Wireless Mobile Communication

Lecture 26, 27

- Traffic Routing in Wireless Network

Topics to be Covered

- Wireless Technology overview
- The IEEE 802.11 WLAN Standards
- Secure Wireless LANs
- Migrating to Wireless LANs (Cutting the cord)

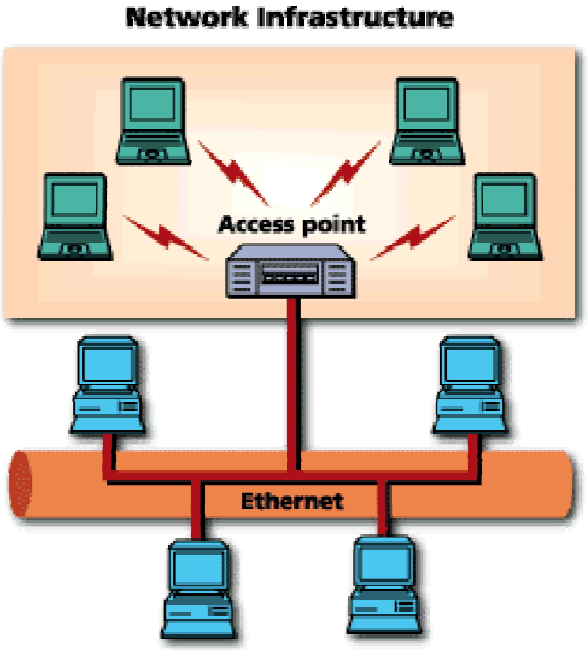
Wireless?

- A wireless LAN or WLAN is a wireless local area network that uses radio waves as its carrier.
- The last link with the users is wireless, to give a network connection to all users in a building or campus.
- The backbone network usually uses cables

Common Topologies

The wireless LAN connects to a wired LAN

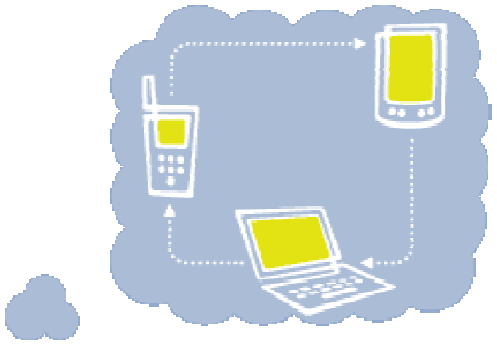
- There is a need of an access point that bridges wireless LAN traffic into the wired LAN.
- The access point (AP) can also act as a repeater for wireless nodes, effectively doubling the maximum possible distance between nodes.



Common Topologies

Complete Wireless Networks

- The physical size of the network is determined by the maximum reliable propagation range of the radio signals.
- Referred to as **ad hoc** networks
- Are self-organizing networks without any centralized control
- Suited for temporary situations such as meetings and conferences.



How do wireless LANs work?

Wireless LANs operate in almost the same way as

wired LANs, using the same networking protocols

and supporting the most of the same

applications.

How are WLANs Different?

- They use specialized **physical and data link** protocols
- They integrate into existing networks through **access points** which provide a bridging function
- They let you stay connected as you **roam** from one coverage area to another
- They have unique **security** considerations
- They have specific **interoperability** requirements
- They require **different hardware**
- They offer **performance** that differs from wired LANs.

Physical and Data Link Layers

Physical Layer:

- The wireless **NIC** takes **frames** of data from the link layer, scrambles the data in a predetermined way, then uses the modified data stream to modulate a **radio carrier signal**.

