

# Routing, Forwarding, IPv4, and IPv6

## 1. Routing vs Forwarding

### Key Idea

**Forwarding** = Per-packet decision: move a packet *from input to output interface* of a router.

**Routing** = Global decision: determine the *entire path* packets take across the network.

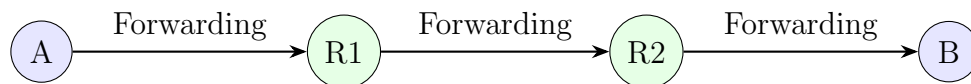
### Forwarding

- Local action **inside a router**.
- Uses the **Forwarding Table** to decide the outgoing interface.
- *Analogy*: Like a **post office clerk** putting each letter in the right truck.

### Routing

- Network-wide process that determines the **end-to-end path**.
- Uses **Routing Algorithms**: Dijkstra's shortest path, Distance Vector.
- *Analogy*: Like a **GPS navigation system** finding the best road trip route.

### Routing Path



## 2. IPv4

### Definition

IPv4 (Internet Protocol v4) uses **32-bit addresses** to identify devices on a network.

## Characteristics

- **32-bit address space:**  $\approx 4.3$  billion unique addresses.
- Written in **dotted-decimal**, e.g., 192.168.1.1.
- Supports fragmentation, checksum, and multiple header fields.

## Analogy

IPv4 is like assigning **house numbers** in a city—eventually, the numbers run out.

### Example

11000000.10101000.00000001.00000001 = 192.168.1.1

## 3. IPv6

### Definition

IPv6 (Internet Protocol v6) uses **128-bit addresses** and was introduced to solve IPv4 exhaustion.

## Characteristics

- **128-bit address space:**  $\approx 3.4 \times 10^{38}$  addresses.
- Written in **hexadecimal, colon-separated** format.
- Simplified headers, no fragmentation, built-in **IPSec**.

## Analogy

IPv6 is like giving **every grain of sand on Earth its own address**—practically unlimited.

### Example

2001:0db8:85a3:0000:0000:8a2e:0370:7334

## 4. IPv4 vs IPv6

Feature	IPv4	IPv6
Address Size	32-bit	128-bit
Address Format	Dotted decimal	Hexadecimal with colons
No. of Addresses	$\approx 4.3 \times 10^9$	$\approx 3.4 \times 10^{38}$
Header Size	20–60 bytes	Fixed 40 bytes (simpler)
Security	Optional (IPSec)	Mandatory (IPSec)
Example	192.168.1.1	2001:db8::1

## 5. Key Takeaways

- **Forwarding:** Local, per-packet action inside a router.
- **Routing:** Global path selection across the network.

- **IPv4:** Limited address space, widely used but running out.
- **IPv6:** Huge address space, designed for the future Internet.