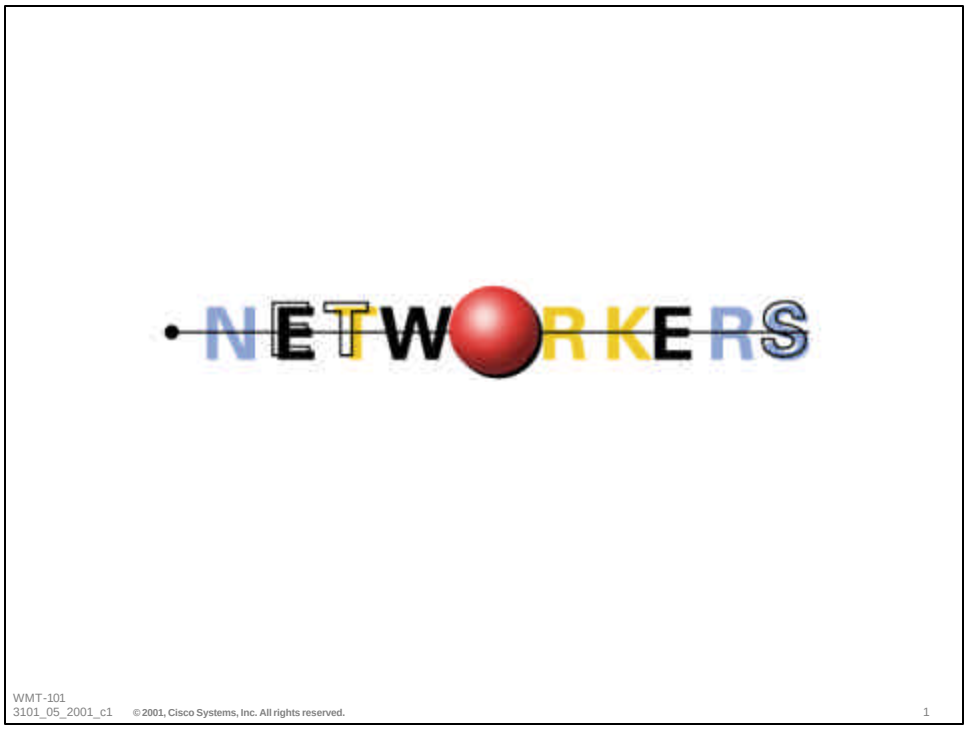

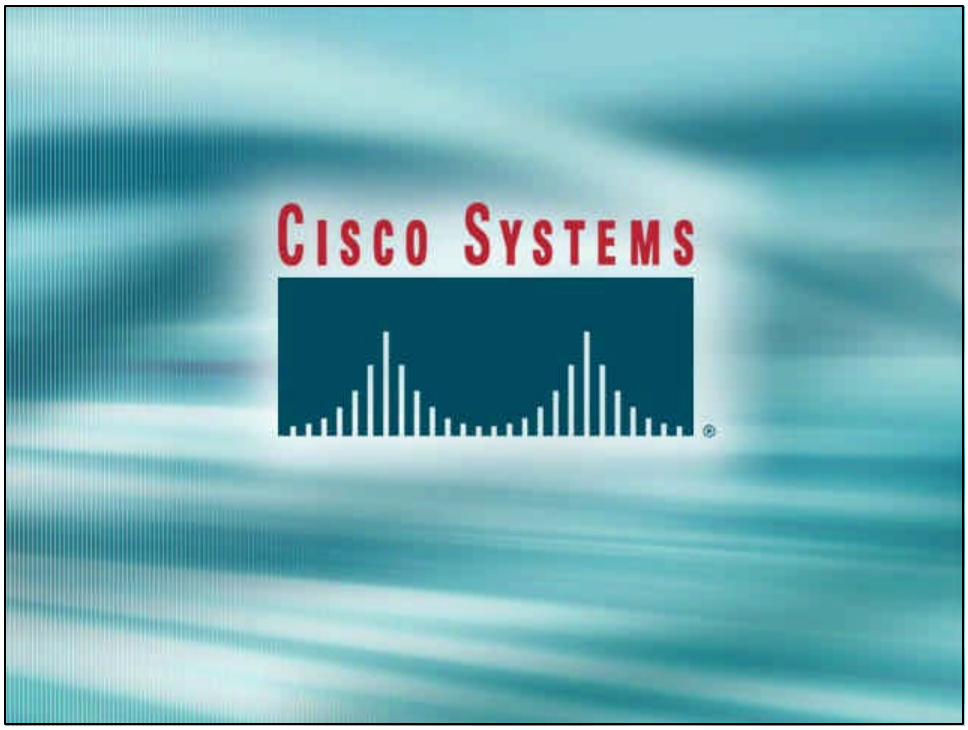

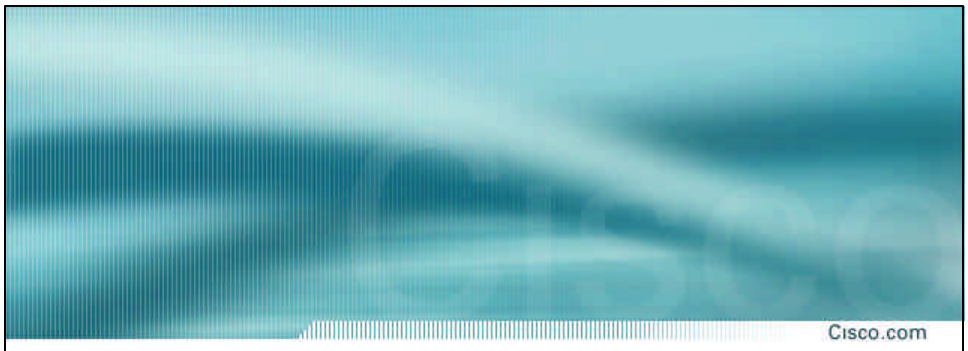

Introduction to Wireless Technology

Session WMT-101

Agenda

- Requirements and Marketplace
- Basics of Radio Technology
- Fixed Wireless Overview
- Mobile Wireless Overview
- Wireless LAN Overview
- Q&A

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Requirements and Marketplace

Wireless Data Network Drivers

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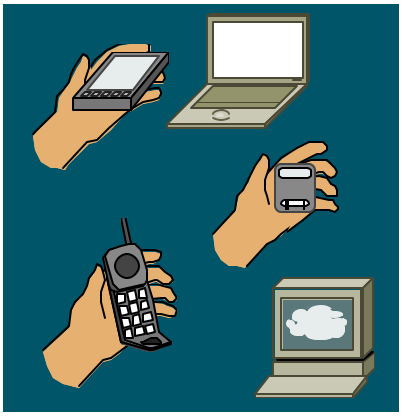
- Information access
- PDAs
- Network computers
- Alpha paging, information distribution
- Web
- Audio and video



What Is the Interest in Wireless?

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- No more cables…
- Mobility
- Increased productivity
- Competition
- Flexibility

Some Wireless Data Solutions

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- Field service—dispatch, parts/order, electronic signature, package tracking
- Public safety—parking enforcement, ambulance-hospital links, anti-theft
- Financial—news, brokerage, pricing
- Telemetry—health care, vending machines, alarm systems, energy
- Identification—inventory in warehouse and stores, anti-theft

Cisco's Wireless Data Initiatives

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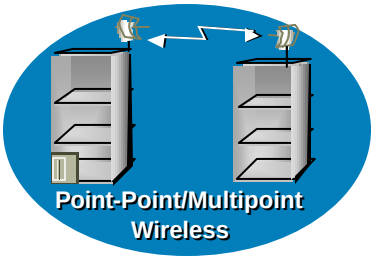

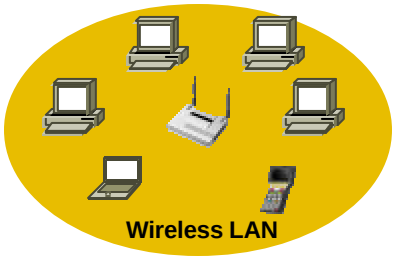

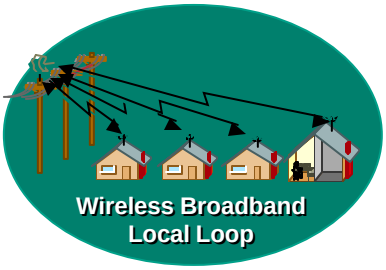

Emerging and Existing Wireless Data Technologies

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- Wireless LAN and PAN: IEEE 802.11, Bluetooth, HomeRF
- Fixed wireless: MMDS, LMDS, satellite dish, microwave, optical
- Mobile wireless: PCS, GSM, CDMA, TDMA, 2.5 G, 3G

Wireless Data Networks

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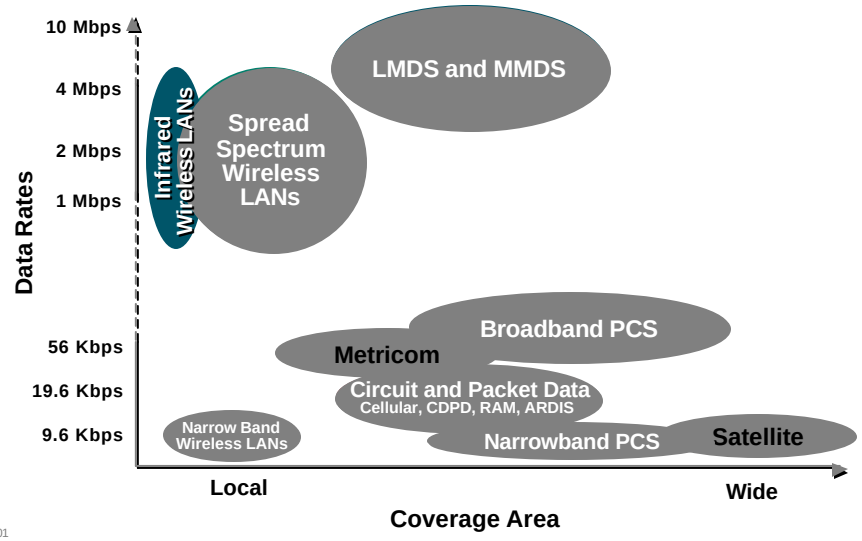

