Overview

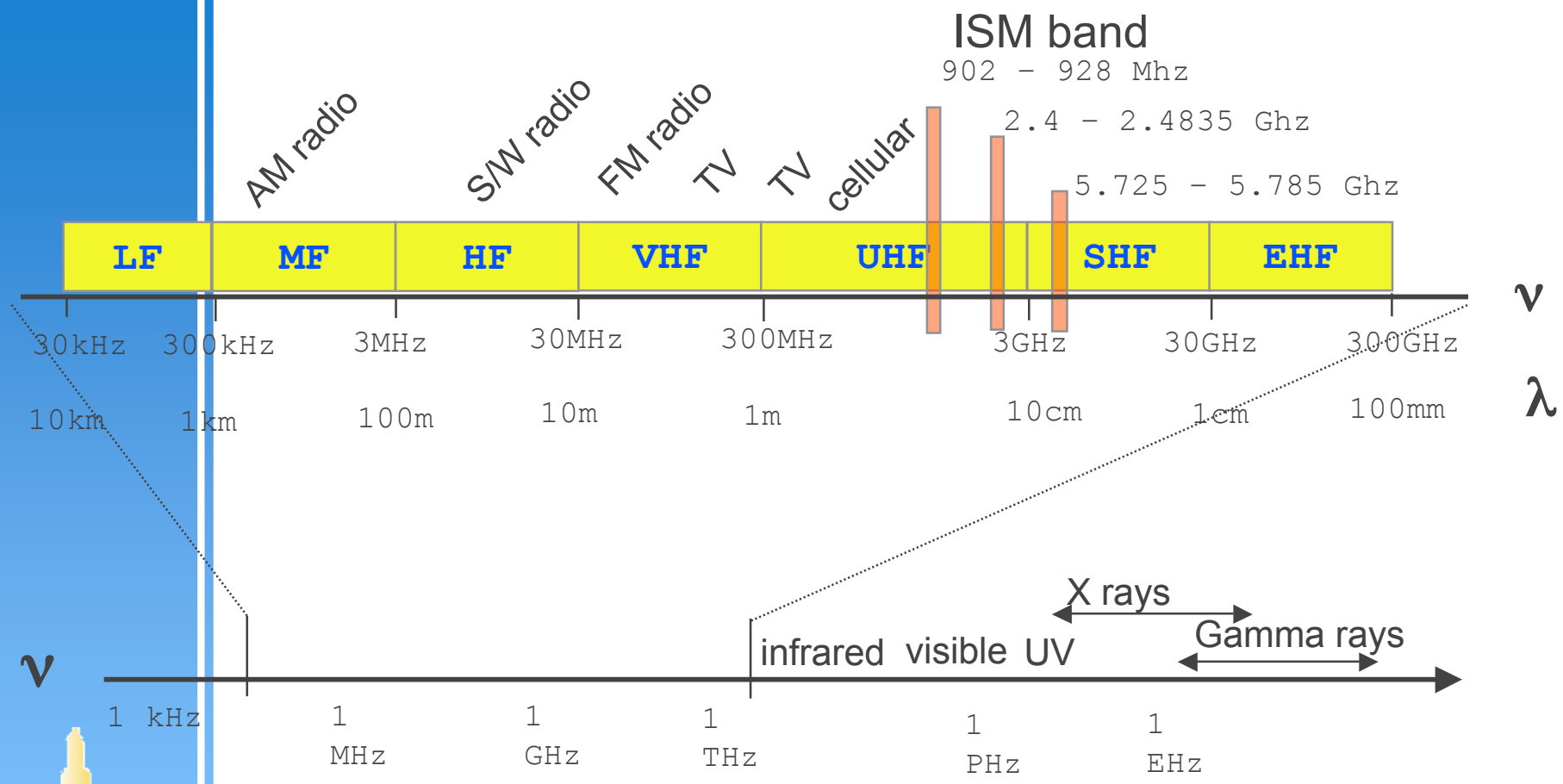
- Yesterday we looked at Ethernet: CSMA/CD network
- Today we will look at wireless networks: CSMA/CA

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)

