h:	Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC)

Task Groups (TG)

802.11e	Quality of Service (QoS)
802.11i:	Security
802.11j:	Japan 5GHz Channels (4.9–5.1 GHz)
802.11k:	Radio Resource Measurement (RRM)
802.11m:	Maintenance
802.11n:	High Throughput (HT)

WLAN Working Groups IEEE 802.11 Activities

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- **802.11i:** Security
- **802.11e:** Quality of Service (QoS)

#1 Concern: Wireless LAN Security

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Lessons:

- Security must be turned on (part of the installation process)
- Employees will install WLAN equipment on their own (compromises security of your entire network)
- WEP keys can be easily broken (business and government users need better security)

Hacking into WEP


THE WALL STREET JOURNAL.

Hackers Can Penetrate Wireless Network

"War Driving"

Limitations of IEEE 802.11 Standard Security

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- Shared, static WEP keys
  - No centralized key management
  - Poor protection from variety of security attacks
- No effective way to deal with lost or stolen adapter
  - Possessor has access to network
  - Re-keying of all WLAN client devices is required
- Lack of integrated user administration
  - Need for separate user databases; no use of RADIUS
  - Potential to identify user only by device attribute like MAC address

IEEE 802.11 TGi

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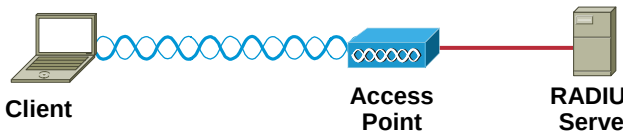
- Mutual authentication via IEEE 802.1x
  - Centralized database
  - Various authentication types
- Dynamic session key
- Message Integrity Check (MIC)
- Temporal Key Integrity Protocol (TKIP)
  - Per-packet key hashing
  - Initialization vector sequencing
  - Rapid re-keying
- Advanced Encryption Standard (AES) is optional (instead of RC4)

IEEE 802.1X Authentication Process

Cisco.com



Start

Request Identity

AP Blocks All Requests until Authentication Completes

Identity

Identity

RADIUS Server Authenticates Client

Client Authenticates RADIUS Server

Success

Success

Wi-Fi Protected Access (WPA)

Cisco.com

- All new “Wi-Fi” products after Aug.’03 MUST have WPA
  - Existing products are grandfathered
- Based on IEEE 802.11i-standard TKIP + 802.1X authentication
- There is a non-802.1X version of WPA for home use which is unsuitable for enterprises

WLAN Security Summary: Update for WPA for Home and Others

Cisco.com

Open Access

No Encryption, Basic Authentication

Public "Hotspots"

Basic Security

40-bit or 128-bit Static WEP Encryption, WPA

Home Use

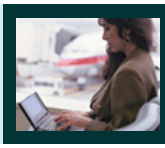
Enhanced Security

802.1x, TKIP Encryption, Mutual Authentication, Scalable Key Mgmt., etc.

Enterprise

Remote Access

Virtual Private Network (VPN)



Business Traveler, Telecommuter

ACC-1N00
9639_05_2004_c2

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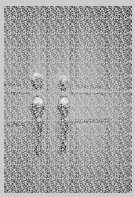

