


18-345 – Fall 08

Lecture 14

Local Area Networks and Ethernet

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reading: Chapter 6



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Datalink Lectures

- Datalink functions
- Framing
- Datalink architectures
- Switching and packet forwarding
- Flow and error control
- Virtual circuits
- Taking turn protocols
- Contention-based access
- LANs, ethernet, and bridging
- Connectivity to the home
- Wireless



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What is a LAN?

Local area LANs are private networks


- Freedom from regulatory constraints of WANs
- More relaxed security constraints
- Minimal accounting

Short distance (~1km) between computers:

- Low cost, high-speed, relatively error-free communication
- Complex error control procedures unnecessary

In local environment, machines may move often:


- Keep track of location a computer at any given time
- Give each machine a unique address
- **Broadcast** all messages to all machines in the LAN



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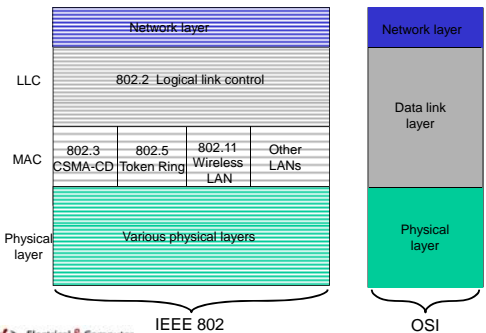
IEEE 802 LAN Family

- The IEEE 802.* set of standards defines a common framing and addressing format for LAN protocols.
 - Simplifies interoperability
 - Addresses are 48 bit strings with no structure
- 802.3 (Ethernet)
- 802.4 (Token bus)
- 802.5 (Token ring)
- 802.6 (Distributed queue dual bus)
- 802.11 (Wireless LAN)
- 802.14 (Cable Modem)
- 802.15 (Wireless Personal Area networks)
- 802.16 (Broadband wireless access)




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MAC Sub-layer

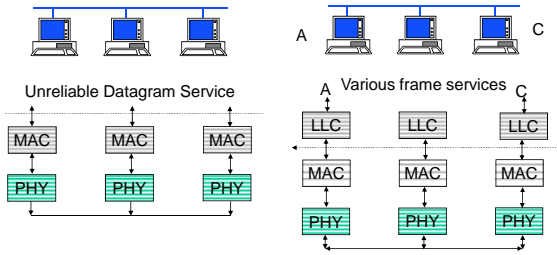



IEEE 802 OSI



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Logical Link Control sub-layer

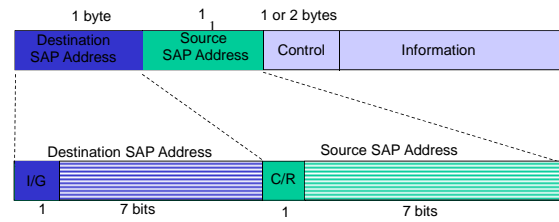



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LLC sub-layer services defined by 802

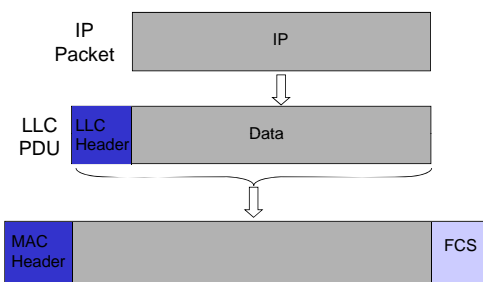
- Type 1: Unacknowledged connectionless service
 - unnumbered frames (HDLC)
- Type 2: Reliable connection-oriented service
 - E.g., asynchronous balanced mode of HDLC
- Type 3: Acknowledged connectionless service
- Additional addressing
 - A workstation has a single MAC physical address
 - Can handle several logical connections (from different upper-layer protocols), distinguished by their SAP (service access points).