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Introduction to Radio Spectrum

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Radio Basics

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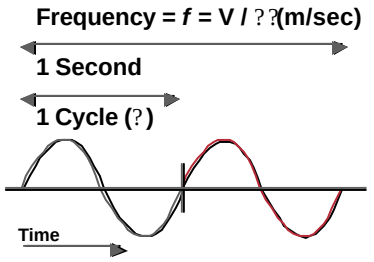
- Waves are measured by frequency of movement
- Radio devices operate in bands or a designated frequency range



2 Cycles in 1 Second = 2 Hertz

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The Electromagnetic Spectrum

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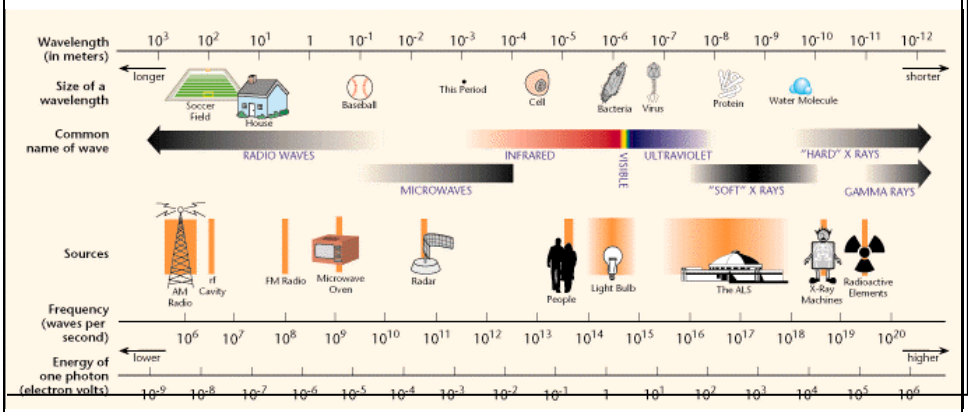

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Regulation of Wireless

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- Radio Frequency (RF) is a scarce and shared resource
  - Each country regulates the use of the radio spectrum by a government agency
    - In the U.S. it is the F.C.C. that allocates spectrum for use and resolves conflict disputes)
  - Internationally coordinated through the ITU (International Telecommunications Union)

Spectrum Licensing

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- Spectrum can be allocated for specific users
  - Civil, government or military
  - Acquired via auction or “beauty contest”
- Unlicensed or Industrial, Scientific and Medical (ISM) bands
  - In most countries does not require a license, but may require registration
  - Needs to conform to power and other parameters to reduce interference

What Is Spread Spectrum RF Technology?

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- Data sent over the air waves
- Two-way radio communications
- Same radio frequency for sending and receiving
- No licensing required

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Access Spectrum Availability and Comparison

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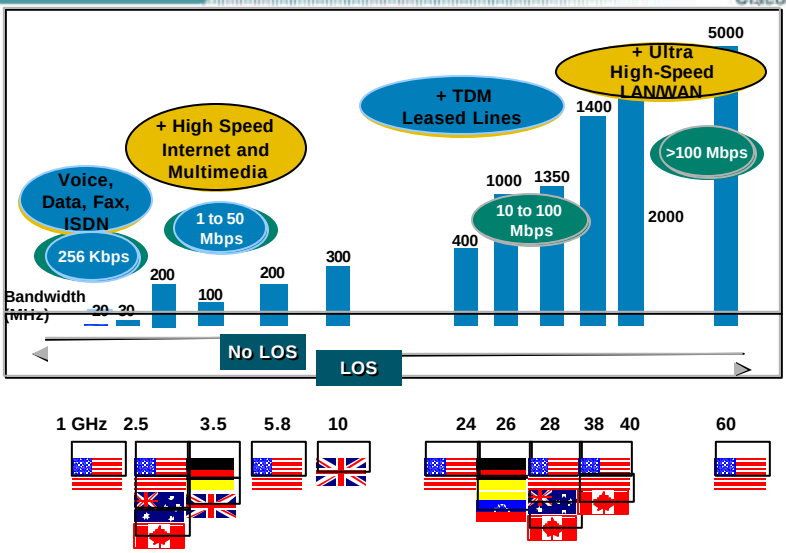

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Spectrum Suitability

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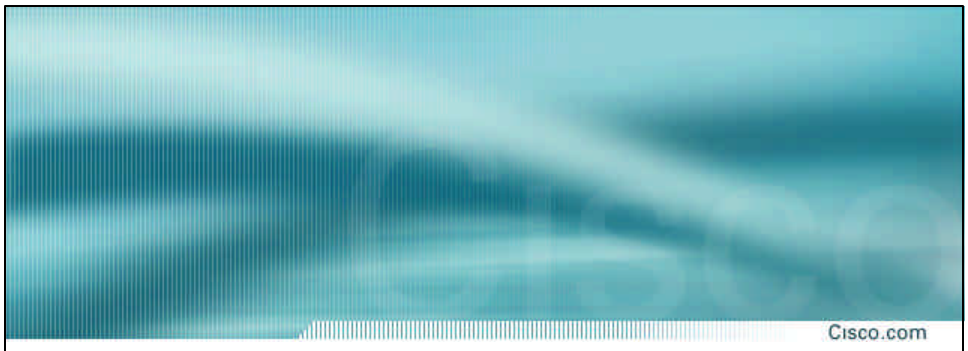
- **Less than 6 GHz**

  Long range (up to 45 km), non Line of Sight (LOS), not affected by weather

- **Greater 6 GHz**

  Line of Sight (LOS), short range (1–5 km), affected by weather, more spectrum (1 Ghz)



Wireless Basics

Wireless Basics

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- Signals
- Modulation
- Access technology
- Antenna theory
- Range
- Interference

Data Bandwidth Depends on...

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- Frequency bandwidth
- Modulation techniques

Transmitting a Signal

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- The goal of sending data over RF is to get information across with as much data as possible, sending it as far as possible and as fast as possible
- More data can be placed on a signal in one of two ways:
  - More frequency used
  - Complex modulation

Signal Processing

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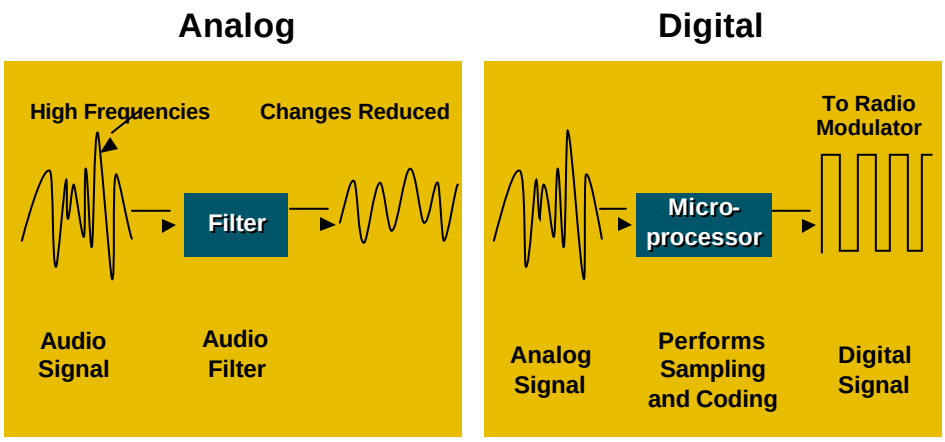

Radio Modulation

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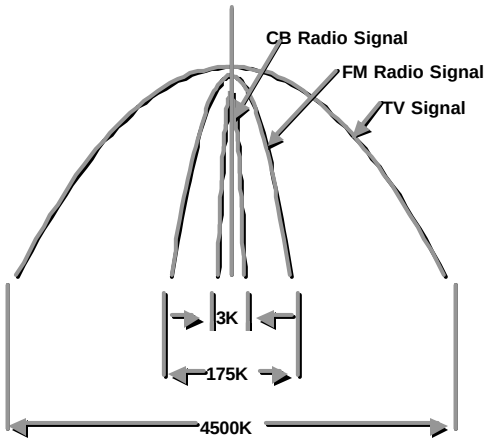
- More information =
- More frequency spectrum used



Bandwidth in KHz

Radio Modulation

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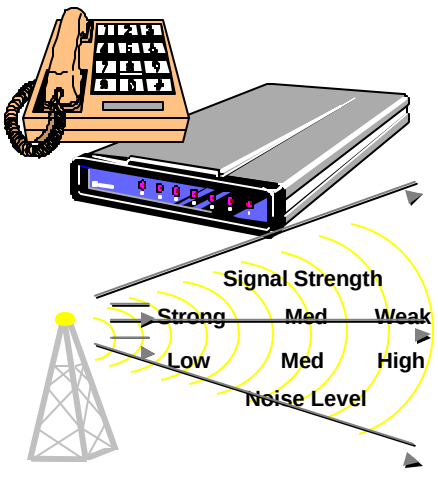
- High speed modem compresses the data to use the same line as an old 300 baud modem; this means the same bandwidth is available
- 56K modems require a better (quieter) phone line to communicate at the higher speed
- If there is noise on the line, the modem will drop down in speed to connect
- Mode noise, less speed
- Complex modulation requires better signal strength, therefore less coverage is available



