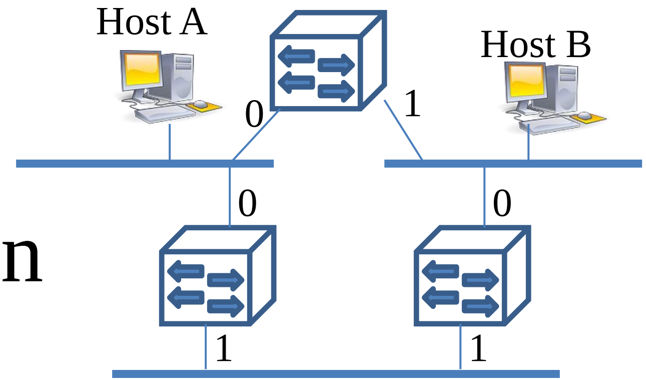
Spanning Tree Algorithm

Kameswari Chebrolu

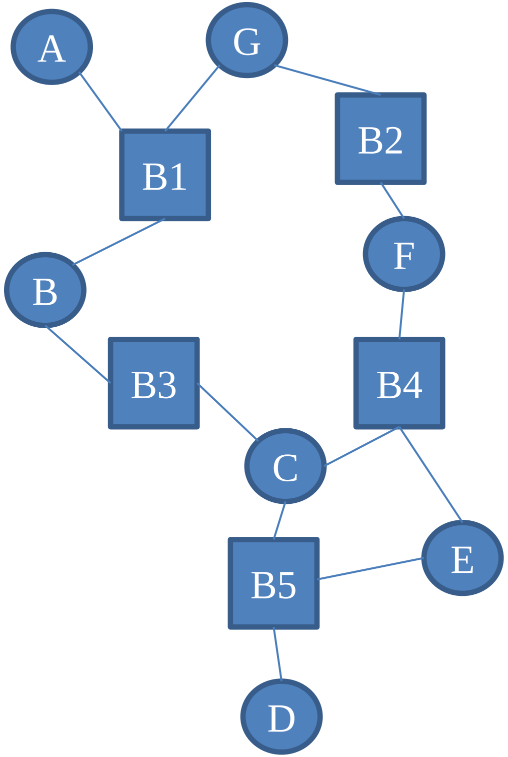
Recap

- Bridges interconnect LANS to form extended LANs
- Forwarding based on learning
- Loops in topology can result in frames looping indefinitely
- How to solve looping?