Nitin Vaidya @ UIUC

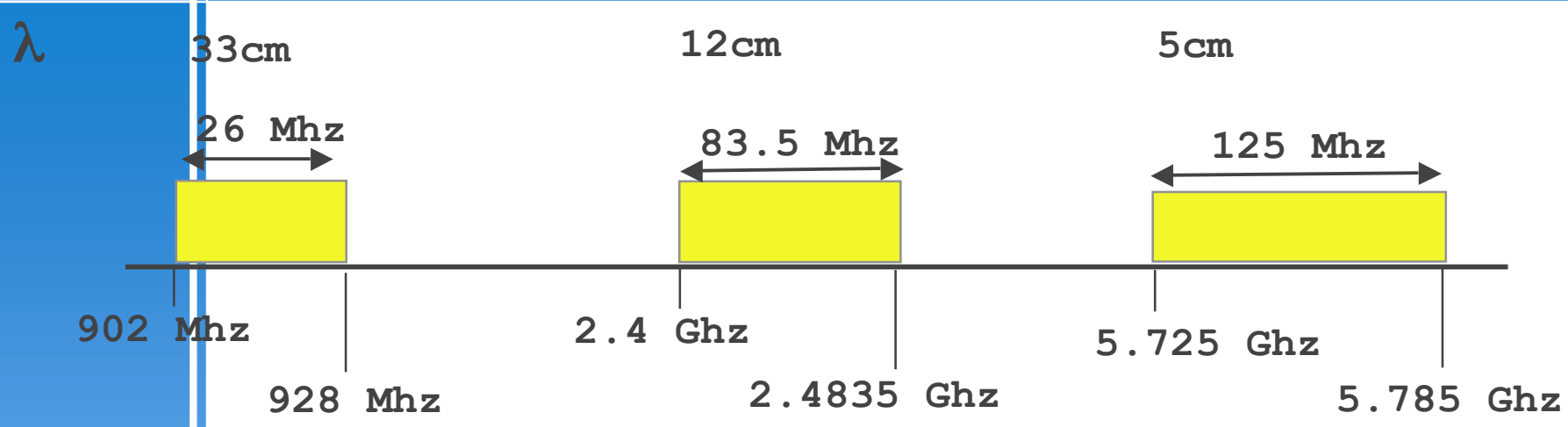
EM Spectrum



Propagation characteristics are different in each frequency band

Pravin Bhagwat @ AT&T Labs

Unlicensed Radio Spectrum



cordless phones
baby monitors
Wireless LANs

802.11
Bluetooth
Microwave oven

802.11a

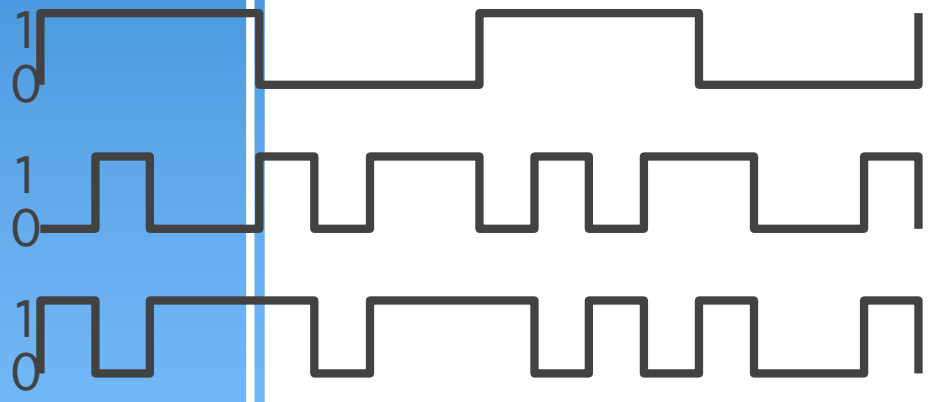
Pravin Bhagwat @ AT&T Labs

Spread Spectrum: resilient transmission