System Access Technology

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- Frequency division multiple access
- Time division multiple access
- Code division multiple access
- Frequency hopping

Each Technique Varies in Its Efficiency (Throughput), Interference and Range; Depends on Application and Environment

TDMA and FDMA

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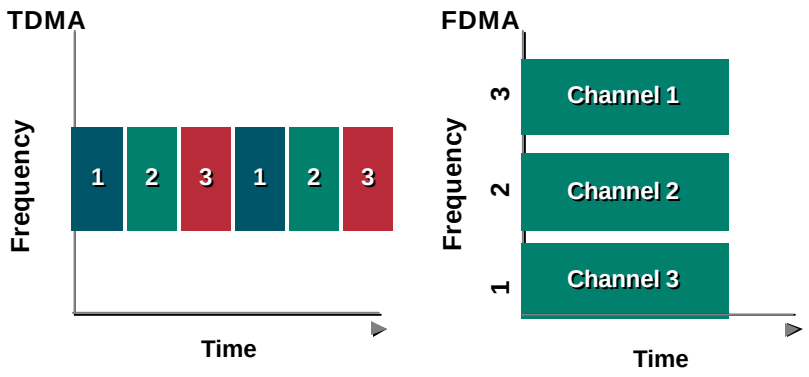

CDMA

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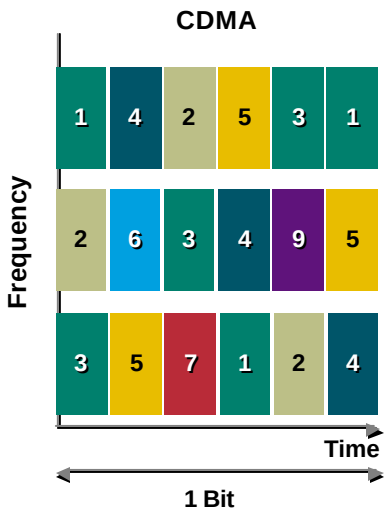

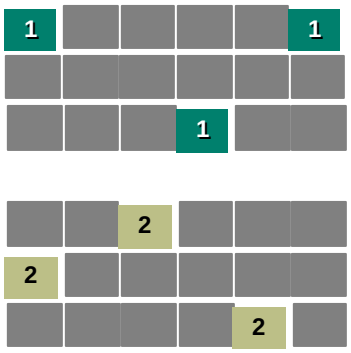

A long Code is Used to Generate a Mask for Each Radio

Typically a Code is Transmitted on a Separate Channel

Frequency Hopping

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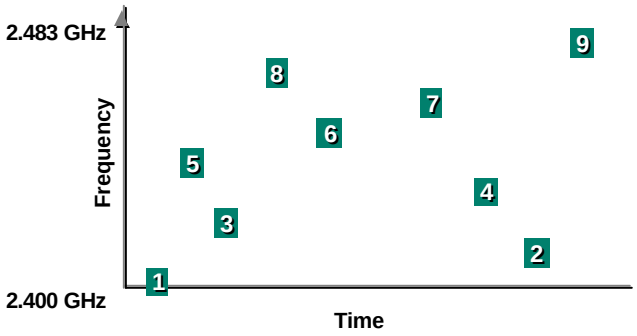

- **79 channels, 1 MHz each**
- **Changes frequency (hops) at least every 0.4 seconds**
- **Synchronized hopping required**

Antenna Concepts

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Coverage Area

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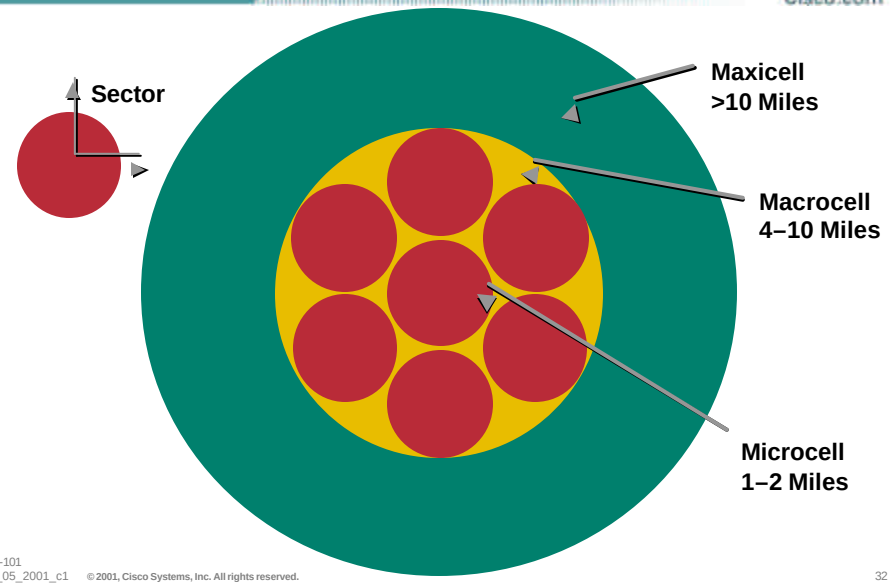

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Antenna Concepts

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- **Directionality**
  - **Omni (360 degree coverage) directional**
  - **Directional (limited range of coverage)**
- **Gain**
  - **Measured in dBi and dBd. (0 dBd = 2.14 dBi)**
  - **More gain means more coverage—in certain directions!**
- **Polarization**
  - **Antennas are used in the vertical polarization**

Antenna Gain

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- **In life you never get 'something for nothing,' the same is true in antenna gain**
- **If the gain of an antenna goes up, the coverage area or angle goes down**
- **Coverage areas or radiation patterns are measured in degrees**
- **These angles are referred to as beamwidth, and have a horizontal and vertical measurement**

Antenna Theory

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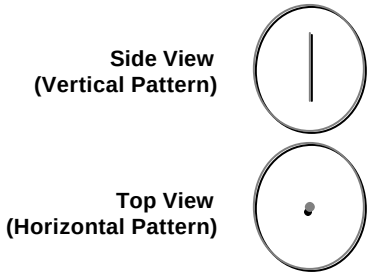
- A theoretical antenna (Isotropic) has a perfect 360 degree vertical and horizontal beamwidth
- This is a reference for all antennas



Antenna Theory—Dipole

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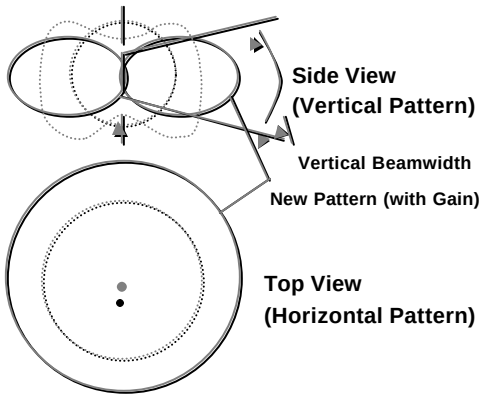
- To obtain omnidirectional gain from an isotropic antenna, the energy lobes are 'pushed in' from the top and bottom, and forced out in a doughnut type pattern
- The higher the gain smaller the vertical beamwidth, and the more horizontal lobe area
- This is the typical dipole pattern; gain of a dipole is 2.14dBi (0dBd)



High Gain Omnidirectionals

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- High gain omnidirectional antennas will create more coverage area in far distances, but the energy level directly below the antenna will become lower, and coverage here may be poor

Area of Poor Coverage Directly Under the Antenna

Directional Antennas

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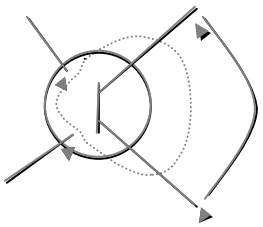
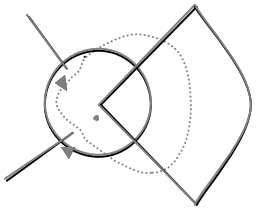
- For directional antennas the lobes are pushed in a certain direction, causing the energy to move be condensed in a particular area
- Very little energy is in the back side of a directional antenna



Side View
(Vertical Pattern)



Top View
(Horizontal Pattern)

Cables Lengths Example for Aironet Antennas

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- Coax cable presents a loss for the RF signal
- 2.4 GHz maximum recommended length is 100 feet—with the new cable

Loss Factor	Cable
20 Ft. Cable	N/A
50 Ft. Cable	2.2
75 Ft. Cable	3.3
100 Ft. Cable	4.4

Diversity and Multipath

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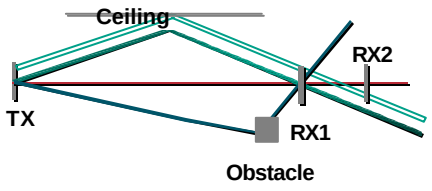
- In a multipath environment, signals null points are located throughout the area
- Moving the antenna slightly will allow you to move out of a null point and receive the signal correctly

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



Multipath

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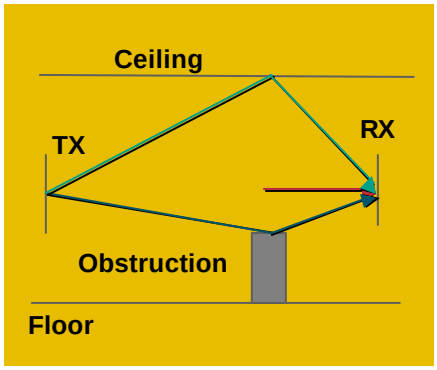

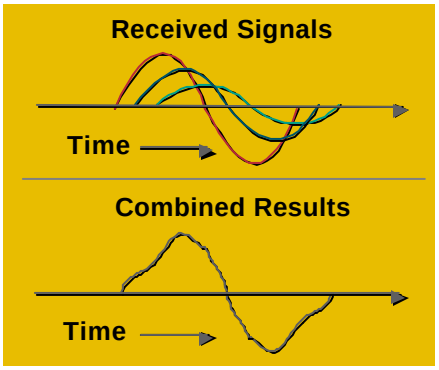

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Multipath and FH

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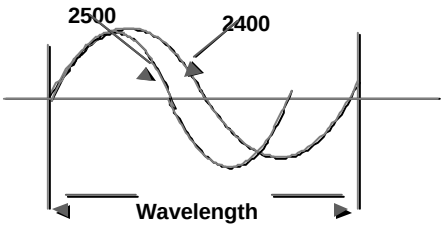
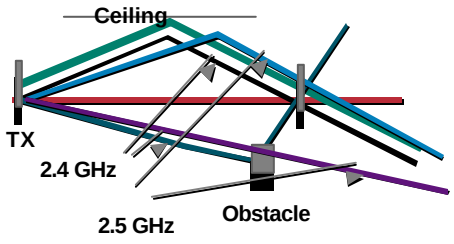
- The distance an RF wave travels, how it bounces and where the multipath nulls occur are based on the wavelength of the frequency
- As frequency changes, so does the wavelength
- Therefore as frequency changes, so will the location of the multipath null





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Multipath (Cont.)