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ACC-1N00
9639_05_2004_c2

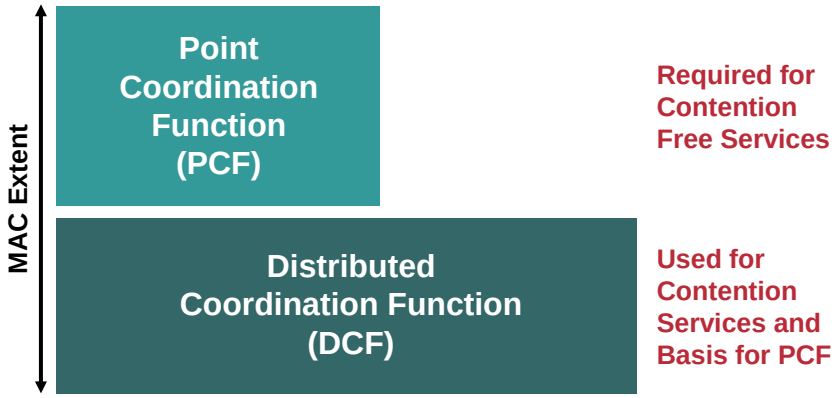
MAC Architecture

Cisco.com

- **Distributed Coordination Function (DCF)**
  - **Based on CSMA/CA (carrier sense multiple access with collision avoidance)**
- **Point Coordination Function (PCF)**
  - **Requires network infrastructure**
  - **Central point coordinator performs polling master and determines access priority**
  - **Not currently implemented**

MAC Architecture

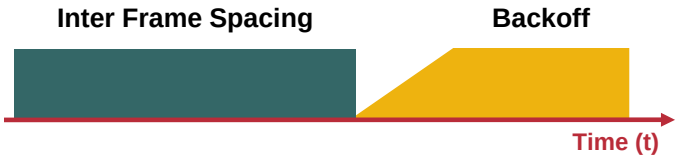
Cisco.com



Distributed Coordination Function (DCF)

Cisco.com

- No claims of QoS
- Uses Inter Frame Spacing and backoff for CSMA (Carrier Sense Multiple Access)
- Use Request to Send (RTS)/Clear to Send (CTS) for CA (Collision Avoidance)

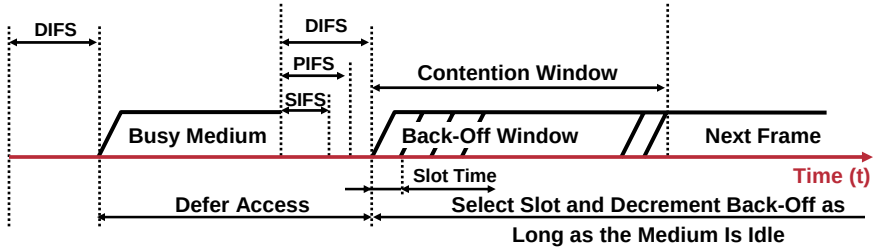


Distributed Coordination Function (DCF) and Inter Frame Spacing (IFS)

Cisco.com

- SIFS—Short Inter Frame Space
- PIFS—PCF Inter Frame Space
- DIFS—DCF Inter Frame Space

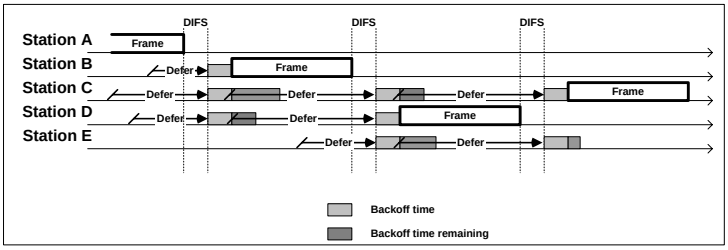
Immediate Access when Medium Is Free >= DIFS



Distributed Coordination Function (DCF)

Cisco.com

- The interframe space begins when the medium becomes free
  - SIFS, and PIFS are shorter than the DIFS
- Once the DIFS expires the random back off mechanism kicks in
  - First random backoff number is between 0 and CWmin
  - If retransmission is required CWmin doubles until it reaches CWmax



IEEE 802.11 TGe QoS (Quality of Service)

