

## The Control Plane

### Network-Layer Functions

- The **data plane** is responsible 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 forwarding 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 achieve that goal, **each router** needs to know **what it is directly connected to**, and what **those routers are connected to**.
- A **path** is a sequence of **routers** that packets must **traverse** from the **initial 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  $\{n_1, n_2, \dots, n_j\}$  and  $E$  is a set of links  $\{e_1, e_2, \dots, e_k\}$ .
- The **cost** of a **link**  $l \in E$  is defined as a function  $C : E \rightarrow \mathbb{R} \cup \{\infty\}$ , denoted by  $C_{a,b}$  where  $a, b \in N$  are the routers that the link  $l$  is connected 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 classifications**:
  1. **Static Routes** — Static routes are routes that **do not change**, or that **change very slowly over time**.
  2. **Dynamic Routes** — Dynamic routes are routes that **change quickly over time**, or have a **quickly changing 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 distance vector algorithms is an algorithm based on Bellman-Ford's equation.