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- Multipath signals can cause high RF signal strength, but poor signal quality levels
- Bottom line
  - Low RF signal strength does not mean poor communications
  - Low signal quality DOES mean poor communications

Range Depends on...

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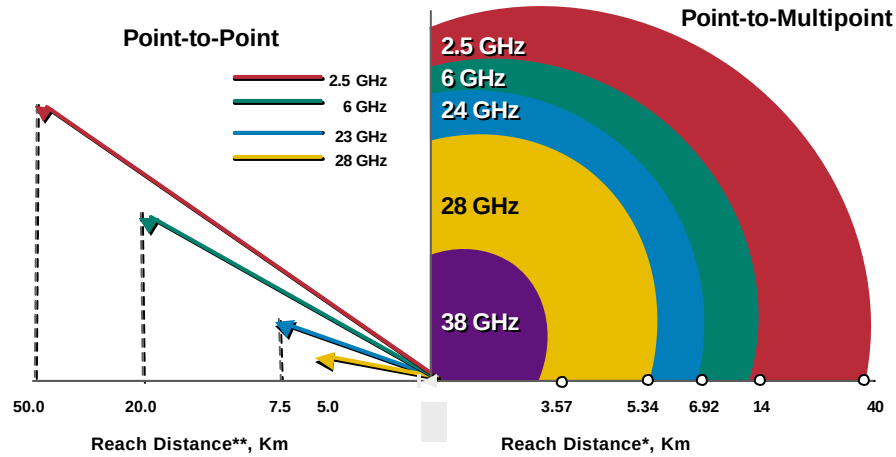
- Frequency
- Transmit power
- Radio sensitivity
- Processing gain from access technique and redundancy
- Interference effects (-)

Reach Distance from Hub



**Assume Rain Zone K, 6cm Antennae for 99.995% Average Availability, Vertical Polarization

*Assume Rain Zone K, Single Channel per Transmitter, Same Power, Same dB Gain Antennas for All Frequencies

Interference Is Caused By...

- Obstacles like buildings, trees, walls that absorb or refract signals
- Atmospherics like rain, fog, solar spots
- Other electromagnetic devices

Interference Can Appear as Noise or Can Cause Loss of Signal Strength

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Fixed Wireless Overview

Cisco's Fixed Wireless

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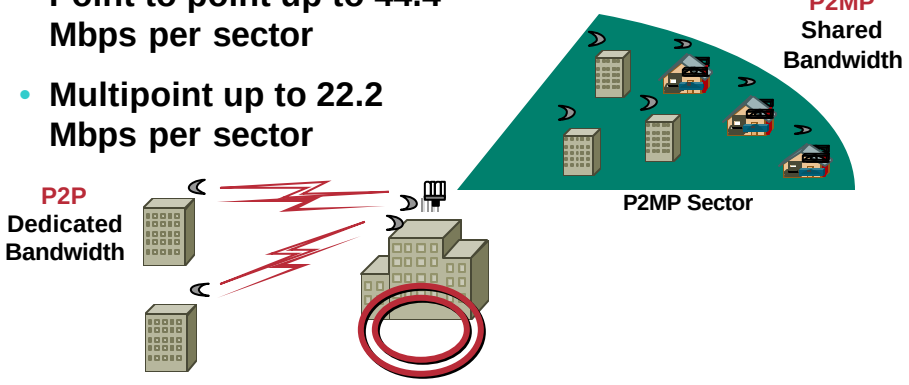
- Provides last mile access
- Point to point up to 44.4 Mbps per sector
- Multipoint up to 22.2 Mbps per sector



Point to Multipoint Features

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- Small-cell and single-cell deployment
- Open interfaces—part of Cisco's dedication to open architectures
- Highly efficient MAC protocol, based on the industry standard DOCSIS MAC

Choice of Frequencies

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	MMDS (Multichannel Multipoint Distribution System)	U-NII (Unlicensed)
Spectrum Band	2.5 Ghz	5.7 Ghz
Channel Size	1.5 MHz, 3 MHz, or 6 MHz	1.5 MHz, 3MHz, or 6 MHz
	Coverage	
Point-to-Point	25 Miles (Approximately)	20 Miles (Approximately)
Multipoint	25 Miles (Approximately)	7 Miles (Approximately)
LOS and NLOS	Yes	Yes
License Required	Yes	No

Headend and Subscriber Overview

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- Headend can support one downstream and four upstream channels
- Subscriber supports one downstream and upstream channel pair
- Downstream and upstream channels may have bandwidths of 1.5, 3 and 6 MHz
- Headend and subscriber both support antenna diversity

Point-to-Point for Campus Networks

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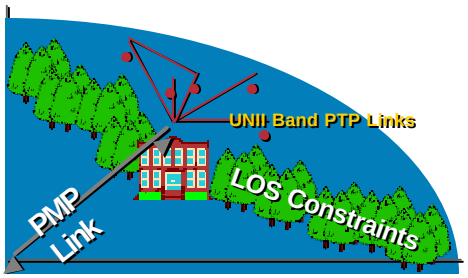
- PTP links in UNII bands available to extend PMP coverage beyond LOS constraints
- Intra-campus data can be transported without using up cell capacity



90º Sector of PMP Network

Point-to-Multipoint Features

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- Small-cell and single-cell deployment
- Multipath robustness
- Adjusts transmit power of subscribers to maintain desired signal levels at headend
- Headend and subscriber both support antenna diversity

Point-to-Point Network Overview

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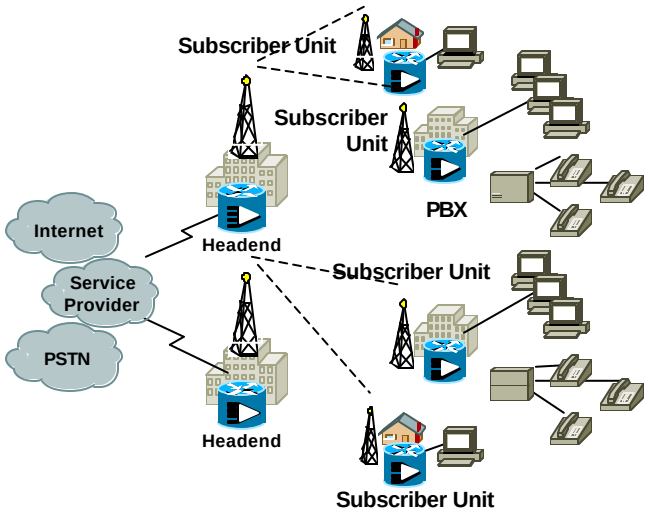

VOFDM and Fixed Wireless

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- **Building New World Networks with Unlicensed Wireless Spectrum**

  (http://www/warp/public/cc/pd/witc/wt2700/2750/bbfw_wp.htm)

- **Cisco's Broadband Wireless Solutions**

  (http://www/warp/public/cc/pd/witc/wt2700/2750/brwis_ai.htm)

Fixed Wireless VOFDM Association

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broadband wireless internet forum

www.bwif.org

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Mobile Wireless Overview

Why Is It Called Cellular?

