# Bridging and Spanning tree Protocol

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# 1 Objective

The purpose of this lab is to study the behavior of Ethernet switches at the data link layer, focusing on frame filtering, ARP exchanges, and MAC learning. The lab also analyzes the Spanning Tree Protocol (STP), which prevents switching loops by creating a loop-free logical topology. Finally, the similarities and differences between STP and RIP are discussed.

# 2 Topology and Setup

The network topology consists of multiple hosts (pc1, pc2, pc3) connected via two Ethernet switches. Additional experiments use four interconnected bridges (bridge1–bridge4) with redundant links to study STP behavior. Wireshark captures are used to analyze ARP and BPDU traffic.

# 3 Procedure and Results

## 3.1 Frame Filtering and ARP Behavior

The first RTT measured between `pc2` and `pc3` is significantly longer (11 ms compared to 0.5 ms on average for subsequent pings). This delay occurs because `pc2` does not initially know the MAC address of `pc3`. Before sending the first ICMP Echo Request, `pc2` broadcasts an ARP request. The ARP exchange is captured in Wireshark : the request broadcast from `pc2` (Figure 1) and the reply from `pc3` (Figure 2). Once the MAC is cached, subsequent pings are transmitted immediately with lower RTT.

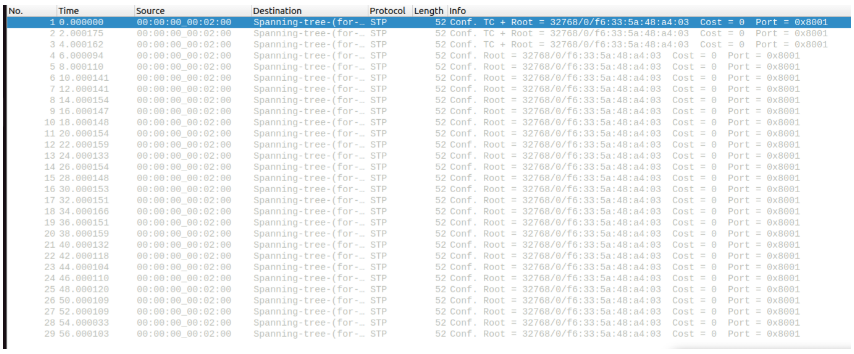


Figure 1 – ARP request broadcast from `pc2`

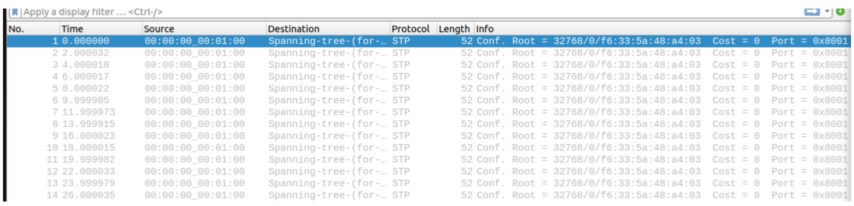


Figure 2 – ARP reply from `pc3`

## 3.2 Broadcast Visibility

`pc1` also sees the ARP request sent by `pc2`. Since ARP requests are broadcast within the collision domain, every host (including `pc1`) receives the request, even if they are not the target of the communication.

## 3.3 Switch MAC Learning

During the ARP exchange, the switches learn MAC addresses :

— Switch1 learns the MAC of `pc2` from the ARP request.

— Switch2 also learns the MAC of `pc2`, and later the MAC of `pc3` from its ARP reply.

This process populates the forwarding tables of both switches, allowing future frames to be delivered more efficiently and without broadcasting.

### 3.4 Switch Transparency and TTL

Switches operate at Layer 2 and do not modify IP headers. When an IP datagram passes through a switch, the TTL remains unchanged, as only routers decrement TTL. Switches only use MAC addresses for forwarding, making them transparent to the hosts, which behave as if directly connected.

### 3.5 IP Addresses on Switches

Switches do not require IP addresses for their basic operation. They function at Layer 2 using MAC addresses to forward frames. Routers, by contrast, operate at Layer 3 and require IP addresses to make routing decisions.