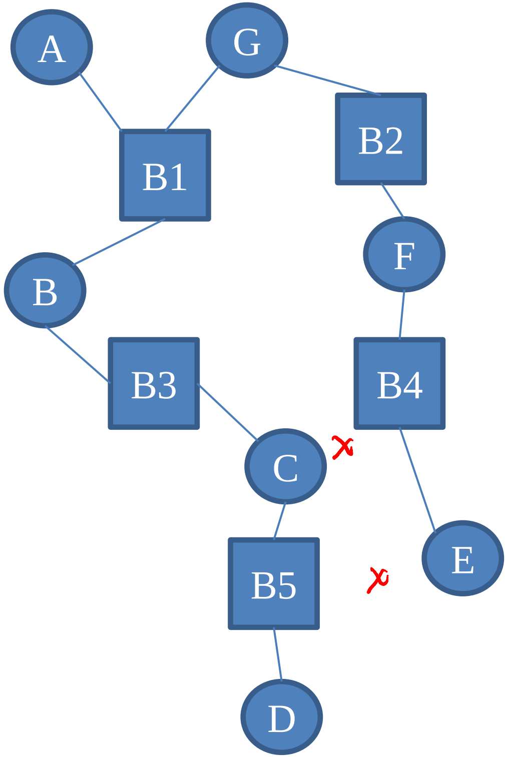


Spanning Tree

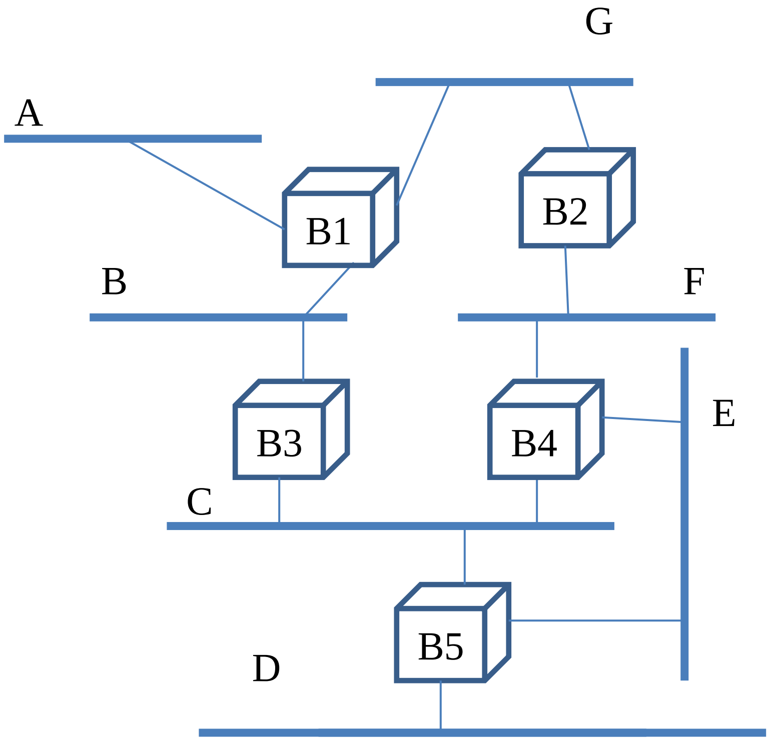
- Define a graph
  - Consider each bridge and each LAN-segment as a node
  - And each interface/port as a link
- Define a spanning tree in this graph
  - Need to span only those nodes that correspond to LAN segments
- Which spanning tree?