- 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

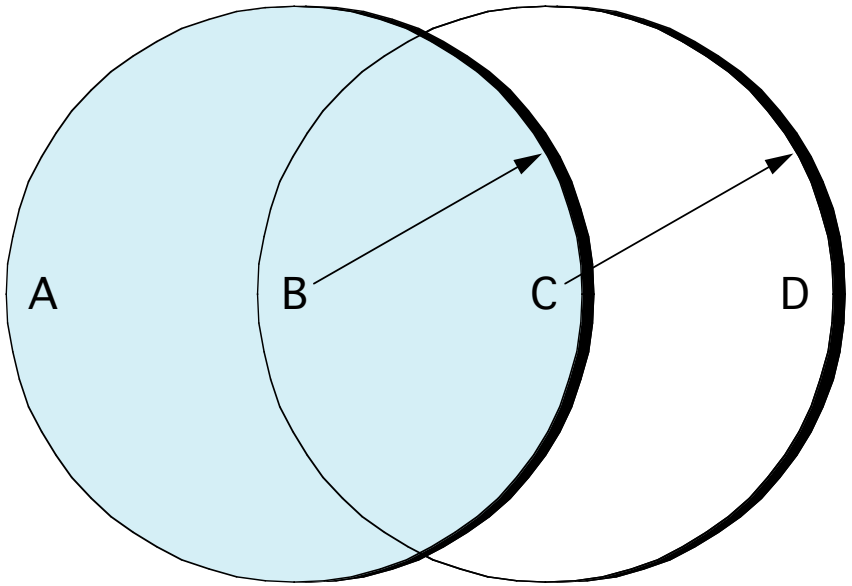
Spread Spectrum (cont)

- 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

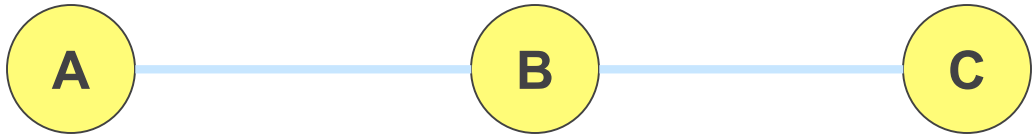
- Similar to Ethernet
- Problem: hidden and exposed nodes



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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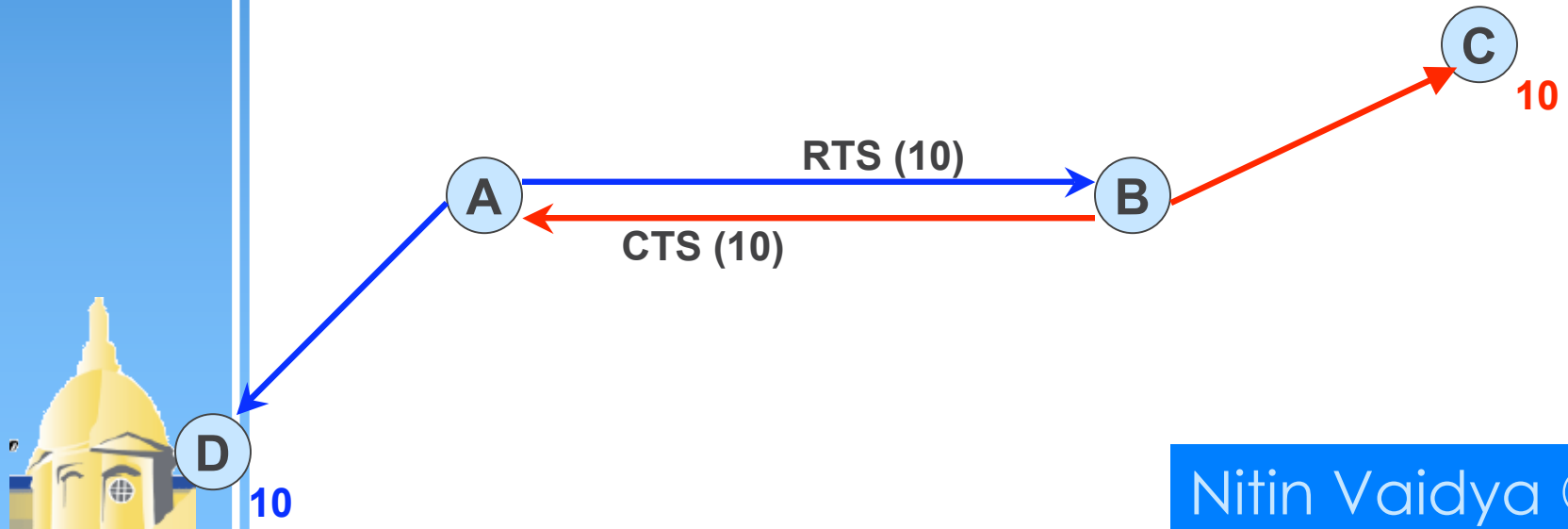
Solution: MACAW