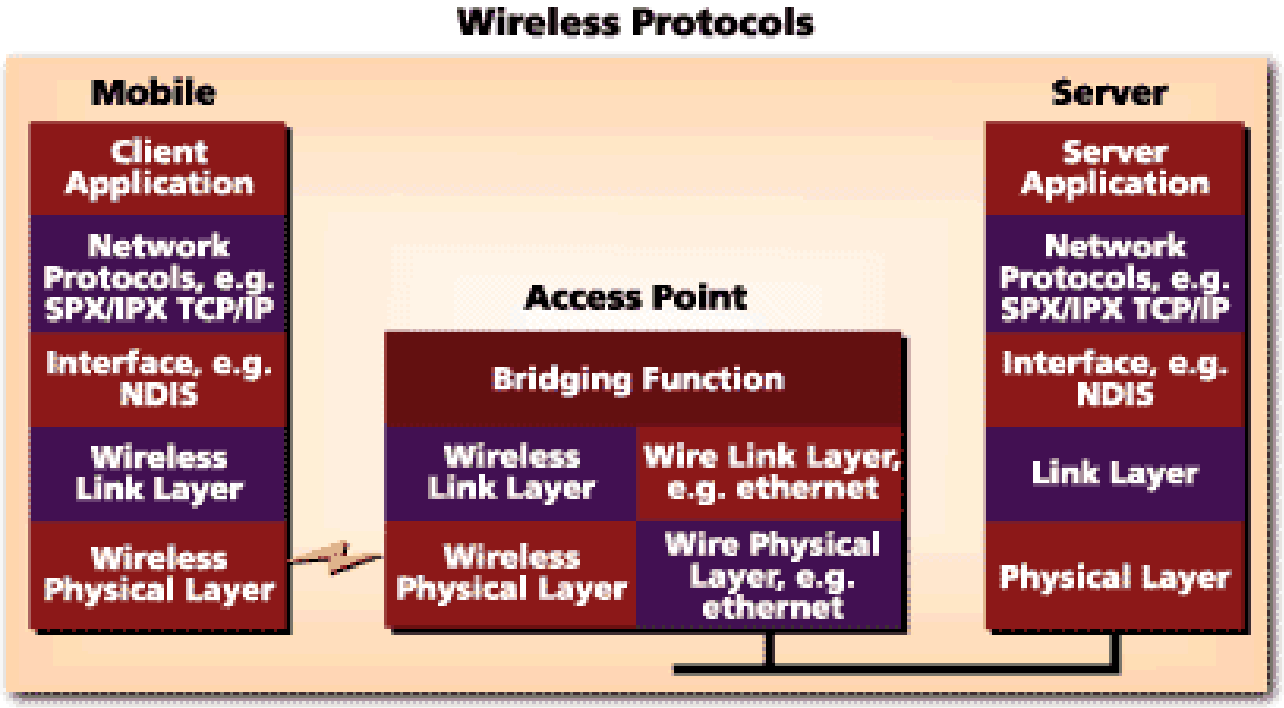
Data Link Layer:

- Uses **C**arriers-**S**ense-**M**ultiple-**A**ccess with **C**ollision **A**voidance (CSMA/CA).

Integration With Existing Networks

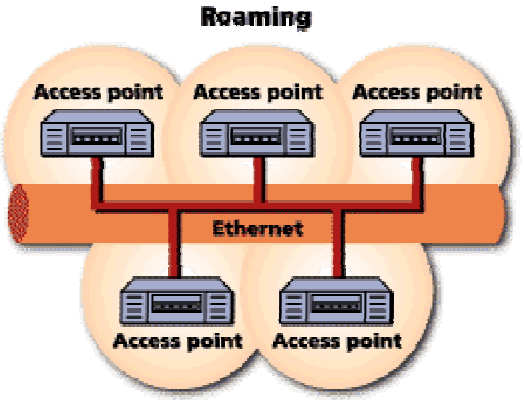
- Wireless Access Points (APs) - a small device that bridges wireless traffic to your network.
- Most access points bridge wireless LANs into Ethernet networks, but Token-Ring options are available as well.

Integration With Existing Networks



Roaming

- Users maintain a continuous connection as they roam from one physical area to another
- Mobile nodes automatically register with the new access point.
- Methods: DHCP, Mobile IP
- IEEE 802.11 standard does not address roaming, you may need to purchase equipment from one vendor if your users need to roam from one access point to another.



Security

- In theory, spread spectrum radio signals are inherently difficult to decipher without knowing the exact hopping sequences or direct sequence codes used
- The IEEE 802.11 standard specifies optional security called "**W**ired **E**quivalent **P**rivacy" whose goal is that a wireless LAN offer privacy equivalent to that offered by a wired LAN. The standard also specifies optional authentication measures.

