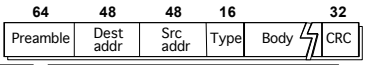
Shared Access Networks

Bus (Ethernet)
Wireless (802.11)

Ethernet Overview

- History
  - developed by Xerox PARC in mid-1970s
  - roots in Aloha packet-radio network
  - standardized by Xerox, DEC, and Intel in 1978
  - similar to IEEE 802.3 standard
- CSMA/CD
  - carrier sense
  - multiple access
  - collision detection
- Frame Format



Ethernet (cont)

- Addresses
  - unique, 48-bit unicast address assigned to each adapter
  - example: 8:0:e4:b1:2
  - broadcast: all 1s
  - multicast: first bit is 1
- Bandwidth: 10Mbps, 100Mbps, 1Gbps
- Length: 2500m (500m segments with 4 repeaters)
- Encoding
  - 10 Mbps - Manchester encoding
  - 100 Mbps - 4B/5B
  - 1000 Mbps - 8B/10B
- Problem: Distributed algorithm that provides fair access

Transmit Algorithm

- If line is idle…
  - send immediately
  - upper bound message size of 1500 bytes (messages can go from 10 to 100 to 1000 Mbit without processing)
    - 9000 bytes for Gbit Ethernet (Jumbo frame)
      - 12000 byte limit for CRC32
  - must wait 9.6us between back-to-back frames
    - 96 bit time (960 ns for 100 Mbps, 96 ns for 1 Gbps)
- If line is busy…
  - wait until idle and transmit immediately
  - called 1-persistent (special case of p-persistent)
    - When channel idle, station transmits with probability 1

Algorithm (cont)

- If collision…
  - jam for 32 bits, then stop transmitting frame
  - minimum frame is 64 bytes (header + 46 bytes of data) for 10/100 Mbps ethernet and 512 bytes for Gigabit Ethernet frame
  - delay and try again
    - 1st time: 0 or 51.2us
    - 2nd time: 0, 51.2, or 102.4us
    - 3rd time: 0, 51.2, 102.4, or 153.6us
    - nth time: k x 51.2us, for randomly selected k=0..2n - 1
    - give up after several tries (usually 16)
    - exponential backoff

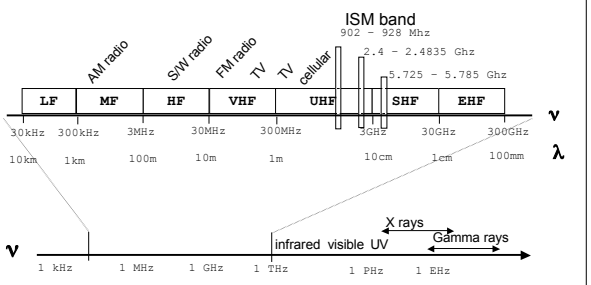
Duplex

- Half duplex - CSMA/CD, Full duplex: both sender and receiver can talk simultaneously
- Peak utilization ~37%

Wireless LANs

- IEEE 802.11
  - Bandwidth: 1 or 2 Mbps
  - 802.11b - 11 Mbps (2.4 GHz)
  - 802.11g - 54 Mbps (2.4 GHz)
  - 802.11a - 54 Mbps (5 GHz)
- Physical Media
  - spread spectrum radio (2.4 GHz)
  - diffused infrared (10 m)
- Wireless LAN
- irDA
- Bluetooth

EM Spectrum



Propagation characteristics are different in each frequency band

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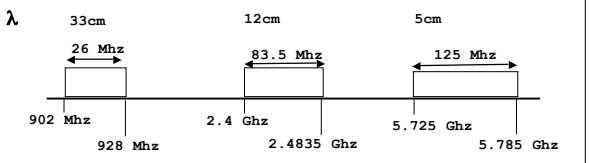
Unlicensed Radio Spectrum



cordless phones	802.11	802.11a
baby monitors	Bluetooth	
Wireless LANs	Microwave oven	

