

WIRELESS AND CELLULAR

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Wireless

2



802....

3

- Contents:
 - ▣ Why do we need it?
 - ▣ Introduction to wireless
 - ▣ Business drivers

Major Factors

4

- Four major factors to implement a wireless network:
 - ▣ High availability
 - ▣ Scalability
 - ▣ Manageability
 - ▣ Open architecture

Momentum is Building in Wireless LANs

5

- ❑ Wireless LANs are an “addictive” technology
- ❑ Strong commitment to Wireless LANs by technology heavy-weights
- ❑ Cisco, IBM, Intel, Microsoft



Momentum is Building in Wireless LANs

6

- Embedded market is growing
 - ▣ Laptop PC's with “wireless inside”
 - ▣ PDA's, Tablet PC's, Smart phones
- The WLAN market is expanding from Industry-Specific Applications, to Universities, Homes, & Offices
- Professional installers and technicians will be and are in demand

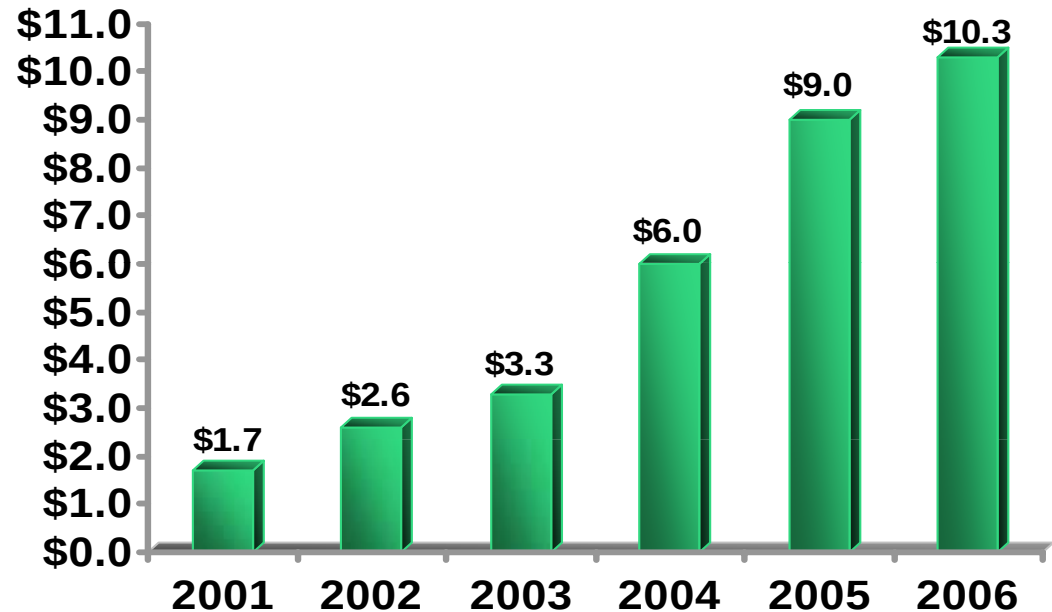
Wireless LANs Are Taking Off

7

□ Worldwide WLAN market

- ▣ embedded clients, add-on client cards, & infrastructure equipment for both the business and consumer segments

(\$ Billions)



Source: Forward Concepts, 2003

Wireless LANs Are Taking Off

8

□ Future Growth Due To:

- Standards
- High Bandwidth Needs
- Low Cost
- Embedded in Laptops
- Variety of Devices
- Voice + Data

□ Future Growth Due To (cont.)

- Multiple Applications
- Security Issues Solved
- Ease of Deployment
- Network Mgmt. Tools
- Enterprise Adoption

Benefits of WLANs

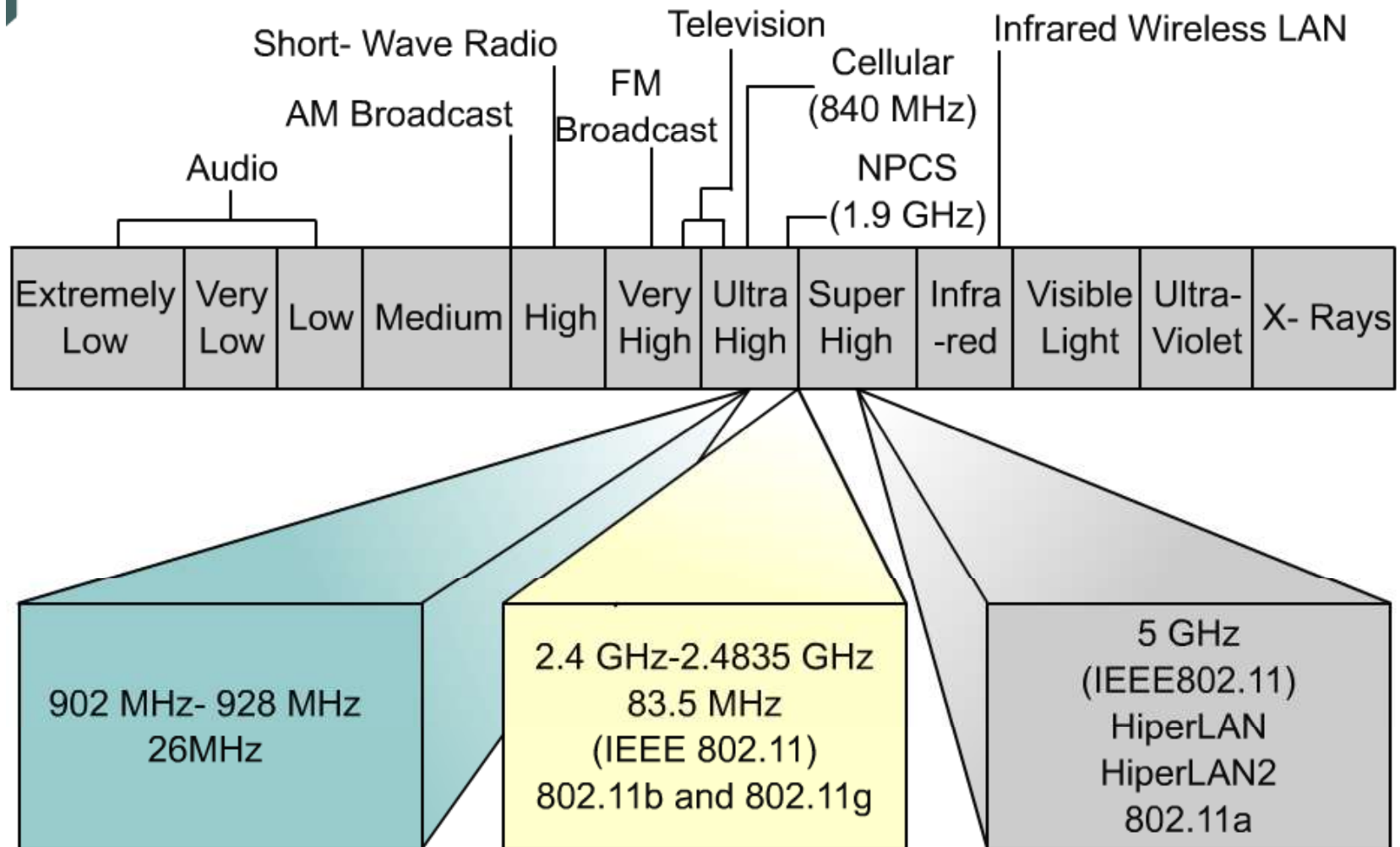
Modern WLANs offer many benefits to networking

Benefits of WLANs

- Mobility
- Scalability
- Flexibility
- Short and long term cost savings
- Installation advantages
- Reliability in harsh environments
- Reduced installation time

Unlicensed Frequency Bands

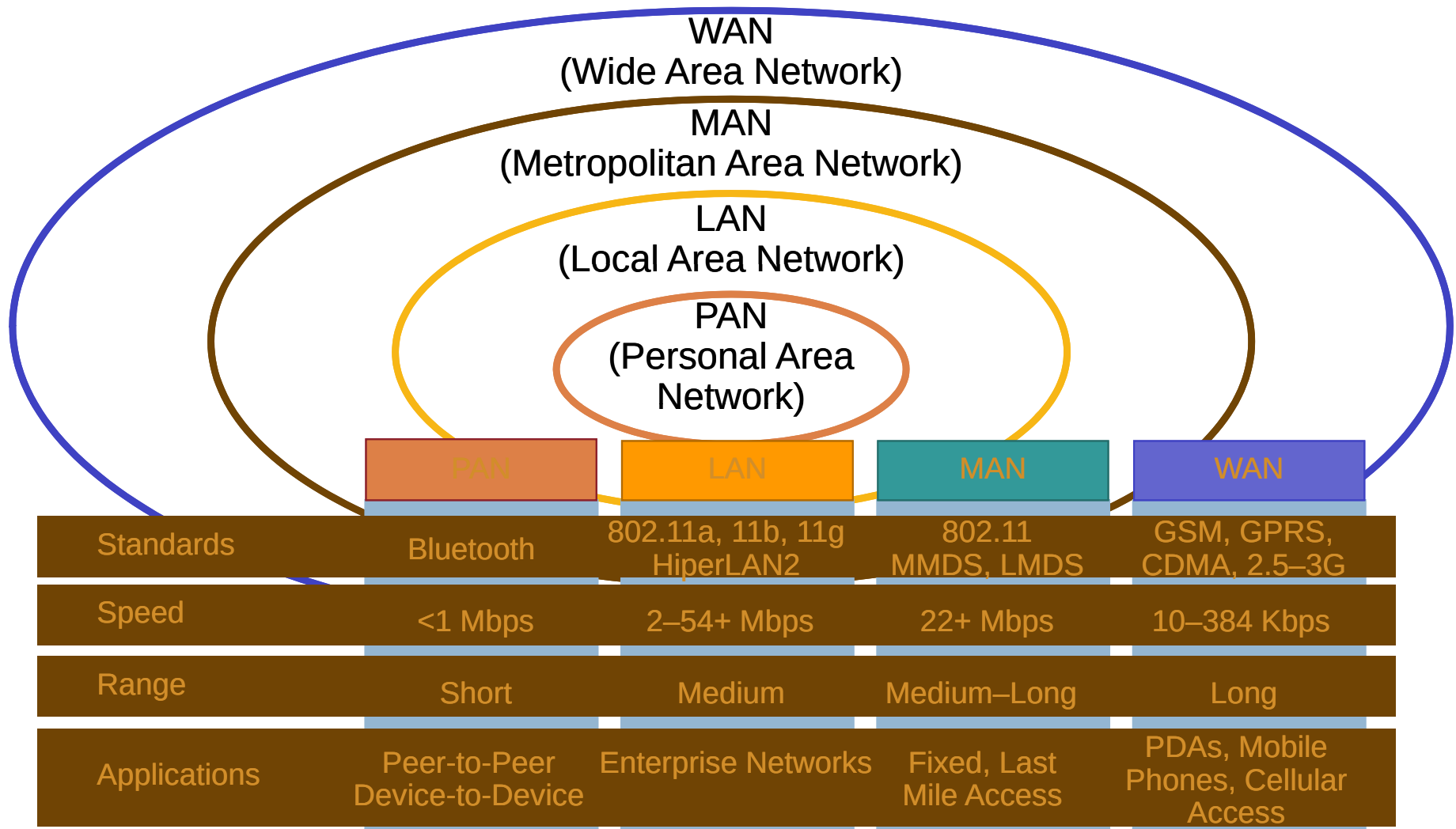
10



Wireless and Cellular

Wireless Technologies

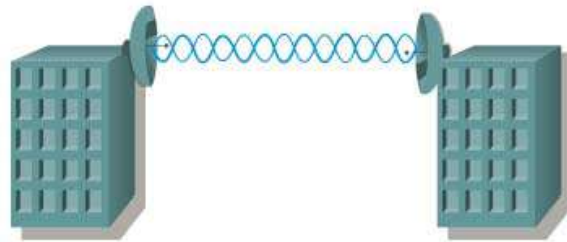
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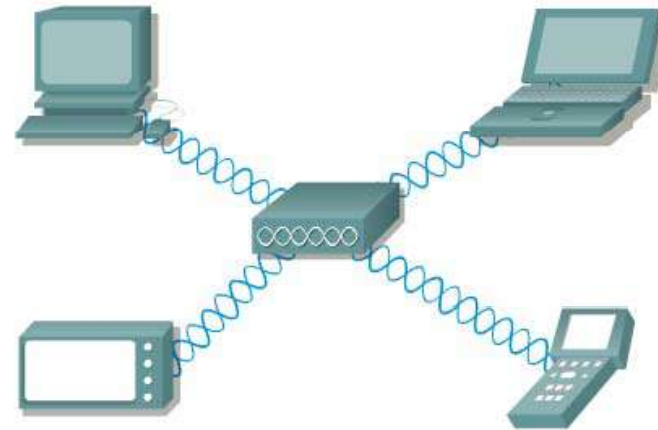
Wireless and Cellular

