# Layer-3 Switching

## Computer Networks, Lecture 15

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March 8, 2021

# Overview

1. Recap of the previous lecture
2. Shortcomings of Ethernet Switching
3. Routing
   - Intra-domain Routing
     - Distance Vector

# Recap of the previous lecture

- Ethernet Switching
- Populating the forward table
- Spanning Tree Protocol

Ethernet switches provide scalability to some extent, but what if we want millions of hosts connected together in a network?

# Shortcomings of Ethernet Switching

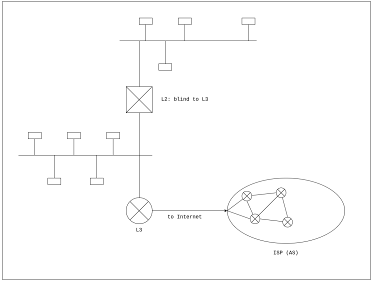
- The path between bridges under **STP** *may* not be optimal (in terms of distance/cost).
- Resource utilisation *is* poor for some links (disabled ports) aren't used.
- **Flat Addressing:** For a bridge, the forwarding table has an entry for every host. So, the forwarding table has size $O(N)$, where $N$ is the number of hosts. Storing the table and lookup mechanism for an entry is non-trivial.
  MAC addresses vary from 0 to $2^{48} - 1$. In flat addressing, there is no intelligent organisation of MAC addresses to reduce the table size. In Layer-3 Switching, we use **Hierarchical Addressing**.
- **Stability:** A switch may go down. What if the root goes down? The network gets disconnected. **STP** is reconstructed: non-trivial, communication is disrupted for that time. (the root periodically sends "keep-alive" *hello* messages to other bridges. If the message isn't heard, the protocol is rerun.) Larger LANS: frequent **STP** reruns.

# IP Addresses

**Other issues:**

- No common addressing schemes across the globe.
- No common communication protocols.

So, we come up with **IP Addresses**.




**ISP**s are **Autonomous Systems**, since they can decide on the architecture of the network (number of routers, connectivity, internal routing protocols). For instance, routing protocols can be chosen based on shortest paths in terms of number of hops, latency or any other optimization criteria.

So, the internet does not give the optimal paths in any sense.

# Routing

### Intra-domain routing

Routing protocols within **AS**.

### Inter-domain routing

Routing protocols between **AS**es.

The internet uses **BGP** (Border Gateway Protocol) as the inter-domain routing protocol that allows to have smaller routing tables.

# Intra-domain Routing

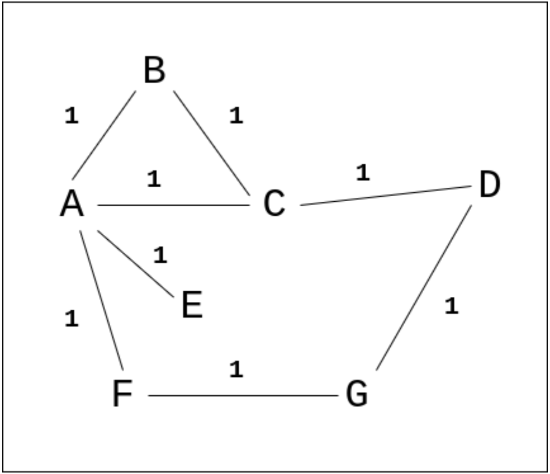
Divided in two, based on its use:

1. Distance Vector
    - RIP: Routing Information Protocol
2. Link-State Routing
    - OSPF: Open Shortest Path First
    - IS-IS: Intermediate System to IS

Based on the Bellman Ford algorithm (distributed version). That is, there is no central node, with all the info of the network.
For instance, A need not know the full shortest path to B, it just need to know the next hop along that path.

# Distance Vector

Consider this example:



- A sends out to its **own neighbours**: (A,0)
  (that is, *I am A and my distance to myself is 0.*)
  A hears: (B,0), (C,0), (E,0) and (F,0).

| **Dest.** | **Next hop** | **Cost** |
|---|---|---|
| A | - | 0 |
| B | B | 1 |
| C | C | 1 |
| E | E | 1 |
| F | F | 1 |

Table: Routing table at A

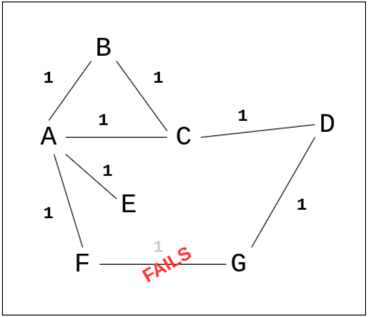
where **Cost** is the total cost of the shortest path.

- A sends out to its **own neighbours**: (A,0), (B,1), (C,1), (E,1), (F,1).
  [ (F,1): *current shortest path that I know to the destination F* ]
  A hears from B: (A,1), (C,1)
  From C: (A,1), (D,1)
  From E: (A,1)
  From F: (A,1), (G,1)

| **Dest.** | **Next hop** | **Cost** |
|---|---|---|
| A | - | 0 |
| B | B | 1 |
| C | C | 1 |
| E | E | 1 |
| F | F | 1 |
| D | C | 2 |
| G | F | 2 |

Table: Routing table at A

# What happens if a link fails?




- F sends out to its neighbours (only A in this case): (G,$\infty$) [**Triggered Update**].
- A looks up its own table and sees that A was able to reach G *through* F. So, A invalidates that entry:

| Dest. | Next hop | Cost |
|---|---|---|
| ~~G~~ | ~~F~~ | ~~2~~ |
| G | - | $\infty$ |

Table: Routing table at A

- A announces (G,$\infty$) to its neighbours. C tells A: (G,2) [**Periodic Update**]. So, A enters (G,C,3) in its routing table.

# Types of updates

1. **Triggered Updates:** Event triggers a routing update to the neighbours. For instance, F$\rightarrow$G link failure triggers an update (G,$\infty$) to A.
2. **Periodic Updates:** Tells neighbours info in routing table about (Dest,Distance) to various destinations.

We will look at the shortcomings of the Distance Vector protocol in the next lecture.
Note that, no node knows the entire topology of the network. This may lead to routing loops in certain situations. But works for smaller networks.

# References

CS224 Computer Networks
Lecture 15 (Spring 2021)
*Prof.* Vinay Joseph Ribeiro