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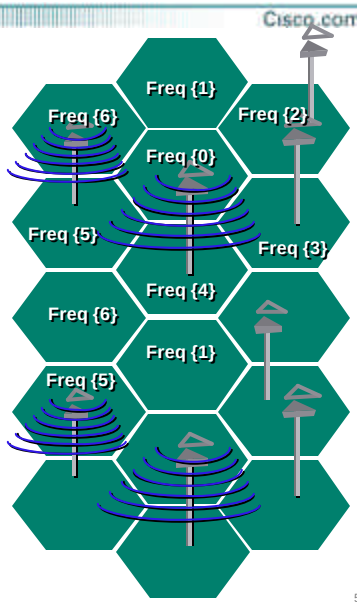
- Originally one set of frequencies across a metro
- Limited number of simultaneous conversations
- Idea was to allocate a subset of frequencies to small areas or"cells"
- Allowed re-use of frequency sets as long as not adjacent
- Vastly increased capacity
- Shrink cell sizes to add even more
- Mobility (call hand-off) required
- Roaming



Radio Frequencies

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- Licenses are required
- Most common frequency bands are 800, 900, 1800 and 1900 Mhz
- No single worldwide standard for roaming
  - Some regions or countries use a single standard and frequencies (mandated)
  - Some countries use more than one standard and frequencies (open market or less regulated)

Spectrum Allocation for Mobile Wireless Services

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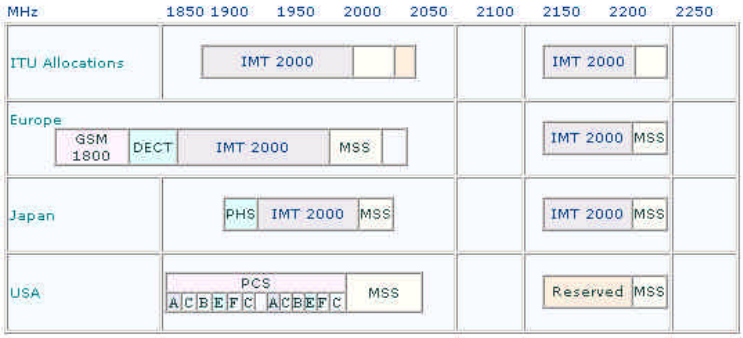

- GSM, PHS, and PCS are the current systems used for digital wireless communications in Europe, Japan, and the U.S., respectively
- IMT 2000 (International Mobile Telecommunications) is the official term referring to 3G services

The Mobile Wireless History and Roadmap

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	1st Generation	2nd Generation	3rd Generation (3G)	Post 3G
Deployment	1980s	1990s	Starting 2001	Starting 2003-4
Technology	Analog-FDMA	Digital -Mostly TDMA and CDMA Based	Packet/IP	All-IP
Services	Ubiquity-Voice	Ubiquity Services—Voice, SMS,Circuit and Basic Packet Data	Advanced Packet Data	Multimedia
Air Interfaces	AMPS-NMT	GSM, IS-136, IS-95, PDC, ...	EDGE, W-CDMA, cdma2000, 1xEV, ...	Not Defined Yet
Data Rates		<20 kbps	384 kbps (Typically) -2MBPS (Marginally)	<2 Mbps

Possible Set of Applications

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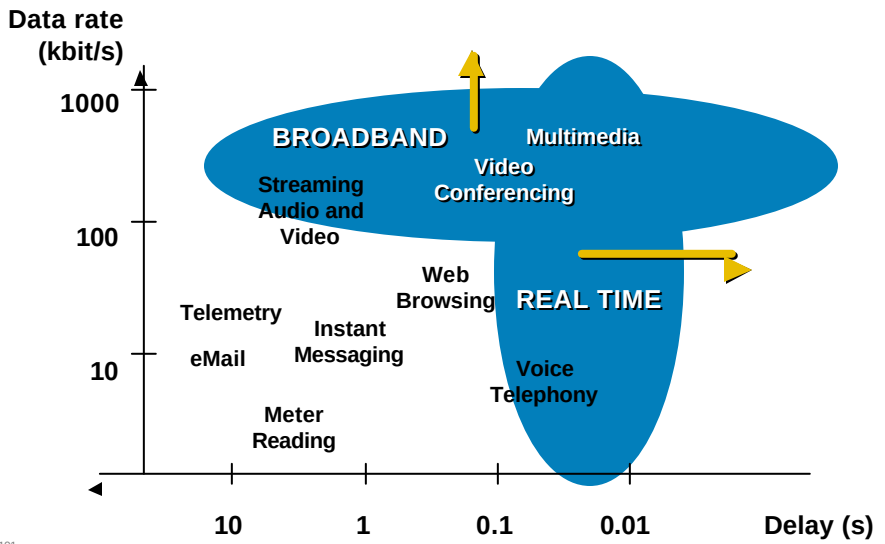

3G Mobile Terminals

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Feature Phone:
Voice Centric Design and Features
Limited WAP-Browsing and Text Entry Capabilities

Smart Phone:
Voice and Data
Full-Blown WAP-Browsing
Basic PDA-Like Capabilities

Multimedia Phone:
Color Video and Rich
Media Capabilities

PDA:
Data Centric
Basic Voice Support

PC Card:
For Laptops

Wireless Architecture Today

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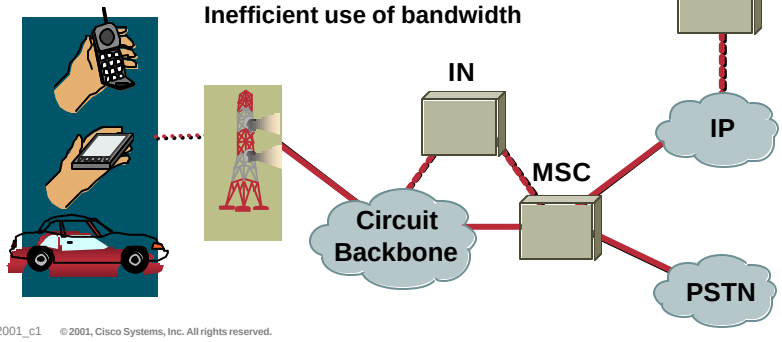
- **Proprietary**
  Slower rate of innovation and higher costs
- **Hierarchical**
  Bottlenecks
- **Circuit—switched**
  Inefficient use of bandwidth



Mobile Wireless Internet Architecture in the Future

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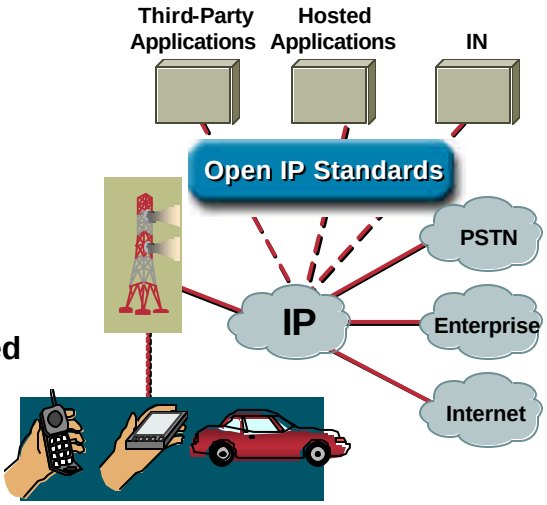
- **Open interfaces**
  - Service and transport independence
  - Services ecosystem
- **Distributed**
  - Scalable
- **Packet based**
  - Bandwidth efficient
- **Options for integrated services**



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The Road to IP 1st Phase: Circuit Data Services

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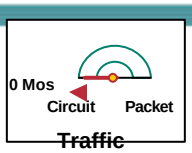

- BSS routes the call to the MSC
- MSC recognizes the call as data and initiates a V.110 call setup to the PSTN-SS7 network
- MSC packs the raw asynchronous data into the 64K ISDN data channel
- Call is routed to Cisco AS5300 or AS5800 universal access servers capable of terminating the V.110 call

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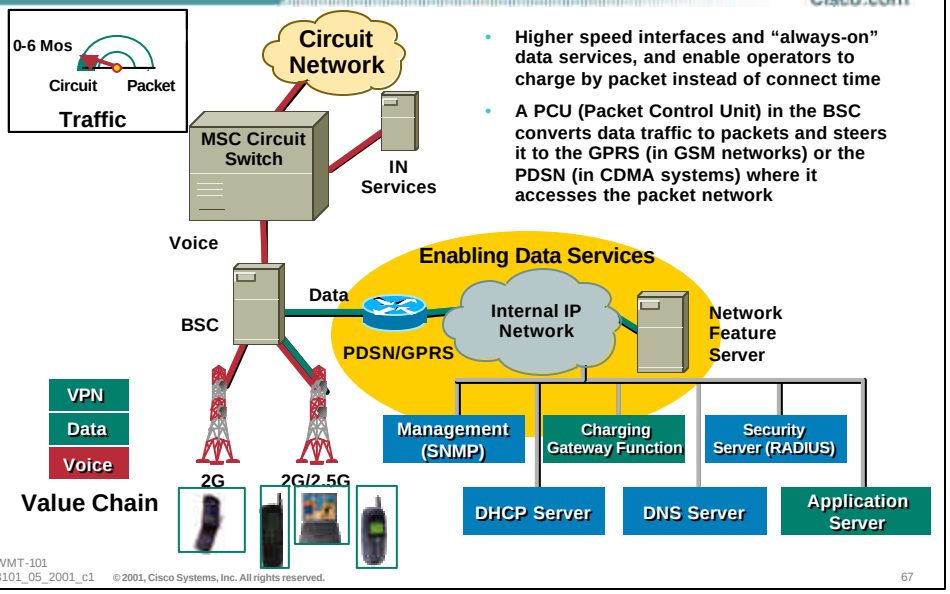
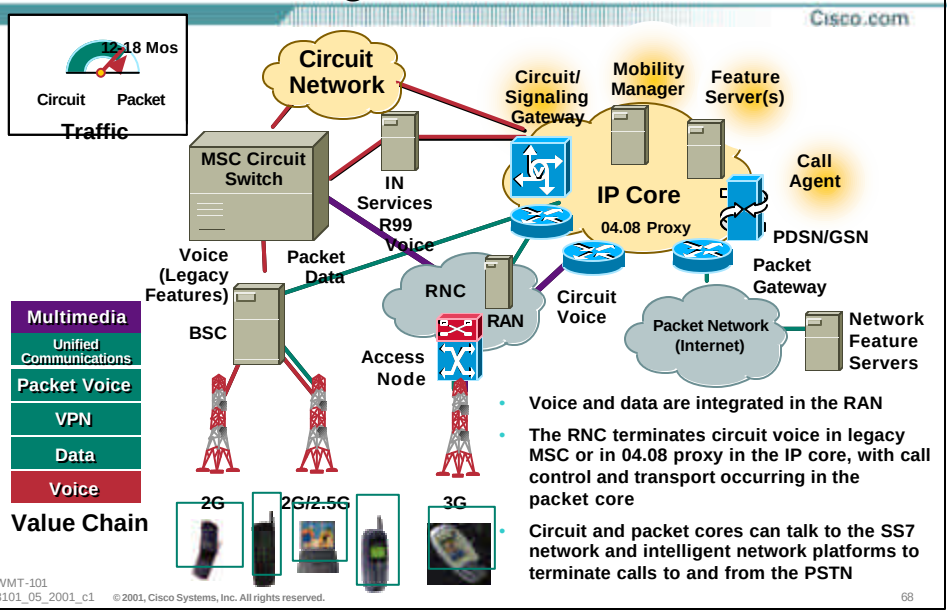
The Road to IP
2nd Phase: Packet Data Services