Wireless Technologies

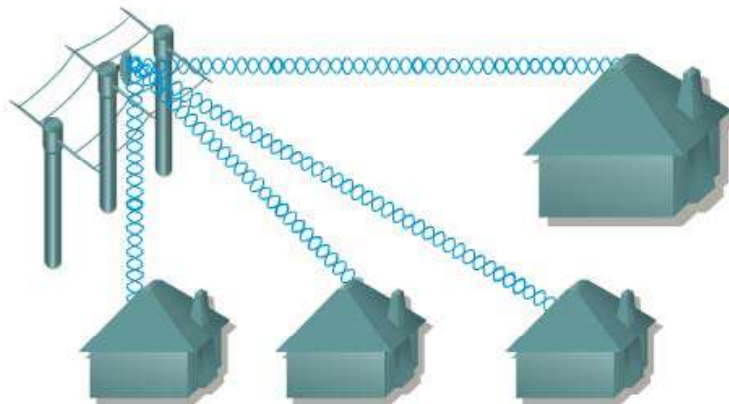
12



Point-to-point / multipoint wireless



Wireless LAN



Local Wireless Loop

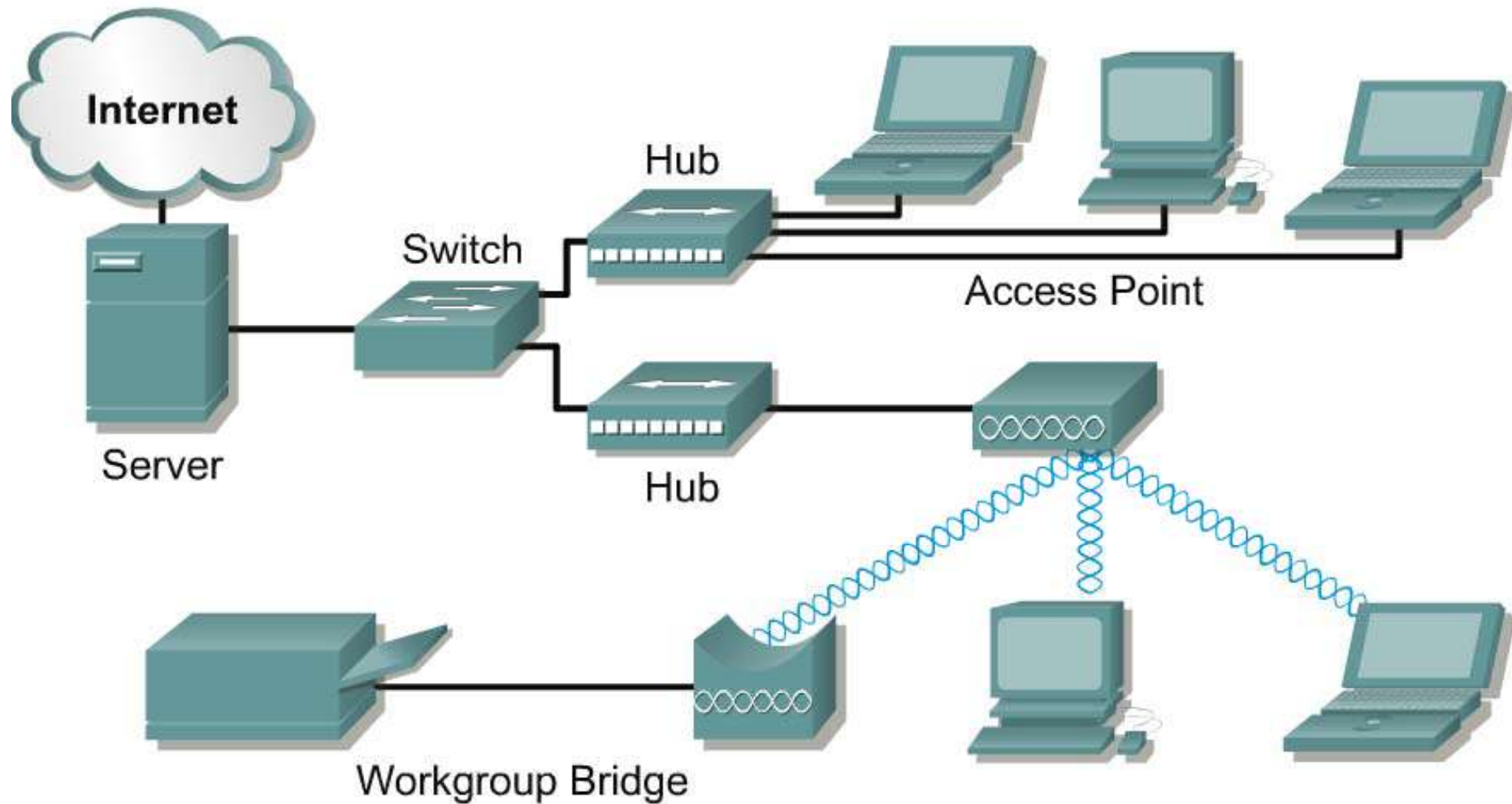


Mobile Cellular Voice /Data

Wireless and Cellular

In Building WLAN

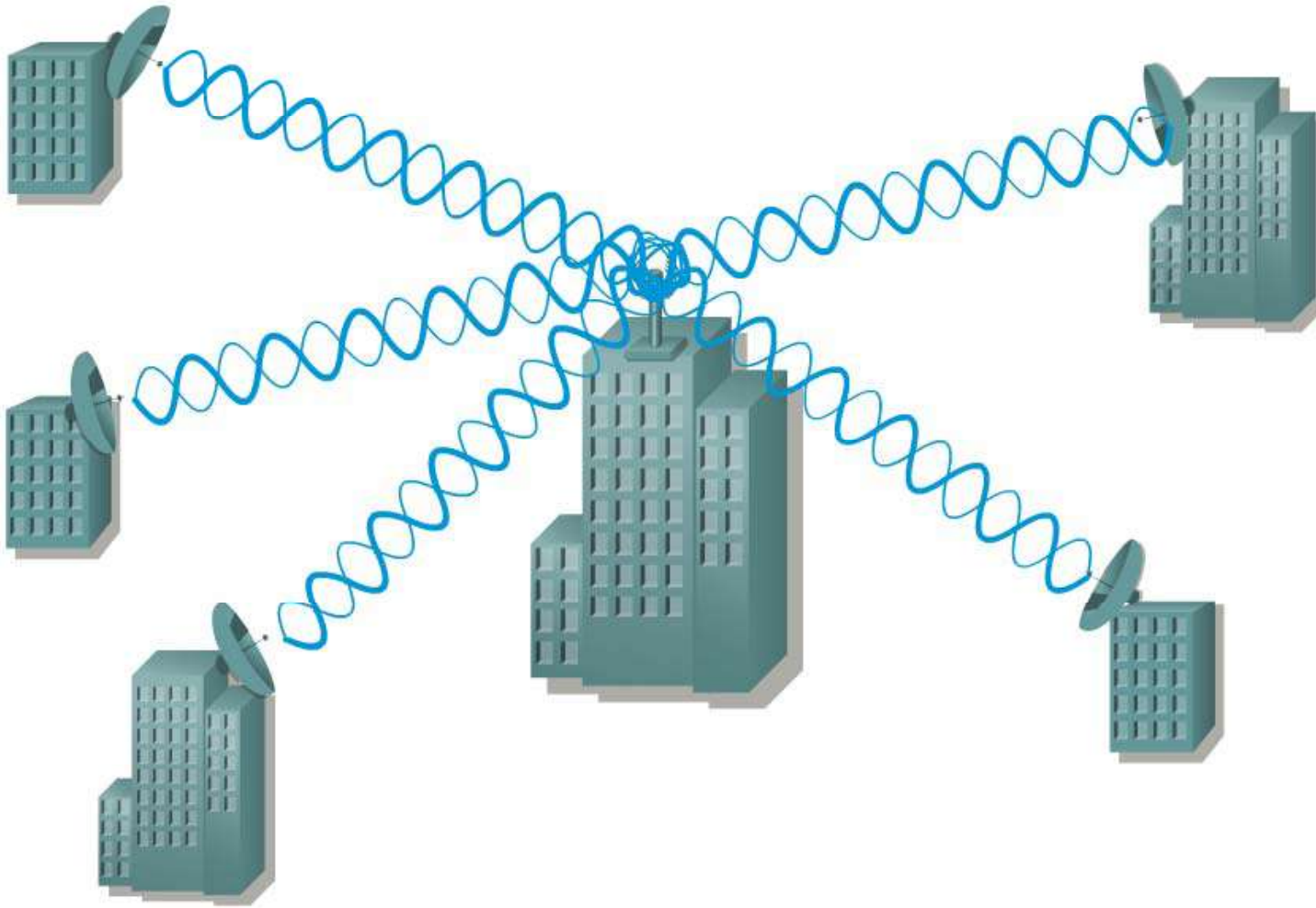
13



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Site to Site WLAN

14



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WLAN Markets

15

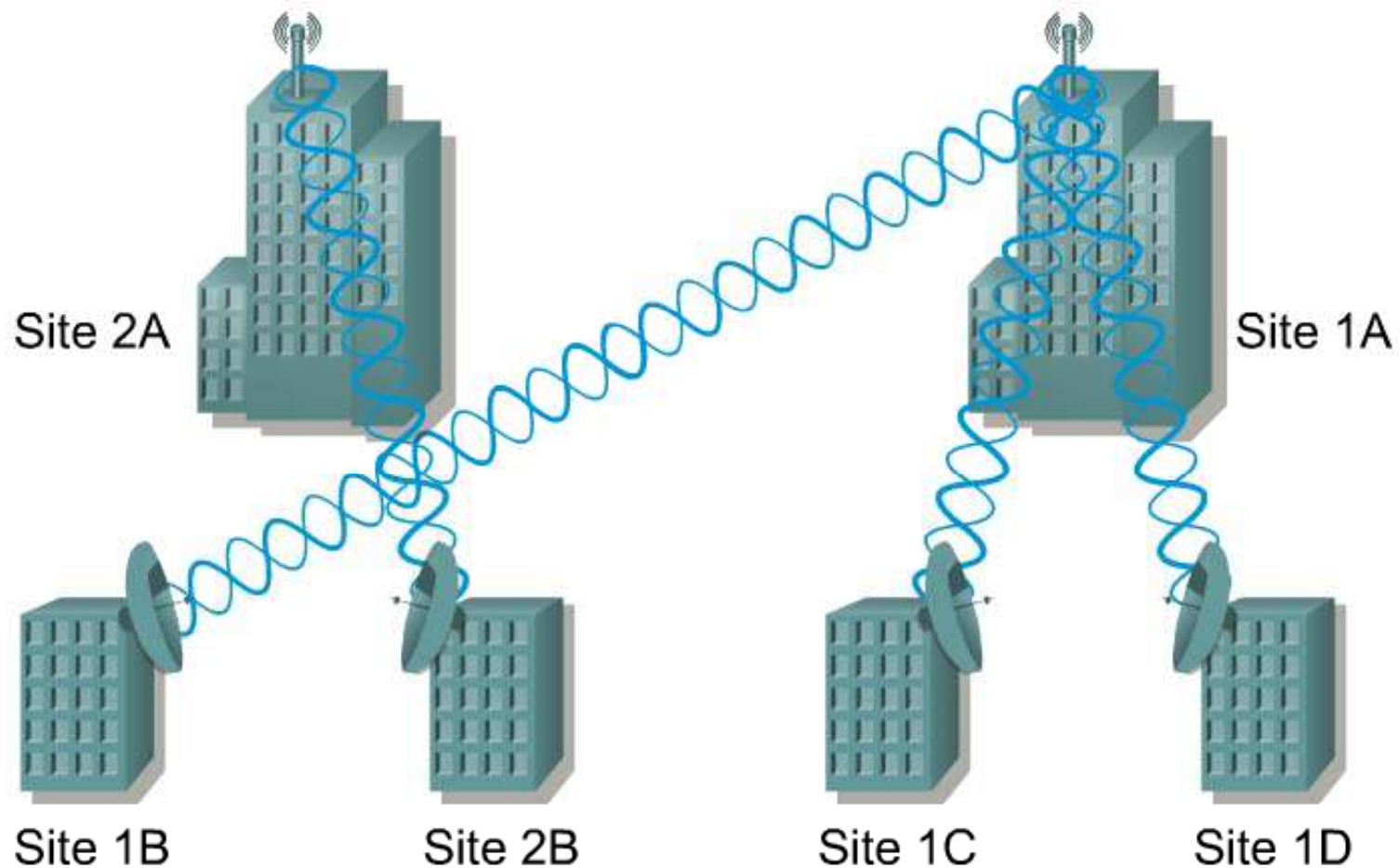
Vertical Markets which are Adopting WLAN Technology

Wireless Application

- Retail
- Warehouses
- Electronics and technology
- Government
- Healthcare
- Insurance
- Real estate
- Transportation
- Delivery by train, ground, ship, and air
- Hospitality and conventions
- Energy and utilities such as water, gas, and electricity
- Banking and financial
- Field service
- Vending
- Manufacturing and industrial
- Education
- Travel and recreation
- Military

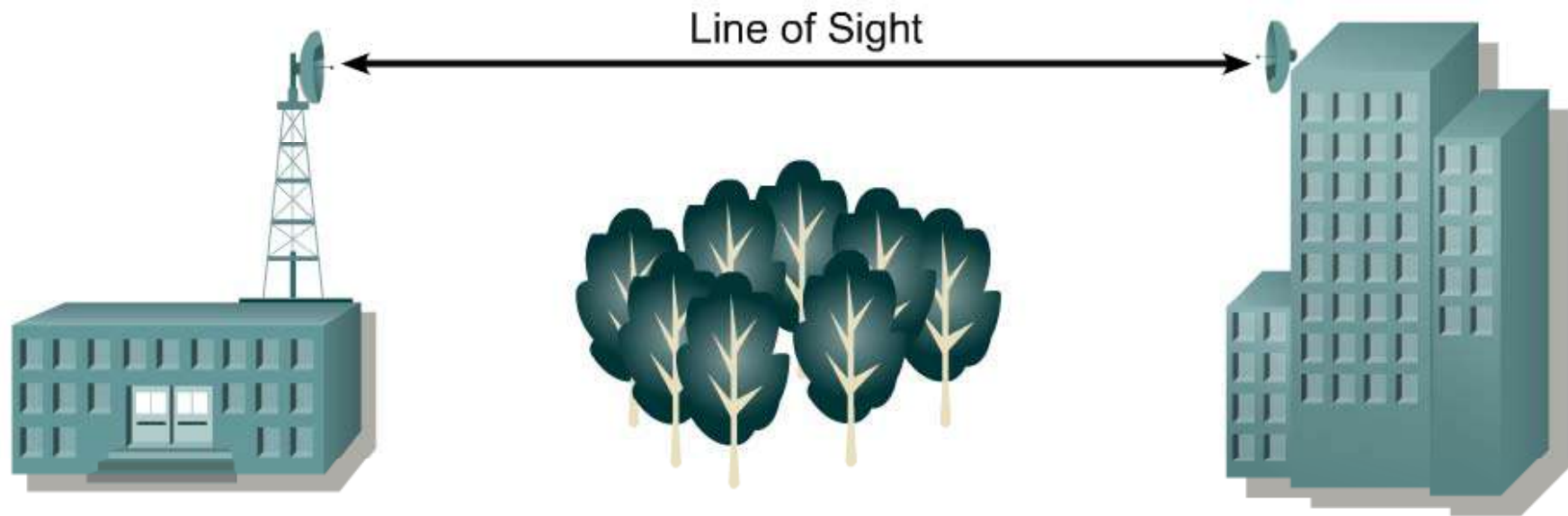
Radio Signal Interference

16



Installation and Site Design Issues - Bridging

17



The following obstructions might obscure a visual link

- Topographic features, such as mountains
- The curvature of the earth
- Buildings or other man made objects
- Trees

Power Consumption

18

Three client adapter modes

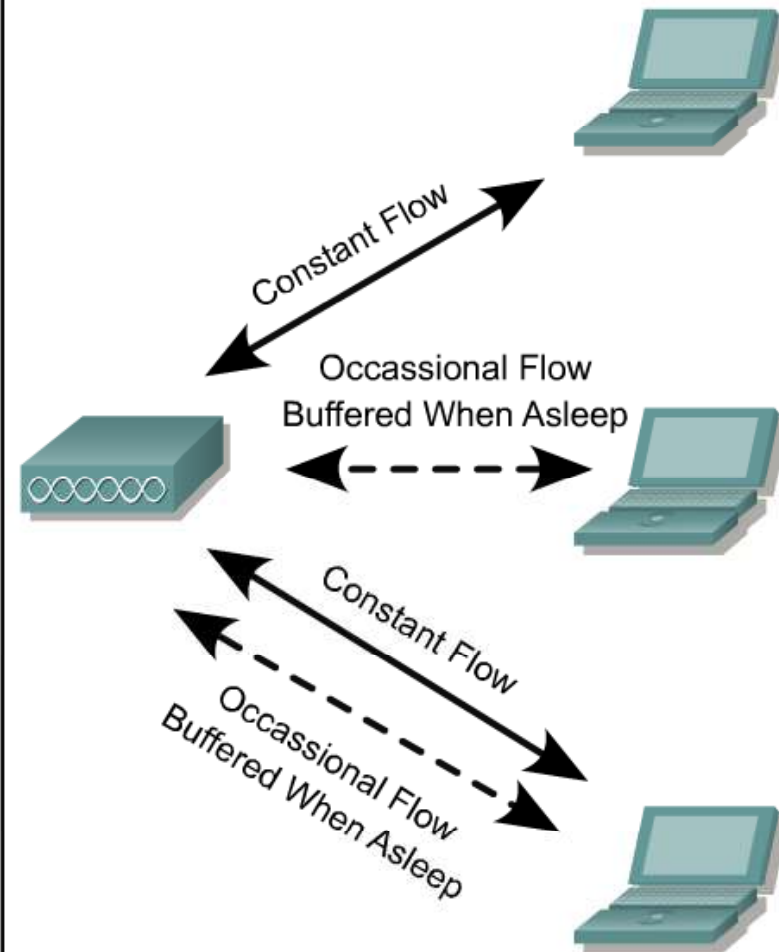
- CAM = Constant awake mode
power not an issue
High availability
- PSP = Power save mode
power is an issue
AP buffers messages
wakes up periodically to receive data
- FastPSP = Fast power save mode
Switch between CAM and PSP
Users who switch between AC and DC

Default is CAM

Only available on PC cards

Only one can be selected

- Windows Network Properties



Health Issues

19

Safety Guidelines

Do not touch or move the antenna while the unit is transmitting or receiving.

Do not hold any component containing a radio, in such a way that the antenna is very close to or touching any exposed parts of the body, especially the face or eyes, while transmitting.

Do not operate the radio or attempt to transmit data unless the antenna is connected, otherwise the radio may be damaged.

Use the following guidelines in specific environments:

- The use of wireless devices in hazardous locations is limited to the constraints posed by the safety directors of such environments.
- The use of wireless devices on airplanes is governed by the U.S. Federal Aviation Administration (FAA).
- The use of wireless devices in hospitals is restricted to the limits set forth by each hospital.

Use the following guidelines for antenna use:

- In order to comply with FCC RF exposure limits, dipole antennas should be located at a minimum distance of 20 cm (7.9 in.) from all persons.

IEEE 802.11 Standards Activities

20

- 802.11a: 5GHz, 54Mbps
- 802.11b: 2.4GHz, 11Mbps
- 802.11d: Multiple regulatory domains
- 802.11e: Quality of Service (QoS)
- 802.11f: Inter-Access Point Protocol (IAPP)
- 802.11g: 2.4GHz, 54Mbps
- 802.11h: Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC)
- 802.11i: Security
- 802.11j: Japan 5GHz Channels (4.9-5.1 GHz)
- 802.11k: Measurement
- 802.11n: approx 230Mbps