Interoperability

- Before the IEEE 802.11 interoperability was based on cooperation between vendors.
- IEEE 802.11 only standardizes the physical and medium access control layers.
- Vendors must still work with each other to ensure their IEEE 802.11 implementations interoperate
- Wireless Ethernet Compatibility Alliance (WECA) introduces the Wi-Fi Certification to ensure cross-vendor interoperability of 802.11b solutions

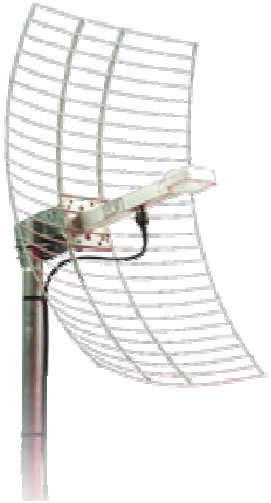
Hardware

- PC Card, either with integral antenna or with external antenna/RF module.
- ISA Card with external antenna connected by cable.
- Handheld terminals
- Access points

Hardware

CISCO Aironet 350 series

Wireless Handheld Terminal



Semi Parabolic Antenna

BreezeCOM AP

Performance

- **802.11a** offers speeds with a theoretically maximum rate of 54Mbps in the 5 GHz band
- **802.11b** offers speeds with a theoretically maximum rate of 11Mbps at in the 2.4 GHz spectrum band
- **802.11g** is a new standard for data rates of up to a theoretical maximum of 54 Mbps at 2.4 GHz.

What is 802.11?

- A family of wireless LAN (WLAN) specifications developed by a working group at the Institute of Electrical and Electronic Engineers (IEEE)
- Defines standard for WLANs using the following four technologies
  - Frequency Hopping Spread Spectrum (FHSS)
  - Direct Sequence Spread Spectrum (DSSS)
  - Infrared (IR)
  - Orthogonal Frequency Division Multiplexing (OFDM)
- Versions: 802.11a, 802.11b, 802.11g, 802.11e, 802.11f, 802.11i

802.11 - Transmission

- Most wireless LAN products operate in unlicensed radio bands
  - 2.4 GHz is most popular
  - Available in most parts of the world
  - No need for user licensing
- Most wireless LANs use spread-spectrum radio
  - Resistant to interference, secure
  - Two popular methods
    - Frequency Hopping (FH)
    - Direct Sequence (DS)

Frequency Hopping Vs. Direct Sequence

- FH systems use a radio carrier that “hops” from frequency to frequency in a pattern known to both transmitter and receiver
  - Easy to implement
  - Resistance to noise
  - Limited throughput (2-3 Mbps @ 2.4 GHz)
- DS systems use a carrier that remains fixed to a specific frequency band. The data signal is spread onto a much larger range of frequencies (at a much lower power level) using a specific encoding scheme.
  - Much higher throughput than FH (11 Mbps)
  - Better range
  - Less resistant to noise (made up for by redundancy – it transmits at least 10 fully redundant copies of the original signal at the same time)

802.11a

- Employs Orthogonal Frequency Division Multiplexing (OFDM)
  - Offers higher bandwidth than that of 802.11b, DSSS (Direct Sequence Spread Spectrum)
  - 802.11a MAC (Media Access Control) is same as 802.11b
- Operates in the 5 GHz range

802.11a Advantages

- Ultra-high spectrum efficiency
  - 5 GHz band is 300 MHz (vs. 83.5 MHz @ 2.4 GHz)
  - More data can travel over a smaller amount of bandwidth
- High speed
  - Up to 54 Mbps
- Less interference
  - Fewer products using the frequency
    - 2.4 GHz band shared by cordless phones, microwave ovens, Bluetooth, and WLANs

802.11a Disadvantages

- Standards and Interoperability
  - Standard not accepted worldwide
  - No interoperability certification available for 802.11a products
  - Not compatible or interoperable with 802.11b
- Legal issues
  - License-free spectrum in 5 GHz band not available worldwide
- Market
  - Beyond LAN-LAN bridging, there is limited interest for 5 GHz adoption

802.11a Disadvantages

- Cost
  - 2.4 GHz will still has >40% cost advantage
- Range
  - At equivalent power, 5 GHz range will be ~50% of 2.4 GHz
- Power consumption
  - Higher data rates and increased signal require more power
    - OFDM is less power-efficient then DSSS

