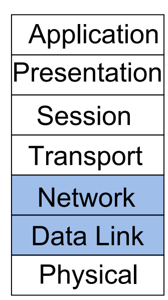
CSE 461: Bridging LANs

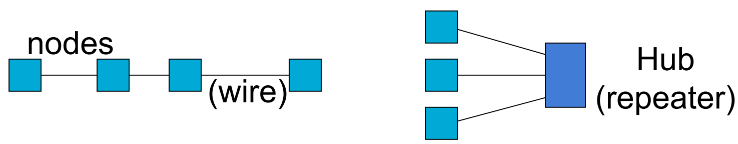
Next Topic -- Switching (a.k.a. Bridging)

- Focus:
  - What to do when one shared LAN isn't big enough?
- Interconnecting LANs
  - Bridges and LAN switches
  - A preview of the Network layer



Limits of a LAN

- One shared LAN can limit us in terms of:
  - Distance
  - Number of nodes
  - Performance



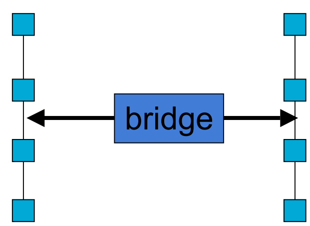
- How do we scale to a larger, faster network?
  - We must be able to interconnect LANs

Switching (a.k.a. Bridging)

- Transferring a packet from one LAN to another LAN
  - Build an "extended LAN"
- Different varieties of switching
  - Packet switched vs. circuit switched
  - Connection vs. Connectionless
- We'll focus on connectionless, packet switched
  - Ethernet

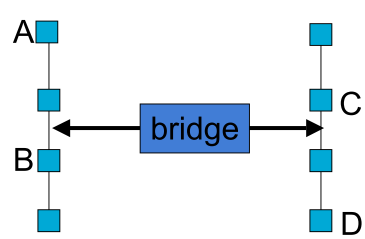
Bridges and Extended LANs

- "Transparently" interconnect LANs with bridge
  - Receive frames from each LAN and forward to the other
  - Each LAN is its own collision domain; bridge isn't a repeater
  - Could have many ports



Learning Bridges

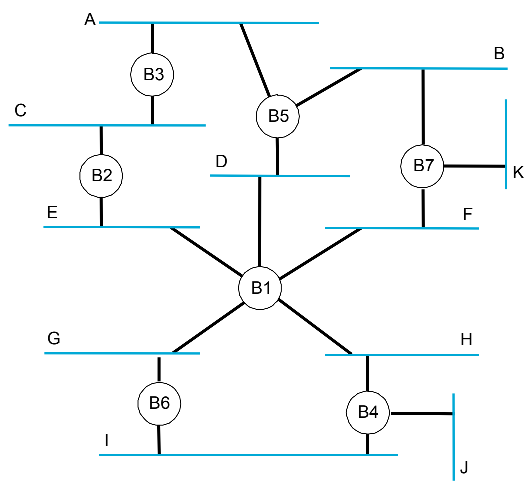
- To optimize overall performance:
  - Shouldn't forward A→B or C→D, should forward A→C and D→B



- How does the bridge know?
  - Learn who is where by observing <u>source</u> addresses and prune
  - Forward using destination address; age for robustness

Why stop at one bridge?

- Allows you to incrementally build out network, across organizations
- What problems could arise?
- How to solve them?

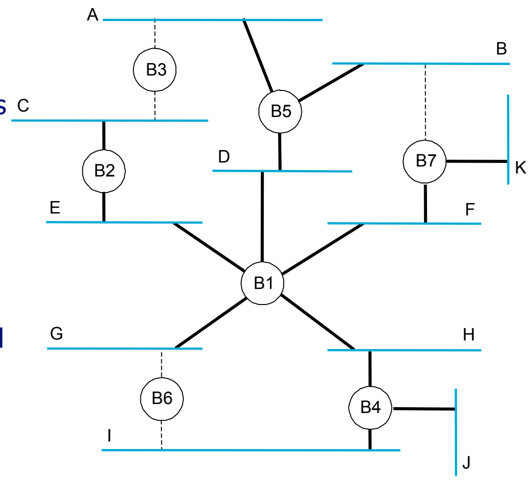


High Level Outline of a Solution

- Take the set of networks and turn off some of the ports in the bridges
  - Goal is to have the bridges form a spanning tree
  - Spanning tree means that there are no cycles
- When a bridge doesn't know where is the destination of the packet:
  - It floods the packet
  - Flooding takes place along the spanning tree
- Over time, bridges learn which links of the spanning tree can be used to route to a given destination

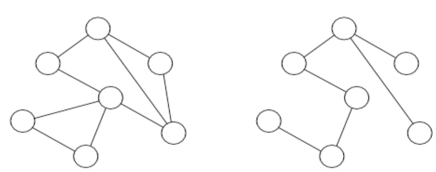
Spanning Tree Example

- Spanning tree uses select bridge ports so there are no cycles
  - Prune some ports
  - Only one tree
- Q: How do we find a spanning tree?
  - Automatically with a distributed algorithm