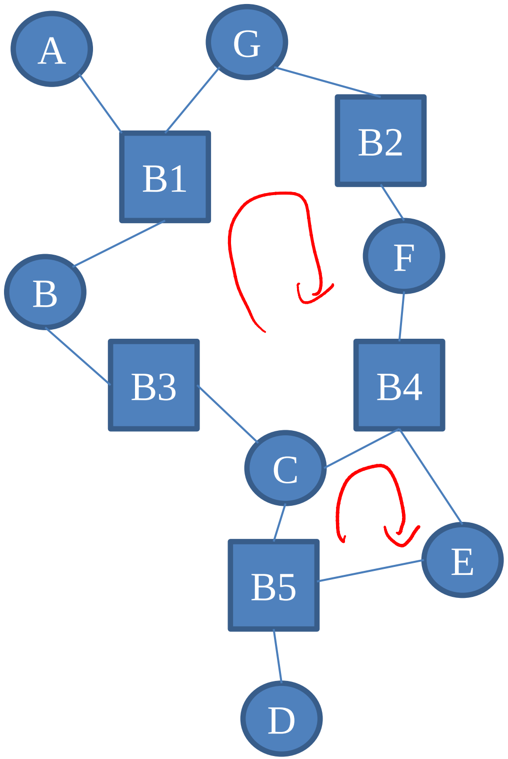
Graph



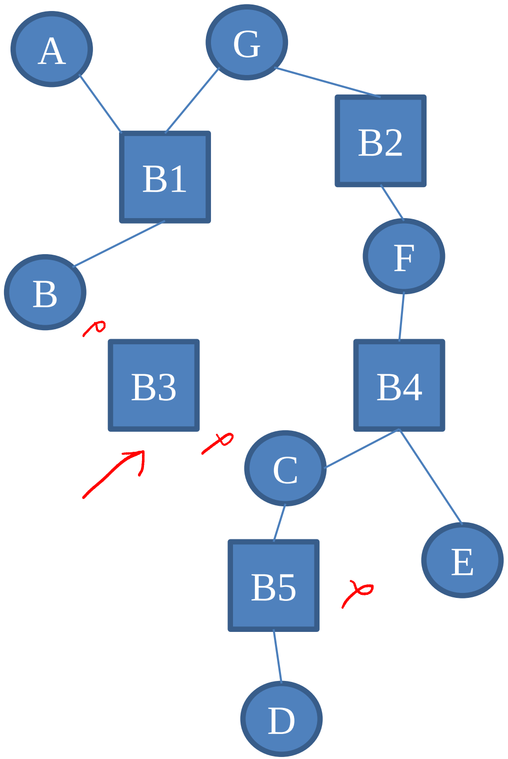
Spanning Tree



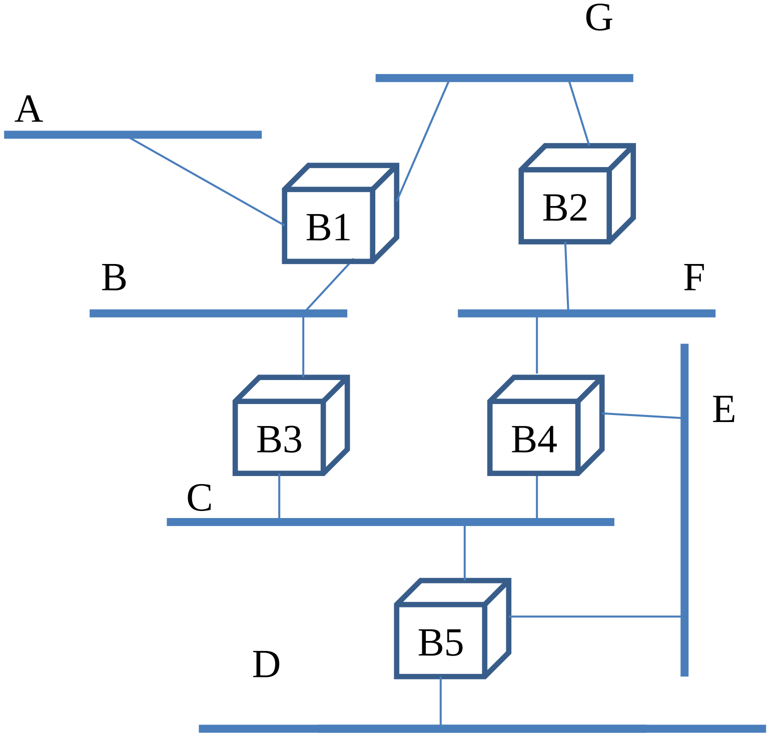
Topology



Graph



Spanning Tree



Topology

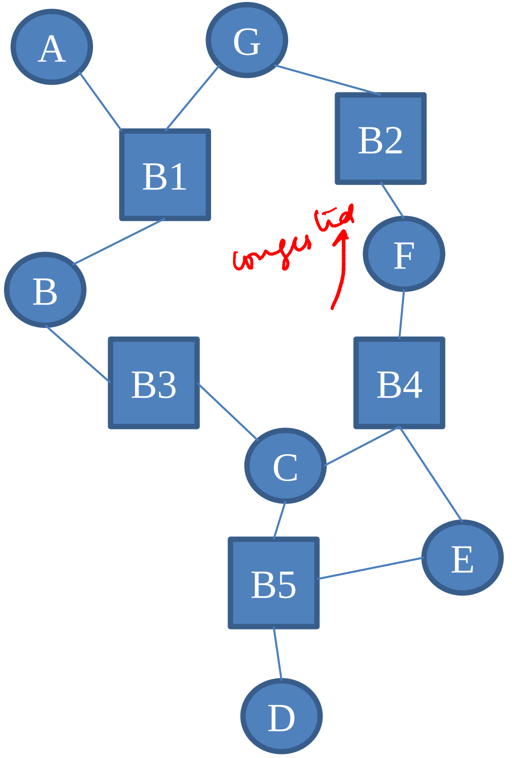
Basic Idea

- Define a root bridge: smallest id
  - All of its interfaces are active
- Each bridge computes the shortest path to the root bridge, and notes this port (root port)
- For a LAN segment, determine which bridge provides shortest path to root (designated bridge)
  - Port connecting LAN segment to bridge (designated port)