- 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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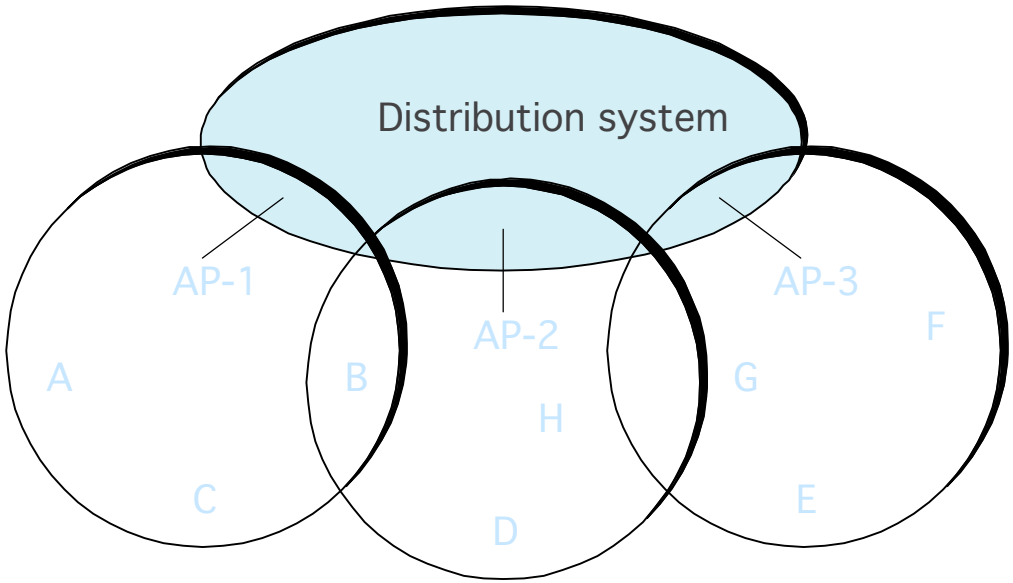
Supporting Mobility

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



Mobility (cont)

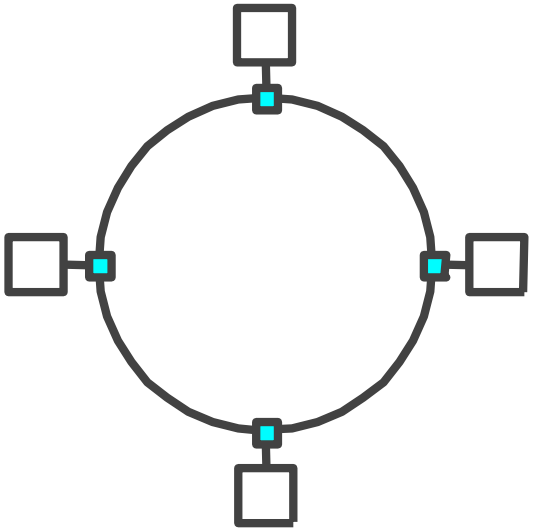
- Scanning (selecting an AP)
  - node sends Probe frame
  - all AP's w/in reach reply with ProbeResponse frame
  - node selects one AP; sends it AssociateRequest frame
  - AP replies with AssociationResponse frame
  - new AP informs old AP via tethered network
- When
  - active: when join or move
  -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

Shared Access Networks

- The next technology that we will look at tries to guarantee who gets access to the network
  - Token Ring
  - ATM
  - Fibre channel
  - Myrinet

Token Ring Overview

- Examples
  - 16Mbps IEEE 802.5 (based on earlier IBM ring)
  - 100Mbps Fiber Distributed Data Interface (FDDI)
    - 4B/5B encoding