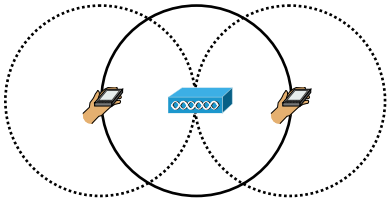
Cisco.com

- Two key issues
  - Prioritization
  - Service commitment

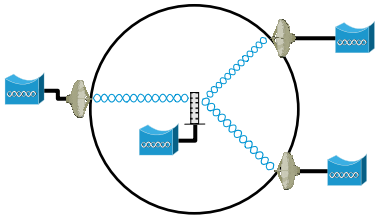
Hidden Nodes Are Also a QoS Issue

Cisco.com

- If you can't see a frame you can't avoid colliding
- RF characteristics make it hard to see all frames
- Hidden nodes usurp priority and break service commitments
- Only the AP can see and be seen by all nodes



Hidden Nodes Due to Range



Hidden Nodes Due to Directional Antennas

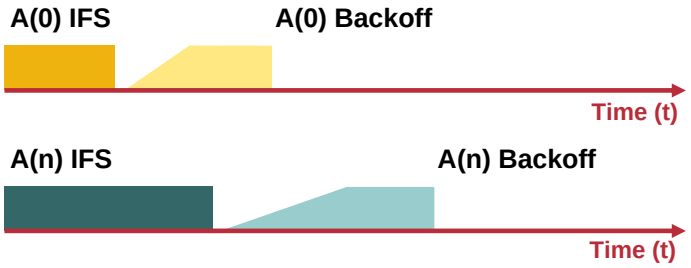
IEEE 802.11 TGe

Cisco.com

- To meet service commitments the AP needs to act as a coordinator
- There are two alternatives
  - PCF, that may be too restrictive and have scaling issues
  - Hybrid Coordination Function (HCF), that is more flexible; this is called HCF contention-based channel access (EDCF)

802.11 TGe
EDCF (Enhanced DCF)

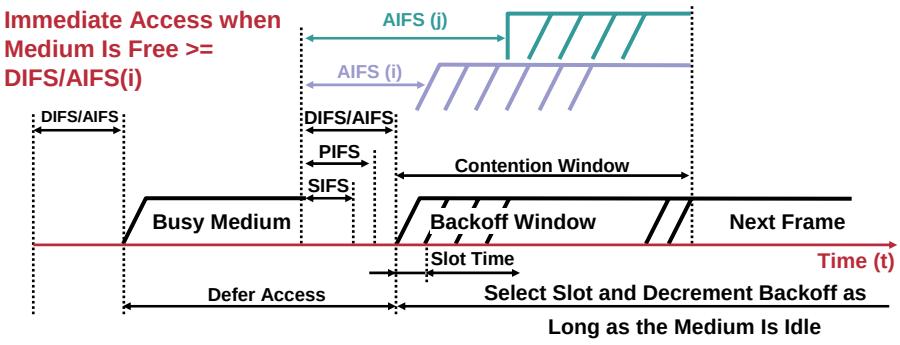
Cisco.com



- EDCF allows high priority traffic first access to the media, by altering the IFS, and the random backoff

802.11 TGe
EDCF (Enhanced DCF) Summary

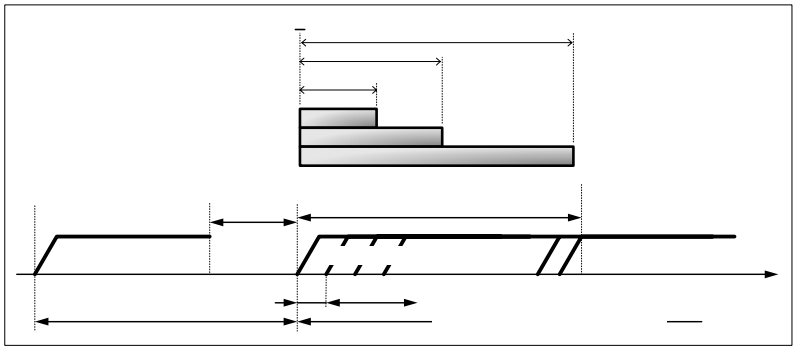
Cisco.com



- EDCF allows different priorities to get different IFS, allowing different priority
- CWmin and CWmax are manipulated to give different QoS
- Does not resolve hidden node issues