IEEE 802. Standards

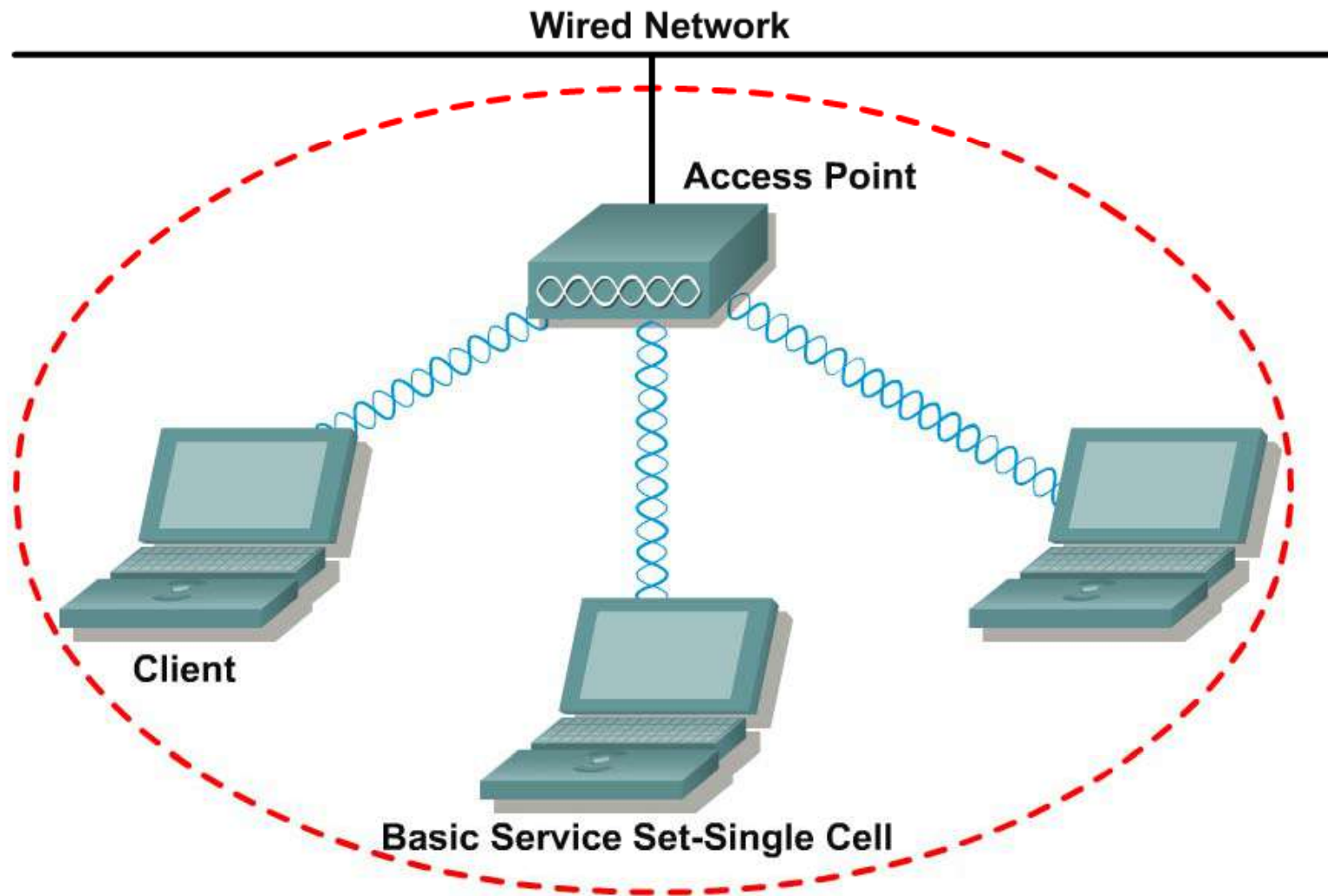
21

IEEE LAN/MAN Standards

- 802.0 Sponsor Executive Committee (SEC)
- 802.1 High Level Interface (HLI)
- 802.2 Logical Link Control (LLC)
- 802.3 CSMA/CD (Ethernet)
- 802.4 Token Bus
- 802.5 Token Ring
- 802.6 Metropolitan Area Network (MAN)
- 802.7 BroadBand Technical Advisory Group (BBTAG)
- 802.8 Fiber Optics Technical Advisory Group (FOTAG)
- 802.9 Integrated Services LAN (ISLAN)
- 802.10 Standard for Interoperable LAN Security (SILS)
- 802.11 Wireless LAN (WLAN)
 - 802.11a, 802.11b, 802.11e, 802.11g, 802.11i
- 802.12 Demand Priority
- 802.14 Cable-TV Based Broadband Communication Network
- 802.15 Wireless Personal Area Network (WPAN)
- 802.16 Broadband Wireless Access (BBWA)
- 802.17 RPRSG Resilient Packet Ring Group (RPRSG)

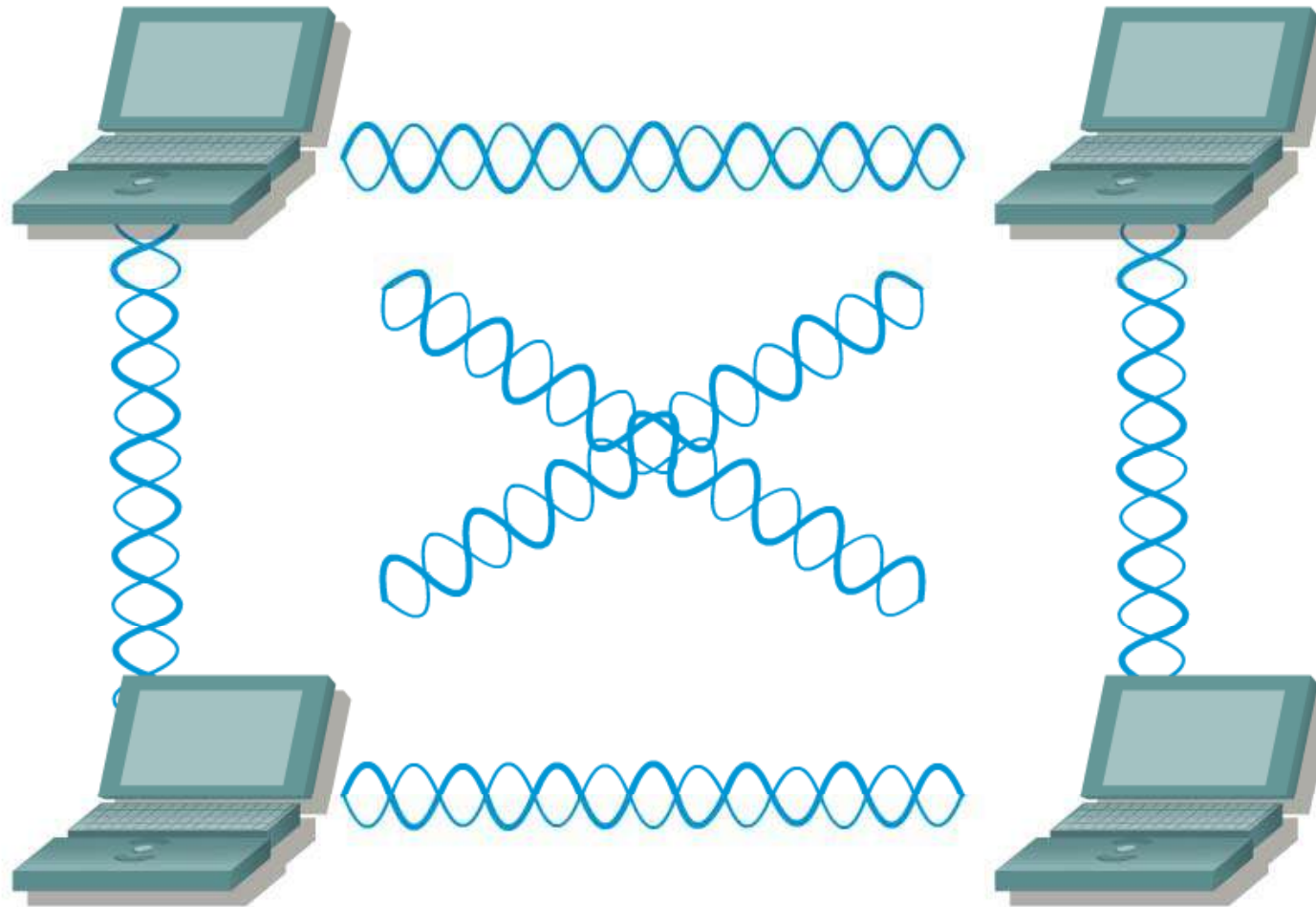
Basic Service Set (BSS)

22



Independent Basic Service Set (IBSS)

23

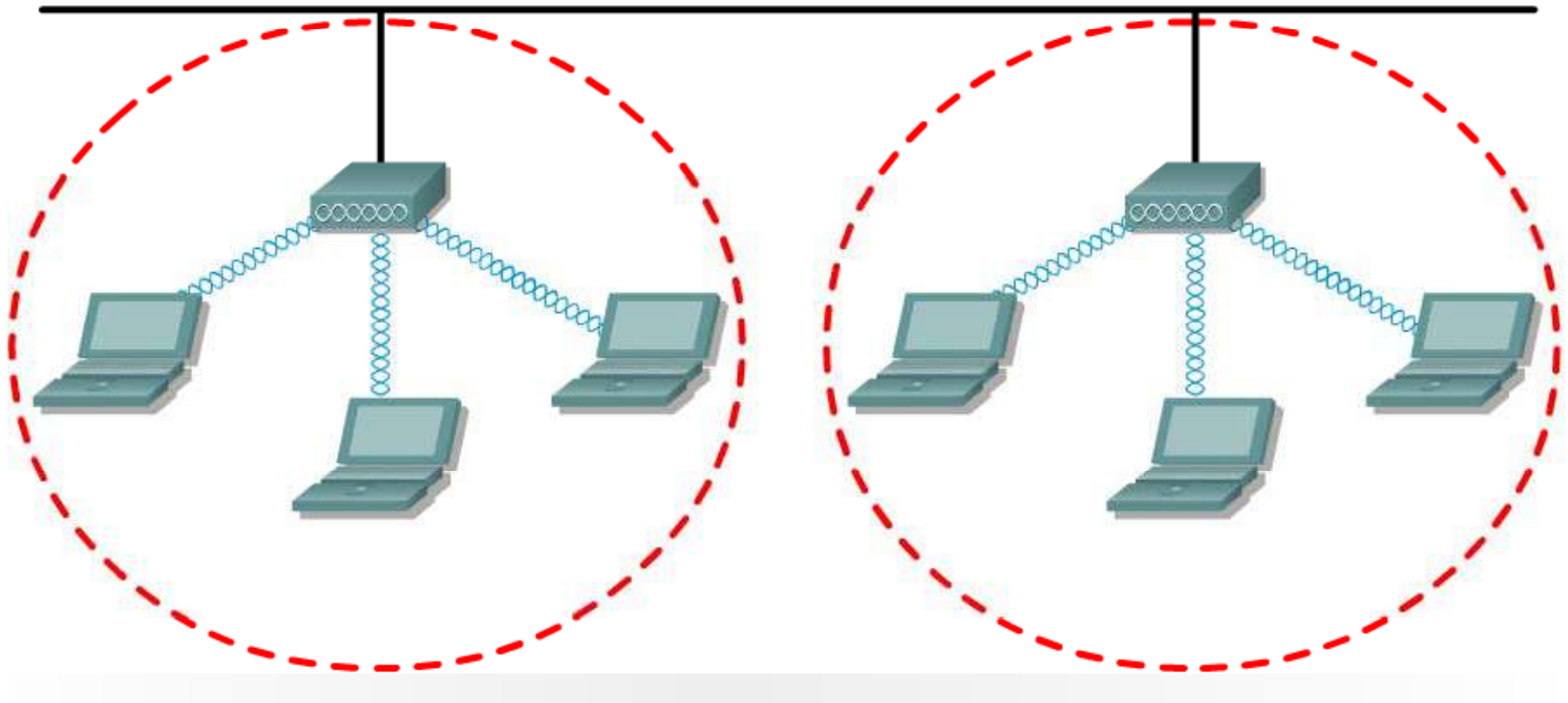


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Extended Service Set (ESS) and Distributed System (DS)

24

Wired Network

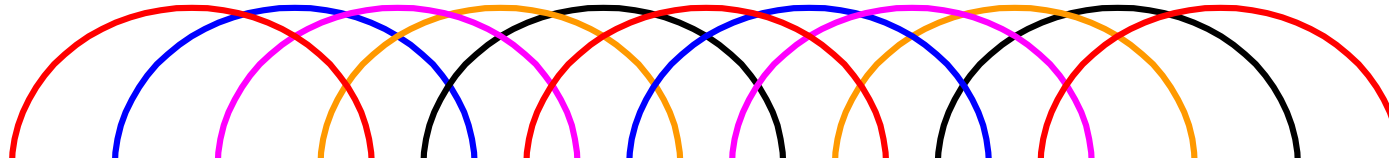


Wireless and Cellular

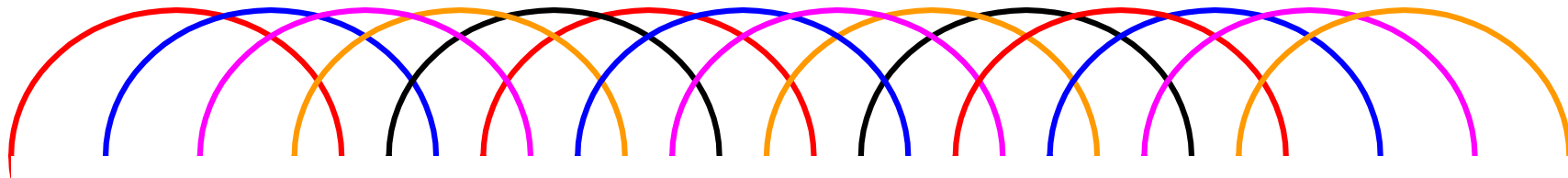
Channels- 2.4 GHz DSSS

25

- 11 “chips per bit” means each bit sent redundantly
- 11 Mbps data rate
- 3 access points can occupy same area



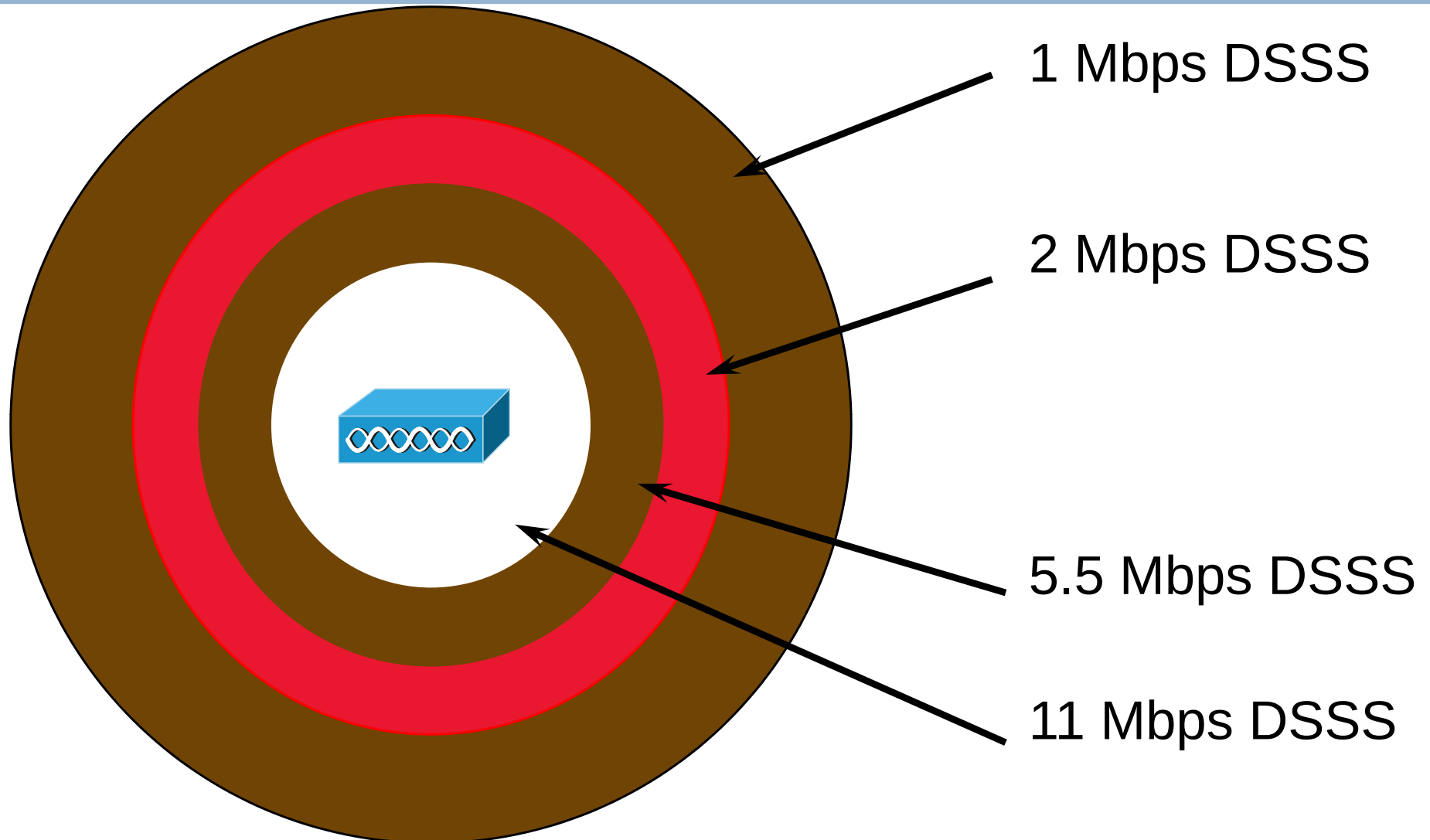
11 Channels – each channel 22 MHz wide
1 set of 3 non-overlapping channels 802.11b/g



