

# LAN Interconnection

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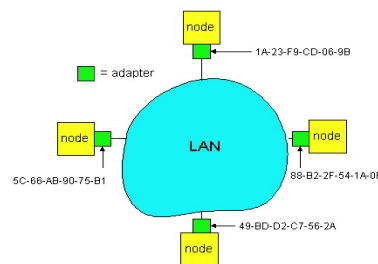
# Ethernet

- "dominant" link layer technology for local-area networks
- Ethernet frame structure
- Ethernet multiple access control
  - CSMA/CD
  - exponential back-off
  - its efficiency
- At different speed: 10, 100, 1000 Mbps

# Link-layer Addresses

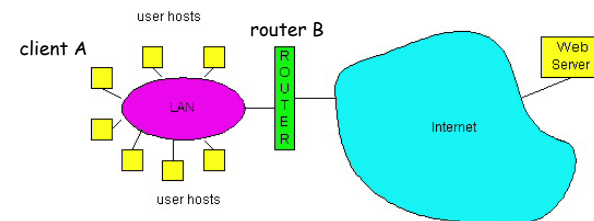
Link-layer (or MAC, LAN) address:

- uniquely identifying each node (or adapter) connected to a shared link
- Universally unique
- Coexistence of link-layer addresses and network-layer addresses.



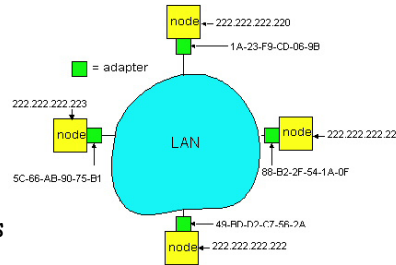
# A Problem

Question: how to determine B's link-layer address knowing B's IP address?



## ARP: Address Resolution Protocol

- Specific to Internet Architecture
- Each node (Host, Router) on LAN has **ARP table**
- ARP Table: IP/Link-layer address mappings for some LAN nodes  
<IP addr; Link-layer addr>



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## How does ARP work?

- First principle: no manual configuration - "plug-and-play"; must deal with dynamic network changes
  - A wants to send datagram to B with an IP address.
  - Suppose B's link-layer address is not in A's ARP table.
  - A **broadcasts** ARP query packet, containing B's IP address.
  - B receives ARP packet, replies to A with its (B's) link-layer address.
  - A caches (saves) IP-to-link-layer address pair in its ARP table until it times out
    - when can a mapping change?
- Go to any Linux machine at the lab:

  - "/sbin/arp" shows the current ARP table;
  - ping any node not in the table, then see the ARP table again.

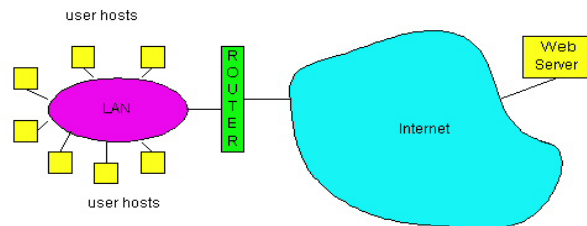
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## Interconnecting Nodes in LAN (Local-Area Network)

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



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## 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 speed



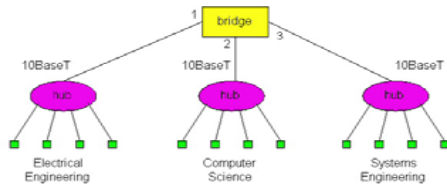
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# Bridges

- Link layer device
  - stores and forwards Ethernet frames
  - examines frame header and **selectively** forwards frame based on dest. address
  - when frame is to be forwarded to a network segment, uses CSMA/CD to access segment



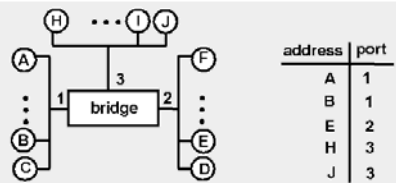
How to determine to which LAN segment to forward frame?

