## Week 5

### 1. Overview of the Internet Layer

* The Internet Layer is responsible for moving packets across networks.
* It enables logical communication between devices by using IP addresses.
* It sits between the Transport Layer (above) and the Network Access Layer (below).

Key Functions of the Internet Layer

1. Addressing – Assigning a unique IP address to each device.
2. Routing – Deciding the best path for data packets.
3. Packetization – Encapsulating data into IP datagrams.
4. Fragmentation – Splitting large packets to fit network constraints.

### 2. Internet Layer vs. Transport Layer

|  |  |  |
| --- | --- | --- |
| **Feature** | **Transport Layer (TCP/UDP)** | **Internet Layer (IP)** |
| **Delivery** | Host-to-host (end-to-end) | Router-to-router (hop-by-hop) |
| **Identifiers** | Uses port numbers | Uses IP addresses |
| **Data Units** | Segments & datagrams | Packets |
| **Reliability** | TCP ensures reliability | IP is best-effort (no guarantees) |

### 3. IP Addressing and Hierarchical Structure

IP Address Format

* IPv4 Address: 32-bit address written in dotted decimal (e.g., 192.168.1.1).
* IPv6 Address: 128-bit address written in hexadecimal (e.g., 2001:db8::1).

IP Address Classes (IPv4)

|  |  |  |
| --- | --- | --- |
| **Class** | **Range** | **Usage** |
| **A** | 0.0.0.0 – 127.255.255.255 | Large networks |
| **B** | 128.0.0.0 – 191.255.255.255 | Medium networks |
| **C** | 192.0.0.0 – 223.255.255.255 | Small networks |
| **D** | 224.0.0.0 – 239.255.255.255 | Multicast |
| **E** | 240.0.0.0 – 255.255.255.255 | Experimental |

Special IPv4 Addresses

* Private IPs (used inside local networks, not routable on the internet):
  + 10.0.0.0/8
  + 172.16.0.0/12
  + 192.168.0.0/16
* Loopback (127.0.0.1) – Used for self-testing.
* Broadcast (255.255.255.255) – Sends messages to all devices in a network.

CIDR (Classless Inter-Domain Routing)

* Uses subnet masks to define address ranges (e.g., 192.168.1.0/24 means 256 addresses).
* CIDR improves IP address allocation efficiency.

### 4. DHCP (Dynamic Host Configuration Protocol)

* DHCP automatically assigns IP addresses to devices when they join a network.
* Process:

1. DHCP Discover – Client asks for an IP.
2. DHCP Offer – Server suggests an available IP.
3. DHCP Request – Client requests the IP.
4. DHCP Acknowledgment (ACK) – Server confirms the assignment.

* DHCP Advantages:
  + Eliminates manual IP configuration.
  + Prevents IP conflicts.
  + Supports mobile devices.

### 5. NAT (Network Address Translation)

* NAT allows multiple devices in a private network to share one public IP.
* Used in home networks where all devices use a single router’s public IP.

Types of NAT

1. Static NAT – One-to-one mapping of private to public IP.
2. Dynamic NAT – Assigns public IPs from a pool.
3. PAT (Port Address Translation) – Maps multiple private IPs to a single public IP using different ports.

NAT Benefits

* Extends IPv4 lifespan.
* Adds security (devices are hidden from the internet).
* Allows multiple devices to share a single public IP.

### 6. Routing and Forwarding

* Routing: Determines the best path for packets.
* Forwarding: Moves packets from one router to another.

Static vs. Dynamic Routing

|  |  |  |
| --- | --- | --- |
| **Feature** | **Static Routing** | **Dynamic Routing** |
| Configuration | Manually Set | Automatically updated |
| Flexibility | