The Control Plane

Network-Layer Functions

- The **data plane** is reponsible for **forwarding packets** (moving them from the router's input, to the router's output).
- The **control plane** is responsible for **determining the route** taken by **packets** from **source to destination**.

Structuring the Control Plane

- There are two ways to **structure the network control plane**:
  1. **Per-router control (traditional)** — Each **router** has a **routing algorithm** that is used to determine **where to route the packet**.
  2. **Logically centralized control (software defined networking)** — Remote controller computes, and **installs a fordwarding table** in the **routers**.

Routing Protocols

Routing Protocols

- The **goal** of a **routing protocol** is to **determine "good" routes** from the **sending host** to the **receiving host** through a network of routers.
- In order to acheive that goal, **each router** needs to know **what it is directly conntected to**, and what **those routers are connected to**.
- A **path** is a sequence of **routers** that packets must **traverse** from the **inital sending host** to the **final destination host**.
- A **"good" route** is a **route** that is the **fastest, least congested, and of least "cost"**.

Routing Graphs

- A **routing graph** is a tuple $G = (N, E)$ where N is a set of routers $\{n_1, n_2, \cdots, n_j\}$ and E is a set of links $\{e_1, e_2, \cdots, e_k\}$.
- The **cost** of a **link** $l \in E$ is defined as a function $C : E \to \mathbb{R} \cup \{\infty\}$, denoted by $C_{a,b}$ where $a, b \in N$ are the routers that the link l is contected to.

Routing Algorithms

- A **routing algorithm** is an **algorithm** that is used to determine the **a "good" path** that a **packet** should take to get from **a sending host** to a **receiving host**.
- **Route classificatons**:
  1. **Static Routes** — Static routes are routes that do **do not change**, or that **change very slowly over time**.
  2. **Dynamic Routes** — Dynamic routers are routes that **change quickly over time**, or have a **quickly chaning cost**.
- **Routing algorithm classifications**:
  1. **Link State Algorithms (Global)** — Link state algorithms are used when **all routers** have a **complete topology of the network, and know the cost of each route**.
     - An example of link state algorithms is Dijkstra's link-state routing algorithm.

2. **Distance Vector Algorithms (decentralized)** — Distance vector algorithms are used routers initially **only know the link cost to attached neighbors**. This algorithm is **iterative**, and information needs to be **exchanged with neighboring routers**.
   - An example of a distance vector algorithm is