14 Channels – each channel 22 MHz wide
4 sets of 3 non-overlapping channels, only one set used at a time 802.11a

802.11b Access Point Coverage

26



802.11b Scalability

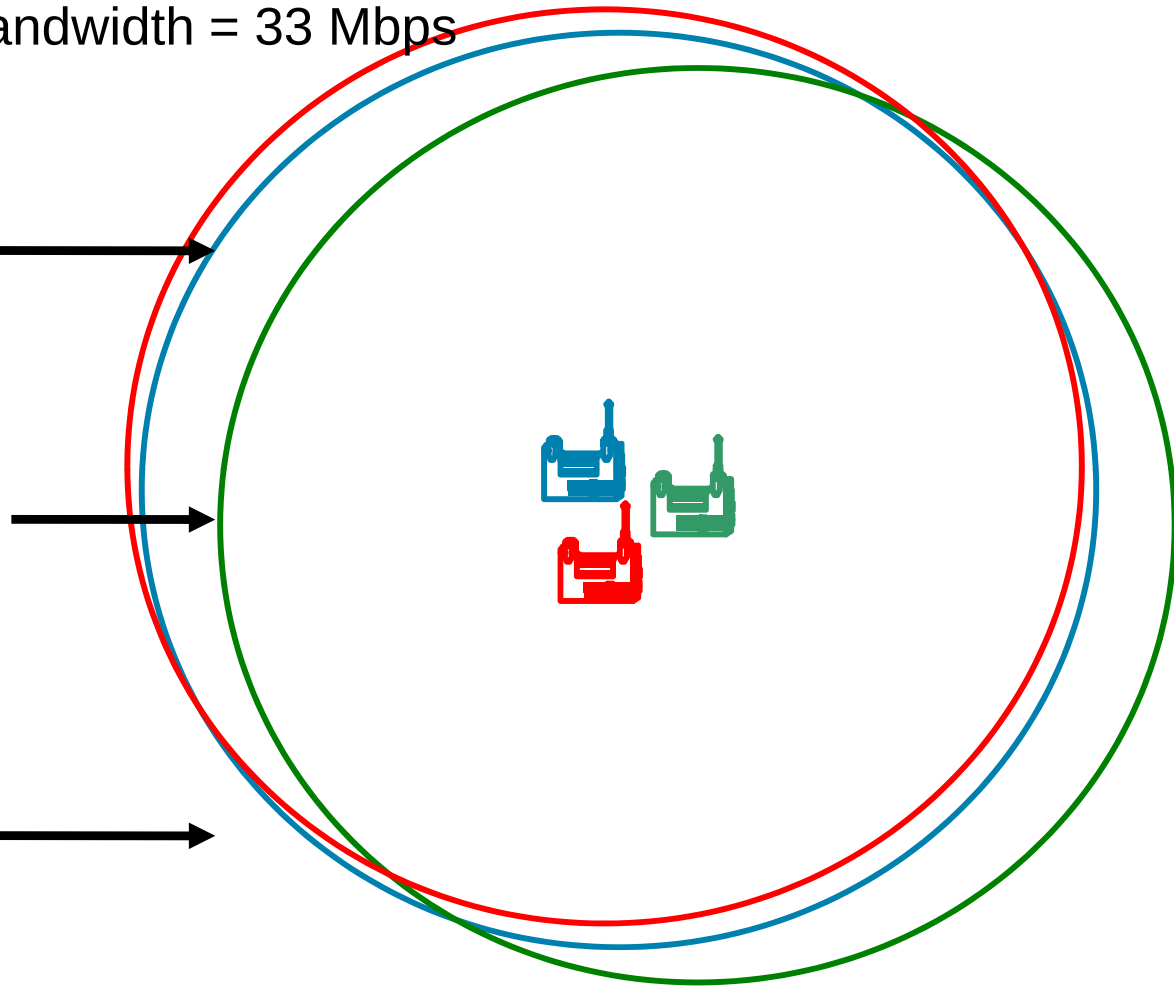
27

Total Theoretical Bandwidth = 33 Mbps

Blue = 11 Mbps

Green = 11
Mbps

Red = 11 Mbps

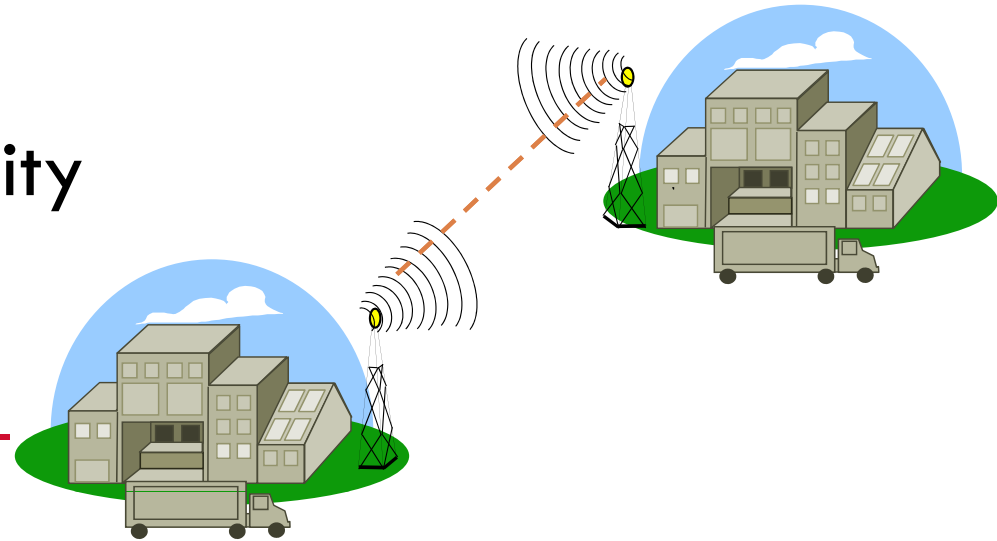
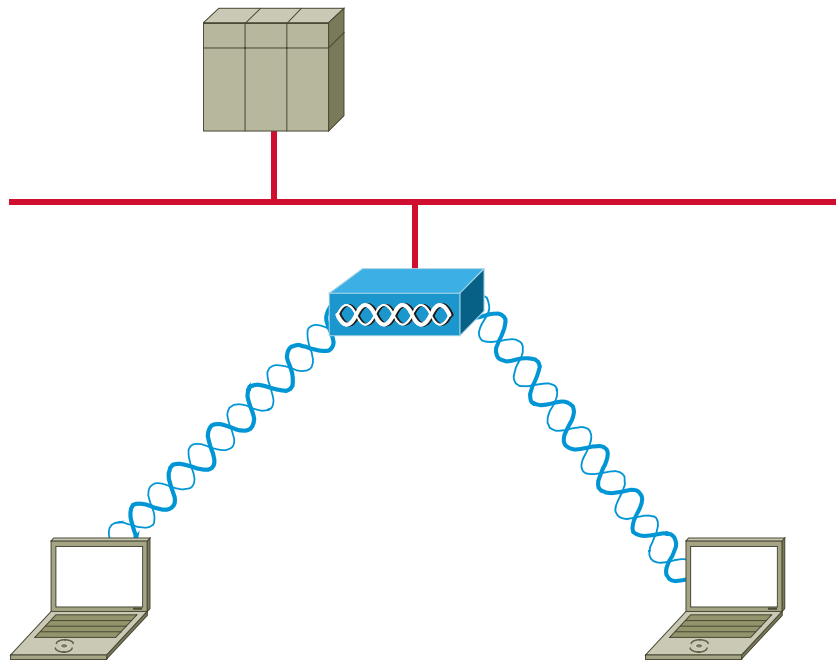


Wireless and Cellular

Wireless LAN Implementations

28

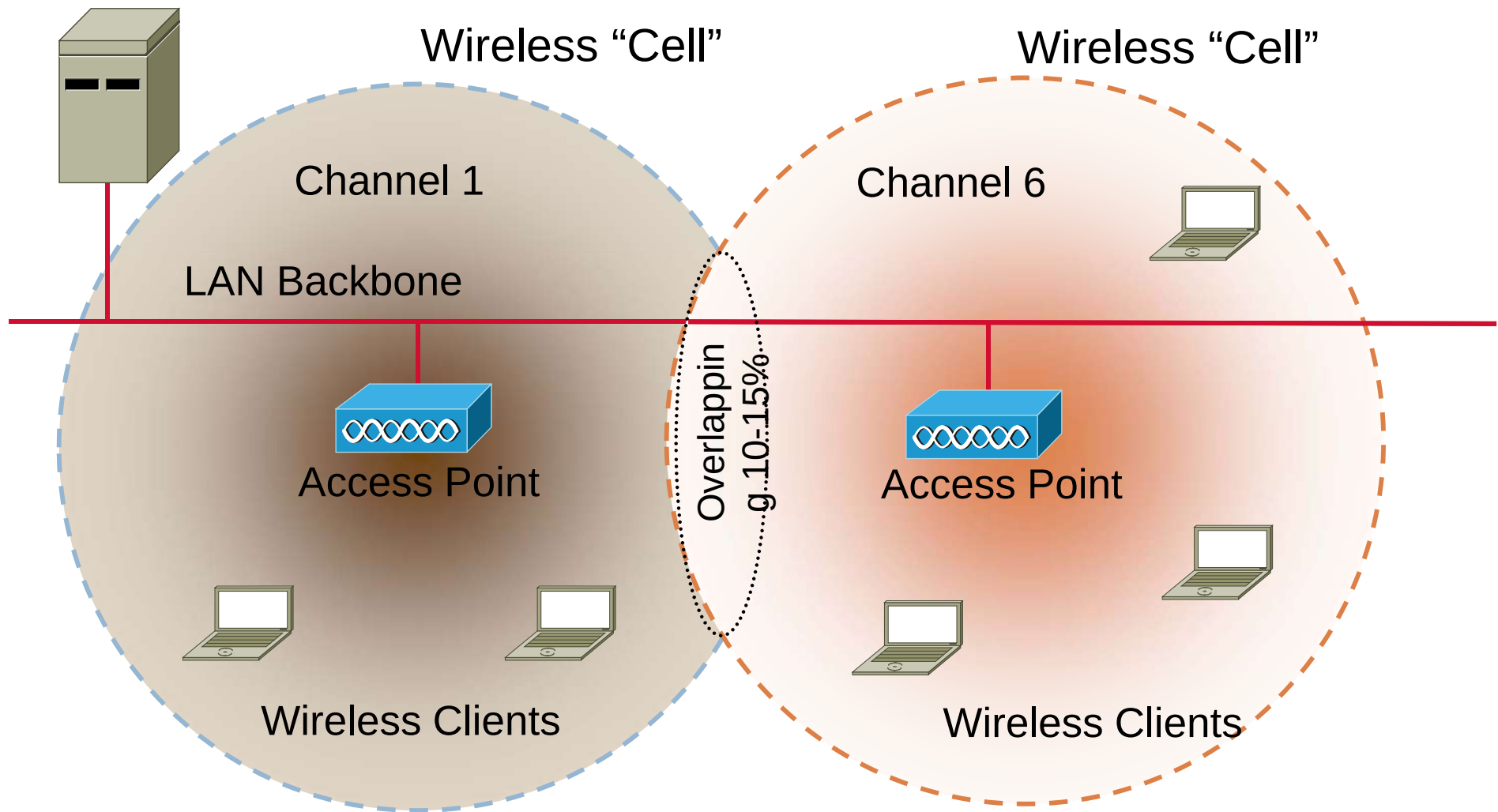
- Wireless Networking
- Mobile user connectivity



- Wireless Bridging
- LAN-to-LAN connectivity

Typical WLAN Topologies

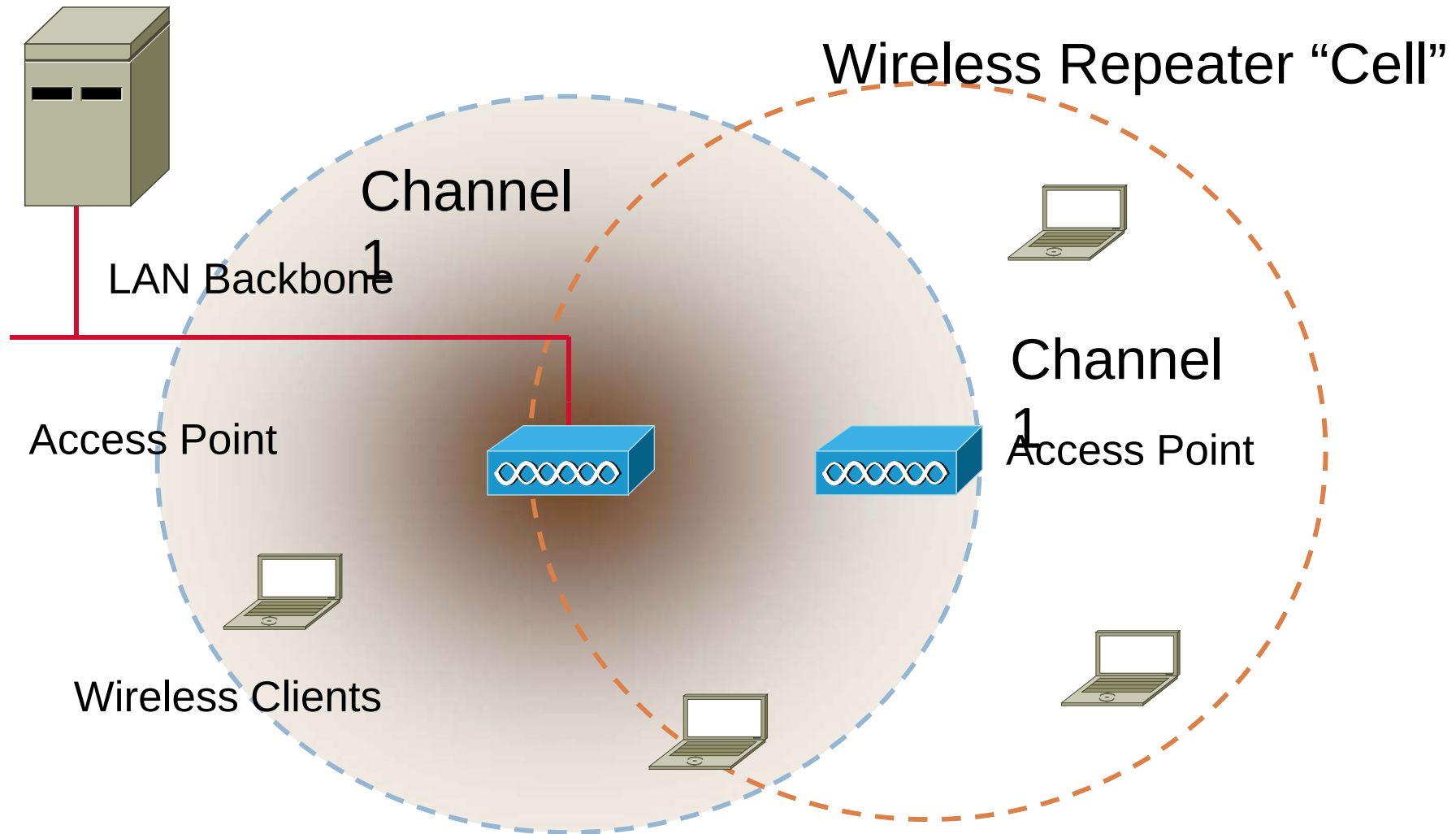
29



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Wireless repeater

30



Wireless and Cellular

Roaming

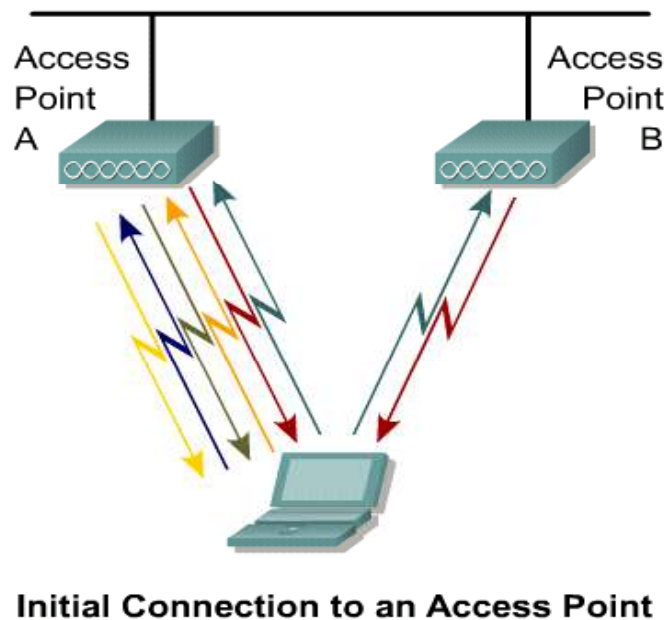
31

- Seamless roaming capabilities while moving from one point to another:
 - ▣ Coverage must be sufficient for the entire path.
 - ▣ A consistent IP address should be available throughout the entire path.
- Clients will associate with initial AP. Re-association will occur as the AP strength weakens, and a new AP is found for association.

Association

32

- If more than one AP replies, the client will associate based on the information returned.

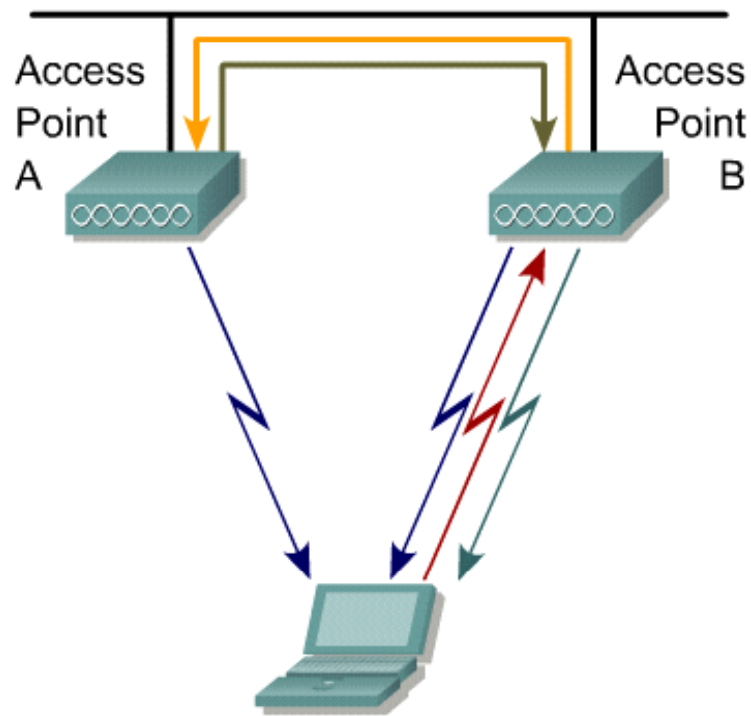


Steps to Association:

- Client sends probe.
- AP sends Probe Response.
- Client evaluates AP response, selects best AP.
- Client sends authentication request to selected AP (A).
- AP A confirms authentication and registers client.
- Client sends association request to selected AP (A).
- AP A confirms association and registers client.