# Self Learning

- A bridge has a **bridge table**
  - each entry: (Dest. address, bridge interface, timestamp)
  - stale entries in table dropped
- 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



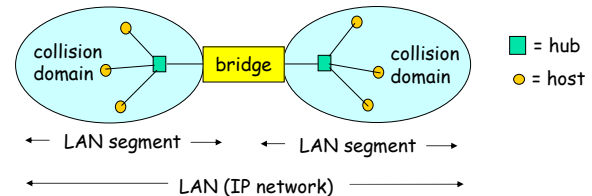
# Bridge Example



- 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

# Bridges: Traffic Isolation

- Bridge understands and participates in CSMA/CD
- Bridge installation breaks LAN into LAN segments
- bridges **filter** packets:
  - same-LAN-segment frames **not usually** forwarded onto other LAN segments
  - segments become separate **collision domains**



## Important Bridge Features

- Transparent ("plug-and-play"): no configuration necessary
- Isolates collision domains resulting in higher total max throughput
- Buffering allow links of different speed on a single bridge: 10/100/1000 Mbps interfaces

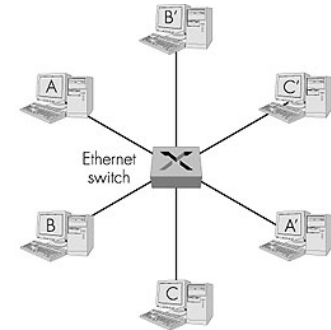
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## Ethernet Switches

- essentially a bridge with a large number ports
  - ⇒ so many ports that each host can connect to one
    - require high interval bandwidth ⇒ costly to build
- After self-learning
  - A-to-A' and B-to-B' simultaneously, no collisions
  - Ethernet, but a shared link with dedicated channel to every node, no collisions!



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## Ethernet Switches (cont.)

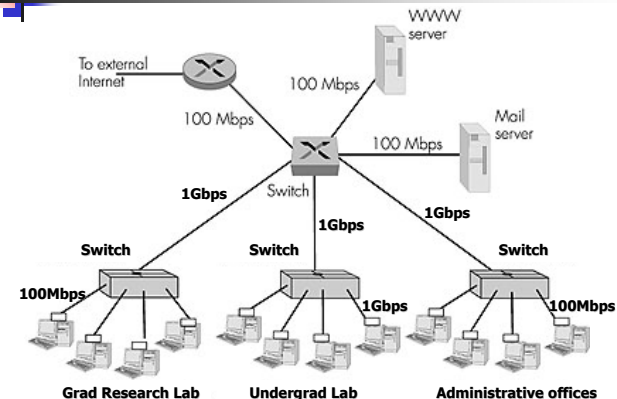
- switch allows simultaneous traffic at full link speed
  - even if each link can operate at full speed, congestion can still occur
- forwarding technologies:
  - **stop and forward**: frame is completely buffered before forwarded to the next hop
  - **cut-through switching**: frame forwarded from input to output port without awaiting for assembly of entire frame
    - reduction in latency
    - can we start forwarding after the first bit is received?

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## Switch Interconnection



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## 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!

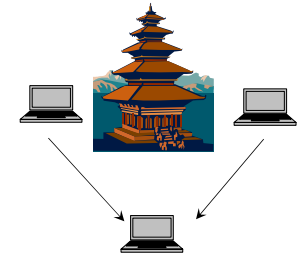
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## Media Access Control in Wireless LAN -- IEEE 802.11

- Collision if 2 or more nodes transmit at same time
- MAC efficiency goal:
  - get all the bandwidth if you're the only one transmitting
  - share the bandwidth fairly if multiple nodes transmit
- Can we use CSMA/CD?
- Carrier sense and collision detection don't work: **hidden terminal problem**



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## 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

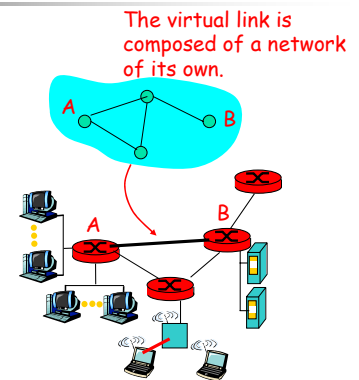
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## Link Virtualization (concept)

- Virtual link
  - virtual communication channel between two Internet nodes
  - the virtual link may not be a single physical wire



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## Link Virtualization (practices)

- **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



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