CSE/EE 461 – Lecture 5

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Last Two Times …

- How do multiple parties share a wire or the air?
  - Random access protocols (Aloha, CSMA, Ethernet)
  - Contention-free protocols (turn-taking, reservations)
  - Wireless protocols (hidden and exposed terminals)

- Medium Access Control (MAC) protocols
  - Part of the OSI Data Link Layer
  - Local Area Networks (LANs)

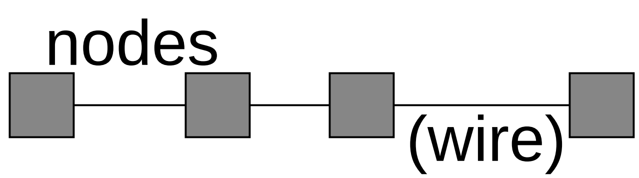
This Time

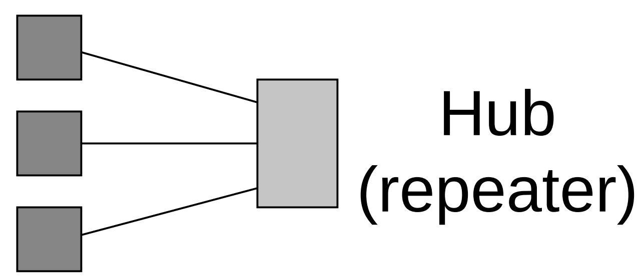
- Focus:
  - What to do when one shared LAN isn't big enough?
- Interconnecting LANs
  - Bridges and LAN switches
- A preview of the Network layer

Application
Presentation
Session
Transport
Network
Data Link
Physical

Limits of a LAN

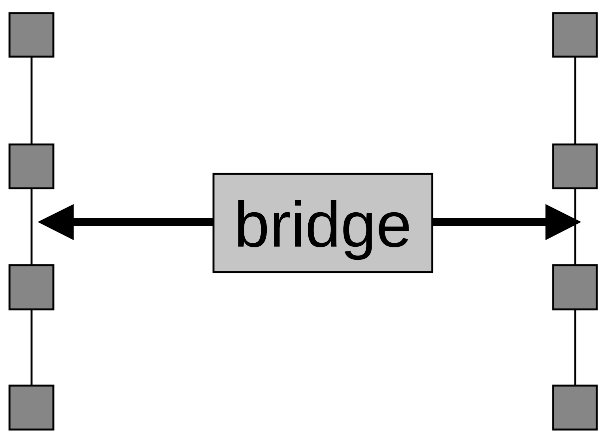
- One shared LAN can limit us in terms of:
  - Distance
  - Number of nodes
  - Performance
- How do we scale to a larger, faster network?
  - We must be able to interconnect LANs





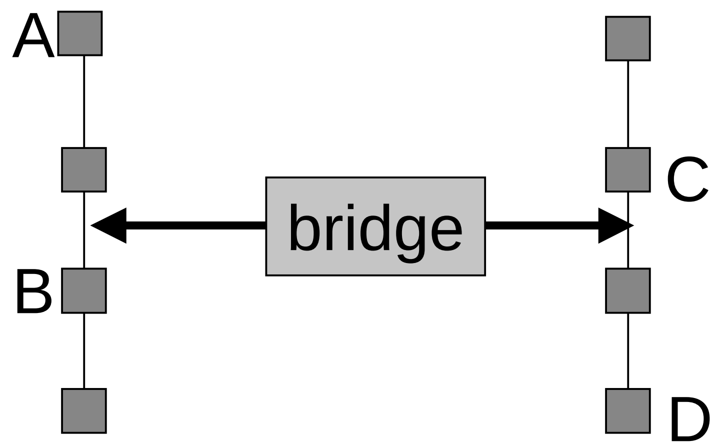
Bridges and Extended LANs

- "Transparently" interconnect LANs
  - Receive frames from each LAN and forward to the other
  - Each LAN is its own domain; a bridge is not a repeater
  - Could have many ports or join to a remote LAN