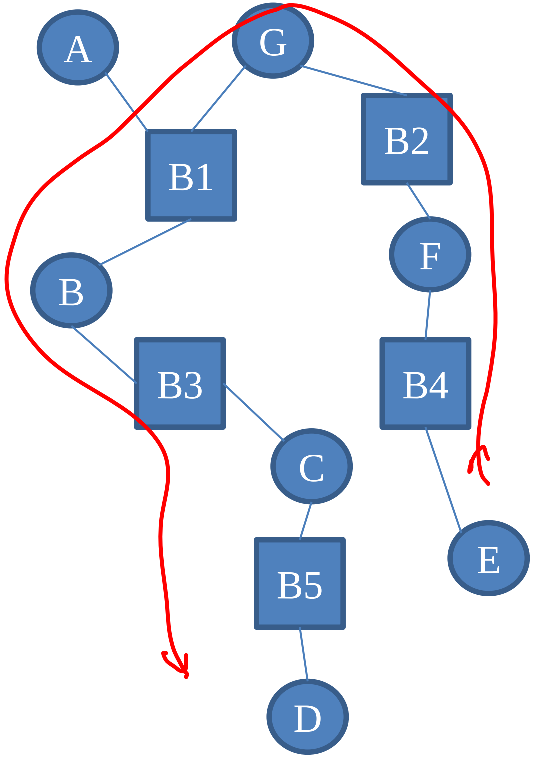
Basic Idea

- Shortest path: smaller-id breaks ties
- Disable all ports that is not a root port or a designated port
  - Don’t forward frames on it or act on frames received on it

