

More on Link Layer

Kai Shen

9/19/2011

CSC 257/457 - Fall 2011

1

Recap of Last Class

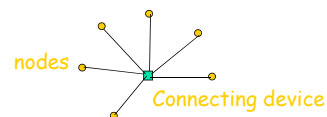
- Ethernet
 - dominant link layer technology for local-area networks
 - Ethernet frame size
 - Ethernet multiple access control
 - CSMA/CD, exponential back-off
 - factors for its efficiency
 - Speed: 10Mbps, 100Mbps, 1Gbps, 10Gbps, ...
- Link-layer addresses
 - Static per-device, universally unique
 - ARP
 - Why multiple addresses at multiple layers?

9/19/2011

CSC 257/457 - Fall 2011

2

Interconnecting Nodes in Local-Area Networks



- **Hubs**: physical-layer signal repeaters.
- **Bridges**: smarter, understands link-layer protocol (Ethernet).
- **Switches**: essentially bridges with large number of ports.

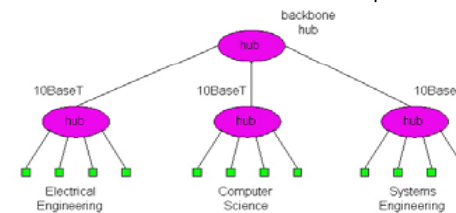
9/19/2011

CSC 257/457 - Fall 2011

3

Interconnecting with Hubs

- **Physical-layer** repeater
 - Repeat signal on all outgoing links
 - Doesn't care whether links are busy or not
 - No buffering
- Problems:
 - Simultaneous traffic from multiple segments may collide
 - Can't interconnect links at different speeds



9/19/2011

CSC 257/457 - Fall 2011

4

Bridges

- **Link layer** device
 - understands and participates in Ethernet
 - buffers frame, uses CSMA/CD to access link
 - traffic isolation ⇒ **selectively** forwards frame based on dest. address (avoid flooding all links)

How to determine to which LAN segment to forward frame?

9/19/2011 CSC 257/457 - Fall 2011 5

Self Learning

- A bridge has a **bridge table**
 - each entry: (Dest. address, bridge interface, timestamp)
- bridges **learn** which host is connected through which interface
 - when frame received, bridge "learns" location of sender: incoming LAN segment
 - records sender/location pair in bridge table

9/19/2011 CSC 257/457 - Fall 2011 6

Bridge Example

address	port
A	1
B	1
E	2
H	3
J	3

- Bridge receives frame from C destined to D
 - bridge learns C is on interface 1
 - because D is not in table, bridge floods
- Another frame from C to D?
- Frame received by D, then a reply is sent back to C
 - bridge learns D is on interface 2
 - in bridge table C is on interface 1, so bridge **selectively** forwards frame to interface 1

9/19/2011 CSC 257/457 - Fall 2011 7

Bridge Forwarding

- When to start forwarding?
 - **stop and forward**: frame is completely buffered before forwarded to the next hop
 - **cut-through forwarding**: frame forwarded from input to output port without awaiting for assembly of entire frame
 - reduction in latency
 - implication on Ethernet frame structure?

9/19/2011 CSC 257/457 - Fall 2011 8

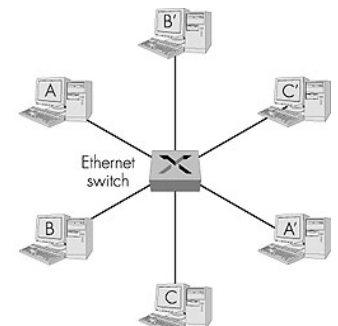
Important Bridge Features

- Isolates collision domains resulting in higher total throughput
- "Plug-and-play": no configuration necessary
- Buffering allow links of different speeds on a single bridge: 100Mbps/1Gbps interfaces
- Cut-through forwarding

9/19/2011
CSC 257/457 - Fall 2011
9

Ethernet Switches

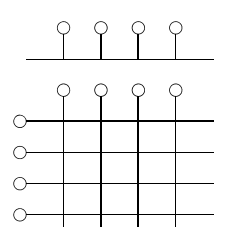
- Essentially a bridge with a large number of ports
⇒ so many ports that each host can connect to one
- After self-learning
 - A-to-A' and B-to-B' simultaneously at full link speed, no collisions
 - Ethernet but no collisions for simultaneous uses
 - How about congestion?