Backward Learning Algorithm

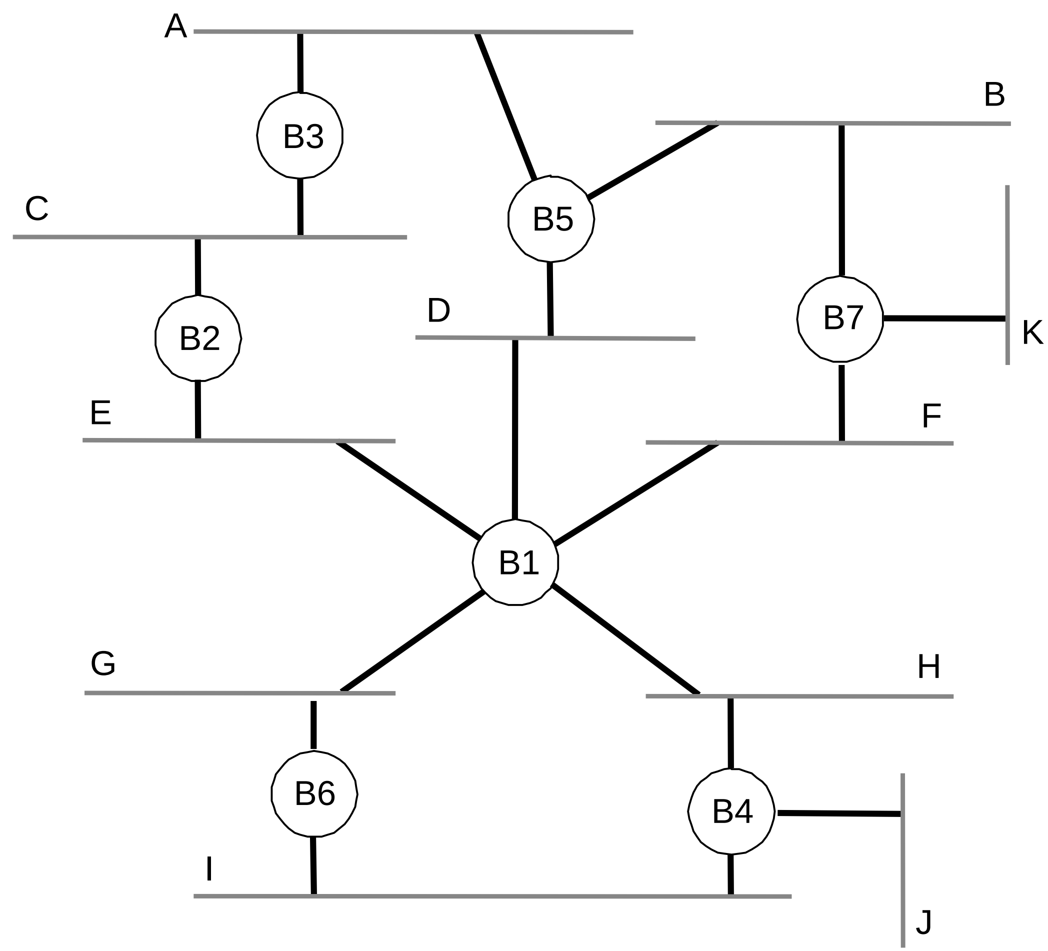
- To increase overall performance:
  - Shouldn't forward A→B or C→D, should forward A→C and D→B



- How does the bridge know?
  - Learn who is where by observing source addresses
  - Forward using destination address; age for robustness

