CS144
An Introduction to Computer Networks

Routing

Spanning Tree Protocol

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Outline

Ethernet “routes” packets too.

We know how addresses are learned, but how are loops prevented?

Ethernet switches build a spanning tree over which packets are forwarded.

Ethernet Switch

1. Examine the header of each arriving frame.
2. If the Ethernet DA is in the forwarding table, forward the frame to the correct output port(s).
3. If the Ethernet DA is not in the table, broadcast the frame to all ports (except the one through which the frame arrived).
4. Entries in the table are learned by examining the Ethernet SA of arriving packets.

Learning could lead to loops

Preventing loops

Spanning Tree Protocol

The topology of switches is a graph.

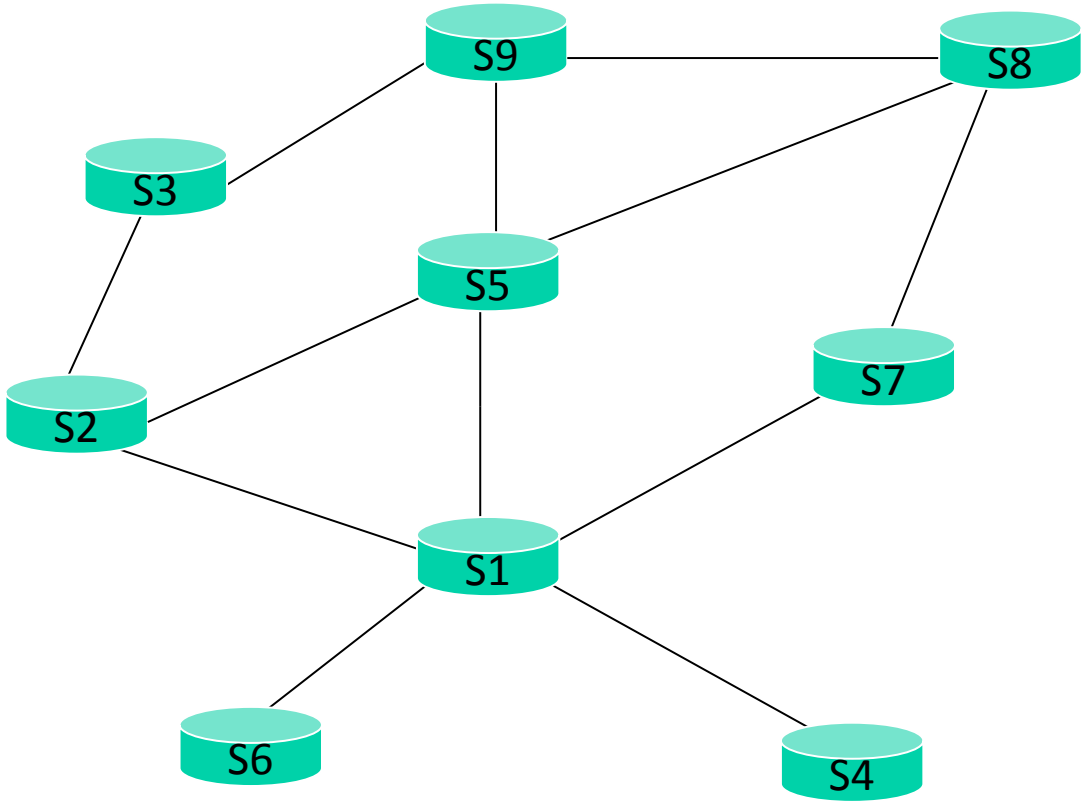
The Spanning Tree Protocol finds a a subgraph that spans all the vertices without loops.

- Spanning: all switches are included.
- Tree: no loops.