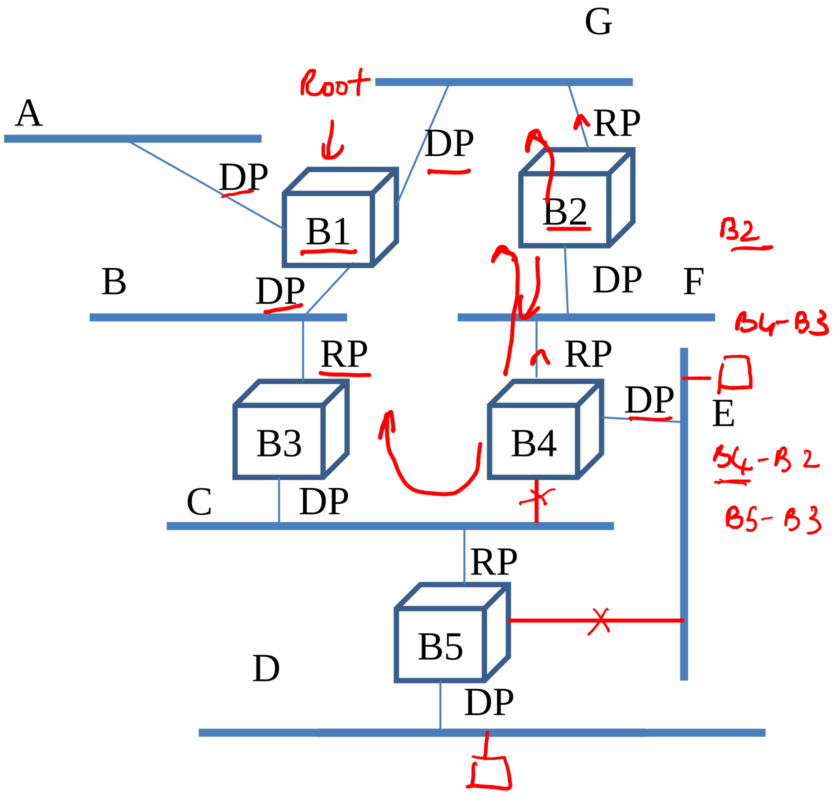
Protocol should be distributed



Graph



Spanning Tree



Topology

INTERMISSION

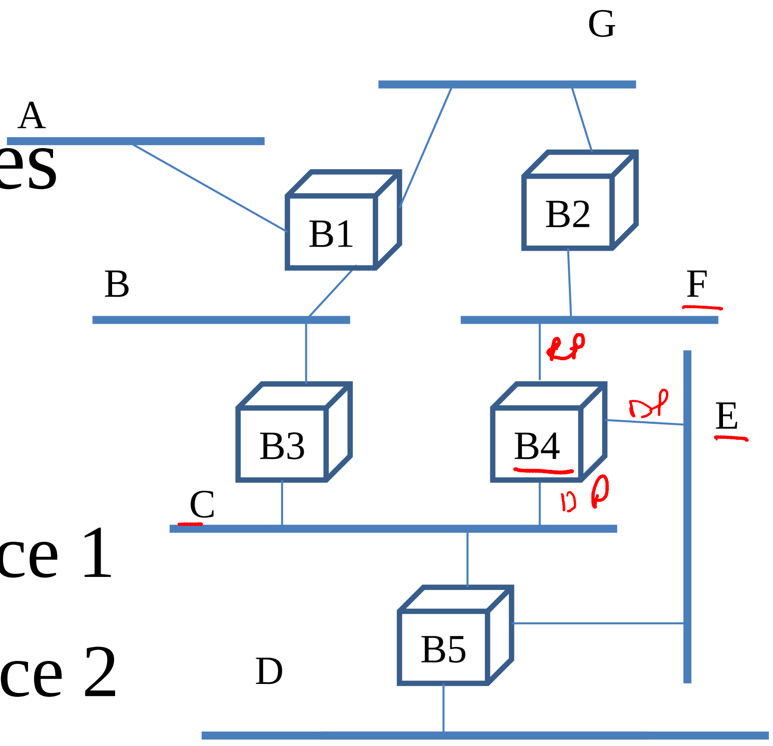
Spanning Tree Algorithm

- Dynamic, distributed algorithm
- At beginning, each bridge thinks itself as root & sends configuration messages on all its interface
- Configuration messages: bridge's id (X), id of the node it considers to be the root (Y), and its distance from root(d) (Y,d,X) ✓
- Each bridge stores the "best" configuration

- New configuration is “better” than stored if
  - It identifies a smaller root id, or
  - Same root id, but with a shorter distance to the root, or
  - Same root id and distance, but smaller sending bridge id
- Bridge stops generating configuration messages once it decides its not root (it still forwards after incrementing distance)
- Bridge stops sending configuration messages on a port if its not the designated bridge for that port
- Only root sends configuration messages periodically

Example

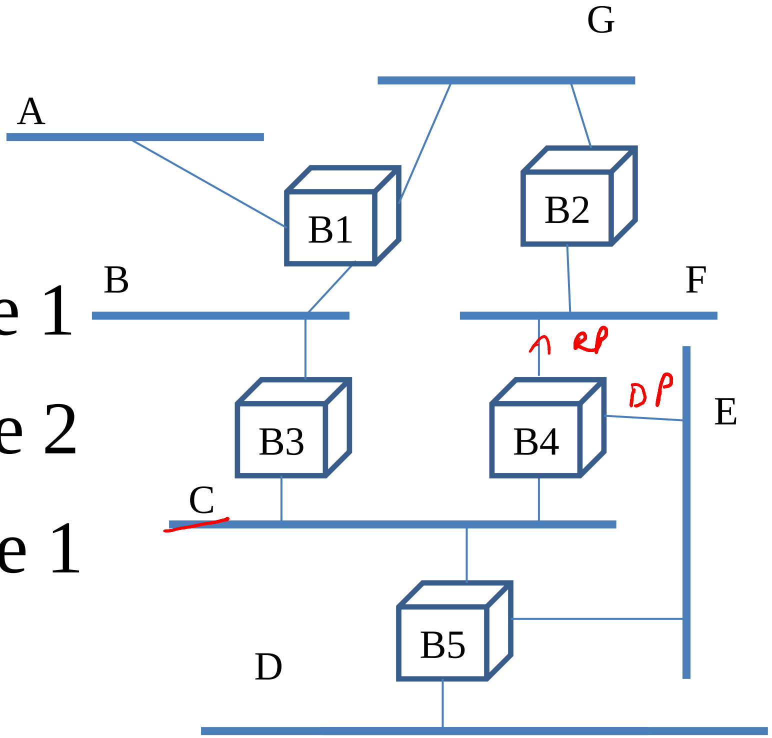
- Focus on B4
- (B4,0,B4) send on all interfaces
- Receive (B1,1,B2) on F
  - B1 is root; RP: B4-F
  - F: B2 designated bridge, distance 1
  - E: B4 designated bridge, distance 2
  - C: B4 designated bridge, distance 2
  - (B1,2,B4) on E and C, All ports active