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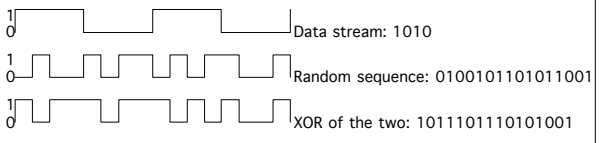
Spread Spectrum

- Idea
  - spread signal over wider frequency band than required
  - originally designed to thwart jamming
- Frequency Hopping
  - transmit over random sequence of frequencies
  - sender and receiver share…
    - pseudorandom number generator
    - seed
  - 802.11 uses 79 x 1MHz-wide frequency bands

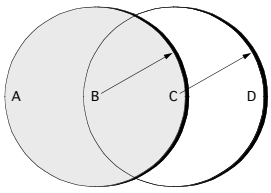
Spread Spectrum (cont)

- Direct Sequence
  - for each bit, send XOR of that bit and n random bits
  - random sequence known to both sender and receiver
  - called n-bit chipping code
  - 802.11 defines an 11-bit chipping code



Collisions Avoidance

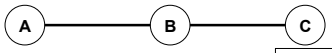
- Similar to Ethernet
- Problem: hidden and exposed nodes



Hidden Terminal Problem

- Node B can communicate with A and C both
- A and C cannot hear each other

- When A transmits to B, C cannot detect the transmission using the *carrier sense* mechanism
- If C transmits, collision will occur at node B



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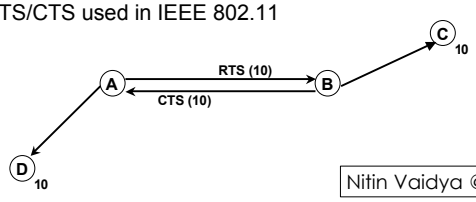
MACAW

- Sender transmits RequestToSend (RTS) frame
- Receiver replies with ClearToSend (CTS) frame
- Neighbors…
  - see CTS: keep quiet
  - see RTS but not CTS: ok to transmit
- Receive sends ACK when has frame
  - neighbors silent until see ACK
- Collisions
  - no collisions detection
  - known when don't receive CTS
  - exponential backoff

RTS/CTS Handshake

- Sender sends Ready-to-Send (RTS)
- Receiver responds with Clear-to-Send (CTS)
- RTS and CTS announce the duration of the transfer
- Nodes overhearing RTS/CTS keep quiet for that duration
- RTS/CTS used in IEEE 802.11



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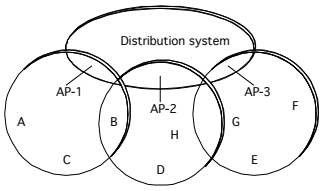
Supporting Mobility

- Case 1: ad hoc networking
- Case 2: access points (AP)
  - tethered
  - each mobile node associates with an AP



Mobility (cont)

- Scanning (selecting an AP)
  - node sends Probe frame
  - all AP's w/in reach reply with ProbeResponse frame
  - node selects one AP; sends it AssociateRequest frame
  - AP replies with AssociationResponse frame
  - new AP informs old AP via tethered network
- When
  - active: when join or move
  - passive: AP periodically sends Beacon frame

Challenges

- Limited wireless transmission range
- Broadcast nature of the wireless medium
  - Hidden terminal problem
- Packet losses due to transmission errors
- Mobility-induced route changes
- Mobility-induced packet losses
- Battery constraints
- Potentially frequent network partitions
- Ease of snooping on wireless transmissions (security hazard)

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irda

- Founded in 1993
- Short range, point-to-point, low cost infra-red based
- Speeds from 9600b to 16Mb
- Great non-cable device
  - Ubiquitous deployment
  - 4 Mbps irda can talk to 9600 irda
- Protocols for point and shoot, exchange mp3, images, vcards, wrist watch ….