802.11a Applications

- Building-to-building connections
- Video, audio conferencing/streaming video, and audio
- Large file transfers, such as engineering CAD drawings
- Faster Web access and browsing
- High worker density or high throughput scenarios
  - Numerous PCs running graphics-intensive applications

802.11a Vs. 802.11b

802.11a vs. 802.11b	802.11a	802.11b
Raw data rates	Up to 54 Mbps (54, 48, 36, 24,18, 12 and 6 Mbps)	Up to 11 Mbps (11, 5.5, 2, and 1 Mbps)
Range	50 Meters	100 Meters
Bandwidth	UNII and ISM (5 GHz range)	ISM (2.4000—2.4835 GHz range)
Modulation	OFDM technology	DSSS technology

802.11g

- 802.11g is a high-speed extension to 802.11b
  - Compatible with 802.11b
  - High speed up to 54 Mbps
  - 2.4 GHz (vs. 802.11a, 5 GHz)
  - Using ODFM for backward compatibility
  - Adaptive Rate Shifting

802.11g Advantages

- Provides higher speeds and higher capacity requirements for applications
  - Wireless Public Access
- Compatible with existing 802.11b standard
- Leverages Worldwide spectrum availability in 2.4 GHz
- Likely to be less costly than 5 GHz alternatives
- Provides easy migration for current users of 802.11b WLANs
  - Delivers backward support for existing 802.11b products
- Provides path to even higher speeds in the future

802.11e Introduces Quality of Service

- Also know as P802.11 TGe
- Purpose:
  - To enhance the 802.11 Medium Access Control (MAC) to improve and manage Quality of Service (QoS)
- Cannot be supported in current chip design
- Requires new radio chips
  - Can do basic QoS in MAC layer

802.11f – Inter Access Point Protocol

- Also know as P802.11 TGf
- Purpose:
  - To develop a set of requirements for Inter-Access Point Protocol (IAPP), including operational and management aspects

802.11b Security Features

- Wired Equivalent Privacy (**WEP**) – A protocol to protect link-level data during wireless transmission between clients and access points.
- Services:
  - **Authentication**: provides access control to the network by denying access to client stations that fail to authenticate properly.
  - **Confidentiality**: intends to prevent information compromise from casual eavesdropping
  - **Integrity**: prevents messages from being modified while in transit between the wireless client and the access point.