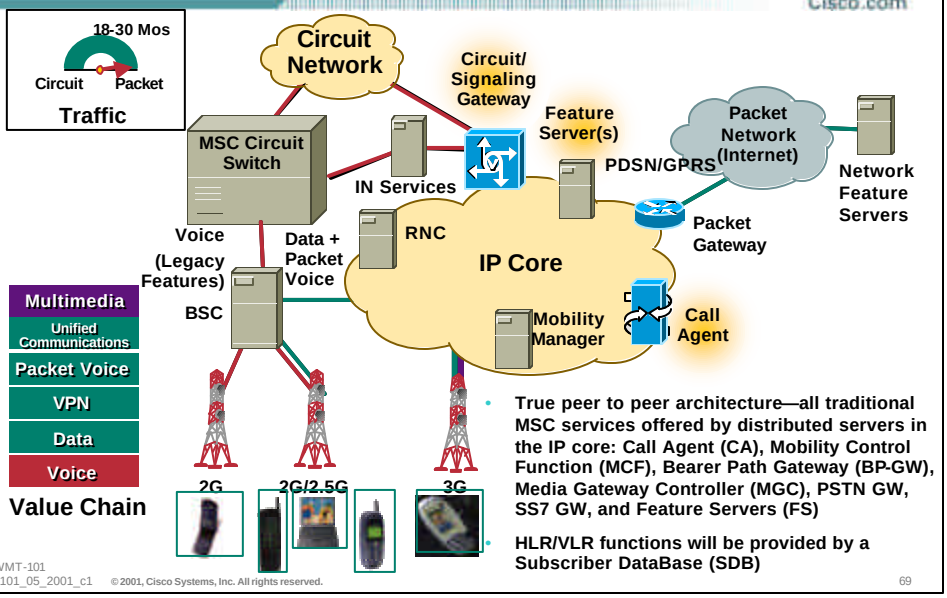
- Higher speed interfaces and "always-on" data services, and enable operators to charge by packet instead of connect time
- A PCU (Packet Control Unit) in the BSC converts data traffic to packets and steers it to the GPRS (in GSM networks) or the PDSN (in CDMA systems) where it accesses the packet network

The Road to IP
3rd Phase: Integrated Voice/Data Services



- Voice and data are integrated in the RAN
- The RNC terminates circuit voice in legacy MSC or in 04.08 proxy in the IP core, with call control and transport occurring in the packet core
- Circuit and packet cores can talk to the SS7 network and intelligent network platforms to terminate calls to and from the PSTN

The Road to IP
4th Phase: True Peer-To-Peer Network



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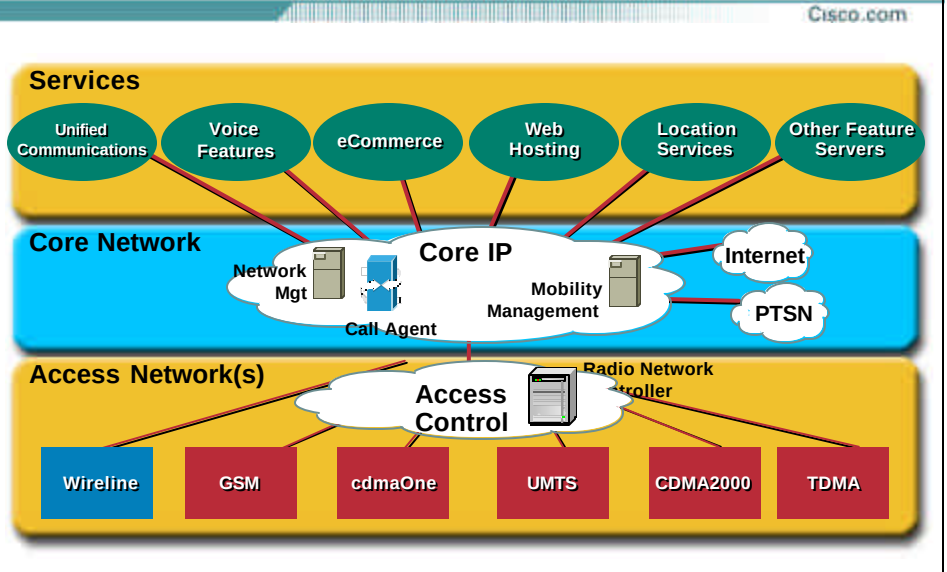
Common IP Architecture



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References

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- "Mobile IP: The Internet Unplugged", Solomon, James D., Prentice Hall, 1998
- "Mobile and Wireless Networks", Black, Uyless, Prentice Hall, 1999
- Cisco IOS Mobile IP:

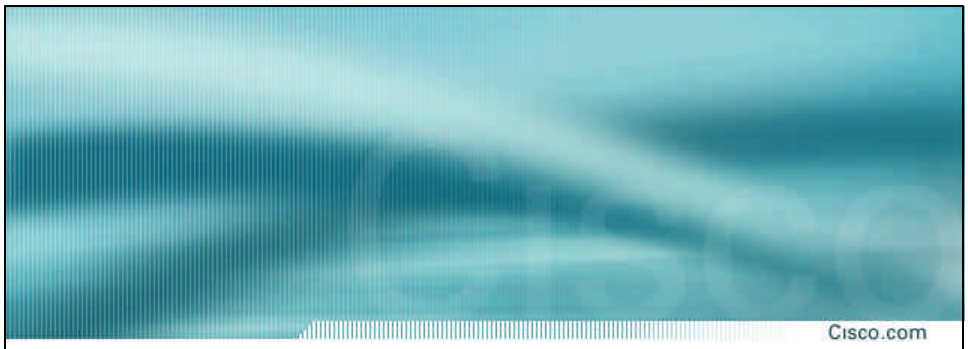
  http://www.cisco.com/warp/public/cc/cisco/mkt/ios/rel/120/prodlit/817_pb.htm

Mobile Wireless Internet Association

Cisco.com

mwif mobile wireless internet forum

www.mwf.org



Wireless LAN Overview

IEEE 802.11 Standard

- IEEE 802.11 became a standard in July 1997
- IEEE 802.11B became a standard in September 1999
- Three technologies defined:
  - FHSS—1 Mbps and 2 Mbps
  - DSSS—2 Mbps and 11Mb
  - Infrared
- 802.11 defines a high-performance radio
- 802.11 promises true vendor interoperability (over the air)

IEEE 802.11 Standard

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- 802.11 incorporates many ARLAN features
  - Power management
  - Active scanning
  - Registering (association) with AP
  - Concept of roaming

Customer WLAN Requirements

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Market Requirement	Proof Points
Secure	Up to 128 Bit Wired Equivalent Privacy (WEP)
Manageable	Must Integrate with Existing LAN Management Infrastructure
Scalable	Roaming to Extend the Network; Deployment in Large Enterprise Facilities
Standards-Based	802.11(b); FCC-Certified

IEEE 802.11 Impact

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- Enables BASIC interoperability over the air
  - DS adapters from different vendors can interact
  - FH adapters from different vendors can interact
- System level interoperability requires more...
  - Vendor co-operation
  - Higher level protocol agreement

802.11b—Higher Datarate

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- With the need for higher datarate, 802.11 decided to add more specifications
- Ratified in September, 1999 an 11 MB specification was ratified
- Direct sequence only
- Utilizing CCK modulation

Radio Technology

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- **Direct Sequence Spread Spectrum (DSSS)**
  - 900 MHz, 2.4 GHz
  - One piece PCMCIA radio product
  - 1, 2, 5.5 and 11 MB
  - 25 mile bridge links
  - Fully compliant 802.11 at all speeds
- **Frequency Hopping Spread Spectrum (FHSS)**
  - 2.4 GHz frequency
  - One piece PCMCIA radio product
  - Fully compliant 802.11
  - 1 and 2 MB

Security

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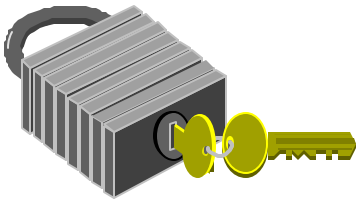
- **128-bit (strong encryption) 802.11 optional Wired Equivalent Privacy (WEP)**
- **Inherent security of spread spectrum**
- **User authorization using 802.1X**



ISM Unlicensed Frequency Bands

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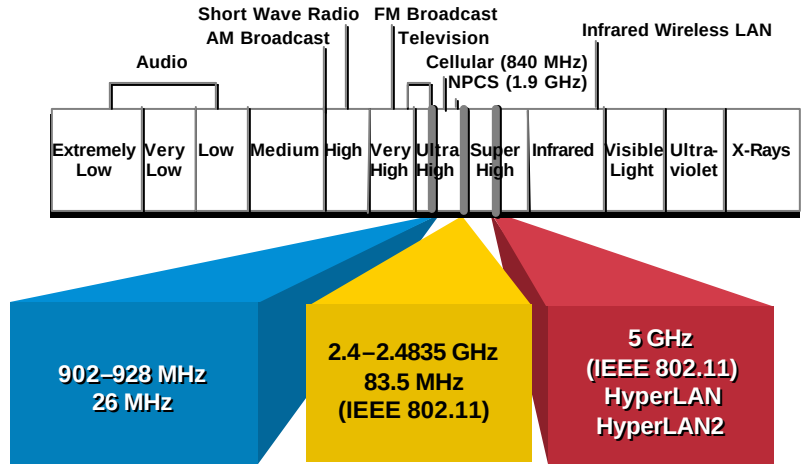