EDCF: CWmin and CWmax

Cisco.com



- CWmin and CWmax are manipulated to give different QoS

EDCF Limitations

Cisco.com

- EDCF provides a statistical benefit for higher classifications of traffic
- Does not guarantee higher classifications will not be delayed on a congested link
- Upstream EDCF doesn't work as well because of hidden nodes

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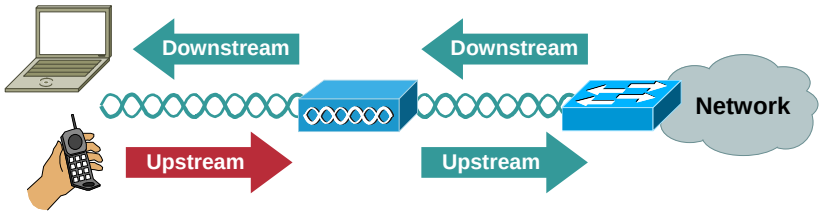
Upstream vs. Downstream WLAN QoS

Cisco.com

- WLAN AP can use EDCF to provide “soft” QoS for downstream traffic based on packet classification
- WLAN clients do NOT currently support an upstream QoS function

  Exception: Currently the only known upstream QoS implementation is the SpectraLink NetLink handsets



Downstream QoS Only

Bidirectional QoS

The Other Task Group Activities

Cisco.com

- 802.11h: DFS and TPC

  Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) as specified in CEPT ERC/DEC/99(23)
- 802.11j: Japan 5GHz Channels (4.9–5.1 GHz)

  Enhance 802.11a PHY and 802.11 MAC to allow operation in 4.9 GHz and 5 GHz bands in Japan
- 802.11k: Radio Resource Measurement (RRM)

  To provide consistent radio and network measurements to higher layers
- 802.11n: High Throughput (HT)

  High throughput extensions (>100MB/s at MAC SAP) in 2.4GHz and/or 5GHz bands

Agenda

Cisco.com

- Introduction
- Radio Considerations
- Basic Radio Elements
- WLAN Network Components
- Standards
- **Beyond the Standards**
- Reference Material and Other Technologies

Virtual LANs

Cisco.com

- **Permits multiple security policies on a single AP**
- **More efficient radio usage**
- **Can impact performance or design**
- **Caveats**
  - **Single Broadcast SSID**
  - **No support for Proxy Mobile IP (PMIP)**
  - **Up to 16 vlans**
  - **802.1q trunking**
  - **Other—review release notes**

VLAN Security Policy Example

Cisco.com

Group	VLAN	Security Solution	Network Access
Staff (Cisco Clients)	1	Cisco LEAP	Full
Students (Cisco Clients)	2	Cisco LEAP	Full Student Network
Students (Multi-Vendor Clients)	3	Static WEP/VPN	Limited/Full Student Network
Public Access	4	None	Internet Only

Agenda

Cisco.com

- Introduction
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- Beyond the Standards
- **Reference Material and Other Technologies**

IEEE Standards Documents

Cisco.com

- http://standards.ieee.org (for fee)
- http://standards.ieee.org/getieee802/ (standards are available 6 months after release for free)

Wireless LAN Compatibility Association

Cisco.com

Wi Fi ® CERTIFIED

http://www.wi-fi.org

Wi-Fi Alliance

For More Wireless Information…

Cisco.com

Other Networkers Breakout Sessions:

- ACC-1011: Introduction to Wireless Mobile Networks
- ACC-2010: Deploying Mobility in High Availability Wireless LANs
- ACC-2011: Deploying Secure Wireless LANs
- ACC-2012: Design and Deployment of Outdoor Wireless LAN/Bridging Networks
- ACC-2013: Wireless LAN and Cisco Voice Deployment Recommendations
- ACC-2014: Deploying Public Wireless LANs
- RST-2304: Introduction to Mobile IP

Q AND A

THANK YOU

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