9/19/2011
CSC 257/457 - Fall 2011
10

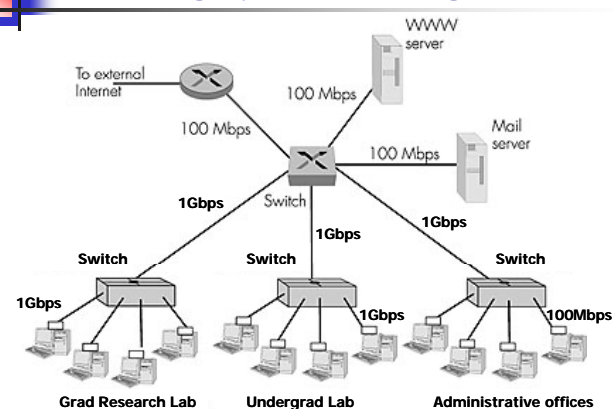
Ethernet Switch Scalability

- Switch allows simultaneous traffic at full link speed
How does it scale?
- Switch architectures
 - Bus
 - Crossbar
- A switch with a large number of ports
 - High implementation complexity ⇒ costly to build



9/19/2011
CSC 257/457 - Fall 2011
11

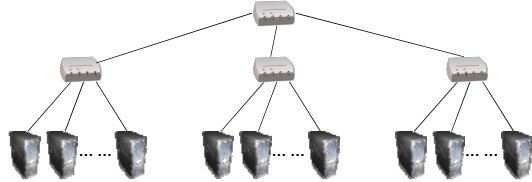
Switch Interconnection (no enough ports on a single switch)



9/19/2011
CSC 257/457 - Fall 2011
12

Network Switching at Internet Server Center

- Thousands of servers with hierarchical network switching



- Reduce congestions:
 - Network load balance across nodes
 - Place highly communicating server modules within same switch domain, or better yet, in same machines
 - Redundancy at backbone links

9/19/2011

CSC 257/457 - Fall 2011

13

Summary Comparison

- Hubs
 - little more than a physical-layer signal repeater, no traffic isolation, buffering
- Bridges
 - understands link-layer protocol (Ethernet), supports smarter forwarding, traffic isolation
 - supports different Ethernet speeds with buffering
- Switches
 - essentially bridges with large number of ports
 - no collision, but congestion is possible at individual links
 - widespread usage today!

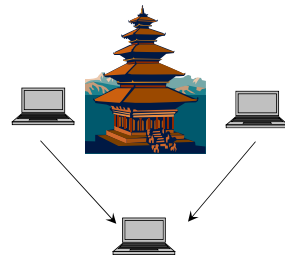
9/19/2011

CSC 257/457 - Fall 2011

14

Media Access Control in Wireless LAN -- IEEE 802.11

- Collision if 2 or more nodes transmit at same time
- Can we use CSMA/CD?
 - hidden terminal problem \Rightarrow carrier sense and collision detection don't work
- Repair carrier sense:
 - carrier probing
- Repair collision detection:
 - success acknowledgement



9/19/2011

CSC 257/457 - Fall 2011

15

PPP (point-to-point protocol)

- one sender, one receiver, one link:
 - no Media Access Control
 - no need for explicit MAC addressing
 - simpler than broadcast link
- deployed in
 - dialup links over telephone lines
 - long-haul fiber-optics links

9/19/2011

CSC 257/457 - Fall 2011

16

Reliability Services

- Error detection
- Error correction or recovery
- Loss recovery
- Flow control
 - pacing between sending and receiving nodes such that the sender does not overwhelm the receiver
- In-order delivery

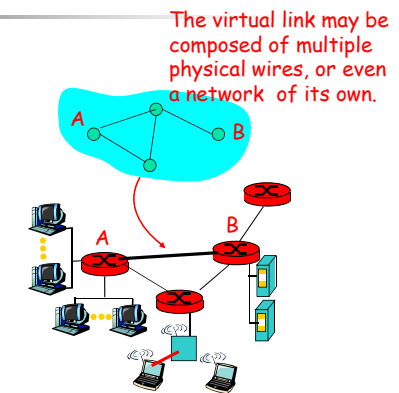
9/19/2011

CSC 257/457 - Fall 2011

17

Link Virtualization

- What is a link?
 - physical wire
 - connection between two IP network-aware nodes
- Virtual link
 - in the case of switched Ethernet?
 - in the case of PPP modem link?
- Why virtual link?
 - more efficient
 - link up legacy networks



9/19/2011

CSC 257/457 - Fall 2011

18

Link Virtualization

- ATM (asynchronous transfer mode)
 - a multilayer network architecture at its own
 - mainly designed for supporting real-time multimedia, with connection-oriented resource reservation
 - deemed as link layer protocols in Internet architecture → IP over ATM
- Frame relay
 - origins in telephony world
 - Like ATM, a network architecture at its own, with connection-oriented resource reservation
 - can be used to carry IP datagrams → IP over frame relay

9/19/2011

CSC 257/457 - Fall 2011

19

Disclaimer

- Parts of the lecture slides contain original work of James Kurose, Larry Peterson, and Keith Ross. The slides are intended for the sole purpose of instruction of computer networks at the University of Rochester. All copyrighted materials belong to their original owner(s).

9/19/2011

CSC 257/457 - Fall 2011

20