Token Ring (cont)

- Idea
  - Frames flow in one direction: upstream to downstream
  - special bit pattern (token) rotates around ring
  - must capture token before transmitting
  - release token after done transmitting
    - immediate release
    - delayed release
  - remove your frame when it comes back around
  - stations get round-robin service
- Frame Format

Timed Token Algorithm

- Token Holding Time (THT)
  - upper limit on how long a station can hold the token
- Token Rotation Time (TRT)
  - how long it takes the token to traverse the ring.
  - TRT <= ActiveNodes x THT + RingLatency
- Target Token Rotation Time (TTRT)
  - agreed-upon upper bound on TRT

Algorithm (cont)

- Each node measures TRT between successive tokens
  - if measured-TRT > TTRT: token is late so don't send
  - if measured-TRT < TTRT: token is early so OK to send
- Two classes of traffic
  - synchronous: can always send
  - asynchronous: can send only if token is early
- Worse case: 2xTTRT between seeing token

Token Maintenance

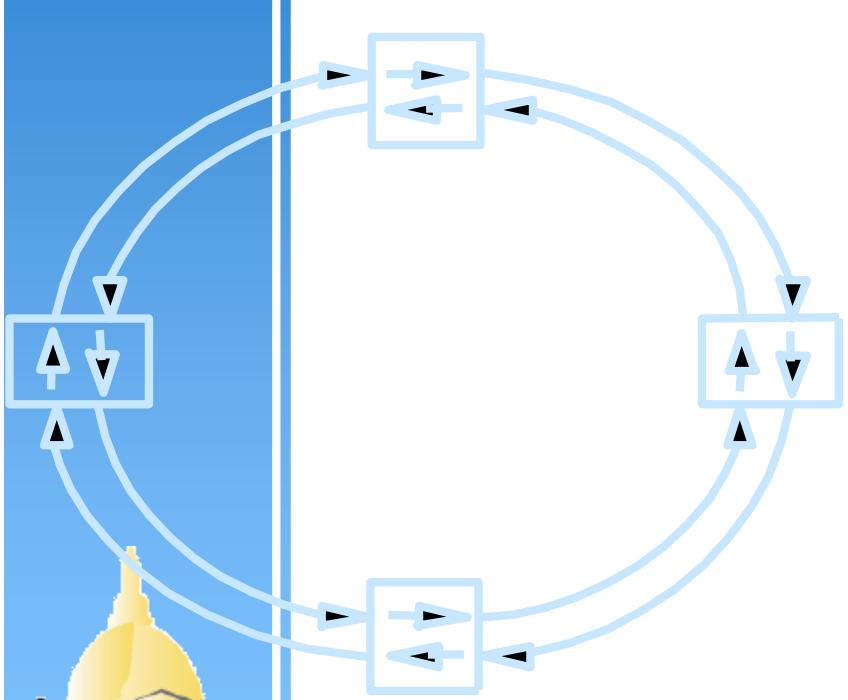
- Lost Token
  - no token when initializing ring
  - bit error corrupts token pattern
  - node holding token crashes
- Generating a Token (and agreeing on TTRT)
  - execute when join ring or suspect a failure
  - send a claim frame that includes the node's TTRT bid
  - when receive claim frame, update the bid and forward
  - if your claim frame makes it all the way around the ring:
    - your bid was the lowest
    - everyone knows TTRT
    - you insert new token