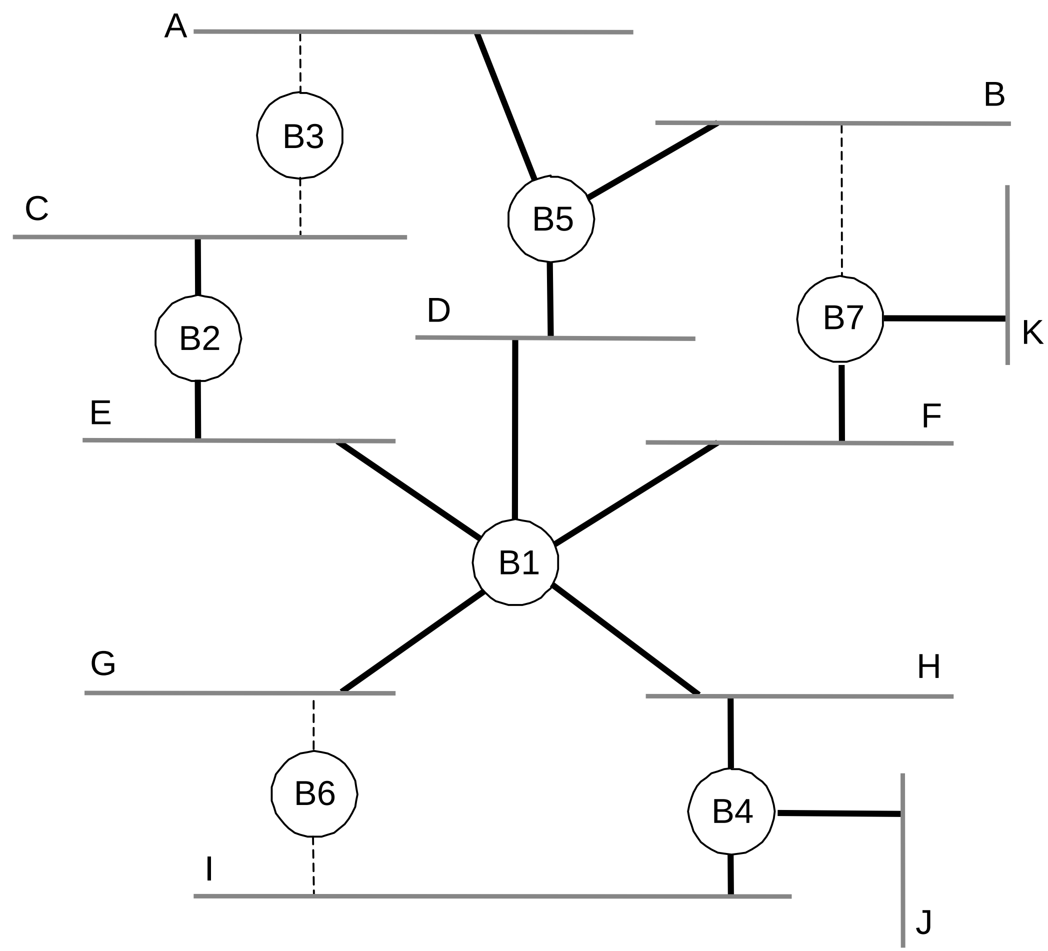
Why stop at one bridge?

- LANs and bridges form a graph
  - LANs = nodes, bridges = edges
- But to avoid loops we forward only on select bridge ports!
  - Spanning Trees



Spanning Tree Example

- Spanning tree is a subset of the graph that spans it but has no cycles
  - Prune some ports
- Q: How do we find a spanning tree?



Spanning Tree Algorithm

- Distributed algorithm to compute spanning tree
  - Robust against failures, needs no organization
- Outline:
  - Goal is to turn some bridge ports off
  - Bridges send periodic "best" configuration messages
  - Elect a root node of the tree (lowest address)
  - Grow tree as shortest distances from the root
  - Turn off ports that aren't on shortest paths

Algorithm continued

- Each bridge sends periodic messages containing:
  - Its address, address of the root bridge, and distance (in hops) to root
- Each bridge receives messages, updates "best" config.
  - Smaller root address is better, then shorter distance
  - To break ties, bridge with smaller address is better
- Initially, each bridge thinks it is the root
  - Sends configuration messages on all ports
- Later, bridges send only "best" configs
  - Add 1 to distance, send configs where still "best" (designated bridge)
  - Turn off forwarding on ports except those that send/receive "best"

Algorithm Example

- Message format: (root, dist to root, 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

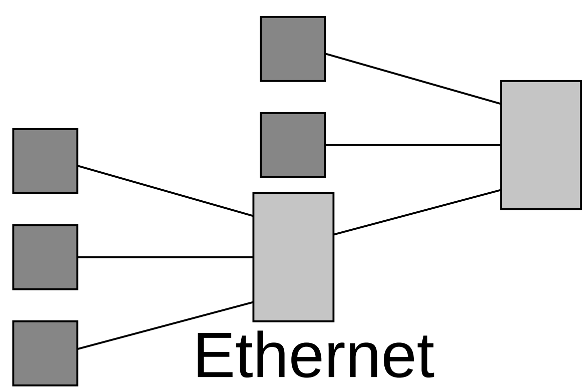
  5. B3 wants to send (B1, 2, B2) but doesn't as its nowhere "best"
  6. B3 receives (B1, 1, B2) and (B1, 1, B5) again … stable
     - Data forwarding is turned off to the LAN A

Some other 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 high performance multi-port bridges
  - Looks like a hub, but frames are switched, not shared
  - Every host on a separate port, or can combine switches



Limitations of Bridges

- 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
  - Poor solution for connecting LANs with different MAC protocols

Key Concepts

- We can overcome LAN limits by interconnection
  - Bridges and LAN switches
  - But there are limits to this strategy …
- Up Next: How to grow large and really large networks
- Network layer functionality
  - Routers (addressing/routing)
  - Scaling the size of the network
  - Combining different LAN technologies