LAN interconnection: Bridges
Outline

- Why interconnect LANs?
- Hubs
- Bridges
  - Remote bridges
  - Backbone networks
  - Source and transparent routing
  - Self learning
  - Spanning Tree
  - Between networks of different types
  - Switches
- Bridges vs routers
- Virtual LANs
Interconnecting LAN segments

Reasons for interconnection:
- Increase geographical span
- Increase number of stations
- Connect LANs from different organisations
- Isolate stations and their traffic:
  - Performance
  - Fault tolerance
  - Security

Interconnection devices:
- Hubs
- Bridges
- Switches
  - Remark: switches are essentially multi-port bridges.
  - What we say about bridges also holds for switches!
Evolution of LAN topologies

1980s

Coaxial cable snakes its way past computers.
× Maintenance is complicated by needing broad physical access.
× Data cable is distinct from twisted pair used for phones.

Early 1990s

Computers connected using twisted pair to wiring closet.
× Hub in closet provides shared medium.

Late 1990s

Switches become cheaper, and replace hubs in closets, improving performance.
Point-to-point links no longer need MAC.

Later: Links become wireless and topology returns to original distributed shared medium!
Evolution of LAN interconnection

1980s

"Bridges" have few (e.g. 2) ports.
"Remote bridges": ports may be widely separated (e.g. by dial-up link)

Early 1990s

Bridge ports become cheaper, and hubs can be replaced by "multi-port bridges" in wiring closet, transparently wrt users.

Late 1990s

Ports become so cheap (relative to management costs) that all users can have their own port.
"Switches": Products with many high-speed ports
Interconnecting with hubs

- Backbone hub interconnects LAN segments
- Extends max distance between nodes
- But individual segment collision domains become one large collision domain
  - if a node in CS and a node EE transmit at same time: collision
- Can’t interconnect 10BaseT & 100BaseT
Outline
Bridges

- **Link layer device**
  - stores and forwards Ethernet frames
  - examines frame header and **selectively** forwards frame based on MAC dest address
  - when frame is to be forwarded on segment, uses CSMA/CD to access segment
2 types of bridges

**Transparent bridges:**
- End-stations don’t need to know about bridges.
- Bridges act independently of end-stations.
- Most common form, especially with Ethernet.

**Source routing bridges:**
- Less transparent: Bridges preserve LAN service, but end-stations need to know about them: *Source specifies route through bridges by identifying each bridge that the frame must traverse* on the path to the destination.
- Less common, used with Token Ring.

We’ll focus on transparent bridges.
Some bridge features

- Isolates collision domains resulting in higher total max throughput
- Limitless number of nodes and geographical coverage†
- Transparent
  - hosts are unaware of presence of bridges
- plug-and-play, self-learning
  - bridges do not need to be configured
- Can connect different Ethernet types

† But can be inefficient due to suboptimal paths and volume of broadcast & flooded traffic increasing with number of nodes ⇒ routers.
Bridges: traffic isolation

Bridge installation breaks LAN into LAN segments. Bridges filter frames:

- same-LAN-segment frames not usually forwarded onto other LAN segments
- segments become separate collision domains
Remote Bridges

Remote bridges can be used to interconnect distant LANs.
Interconnection without backbone

- Not recommended for two reasons:
  - single point of failure at Computer Science hub
  - all traffic between EE and SE must path over CS segment
Backbone configuration

Recommended!

How does the bridge determine to which LAN segment to forward a frame?
Outline
Self learning

- A bridge has a bridge table
- entry in bridge table:
  - (Node LAN Address, Bridge Interface, Time Stamp)
  - stale entries in table dropped (TTL can be 60 min)
- bridges **learn** which hosts can be reached through which interfaces
  - when frame received, bridge “learns” location of sender: incoming LAN segment
  - records sender/location pair in bridge table
Filtering/Forwarding

When bridge receives a frame:

index bridge table using MAC dest address
if entry found for destination
    then{
        if dest on segment from which frame arrived
            then drop the frame
            else forward the frame on interface indicated
    }
else flood

forward on all but the interface on which the frame arrived
Bridge example

Suppose C sends frame to D and D replies back with frame to C.

- Bridge receives frame from C
  - notes in bridge table that C is on interface 1
  - because D is not in table, bridge sends frame to interfaces 2 and 3
- frame received by D
Bridge Learning: example

- D generates frame for C, sends
- bridge receives frame
  - notes in bridge table that D is on interface 2
  - bridge knows C is on interface 1, so selectively forwards frame to interface 1
Bridges Spanning Tree

• for increased reliability, desirable to have redundant, alternative paths from source to dest
• with multiple paths, cycles result - bridges may multiply and forward frame forever
• solution: organize bridges in a spanning tree by disabling subset of interfaces
Spanning Tree Bridges (2)

(a) Interconnected LANs. (b) A spanning tree covering the LANs. The dotted lines are not part of the spanning tree.

Fig. 4-44
Outline
Ethernet Switches

Essentially a multi-interface bridge
layer 2 (frame) forwarding, filtering using LAN addresses

**Switching:** A-to-A’ and B-to-B’ simultaneously, no collisions
large number of interfaces often: individual hosts, star-connected into switch
  o Ethernet, but no collisions!
Not an atypical LAN (IP network)
Outline
Bridges vs. Routers

- both store-and-forward devices
  - routers: network layer devices (examine network layer headers)
  - bridges are link layer devices
- routers maintain routing tables, implement routing algorithms
- bridges maintain bridge tables, implement filtering, learning and spanning tree algorithms
Routers vs. Bridges

Bridges + and -
+ Bridge operation is simpler requiring less packet processing
+ Bridge tables are self learning
- All traffic confined to spanning tree, even when alternative bandwidth is available
- Bridges do not offer protection from broadcast storms†

† “Broadcast storms” occur when broadcast traffic is continuously sent. e.g. A misbehaving host continuously transmits broadcast traffic. e.g. Poor protocols that broadcast responses to broadcast traffic, leading to escalation.
Routers vs. Bridges

Routers + and -
+ arbitrary topologies can be supported, cycling is limited by TTL counters (and good routing protocols)
+ provide protection against broadcast storms
- require IP address configuration (not plug and play)
- require higher layer packet processing

• bridges do well in small (few hundred hosts) while routers used in large networks (thousands of hosts)
## Summary comparison

<table>
<thead>
<tr>
<th></th>
<th>hubs</th>
<th>bridges</th>
<th>routers</th>
<th>switches</th>
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<td>traffic isolation</td>
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<td>yes</td>
<td>yes</td>
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<tr>
<td>plug &amp; play</td>
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<td>optimal routing</td>
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<tr>
<td>cut through</td>
<td>yes</td>
<td>no†</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

† Bridges can also offer cut-through, except the early ones didn’t.
Chapter 5
Data Link Layer

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