LLC PDU Structure



I/G = Individual or group address
C/R = Command or response frame

Encapsulation by MAC frames

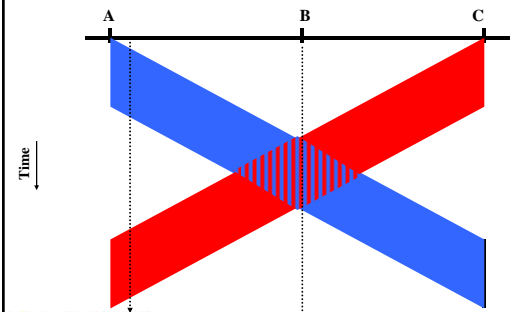


Ethernet

IEEE 802.3: Ethernet

- Example of CSMA/CD – earlier lecture
- Slot Time is the critical system parameter
 - upper bound on time to detect collision
 - upper bound on time to acquire channel
 - upper bound on length of frame segment generated by collision
 - quantum for retransmission scheduling
- Minimum slot time is the maximum round-trip propagation delay
- Truncated binary exponential backoff
 - for retransmission n : $0 < r < 2^k$, where $k = \min(n, 10)$

Collision Detection



Collision Detection: Implications

- All nodes must be able to detect the collision.
- The implication is that either we must have a short wires, or long packets
 - Or a combination of both
- Can calculate length based on transmission rate and propagation speed.
 - Messy: propagation speed is media-dependent, low-level protocol details, ..
 - Minimum packet size is 64 bytes
 - Cable length ~256 bit times
 - Example: maximum coax cable length is 2.5 km

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CSMA/CD: Some Details

- Successive frames are separated by an "inter-frame" gap.
 - Nodes must switch from "send" to "receive" mode
 - Set to 9.6 μsec or 96 bit times
- Exponential backoff operates in multiples of 512 bit times.
 - Longer than a roundtrip time
 - Guarantees that nodes that back off longer will notice the earlier retransmission before starting to send

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Parameters: Summary

- Transmission Rate: 10 Mbps
- Max Length: 2500 meters + 4 repeaters
- Min Frame allowed: 64 bytes
 - Corresponds to 51.2 μs
 - Chosen so that minimum frame transmission time X is longer than $2 \times t_{\text{prop}}$
- Each increase of transmission rate by factor of 10 implies an increase in frame size of 10 or a decrease in length of 10

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CSMA/CD Performance

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IEEE 802.3 MAC Frame

- Destination address is either single address or group address (broadcast = 111...111)
- Addresses are defined on local or universal basis
- 2^{48} possible global addresses

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Physical Layer 802.3 - 10Mbps

	10base5	10base2	10baseT	10baseFX
Medium	Thick coax	Thin coax	Twisted pair	Optical fiber
Max. Segment Length	500 m	200 m	100 m	2 km
Topology	Bus	Bus	Star	Point-to-point link

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How Do We Go Faster?

- How about FDDI?
 - Too complex
- How about switching, e.g. ATM?
 - Too expensive and complicated
- How about a “better” Ethernet?
 - Higher capacity by increasing link rate or through switching
 - Make sure it interoperates with “old” Ethernet

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Why Ethernet?

- Easy to manage.
 - You plug in the host and it basically works
 - No configuration at the datalink layer
- Broadcast-based.
 - In part explains the easy management
 - Some LAN protocols (e.g. ARP) rely on broadcast
 - Networking would be harder without ARP
 - Not having natural broadcast capabilities adds a lot of complexity to a LAN (e.g. ATM)
- Drawbacks.
 - Broadcast-based: limits bandwidth since each packets consumes bandwidth on the entire network
 - Distance (if shared)

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Faster Ethernet

- Exploit better PHY layer implementations
 - Better transmit/receive hardware over same medium
 - Higher capacity transmission media
- 802.3u: Fast Ethernet – 100 Mbit/sec
 - Reduce diameter – same minimum frame size
 - Only star topologies
- 802.3z: Gigabit Ethernet
 - Cannot further reduce diameter – increase frame time to 256 byte times
 - “jumbo frames”, flow control for increased efficiency
- 10 Gigabit Ethernet
 - Only point to point links

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Fast & Gigabit Ethernet

IEEE 802.3 Fast Ethernet medium alternatives (100 Mbps)