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Global RF Regulations

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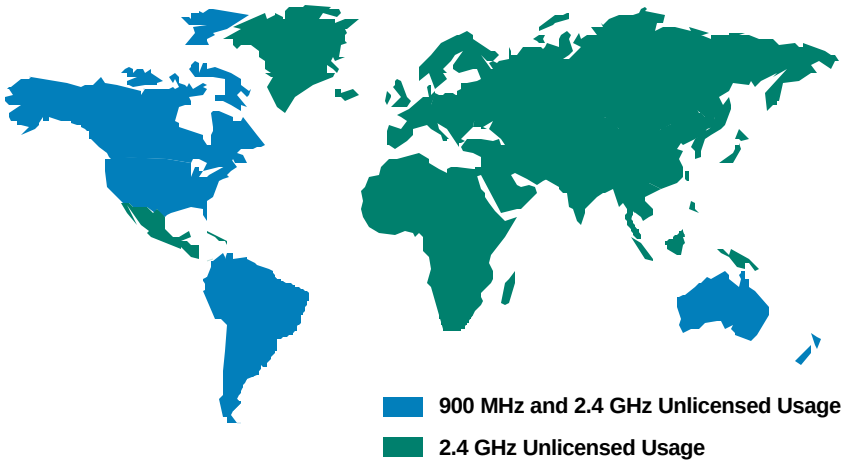

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900 MHz vs. 2.4 GHz vs. 5GHz

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	900 MHz	2.4 GHz	5 GHz
PROs	Greater Range than 2.4 GHz (for In- Building LANs)	Global Market IEEE 802.11 Higher Data Rates (10+ Mbps)	Global Market IEEE 802.11 Higher Data Rates (20+ Mbps)
CONs	Maximum Data Rate 1 Mbps Limited Bandwidth Crowded Band	Less Range than 900 MHz (for In-Building LANs)	Much Less Range than 900 or 2.4 GHz Higher Cost RF Components Large Antenna Required

What's the Difference?

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- **Frequency hopping**
  - Multipath interference tolerance
- **Direct sequence**
  - Throughput
  - Range

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
- Minimum chip rate per the FCC is 10; Aironet uses 11 for 1 and 2 MB data rates

If the data bit was: 1001

Chipping code is: 1=00110011011 0=11001100100

Transmitted data would be:

00110011011	11001100100	11001100100	0110011011
1	0	0	1

FH vs. DS: A Summary on Interference Handling

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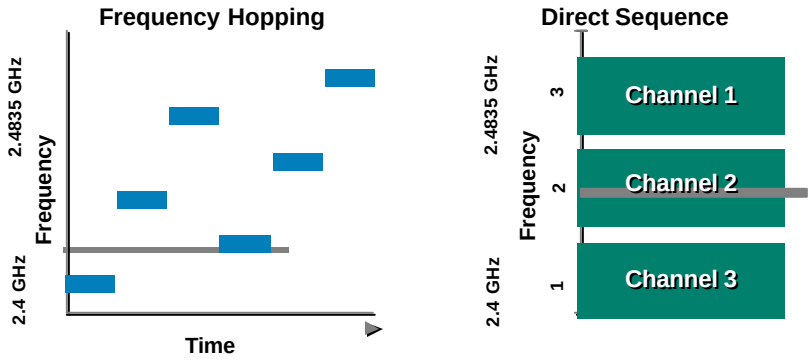

- FH system hops around interference
- Lost packets are re-transmitted on next hop
- Data may be decoded from redundant bits
- Can move to an alternate channel to avoid interference

Direct Sequence vs. Frequency Hopping (802.11)

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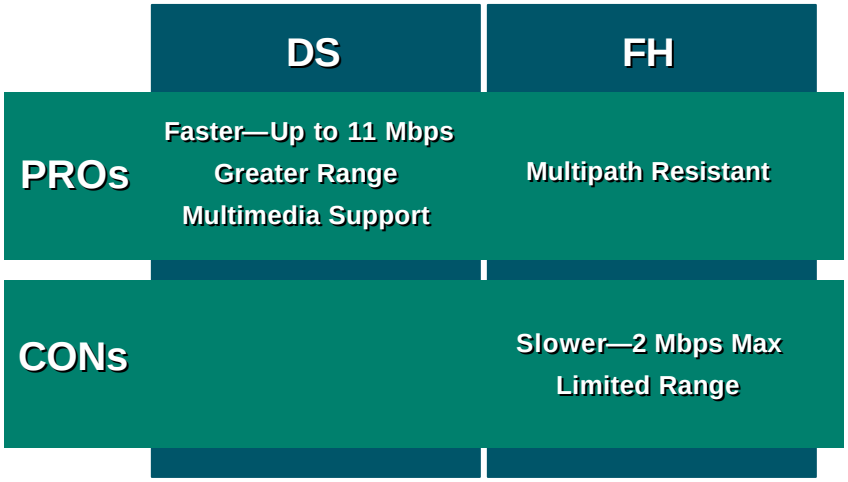

Data Rates

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- The “over-the-air” data rate at a given range and given similar implementations will favor DSSS by a factor of 2 to 1
- A 1 Mbps DSSS system should have twice the range of a 1 Mbps FHSS
- 2 Mbps DSSS system will offer comparable range to 1 Mbps FHSS technology
- For these reasons, the data rate advantage goes to DSSS

RANGE—FH vs DS

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- **Because of this processing gain, the DSSS technology will have more range than FHSS at a given data rate**

Access Point Coverage

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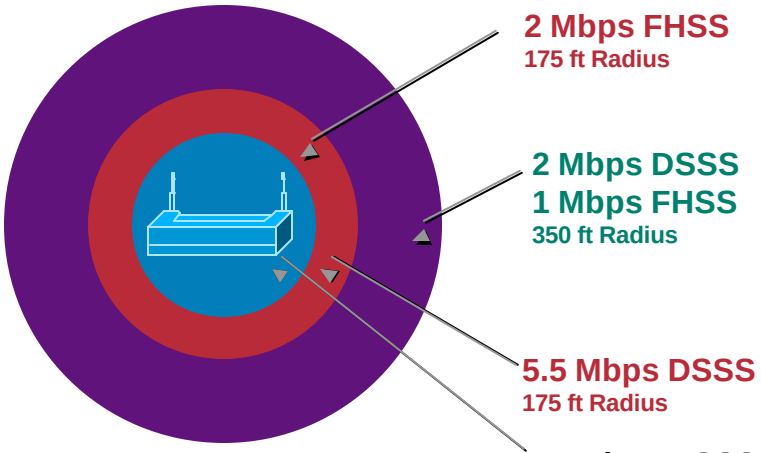

Wireless LAN Compatibility Association

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www.wi-fi.org

WECA (Wireless Ethernet Compatibility Alliance)