Point and shoot model

- Point to the device. If both device understand object begin shared then transparent access
- Push server – the device that provides an object exchange server. Waits passively for the client to initiate an operation
- Push client – the client that pushes the object to the push server. Push client initiates operation
- Security not an issue because of range

Bluetooth

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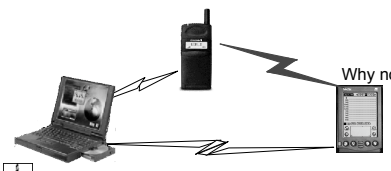
- A cable replacement technology
- 1 Mb/s symbol rate
- Range 10+ meters
- Single chip radio + baseband
  - at low power & low price point



Why not use Wireless LANs?
- power
- cost

Synchronization

- User benefits
- Automatic synchronization of calendars, address books, business cards
- Push button synchronization
- Proximity operation

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Cordless Headset

- User benefits
- Multiple device access
- Cordless phone benefits
- Hands free operation

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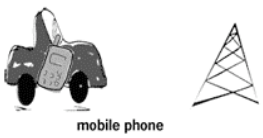
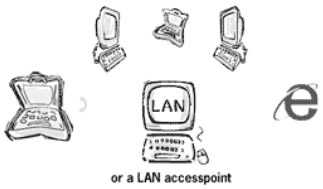
Three-in-one phone

- At home, your phone functions as a portable phone (fixed line charge). When you're on the move, it functions as a mobile phone (cellular charge). And when your phone comes within range of another mobile phone with built-in Bluetooth wireless technology it functions as a walkie talkie (no telephony charge).
- Source: bluetooth.com



The Internet Bridge

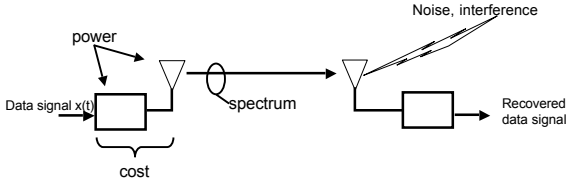
- Use your mobile computer to surf the Internet wherever your are, and regardless if you're cordlessly connected through a mobile phone (cellular) or through a wire-bound connection (e.g. PSTN, ISDN, LAN, xDSL).
- Source: bluetooth.com



The Interactive Conference

- In meetings and conferences you can transfer selected documents instantly with selected participants, and exchange electronic business cards automatically, without any wired connections
- Source: bluetooth.com

Design considerations



Goal

- high bandwidth
- conserve battery power
- cost < $10

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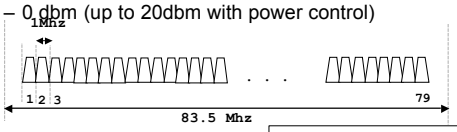
Bluetooth radio link

- frequency hopping spread spectrum
  - 2.402 GHz + k MHz, k=0, …, 78
  - 1,600 hops per second
- GFSK modulation
  - 1 Mb/s symbol rate
- transmit power
  - 0 dbm (up to 20dbm with power control)



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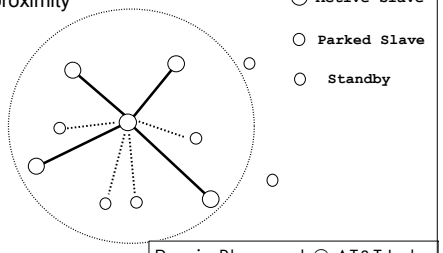
Piconet formation

- Page - scan protocol
  - to establish links with nodes in proximity



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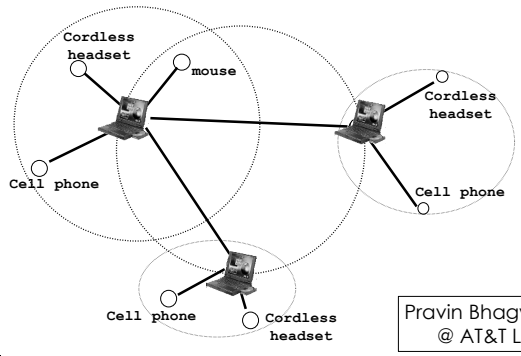
Inter piconet communication



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