Re-association

33



**Roaming from Access Point A
to Access Point B**

Steps to Re-association:

- ➡ Adapter listens for beacons from APs.
- Adapter evaluates AP beacons, selects best AP.
- ➡ Adapter sends association request to selected AP (B).
- ➡ AP B confirms association and registers adapter.
- ➡ AP B informs AP A of re-association with AP B.
- ➡ AP A forwards buffered packets to AP B and de-registers adapter.

Scalability

34

- Scalability is the ability to locate more than one access point in the same area.
 - ▣ This will increase the available bandwidth of that area for all users local to that access point.

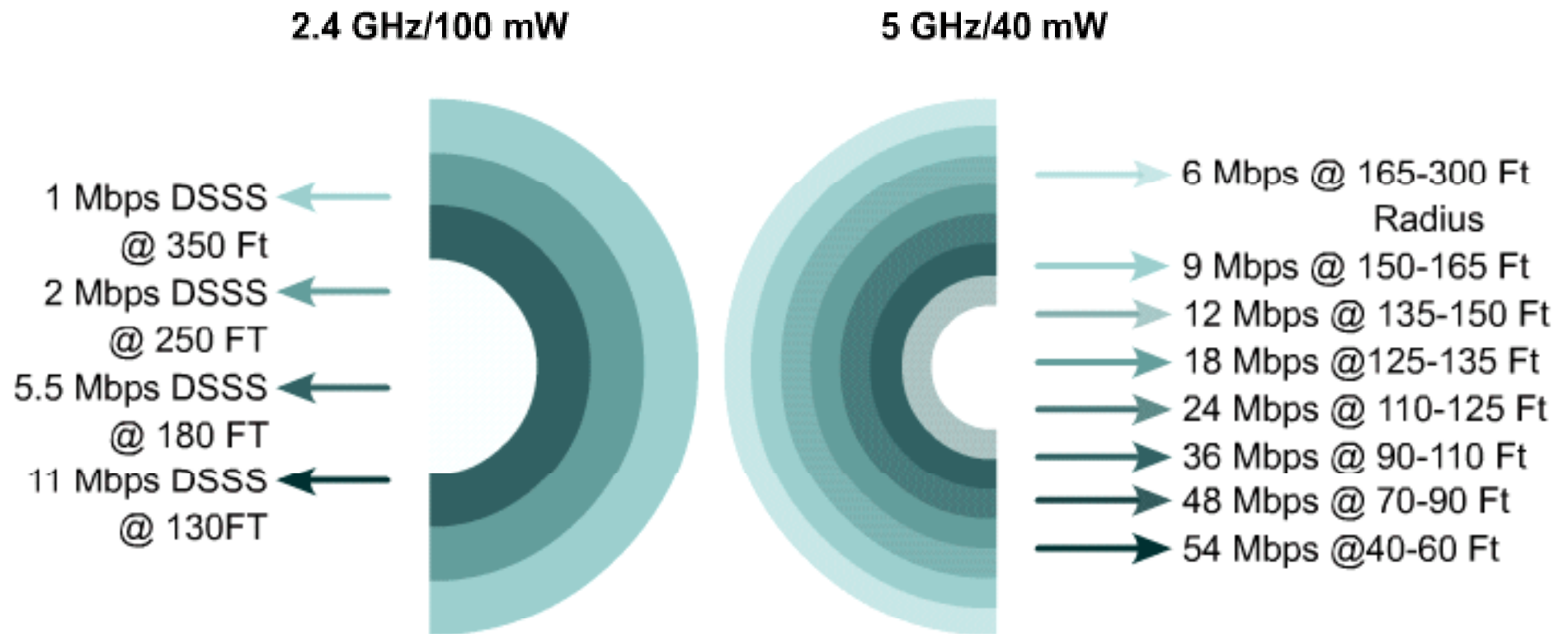
Scalability

35

- Depending on the number and speed of the available channels, cells can achieve higher data rates.
- With 802.11b, there are 3 separate, 11-Mbps channels, yielding up to a theoretical 33 Mbps per cell. User devices operate at a maximum theoretical value of 11 Mbps, since they can only connect to one AP at any given time.
- 802.11a has 8 x 54 Mbps channels, yielding a theoretical 432 Mbps.

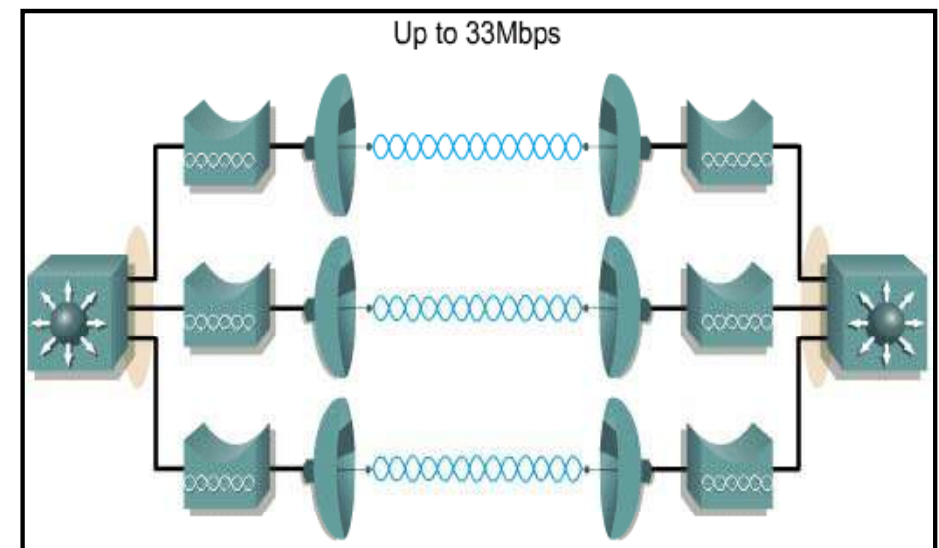
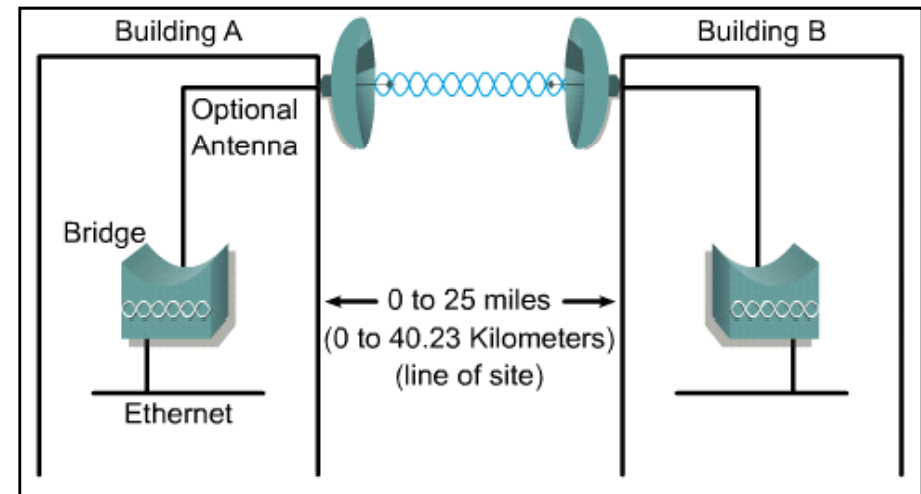
Rate Shifting

36



Point-To-Point Wireless Bridging

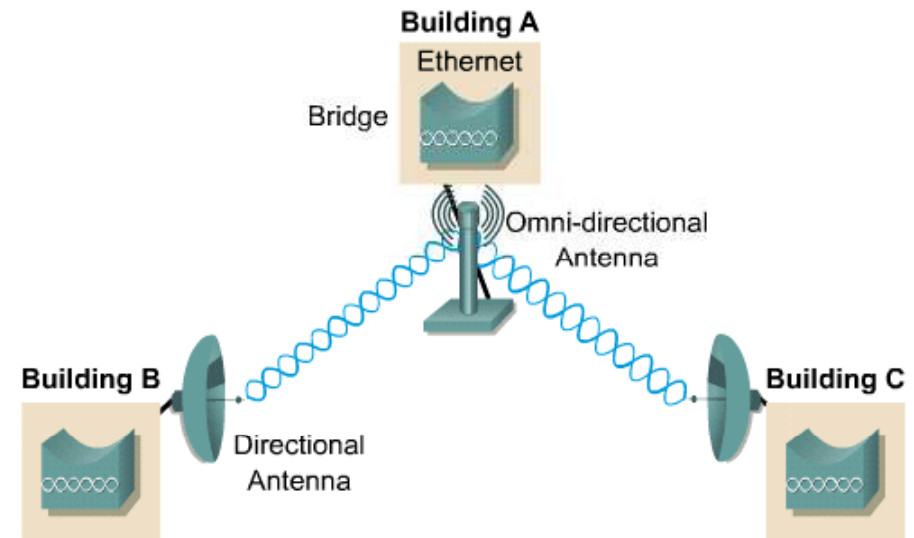
- Point-to-point wireless bridges, two LANs can be located up to 25 miles apart.
- Antennas must have line-of-site. Obstacles cause communication problems.
- One bridge to Root = ON and the other Root = OFF.
- With Cisco IOS, it is possible to use Fast Etherchannel or multi-link trunking, to aggregate up to three bridges together, yielding 33 Mbps.



Point-to-multipoint configuration

38

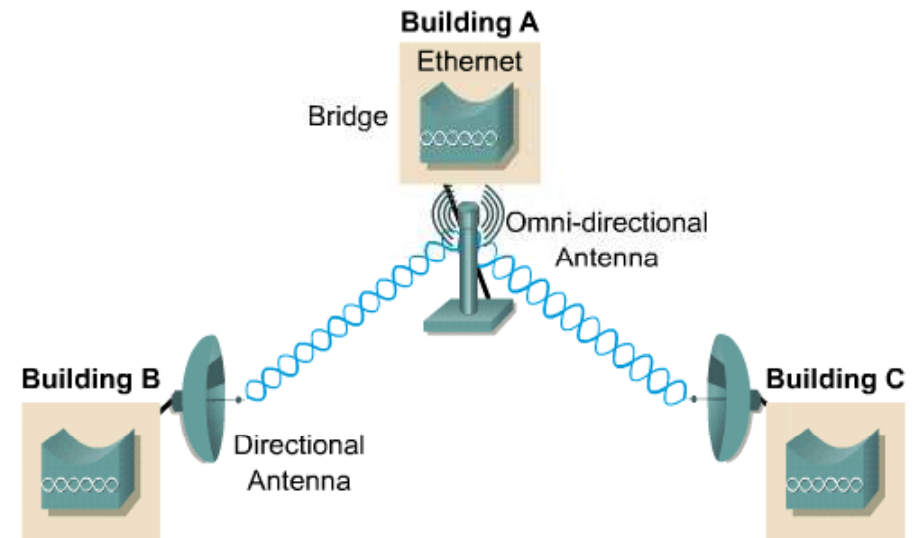
- All the LANs appear as a single segment.
- Traffic from one remote site to another will be sent to the main site and then forwarded to the other remote site.
- Remote sites cannot communicate directly with one another.



Point-to-multipoint configuration

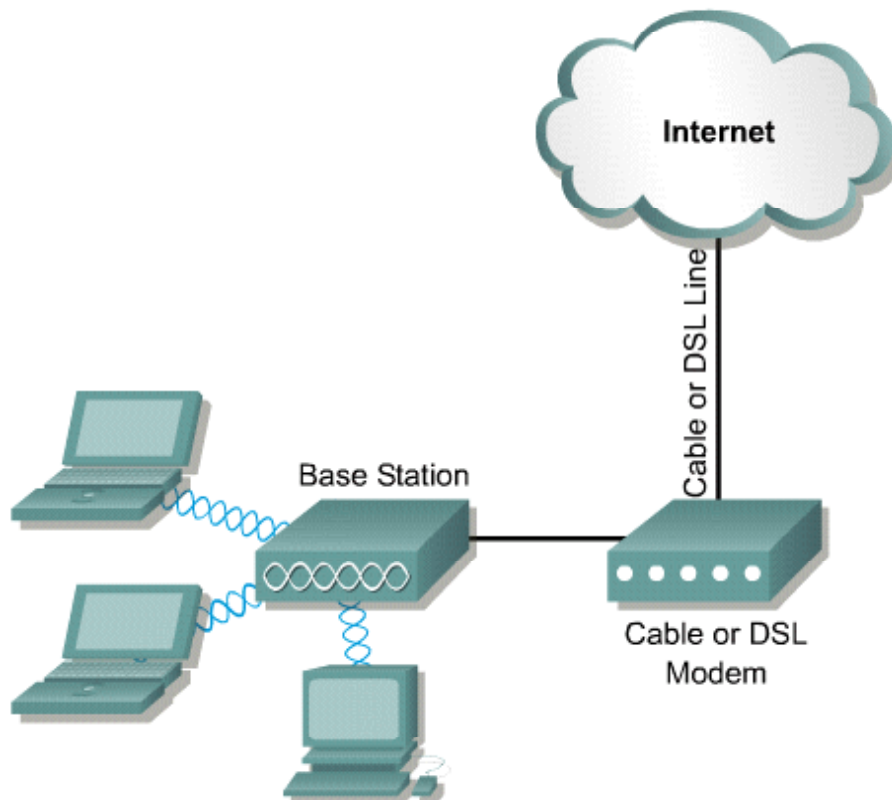
39

- Omni directional antenna used at the main site.
 - ▣ Directional antennas at the remote sites.
 - ▣ Line of sight must be maintained between remote and main sites.
- Main bridge Root = ON and all other bridges Root = OFF/



Base Station—DSL

40



- ❑ Offers support for a Cable or DSL modem
- ❑ Only supports wireless clients.
- ❑ DHCP functionality is supported, but access to the wired network is not provided, as the Ethernet port must be used to connect to the Cable/DSL modem.
- ❑ Support for PPP over Ethernet.

Important Antenna Concepts

41

Important Antenna Concepts

Directionality

- Omnidirectional (360 degree coverage)
- Directional (limited angle of coverage)

Gain

- Measured in dBi and dBd. (0 dBd is equal to 2.14 dBi)
- More gain mean more coverage in certain directions

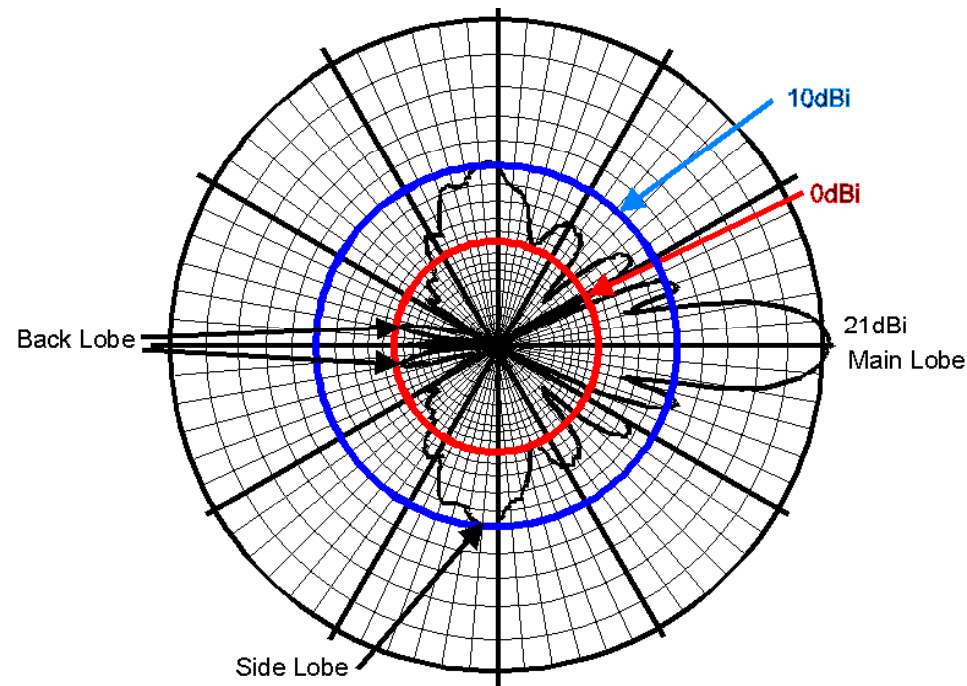
Polarization

- Cisco Aironet antennas use vertical polarization.

Antenna Issues (cont.)