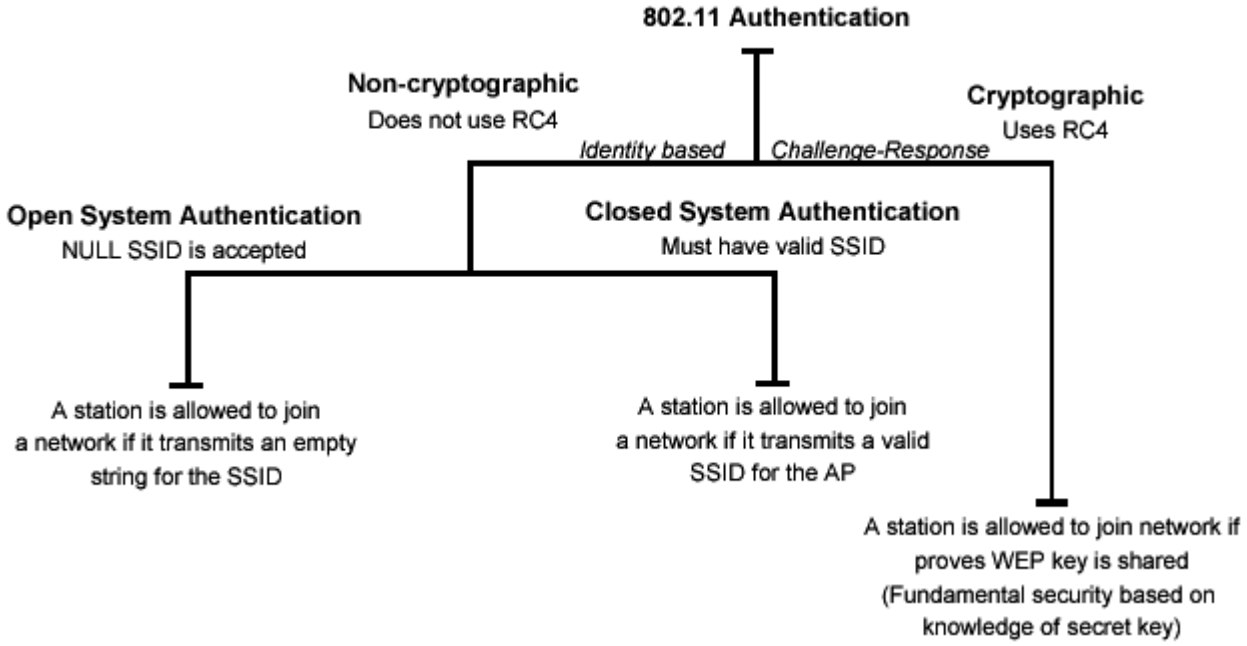
Authentication

Means:

- Based on cryptography
- Non-cryptographic
- Both are identity-based verification mechanisms (devices request access based on the SSID – Service Set Identifier of the wireless network).

Authentication

- Autl



Privacy

- Cryptographic techniques
- WEP Uses RC4 symmetric key, stream cipher algorithm to generate a pseudo random data sequence. The stream is XORed with the data to be transmitted
- Key sizes: 40bits to 128bits
- Unfortunately, recent attacks have shown that the WEP approach for privacy is vulnerable to certain attack regardless of key size

Data Integrity

- Data integrity is ensured by a simple encrypted version of CRC (Cyclic Redundant Check)
- Also vulnerable to some attacks

Security Problems

- Security features in Wireless products are frequently not enabled.
- Use of static WEP keys (keys are in use for a very long time). WEP does not provide key management.
- Cryptographic keys are short.
- No user authentication occurs – only devices are authenticated. A stolen device can access the network.
- Identity based systems are vulnerable.
- Packet integrity is poor.

Other WLAN Security Mechanisms

- 3Com Dynamic Security Link
- CISCO LEAP - Lightweight Extensible Authentication Protocol
- IEEE 802.1x – Port-Based Network Access Control
- RADIUS Authentication Support
- EAP-MD5
- EAP-TLS
- EAP-TTLS
- PEAP - Protected EAP
- TKIP - Temporal Key Integrity Protocol
- IEEE 802.11i

WLAN Migration – Cutting The Cord

- Essential Questions
- Choosing the Right Technology
- Data Rates
- Access Point Placement and Power
- Antenna Selection and Placement
- Connecting to the Wired LAN
- The Site Survey

Essential Questions

- Why is the organization considering wireless? Allows to clearly define requirements of the WLAN -> development plan
- How many users require mobility?
- What are the applications that will run over the WLAN? Helps to determine bandwidth requirements, a criteria to choose between available technologies. Wireless is a **shared** medium, not switched!!!

Choose the right technology

- Usually IEEE 802.11b or 802.11a
- 802.11b offers interoperability (WECA Wi-Fi Certification Program)
- 802.11a offers higher data rates (up to 54 mbps) -> higher throughput per user. Limited interoperability.

Data rates

- Data rates affect range
- 802.11b 1 to 11 Mbps in 4 increments
- 802.11a 6 to 54 Mbps in 7 increments
- The minimum data rate must be determined at design time
- Selecting only the highest data rate will require a greater number of APs to cover a specific area
- Compromise between data rates and overall system cost

Access Point Placement and Power

- Typically – mounted at ceiling height.
- Between 15 and 25 feet (4.5m to 8m)
- The greater the height, the greater the difficulty to get power to the unit. Solution: consider devices that can be powered using CAT5 Ethernet cable (CISCO Aironet 1200 Series).
- Access points have internal or external antennas

Antenna Selection and Placement

- Permanently attached.
- Remote antennas connected using an antenna cable.
- Coax cable used for RF has a high signal loss, should not be mounted more than a 1 or 2 meters away from the device.
- Placement: consider building construction, ceiling height, obstacles, and aesthetics. Different materials (cement, steel) have different radio propagation characteristics.