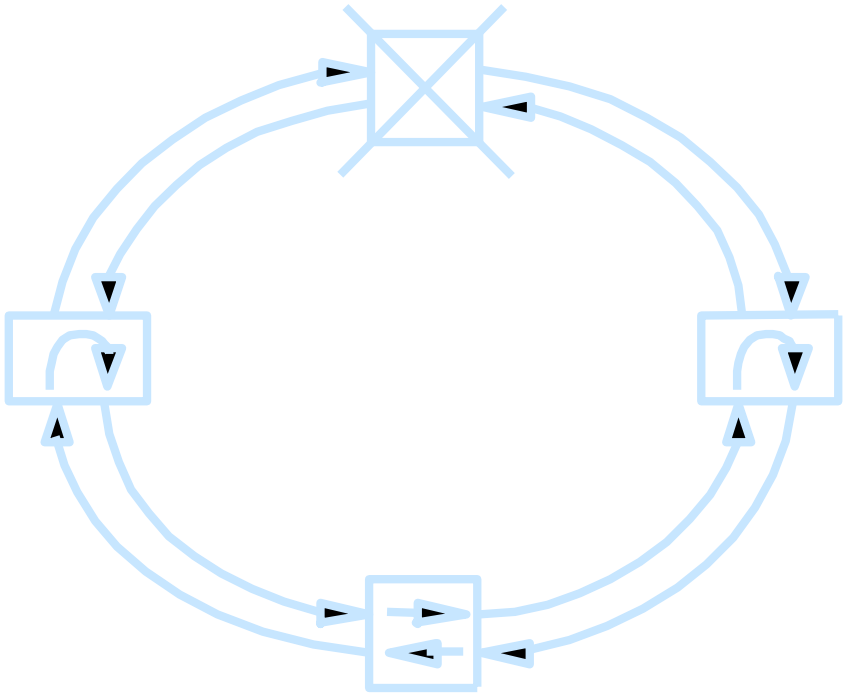
Maintenance (cont)

- Monitoring for a Valid Token
  - should periodically see valid transmission (frame or token)
  - maximum gap = ring latency + max frame < = 2.5ms
  - set timer at 2.5ms and send claim frame if it fires

FDDI (Fiber Distributed Data Interface)

- The late-80's version of token ring (100Mbps, fiber-based)
- Dual-ring (two fibers): 2nd ring used for fault recovery
- Can handle single point failures

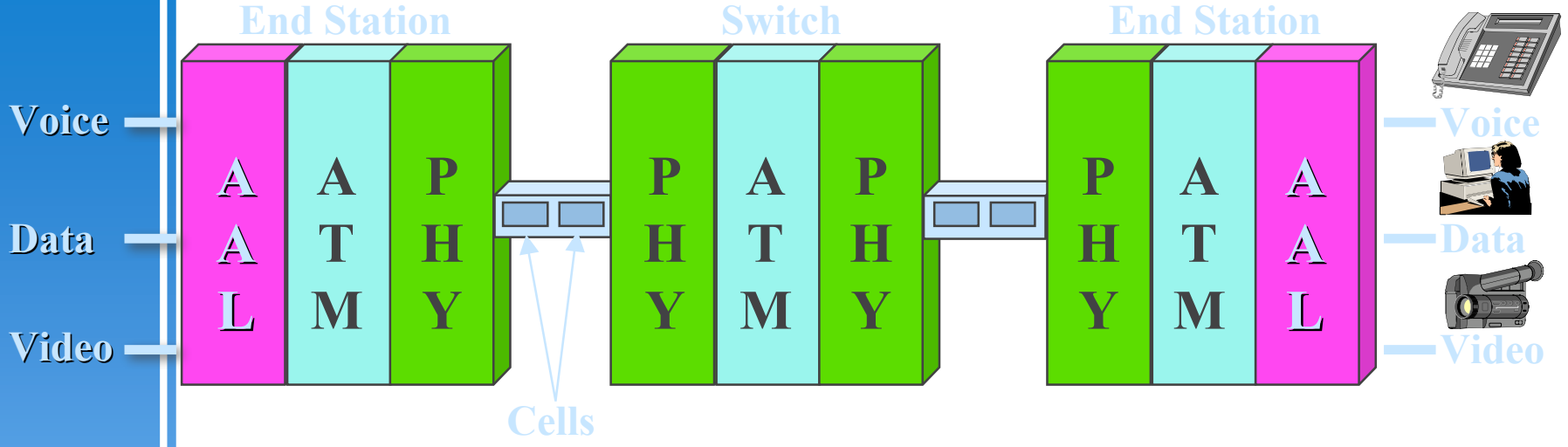




ATM Technology (courtesy: ATM Forum)

- Negotiated Service Contract
  - Connection Oriented - virtual circuit
  - End-to-End Quality of Service
- Cell Switching
  - 53 Byte Cell
  - 48 Byte Payload, 5 Byte Header
- Fixed Size
- Header contains virtual circuit information
- Payload can be voice, video or other data types