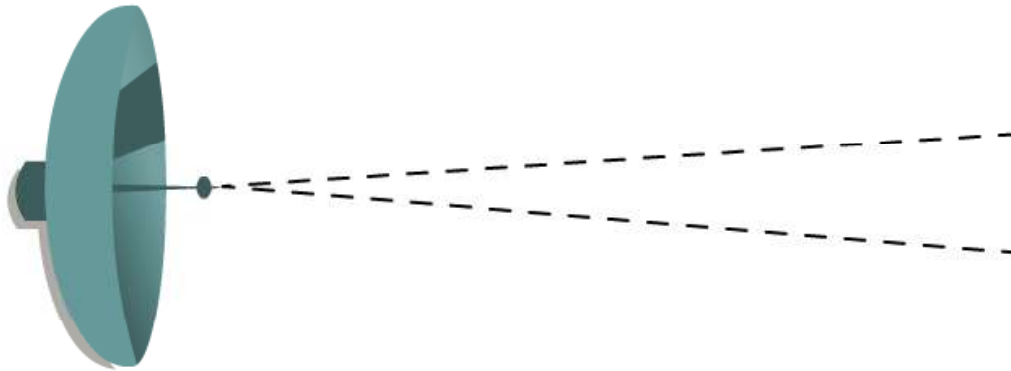
42

- Antennas have gain in particular directions
- Direction other than the main intended radiation pattern, are typically related to the main lobe gain

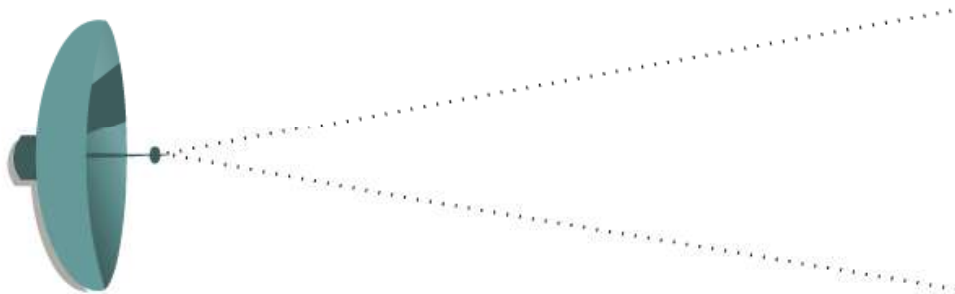


Beamwidth vs. Gain

43



Higher-gain antennas have narrower beamwidths and less chance of receiving interference.

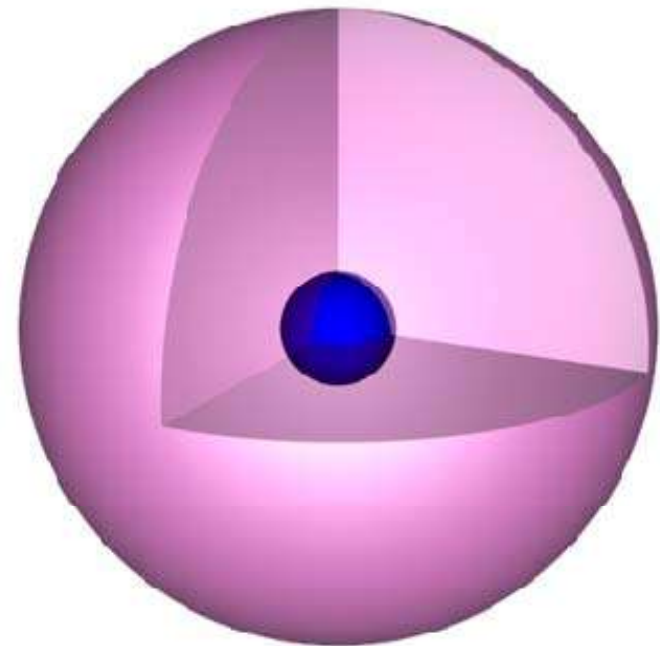


Lower-gain antennas have wider beamwidths and a greater chance of receiving interference.

Antenna Theory

44

- A theoretical isotropic antenna has a perfect 360° vertical and horizontal beamwidth
- This is a reference for ALL antennas



Path Considerations

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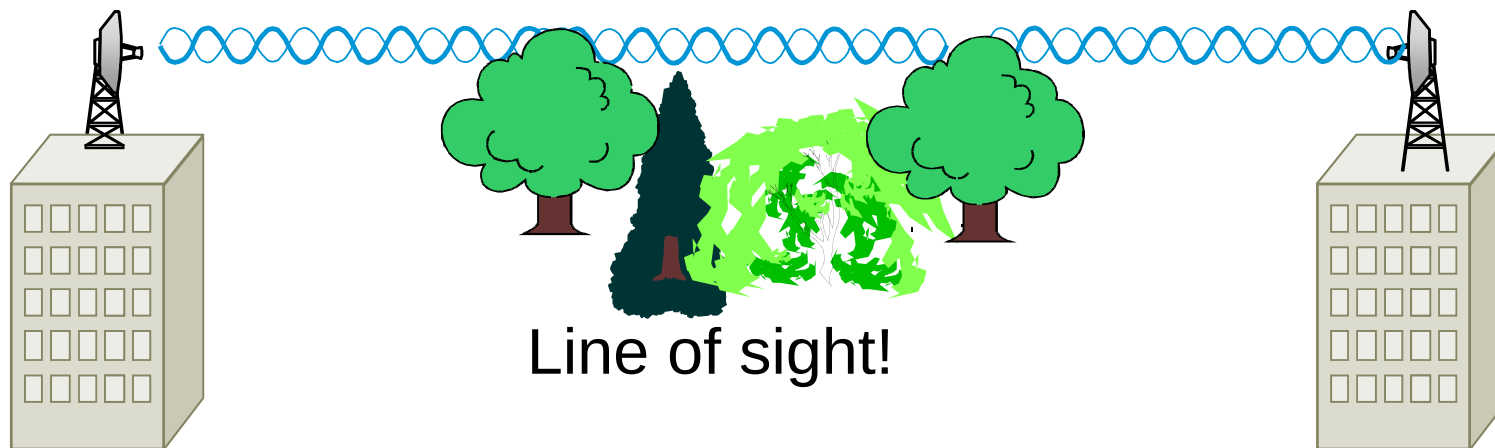
- ❑ Radio line of sight
- ❑ Earth bulge
- ❑ Fresnel zone
- ❑ Antenna and cabling
- ❑ Data rate



Line of Sight

46

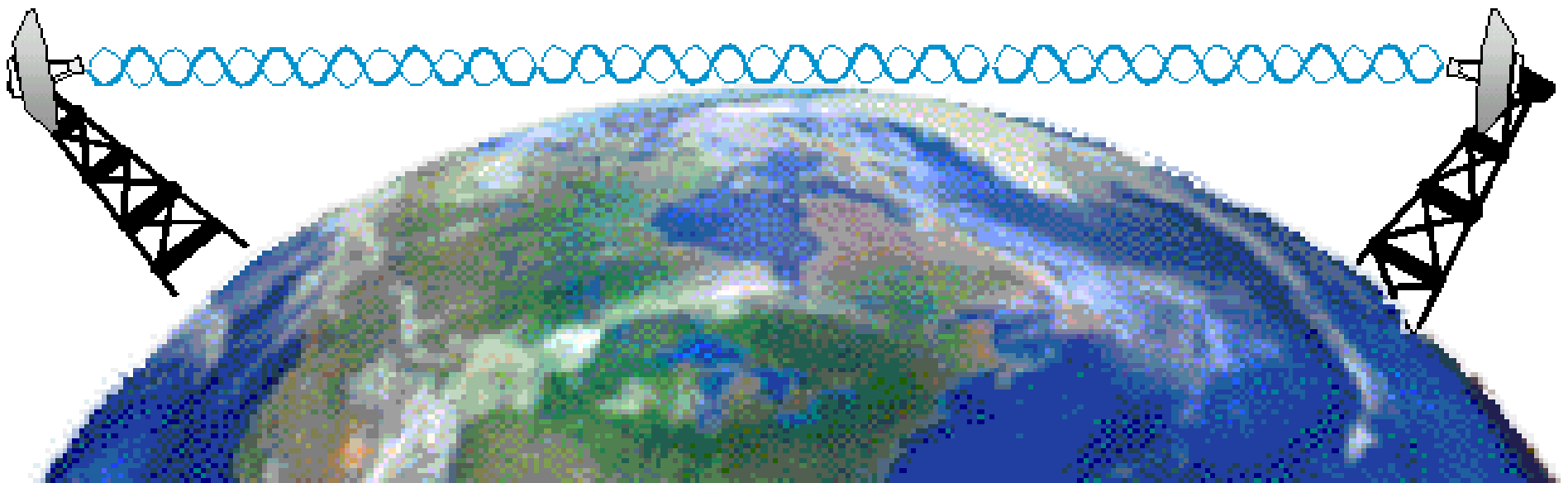
- Obstructions that might obscure a visual link:
 - ▣ Topographic features, such as mountains
 - ▣ Curvature of the Earth
 - ▣ Buildings and other man-made objects
 - ▣ Trees



Longer Distances

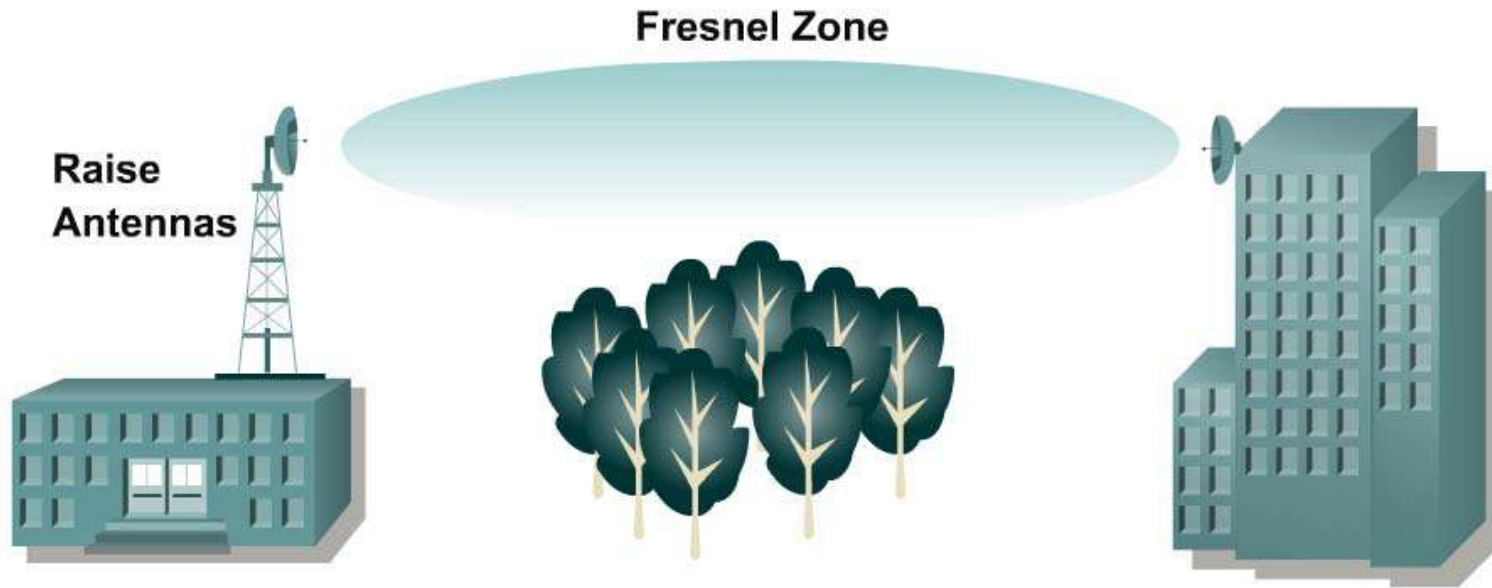
47

- Line of Sight disappears at 6 miles (9.7 Km) due to the earth curve



Fresnel Zone

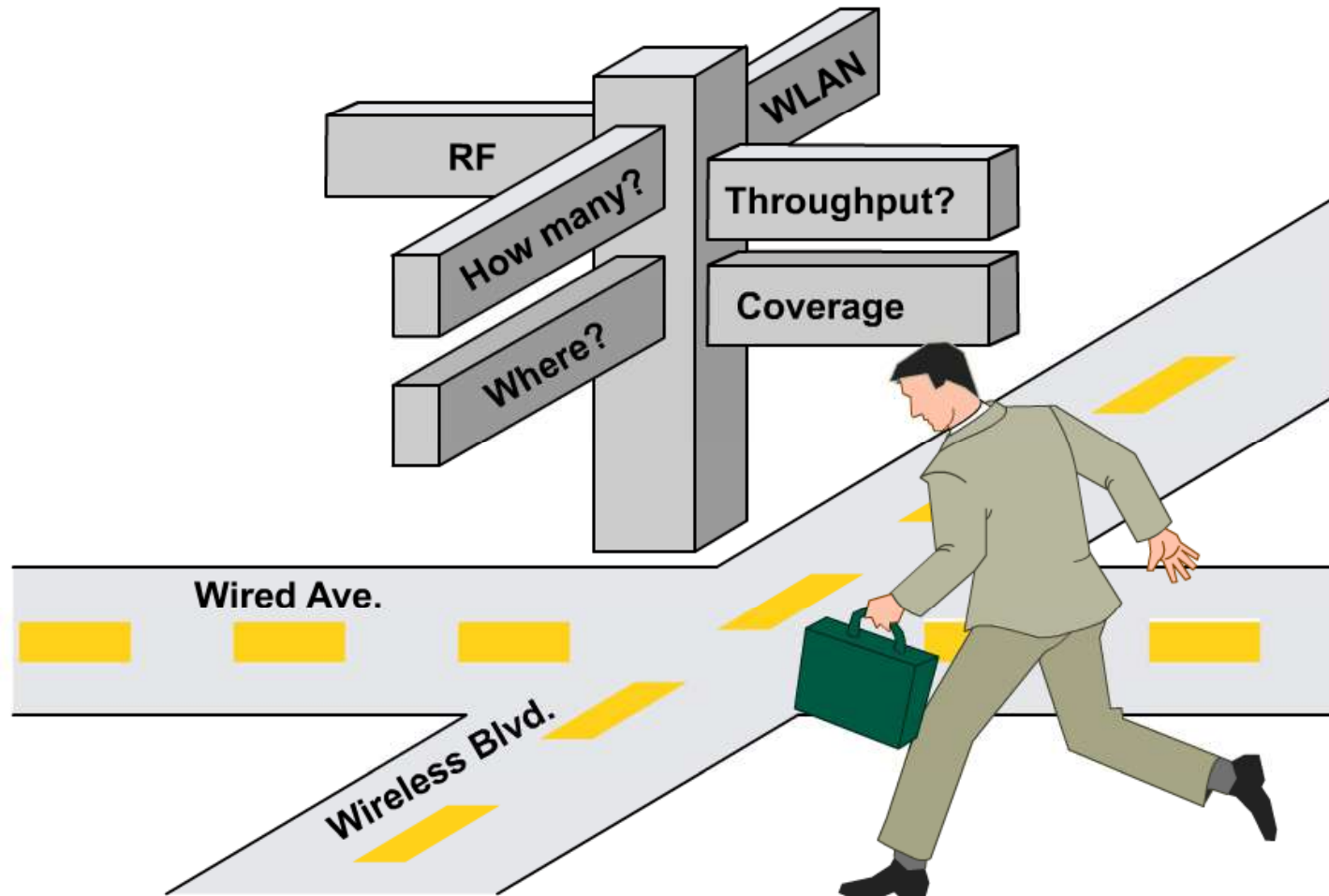
48



- Raise the antenna mounting point
- Build a new structure i.e. a radio tower, tall enough to mount the antenna
- Increase the height of an existing tower
- Locate a different mounting point, for the antenna
- Cut down problem trees

Investigate Customer Requirements

49



Wireless and Cellular

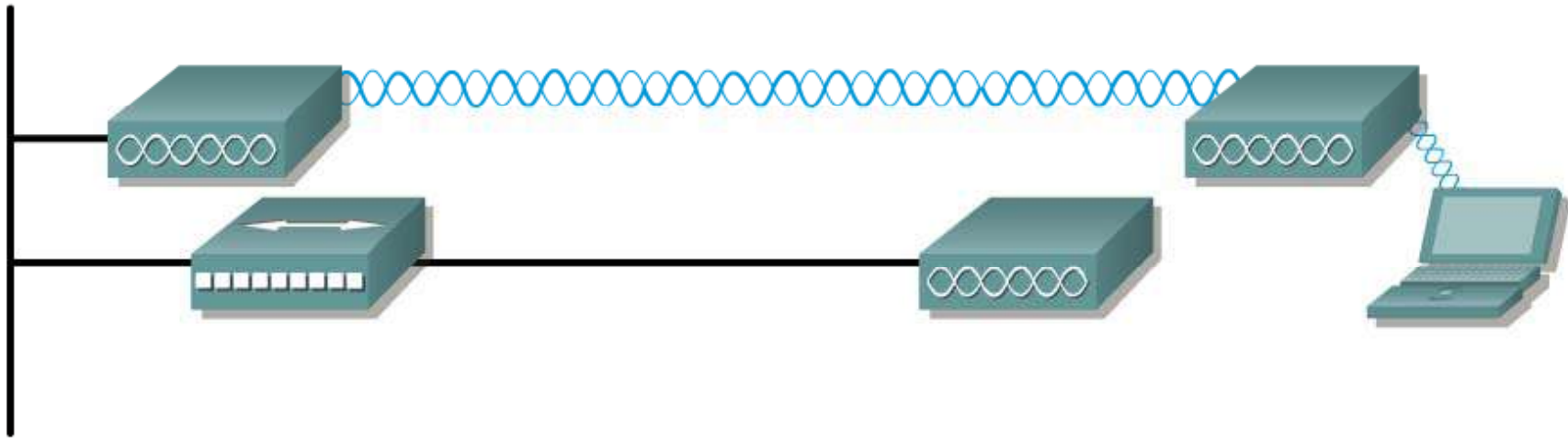
Site Survey Steps

50

- The process of a site survey includes:
 - ▣ Gather tools and configuration
 - ▣ Research and investigate industry specific concerns
 - ▣ Gather the recommended equipment list, or site survey kit
 - ▣ Implement the site survey
 - ▣ Document the site survey