	100baseT4	100baseTX	100baseFX
Medium	Twisted pair category 3 UTP 4 pairs	Twisted pair category 5 UTP two pairs	Optical fiber multimode Two strands
Max. Segment Length	100 m	100 m	2 km
Topology	Star	Star	Star

	1000baseSX	1000baseLX	1000baseCX	1000baseT
Medium	Optical fiber multimode Two strands	Optical fiber single mode Two strands	Shielded copper cable	Twisted pair category 5 UTP
Max. Segment Length	550 m	5 km	25 m	100 m
Topology	Star	Star	Star	Star

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10 Gigabit Ethernet

IEEE 802.3 10 Gigabit Ethernet medium alternatives

	10GbaseSR	10GBaseLR	10GbaseEW	10GbaseLX4
Medium	Two optical fibers Multimode at 850 nm 64B66B code	Two optical fibers Single-mode at 1310 nm 64B66B	Two optical fibers Single-mode at 1550 nm SONET compatibility	Two optical fibers multimode/single-mode with four wavelengths at 1310 nm band 8B10B code
Max. Segment Length	300 m	10 km	40 km	300 m – 10 km

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LAN Hubs, Bridges, and Switches

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Transparent Bridges

- Design goals:
 - “Plug and play” capability
 - Self-configuring without hardware or software changes
 - Bridge does not impact the operation of the individual LANs
- Three parts to making bridges transparent:
 - 1) Forwarding of frames
 - 2) Learning of addresses
 - 3) Spanning tree algorithm

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Bridge with more than two ports

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Multiple bridges

Strategy works for any loop-free topology

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Building forwarding table

Address	Port

Address	Port

Initially, forwarding tables of all bridges are empty

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S1 → S5

Address	Port
S1	1

Address	Port
S1	1

By noting which port a packet came from, the bridge learns the port to reach that source

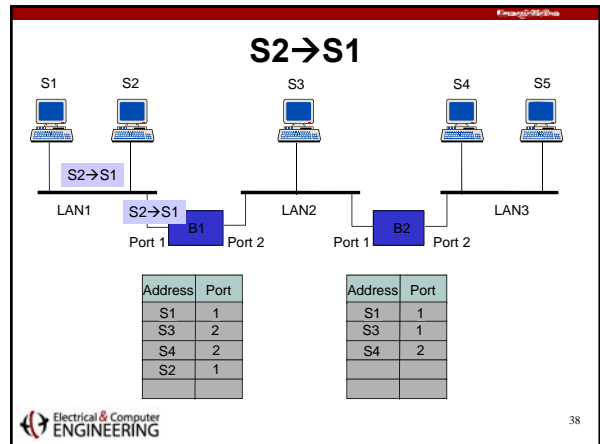
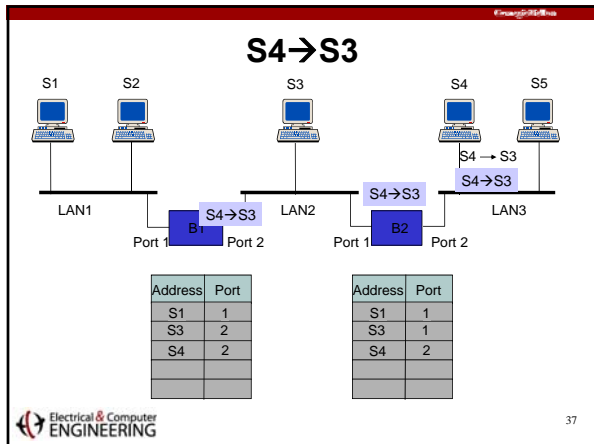
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S3 → S2

Address	Port
S1	1
S3	2

Address	Port
S1	1
S3	1

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Frame Forwarding: Summary

- Each switch maintains a forwarding database:
 - <MAC address, port, age>
 - MAC address: host or group address
 - Port: port number on the bridge
 - Age: age of the entry
- Meaning: A machine with MAC address lies in the direction of number port of the bridge
- For every packet, the bridge "looks up" the entry for the packets destination MAC address and forwards the packet on that port.
- Other packets are broadcasted – why?

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