### 3.6 Spanning Tree Protocol (STP)

STP eliminates loops in redundant switch topologies. It elects a root bridge, which in this setup is `bridge1` because it has the lowest bridge ID (priority 80-00, lowest MAC). Other bridges select root ports, which are the ports with the lowest-cost path to the root bridge :

— `bridge2` selects its direct link to `bridge1` (segment A).
— `bridge4` selects its direct link to `bridge1` (segment B).
— `bridge3` can reach `bridge1` either via `bridge2` or `bridge4`. Since both paths have equal cost, STP rules break the tie, and `bridge3` selects one as its root port.

On each link, STP designates one forwarding port. The ports on the root bridge are always designated. Other ports may be blocked to prevent loops, for example, one of the redundant links between `bridge3` and `bridge4`.

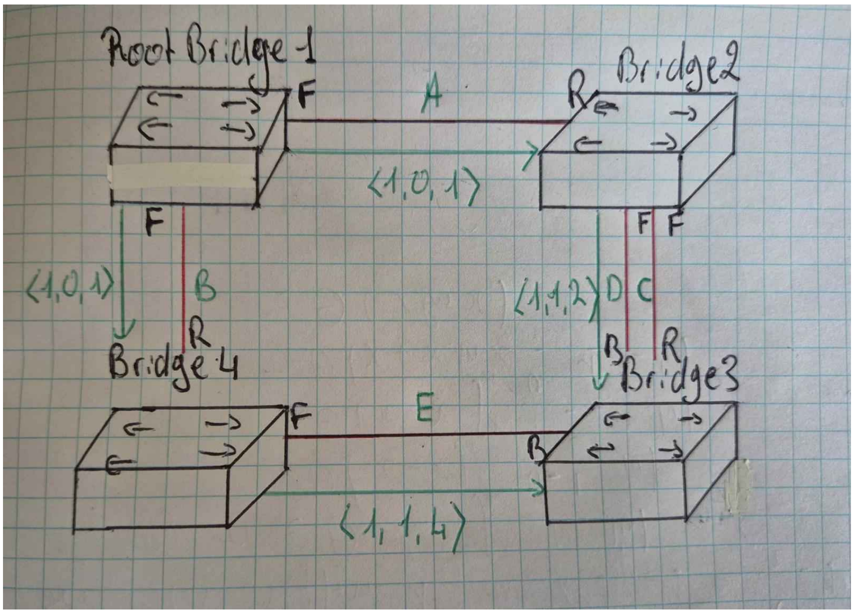


FIGURE 3 – Spanning Tree Protocol topology with root and designated ports

### 3.7 Traffic Flow

A frame sent from `host1` to `host2` passes through `bridge4`, then `bridge3`, and finally reaches `host2`. Blocked ports ensure that no loops occur along the path.

### 3.8 Failure and Recalculation

When `bridge2` fails, STP requires about 30–50 seconds to recalculate the spanning tree. Other bridges notice the absence of BPDUs from `bridge2` and recompute their roles. `bridge1` remains the root bridge, and previously blocked ports, such as the link between `bridge3` and `bridge4`, transition through Listening and Learning states before becoming Forwarding. This restores connectivity between `host1` and `host2`.

### 3.9 Comparison of RIP and STP

Although both RIP and STP aim to determine efficient paths, they operate at different layers :

- STP operates at Layer 2, preventing loops by blocking redundant links. It ensures one unique active path between any two nodes.
- RIP operates at Layer 3, using hop counts to compute shortest paths. Unlike STP, RIP supports multiple routes and updates routing tables periodically.

## 4 Analysis

The experiments confirm that switches learn MAC addresses dynamically and forward frames without modifying IP headers. ARP requests explain the longer RTT for the first ping. STP proves essential in redundant switch networks by ensuring a loop-free topology, though its convergence is relatively slow compared to modern protocols like RSTP. The comparison with RIP emphasizes the different roles of Layer 2 and Layer 3 protocols in path selection and redundancy management.

## 5 Conclusion

This lab demonstrates frame filtering, ARP exchanges, and MAC learning at the data link layer. It also highlights the operation of the Spanning Tree Protocol, including root bridge election, port roles, and convergence following a failure. Finally, the comparison between STP and RIP illustrates how loop prevention and path optimization are addressed differently at Layer 2 and Layer 3.