Topology

Example

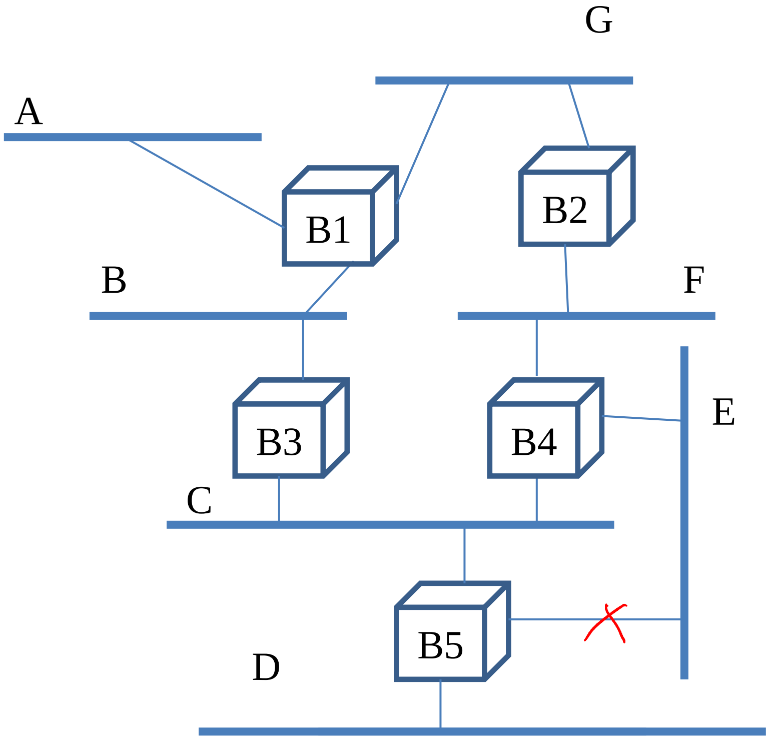
- Receive (B1,1,B3) on C
  - B1 is root; RP: B4-F
  - F: B2 designated bridge, distance 1
  - E: B4 designated bridge, distance 2
  - C: B3 designated bridge, distance 1
  - (B1,2,B4) on E
  - Ports to F and E are only active



Topology

Example

- B4 Should not receive (B1,2,B5) on E at this time
  - When B5 receives (B1,2,B4) on E, it would conclude B4 is designated port for E and disable the port B5 to E.



Topology

Bridge Failure

- Downstream nodes stop receiving ‘config’ messages and timeout and declare self as root.
- Spanning tree algorithm kicks in to elect new designated bridges

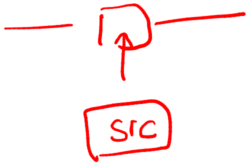
Limitations

10,000 Table
→ 10,000

- Not scalable
  - Flat Addressing: address look-up cost can be significant MAC
  - Forwarding can result in flooding
  - Broadcast frames are sent everywhere
    - Example: ARP, DHCP
  - Spanning tree can lead to inefficient paths, prevents load-balancing

Limitations

- Can't handle heterogeneity
  - Networks should have same address format



Summary

- Extended LANs can build relatively big networks
- Loops are unavoidable in such topologies
- Impose a tree (spanning) on the network graph to circumvent them
    - Plug-and-play solution
- Ahead: Network Layer Switching

Algorhyme – Radia Perlman

I think that I shall never see
A graph more lovely than a tree.
A tree whose crucial property
Is loop-free connectivity.
A tree that must be sure to span
So packets can reach every LAN.
First, the root must be selected.
By ID, it is elected.
Least-cost paths from root are traced.
In the tree, these paths are placed.
A mesh is made by folks like me,
Then bridges find a spanning tree.