LAN Limitations

51

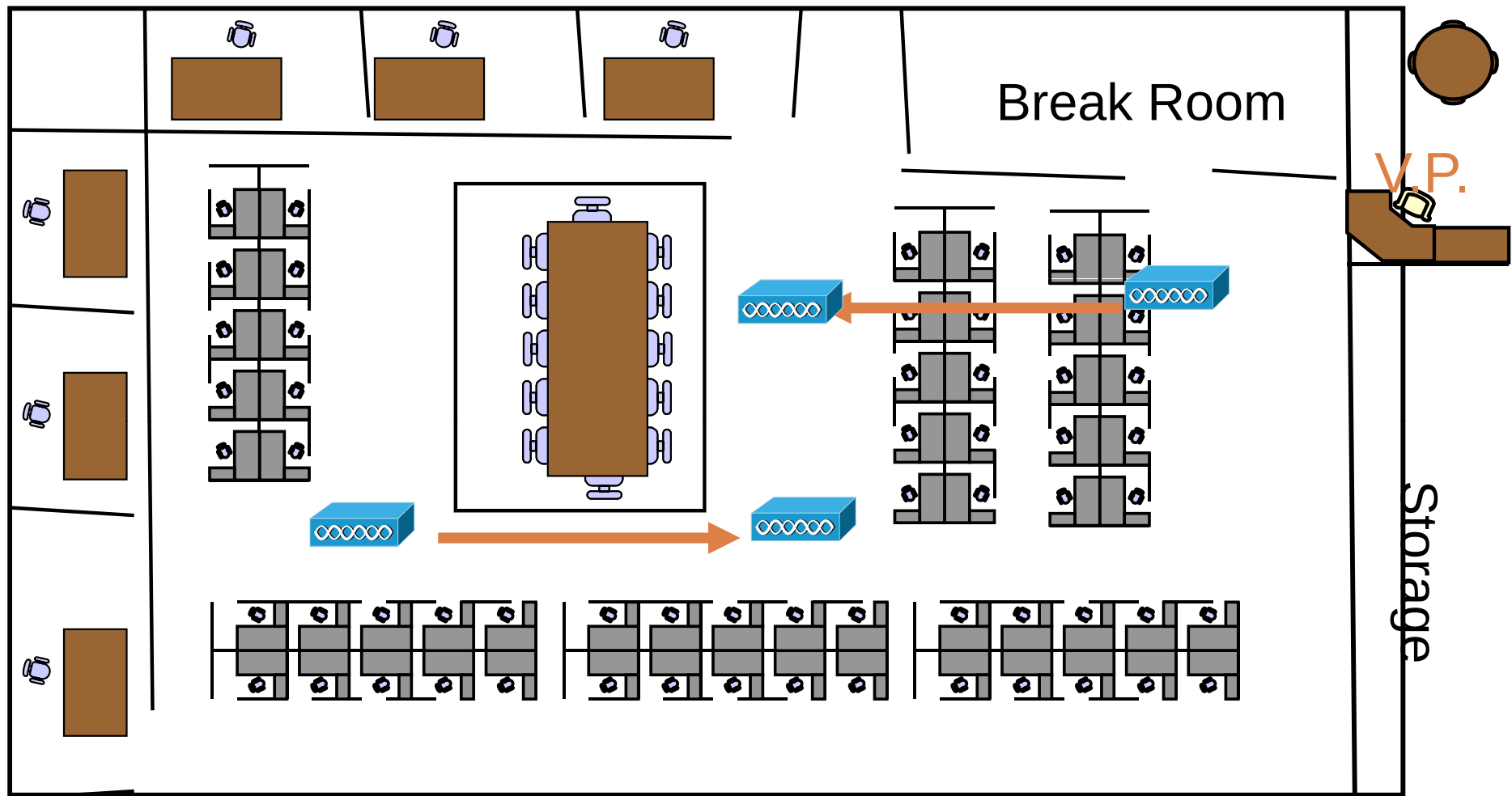


Sometimes the limitations of the wired network may decide how you design your WLAN

- Knowledge of wired LANs allows you to be creative in your WLAN design. This means a superior design for your customer
- Know your wired and wireless alternatives

Wireless LAN Office Design (cont.)

52



Wireless Networks Connect Anytime, Anywhere

53

- A secure, scalable, cost-effective solution, wireless networks offer:
- Anytime, anywhere access to information, promoting collaboration with colleagues, business partners, and customers
- Real-time access to instant messaging, e-mail, and network resources, boosting productivity and speeding business decision making
- Mobility services, such as voice, guest access, advanced security, and location, that help you transform business operations
- Modular architecture that supports 802.11n, 802.11a/b/g, and enterprise wireless mesh for indoor and outdoor locations, while ensuring a smooth migration path to future technologies and services

Application?

54

- Dukes University

- http://oit.duke.edu/news/2007/2007_12_01_wifi.php
 - <http://law.duke.edu/actech/networkaccess/>

802.11n

55

- 802.11n wireless networks let you create a seamless working environment by combining the mobility of wireless with the performance of wired networks. 802.11n technology delivers unprecedented reliability and up to five times the throughput of current 802.11a/b/g networks. It makes wireless networks an integral part of every type of organization by offering the following benefits:
- Data rates of up to 300 Mbps per radio support more users, devices, and mission-critical, bandwidth-intensive applications
- New multiple-input, multiple-output (MIMO) technology provide predictable WLAN coverage and reliable connectivity
- Next-generation wireless provides the greatest investment protection to support emerging mobility applications

802.11 cont Enterprise wireless mesh.

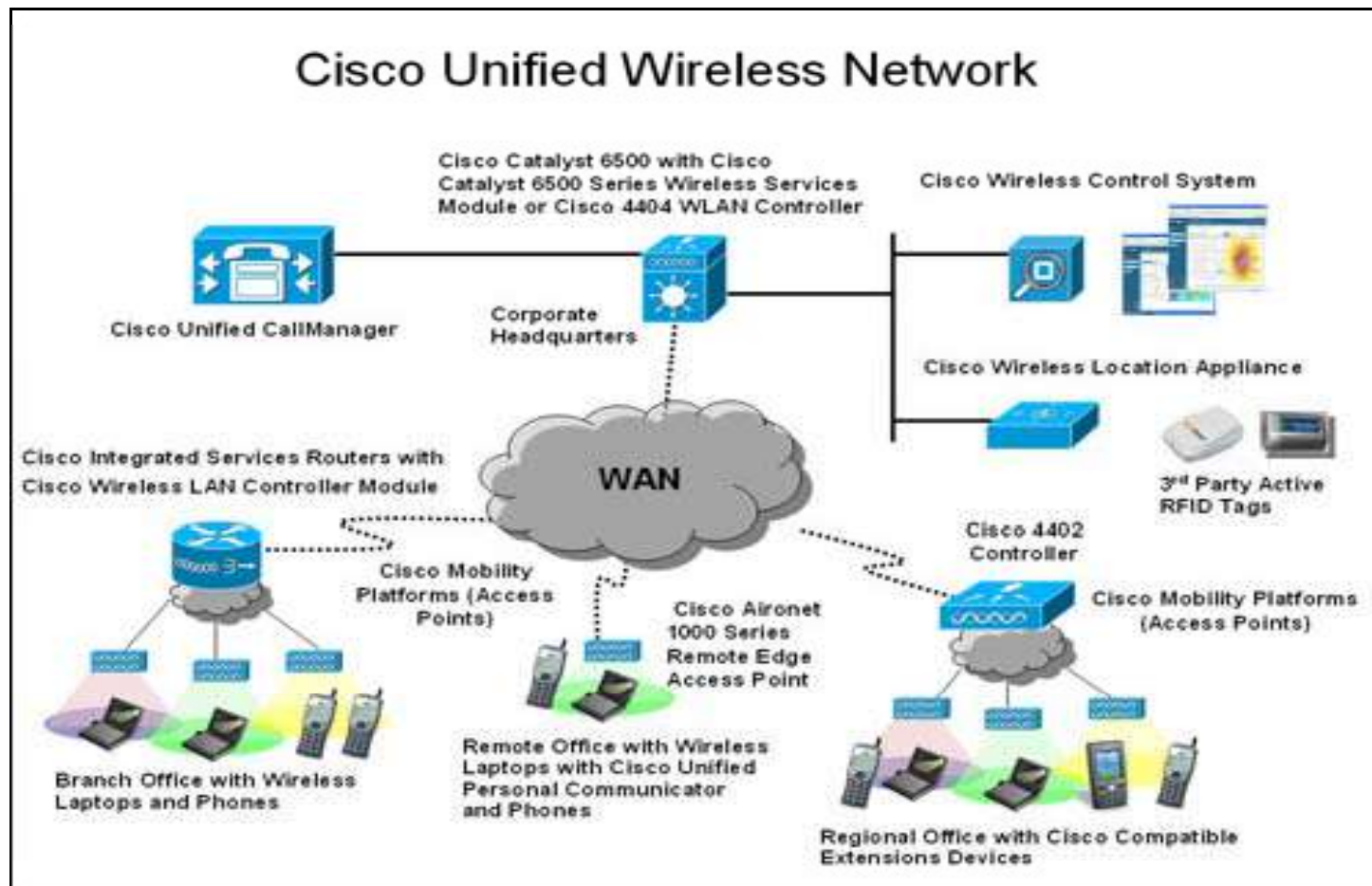
56

- An Enterprise Wireless Mesh lets your enterprise provide wireless connectivity in indoor areas that, until now, have been difficult or impossible to wire. Without requiring wired connections, mesh access points use the 2.4-GHz frequency to deliver network access to users in hard-to-reach areas, and use the 5-GHz band to backhaul traffic to traditional access points connected to Ethernet ports. Benefits include:
 - ▣ High availability through dynamic wireless mesh self-healing
 - ▣ Unified architecture for indoor and outdoor networks
 - ▣ Simple, flexible radio frequency (RF) coverage
 - ▣ Optimal network performance for your entire enterprise facility

VoIP - Wireless

57

- Quality of service, Fast secure roaming, Diverse client support, Simplified management



Wireless and Cellular

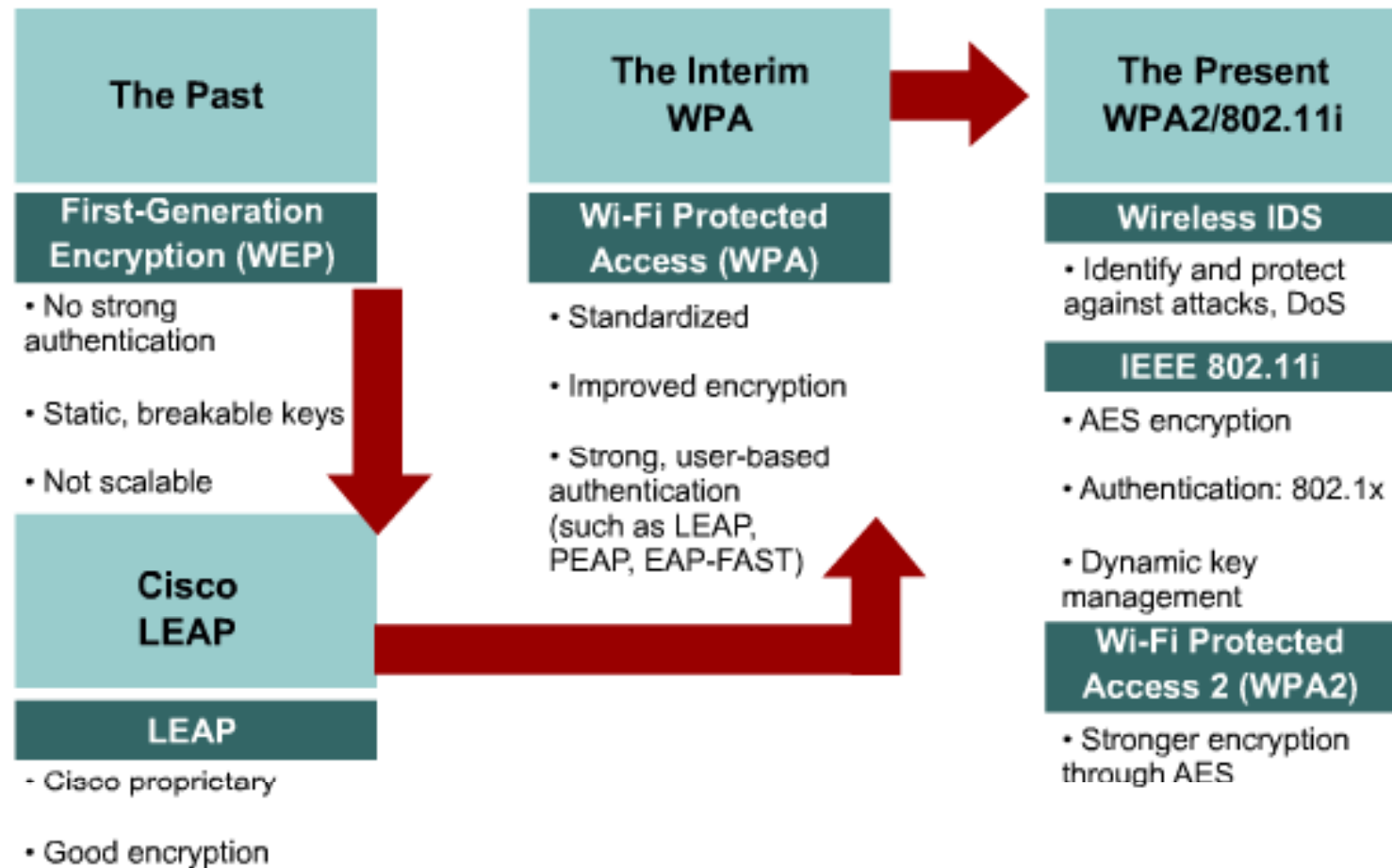
Guest access?

58

- Make a research or conference center more attractive to prospective customers
- Help minimize stock shortages in retail, healthcare, and government
- Increase customer spending
- Enable consultants to large enterprises to complete audits more efficiently
- With the Cisco Unified Wireless Network, you can ensure that client devices comply with security policies, automatically quarantining threats to network security. Cisco WLAN solutions let you:
 - Authorize guest access to both the wired and wireless network
 - Automatically prioritize traffic to optimize network performance
 - Easily provision guest user access
 - Monitor guest use of the network

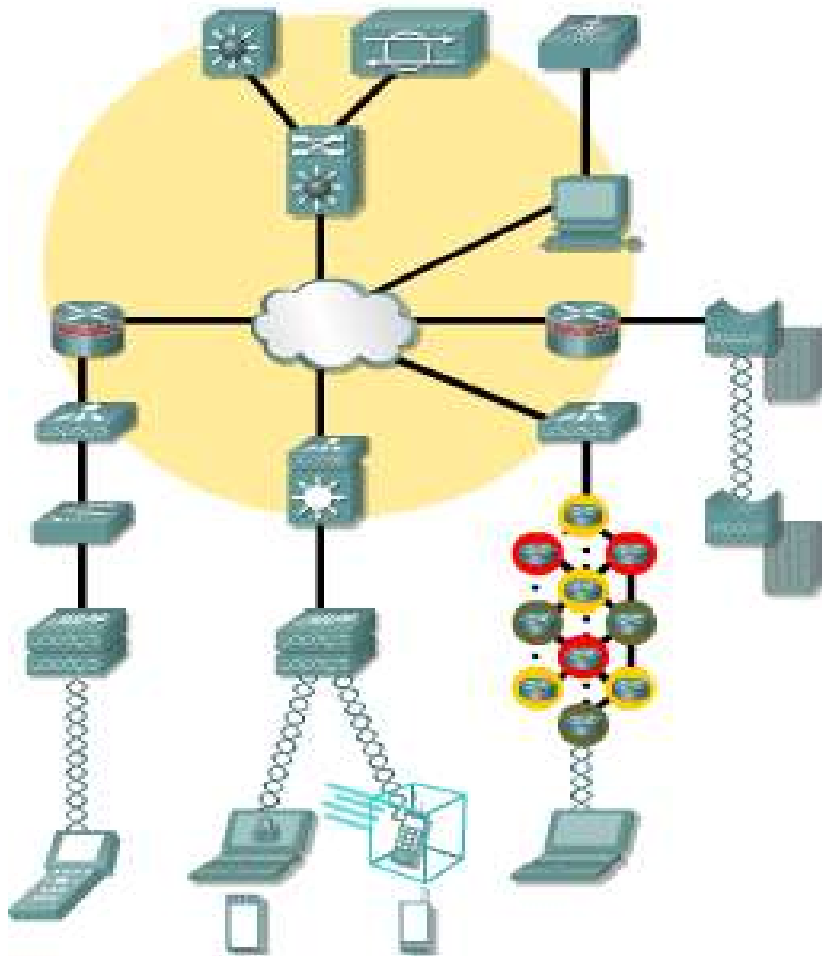
Evolution of Wireless Security

59



Unified Wireless Network

60



Unified Advanced Services

Unified cellular and Wi-Fi VoIP. Advanced threat detection, identity networking, location-based security, asset tracking, and guest access.

World-Class Network Management

Same level of security, scalability, reliability, ease of deployment, and management for wireless LANs as wired LANs.

Network Unification

Integration into all major switching and routing platforms. Secure, innovative WLAN controllers.