ATM System Architecture



- Adaptation Layer (AAL): Inserts/extracts information into 48 byte payload
- ATM Layer: Adds/removes 5 byte header to payload
- Physical Layer: Converts to appropriate electrical or optical format

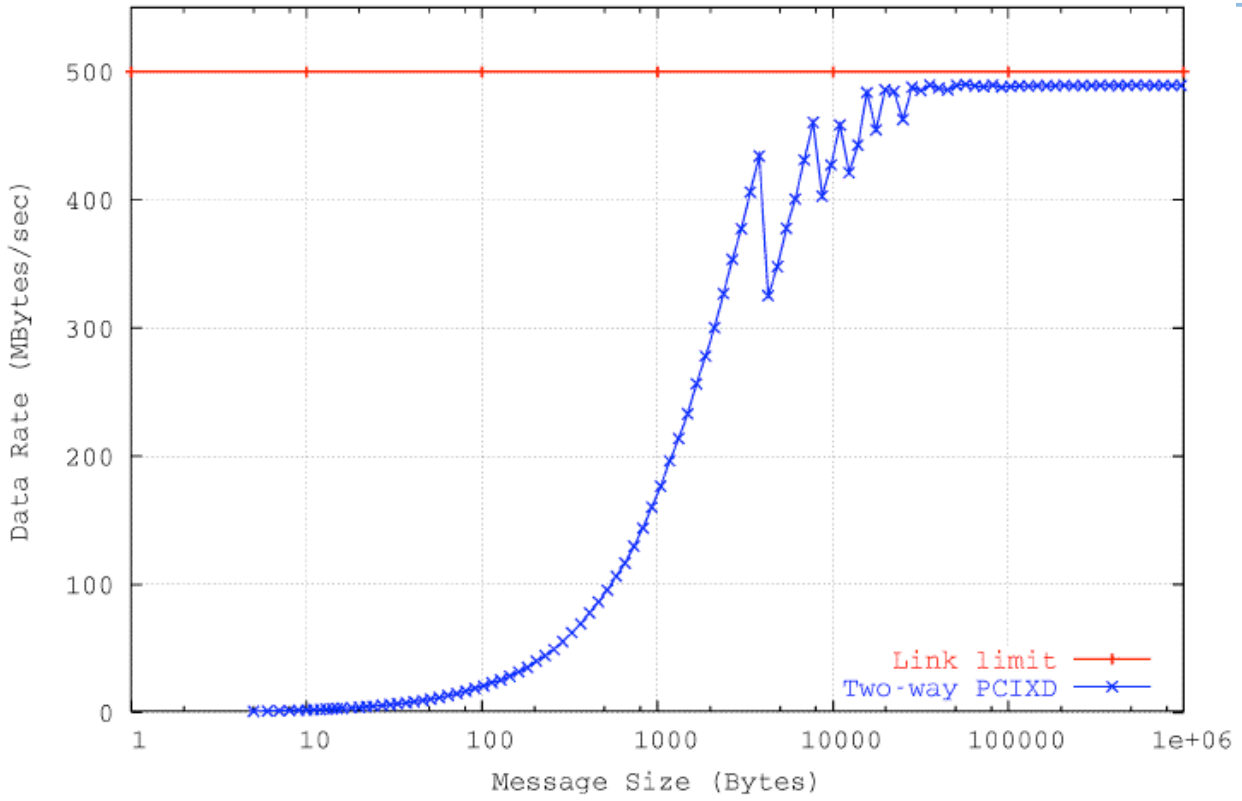
Fibre Channel

- Connect servers, workstations, disk storage etc.
- Optical or electrical media
- 133 Mbps to 1062 Mbps
- 10 km
- point-to-point links or loop or connect to a switch
- IP, SCSI etc.

- http://hsi.web.cern.ch/HSI/fcs/spec/overview.htm

Myrinet

- 2 GB full duplex high speed network interface
- http://www.myri.com/myrinet/performance/index.html
- http://www.conservativecomputer.com/myrinet/perf.



Myrinet

- Few μsec latency