Spanning Tree

- Compute ST with *a* bridge as *root* such that
  - Root forwards onto all of its outgoing ports
  - Other bridges forward TO the root if a packet is coming from a bridge further from the root, else they forward away from the root
    - Packet traversal: forwards (UP)* then (DOWN*)



(a) (b)

Spanning tree with learning

- Once the spanning tree is in place…
  - the bridge uses the regular learning algorithm to figure out which ports to forward / flood packet on

- Job of spanning tree algorithm is to disable some ports to eliminate cycles

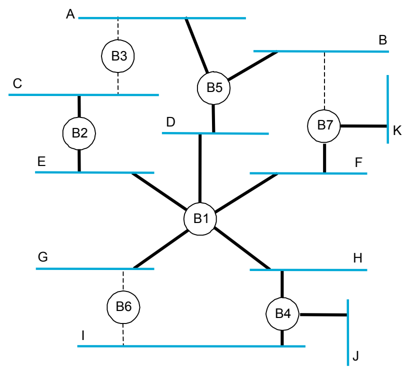
Spanning Tree Algorithm

- Distributed algorithm to compute spanning tree
  - Robust against failures, needs no organization
  - Developed by Radia Perlman at DEC
    - IEEE 802.1 spec
    - http://www1.cs.columbia.edu/~ji/F02/ir02/p44-perlman.pdf

- Outline: Goal is to turn some bridge ports off
  1. Elect a root node of the tree (lowest address)
  2. Grow tree as shortest distances from the root (using lowest address to break distance ties)
     - All done by bridges sending periodic configuration messages over ports for which they are the "best" path
     - Then turn off ports that aren't on "best" paths

Algorithm Overview

- Each bridge has a unique id
  - e.g., B1, B2, B3
- Select the bridge with the smallest id as root
- Select bridge on each LAN that is closest to the root as that LAN's designated bridge
  - use ids to break ties
- Each bridge forwards frames over each LAN on which it is the designated bridge



Algorithm continued

- Bridges exchange configuration messages, containing:
  - id for bridge sending the message
  - id for what the sending bridge believes to be the root bridge
  - distance (hops) from sending bridge to root bridge
- Each bridge records current best configuration message for each port

Algorithm continued

- Initially, each bridge believes it is the root
  - when learn not root, stop generating configuration messages
  - instead, forward root's configuration message
    - incrementing distance field by 1
  - in steady state, only root generates configuration messages

Algorithm More…

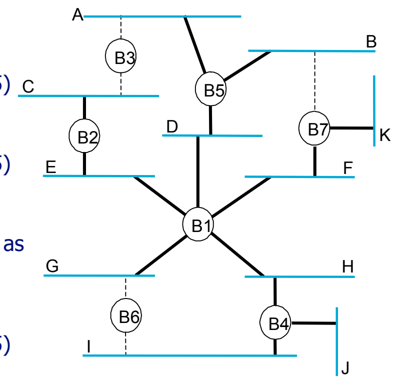
- When bridge learns it is not designated bridge on LAN, stop forwarding configuration messages
  - in steady state, only designated bridges forward configuration messages
- Root bridge continues to send configuration messages periodically
- If a bridge does not receive config. message after a period of time:
  - assumes topology has changed
  - starts generating configuration messages claiming to be root

Algorithm Example

Message format: (root, dist-to-root, sending bridge)

Sample messages sequences to and from B3:

1. B3 sends (B3, 0, B3) to B2 and B5
2. B3 receives (B2, 0, B2) and (B5, 0, B5) and accepts B2 as root
3. B3 sends (B2, 1, B3) to B5
4. B3 receives (B1, 1, B2) and (B1, 1, B5) and accepts B1 as root
5. B3 could send (B1, 2, B3) but doesn't as its nowhere "best"
   - B2 and B5 are better choices.
     - so B3 is NOT a designated bridge
6. B3 receives (B1, 1, B2) and (B1, 1, B5) again … stable
   - B3 turns off data forwarding to LANs A and C

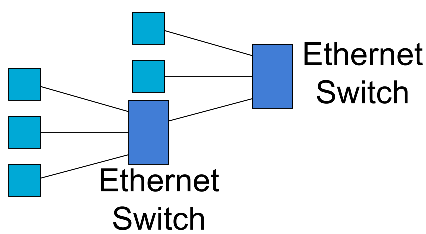


Some other tricky details

- Configuration information is aged
  - If the root fails a new one will be elected
- Reconfiguration is damped
  - Adopt new spanning trees slowly to avoid temporary loops

LAN Switches

- LAN switches are multi-port bridges
  - Modern, high performance form of bridged LANs
  - Looks like a hub, but frames are switched, not shared
  - Every host on a separate port, or can combine switches



Limitations of Bridges/Switches

- LAN switches form an effective small-scale network
  - Plug and play for real!

- Why can't we build a large network using bridges?
  - Little control over forwarding paths
  - Size of bridge forwarding tables grows with number of hosts
  - Broadcast traffic flows freely over whole extended LAN
  - Spanning tree algorithm limits reconfiguration speed

Key Concepts

- We can overcome LAN limits by interconnection
  - Bridges and LAN switches
  - But there are limits to this strategy …