Mobility Platform

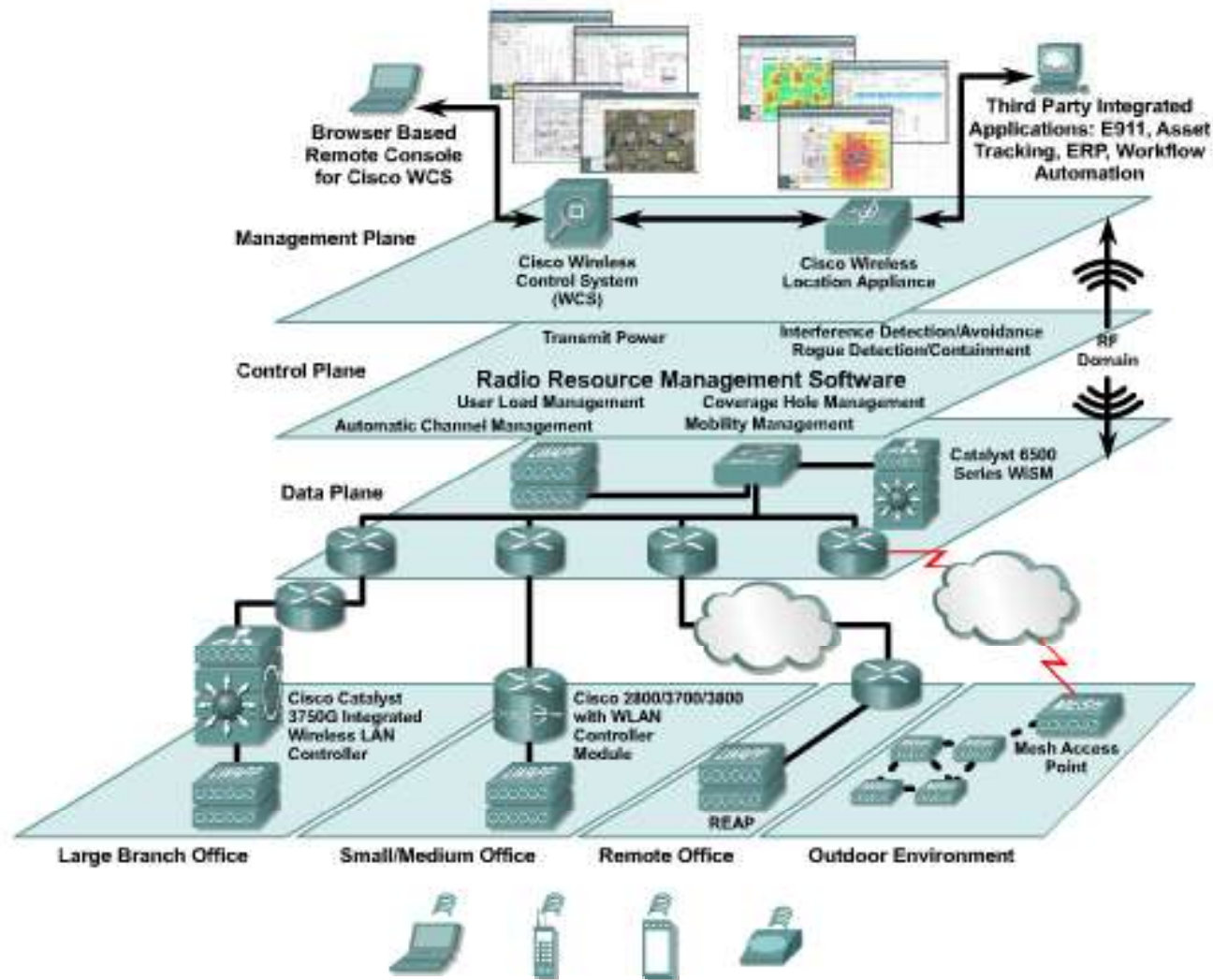
Ubiquitous network access in all environments. Plug and play.

Client Devices

90% of Wi-Fi silicon Cisco Compatible Certified. Advanced services support.

Enterprise wide RF intelligence

61



Wireless and Cellular

Examples

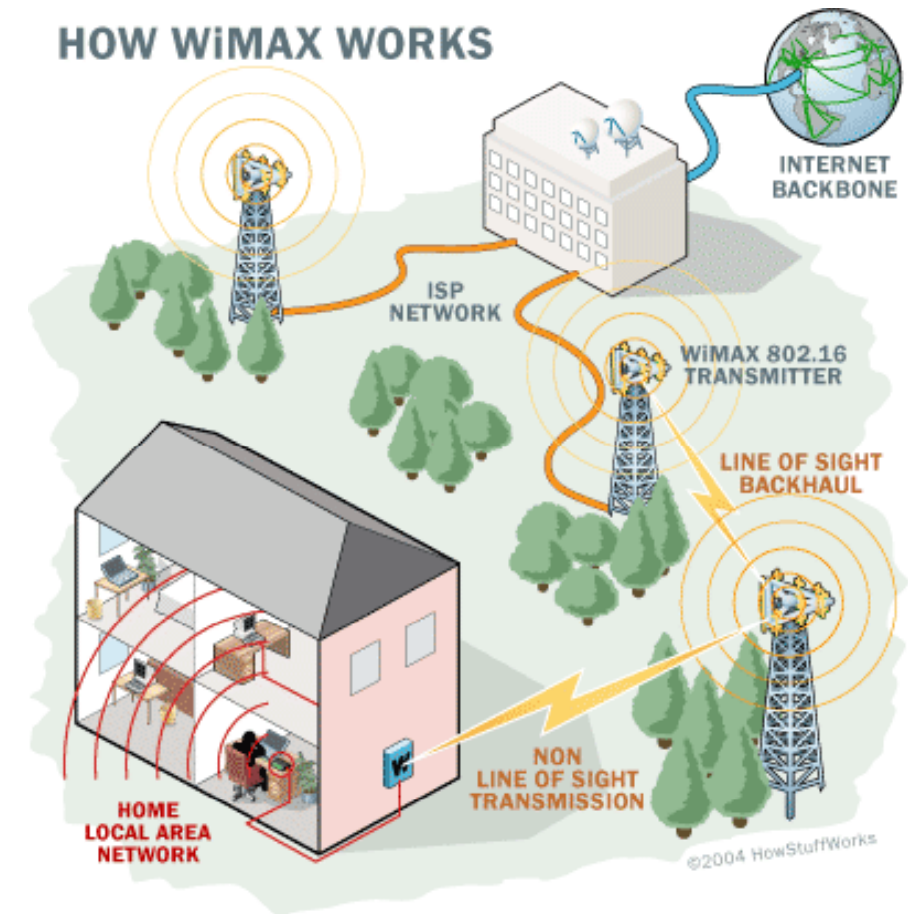
62

- T.K.maxx
- Bank Fashion

WiMAX, the Worldwide Interoperability for Microwave Access

63

- Technology for providing wireless data over long distances in a variety of ways
- from point-to-point links to full mobile cellular type access.
- It is based on the IEEE 802.16 standard, which is also called WirelessMAN.
-



- The name WiMAX was created by the WiMAX Forum, which was formed in June 2001 to promote conformance and interoperability of the standard.
- The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL."

WiMAX overview

65

- ❑ Connecting Wi-Fi hotspots with each other and to other parts of the Internet.
- ❑ Providing a wireless alternative to cable and DSL for last mile broadband access.
- ❑ Providing high-speed data and telecommunications services.
- ❑ Providing a diverse source of Internet connectivity as part of a business continuity plan. That is, if a business has a fixed and a wireless Internet connection, especially from unrelated providers, they are unlikely to be affected by the same service outage.
- ❑ Providing nomadic connectivity.

Physical layer

66

- The original version of the standard on which WiMAX is based (IEEE 802.16) specified a physical layer operating in the 10 to 66 GHz range. 802.16a, updated in 2004 to 802.16-2004, added specifications for the 2 to 11 GHz range.
- 802.16-2004 was updated by 802.16e-2005 in 2005 and uses scalable orthogonal frequency-division multiple access (SOFDMA) as opposed to the OFDM version with 256 sub-carriers (of which 200 are used) in 802.16d.
- More advanced versions, including 802.16e, also bring Multiple Antenna Support through Multiple-input multiple-output communications (MIMO) See WiMAX MIMO.
- This brings potential benefits in terms of coverage, self installation, power consumption, frequency re-use and bandwidth efficiency. 802.16e also adds a capability for full mobility support.

WiMAX Vs WiFi

67

- WiMAX is a long-range system, covering many kilometers that typically uses licensed spectrum (although it is also possible to use unlicensed spectrum) to deliver a point-to-point connection to the Internet from an ISP to an end user. Different 802.16 standards provide different types of access, from mobile (similar to data access via a cellphone) to fixed (an alternative to wired access, where the end user's wireless termination point is fixed in location.)
- Wi-Fi is a shorter range system, typically hundreds of meters, that uses unlicensed spectrum to provide access to a network, typically covering only the network operator's own property. Typically Wi-Fi is used by an end user to access their own network, which may or may not be connected to the Internet. If WiMAX provides services analogous to a cellphone, Wi-Fi is more analogous to a cordless phone.

WiMAX Vs WiFi cont.

68

- WiMAX and Wi-Fi have quite different Quality of Service (QoS) mechanisms. WiMAX uses a mechanism based on setting up connections between the Base Station and the user device. Each connection is based on specific scheduling algorithms, which means that QoS parameters can be guaranteed for each flow. Wi-Fi has introduced a QoS mechanism similar to fixed Ethernet, where packets can receive different priorities based on their tags. This means that QoS is relative between packets/flows, as opposed to guaranteed.
- WiMAX is highly scalable from what are called "femto"-scale remote stations to multi-sector 'maxi' scale base that handle complex tasks of management and mobile handoff functions and include MIMO-AAS smart antenna subsystems.

Limitations

69

- A commonly-held misconception is that WiMAX will deliver 70 Mbit/s over 50 kilometers. In reality, WiMAX can do one or the other — operating over maximum range (50 km) increases bit error rate and thus must use a lower bitrate. Lowering the range allows a device to operate at higher bitrates.
- Typically, fixed WiMAX networks have a higher-gain directional antenna installed near the client (customer) which results in greatly increased range and throughput. Mobile WiMAX networks are usually made of indoor "customer premises equipment" (CPE) such as desktop modems, laptops with integrated Mobile WiMAX or other Mobile WiMAX devices.
- Mobile WiMAX devices typically have an omni-directional antenna which is of lower-gain compared to directional antennas but are more portable. In practice, this means that in a line-of-sight environment with a portable Mobile WiMAX CPE, speeds of 10 Mbit/s at 10 km could be delivered. However, in urban environments they may not have line-of-sight and therefore users may only receive 10 Mbit/s over 2 km.

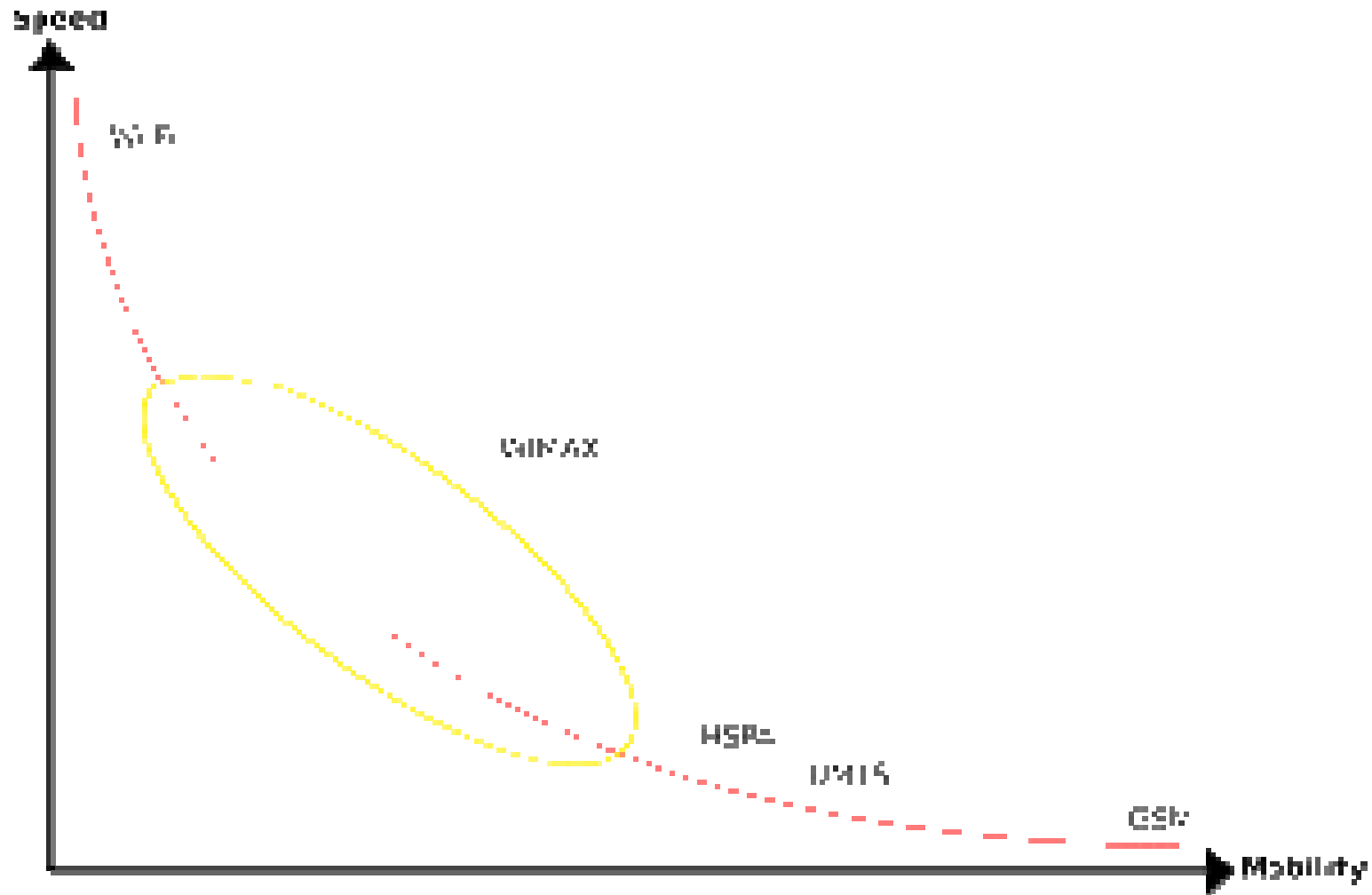
Limitations cont.

70

- In current deployments, throughputs are often closer to 2 Mbit/s symmetric at 10 km with fixed WiMAX and a high gain antenna.
- It is also important to consider that a throughput of 2 Mbit/s can mean 2 Mbit/s, symmetric simultaneously, 1 Mbit/s symmetric or some asymmetric mix (e.g. 2 Mbit/s downlink and 1 Mbit/s uplink or 1.5 Mbit/s downlink and 0.5 Mbit/s uplink, each of which required slightly different network equipment and configurations. Higher-gain directional antennas can be used with a Mobile WiMAX network with range and throughput benefits but the obvious loss of practical mobility.
- Like most wireless systems, available bandwidth is shared between users in a given radio sector, so performance could deteriorate in the case of many active users in a single sector. In practice, many users will have a range of 2-, 4-, 6-, 8-, 10- or 12 Mbit/s services and additional radio cards will be added to the base station to increase the capacity as required.

Competing technologies

71



Wireless and Cellular

Comparison of Mobile Internet Access methods

72

Standard	Family	Primary Use	Radio Tech	Downlink (Mbit/s)	Uplink (Mbit/s)
<u>802.16e</u>	WiMAX	Mobile Internet	MIMO-SOFDMA	70	70
<u>HIPERMAN</u>	HIPERMAN	Mobile Internet	<u>OFDM</u>	56.9	56.9
<u>WiBro</u>	WiBro	Mobile Internet	<u>OFDMA</u>	50	50
<u>iBurst</u>	iBurst 802.20	Mobile Internet	<u>HC-SDMA/TDD/MIMO</u>	64	64
<u>EDGE Evolution</u>	<u>GSM</u>	Mobile Internet	<u>TDMA/FDD</u>	1.9	0.9
<u>UMTS W-CDMA</u> <u>HSDPA+HSUPA</u> <u>HSPA+</u>	<u>UMTS/3GSM</u>	Mobile phone	<u>CDMA/FDD</u> <u>CDMA/FDD/MIMO</u>	0.384 14.4 42	0.384 5.76 11.5
<u>UMTS-TDD</u>	UMTS/3GSM	Mobile Internet	<u>CDMA/TDD</u>	16	16
<u>LTE UMTS</u>	UMTS/4GSM	General 4G	<u>OFDMA/MIMO/SC-FDMA (HSOPA)</u>	>100	>50
<u>1xRTT</u>	<u>CDMA2000</u>	Mobile phone	<u>CDMA</u>	0.144	0.144
<u>EV-DO 1x Rev. 0</u> <u>EV-DO 1x Rev.A</u> <u>EV-DO Rev.B</u>	CDMA2000	Mobile Internet	<u>CDMA/FDD</u>	2.45 3.1 4.9xN	0.15 1.8 1.8xN

User security issues

73

- Scansafe [6 degrees, 2008]
 - ▣ Mobile workers visit pornographic websites 2.5 times more than their office counterparts
 - ▣ Mobile workers visit illegal file sharing sites 8.5 times more than office counterparts
 - ▣ Mobile workers visit illegal activity sites 3.9 times more often than their office counterparts
 - ▣ Mobile workers are 66% more likely to do online banking than their office counterparts