Other Pointers

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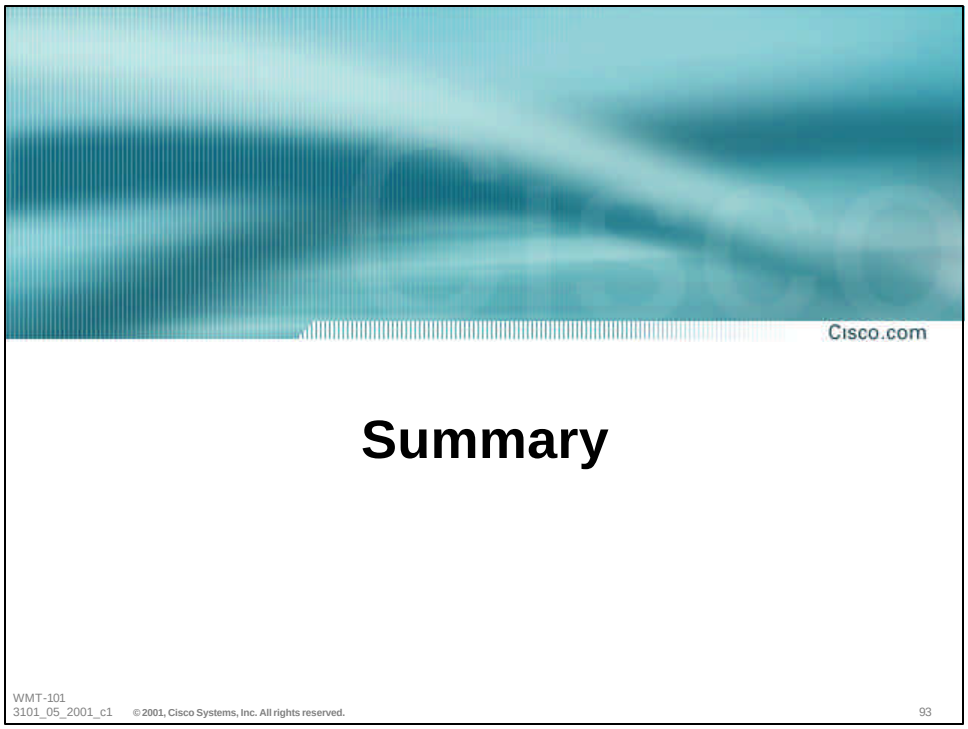
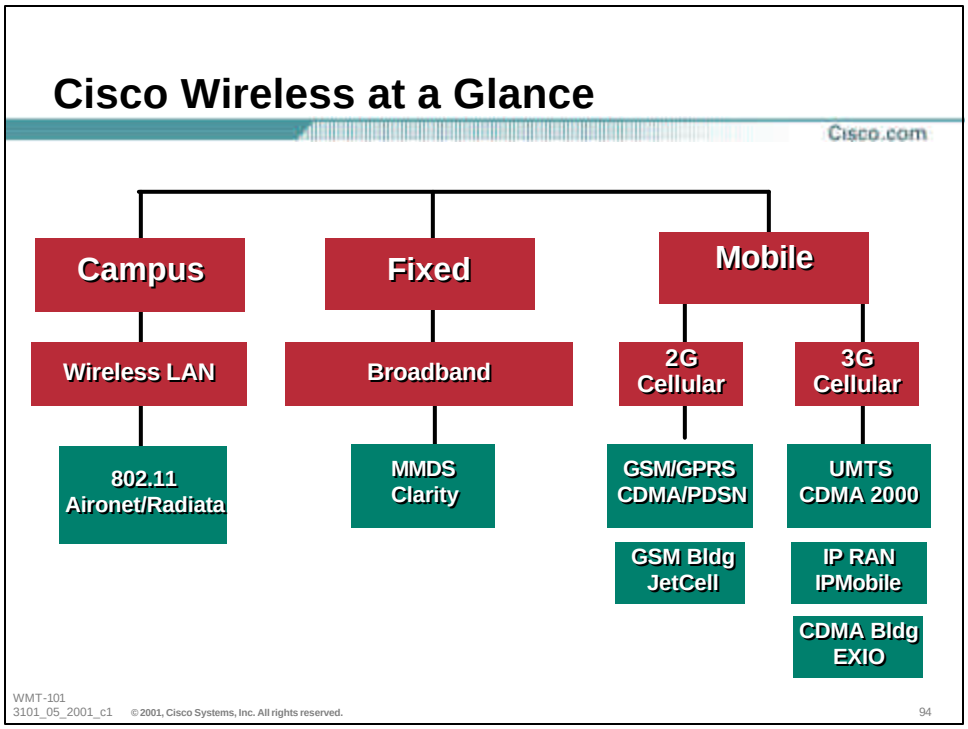
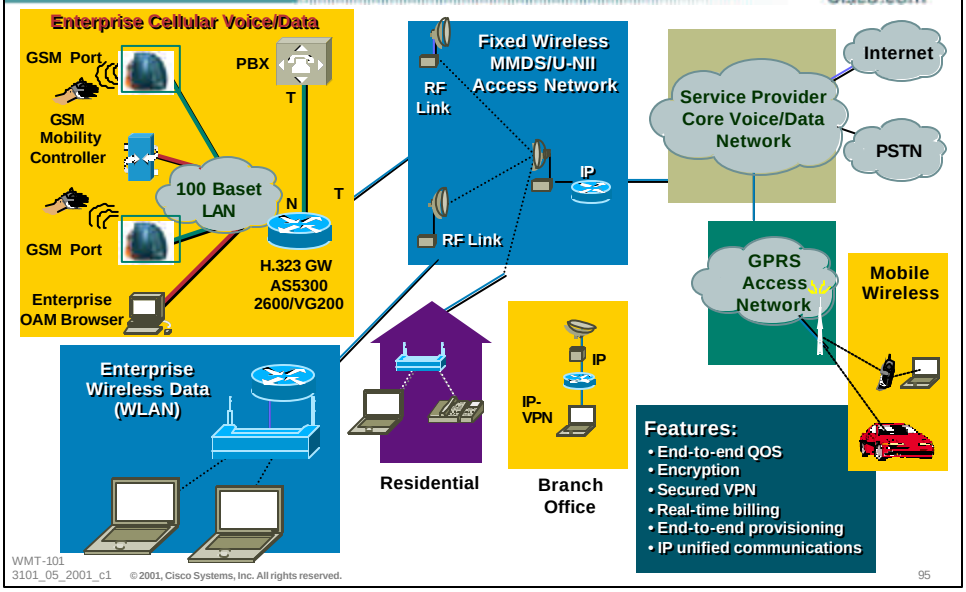
- http://standards.ieee.org/getieee802/ (standards are available after 6 months for free)
- http://www/warp/public/44/jump/wireless.shtml

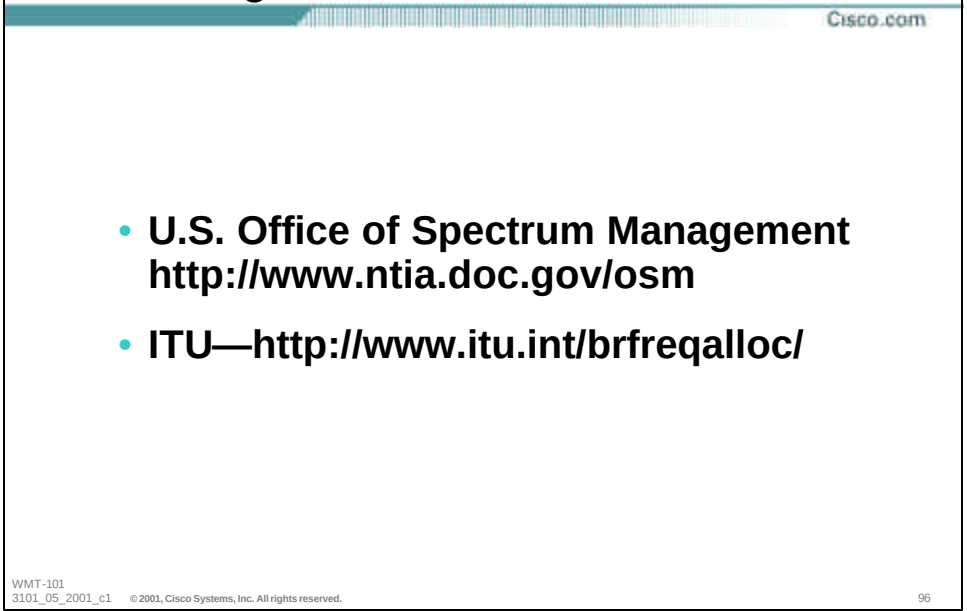




Cisco's Wireless Products—Overview



Interesting URLs



Other Networker's Presentations

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- WMT-210 Deploying and Managing Wireless LAN
- WMT-230 Deploying Fixed Wireless Wide Area Networks
- WMT-240 Deploying Mobile Wireless Application and Services
- WMT-241 Deploying Packet Data Services in Mobile Wireless Networks
- WMT-310 Troubleshooting Wireless LANs
- RST-110 Introduction to IP Mobility

Questions?

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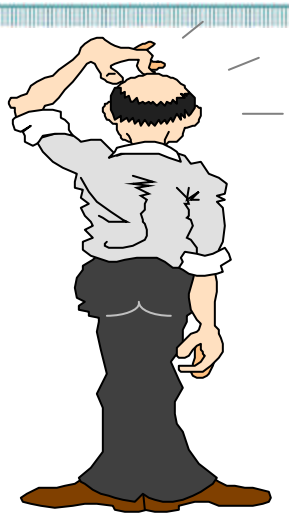
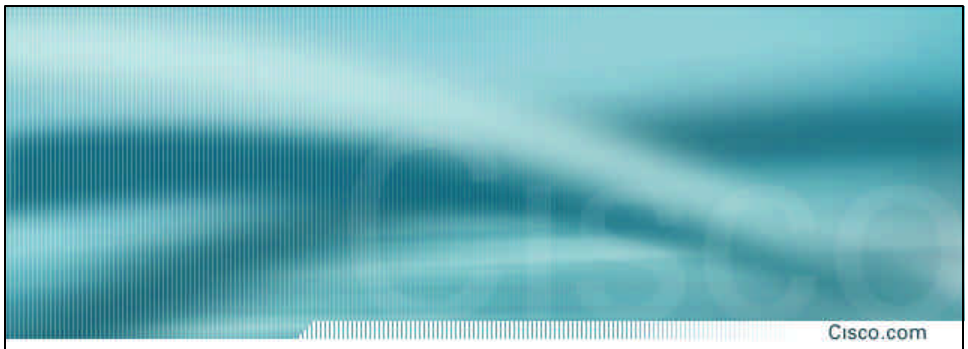
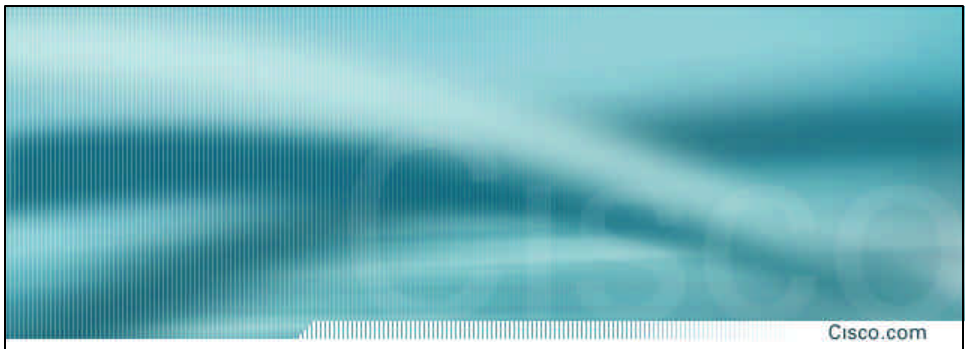




Introduction to Wireless Technology

Session WMT-101



Please Complete Your Evaluation Form

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