The distributed protocol decides:

1. Which switch is the Root of the tree, and
2. Which ports are allowed to forward packets along the tree.

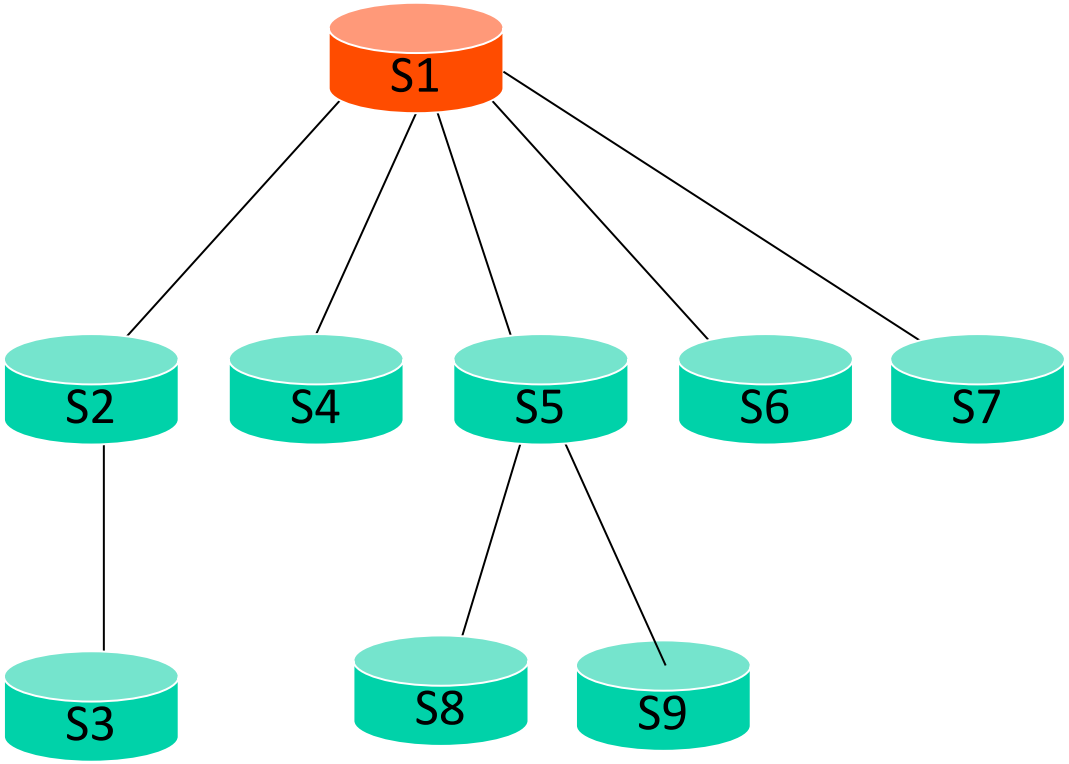
Example Spanning Tree



1: Pick a single root.

2: Only forward packets on ports on the shortest hop-count to root.

Resulting Spanning Tree



How it works

1. Periodically, all switches broadcast a "Bridge Protocol Data Unit" (BPDU) (ID of sender, ID of root, distance from sender to root).

2. Initially, every switch claims to be Root: sets distance field to 0.
3. Every switch broadcasts until it hears a "better" message:
   - A root with a smaller ID
   - A root with equal ID, but with shorter distance
   - Ties broken by smaller ID of sender.
4. If a switch hears a better message, retransmit message (add 1 to distance).

Root port: The port on a switch that is closest to the Root.
Designated port: The port neighbors agree to use to reach the Root.
All other ports are blocked from forwarding (but still send/receive BPDUs).

Eventually:
- Only the root originates configuration messages (others retransmit them).
- Locally, switch only forwards on ports.

A brief history

1985: STP proposed; IEEE standard in 1990.
Still very widely used

2004: STP replaced by RSTP which converges faster.
Still, RSTP uses the network inefficiently.

2012: A new standard for Ethernet switches was introduced Shortest-Path Bridging (SPB, or 802.1aq). It is a link-state protocol like OSPF.