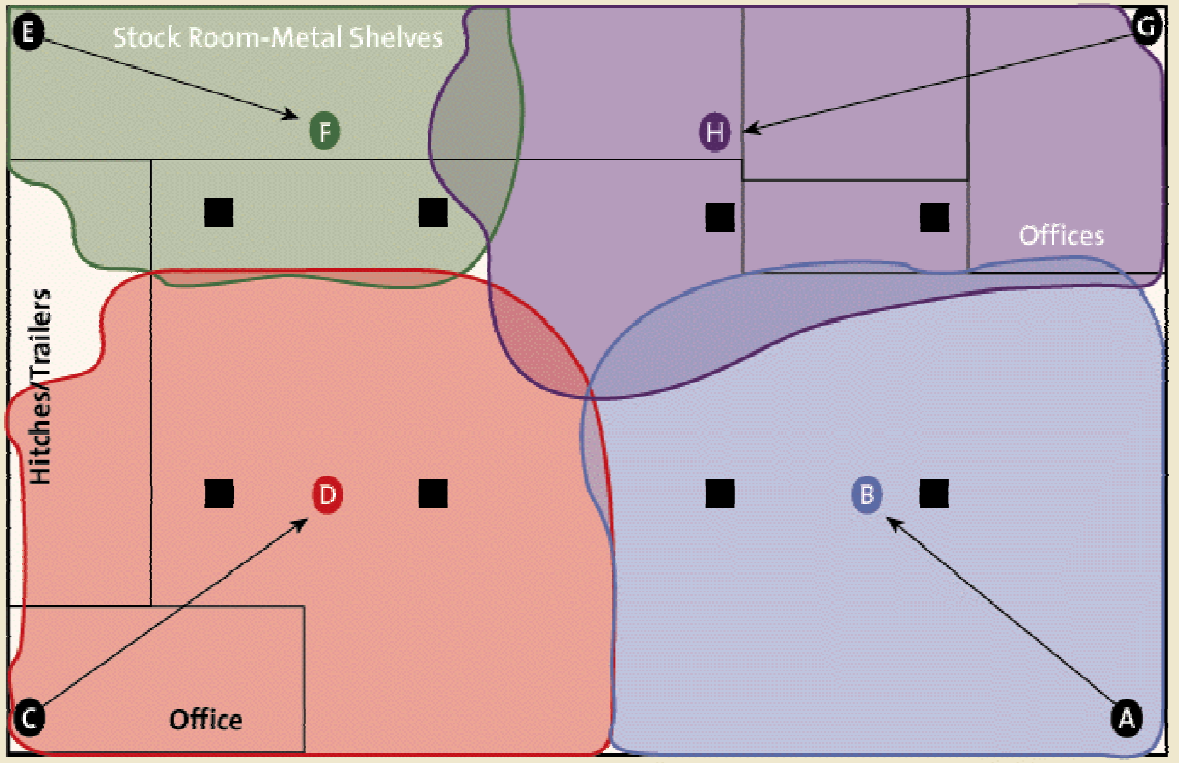
Connecting to the Wired LAN

- Consider user mobility
- If users move between subnets, there are challenges to consider.
- OSes like Windows XP and 2000, Linux support DHCP to obtain the new IP address for the subnet. Certain applications such as VPN will fail.
- Solution: access points in a roaming area are on the same segment.

The Site Survey

- Helps define the coverage areas, data rates, the precise placement of access point.
- Gather information: diagramming the coverage area and measuring the signal strength, SNR (signal to noise ratio), RF interference levels

"OUTSIDE IN" SURVEY METHOD—EXAMPLE



Vendor Information

- **CISCO Systems Wireless** http://www.cisco.com/warp/public/44/jump/wireless.shtml
- **3Com Wireless** http://www.3com.com/products/en_US/prodlist.jsp?tab=cat&pathtype=purchase&cat=13&selcat=Wireless+Products
- **Breeze Wireless Communications** http://www.breezecom.com
- **Lucent Technologies** http://www.wavelan.com
- **Symbol Technologies** http://www.symbol.com

References

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- 3Com University – Wireless LANs A Technology Overview www.3com.com/3comu
- National Institute of Standards and Technology Wireless Network Security http://csrc.nist.gov/publications/drafts/draft-sp800-48.pdf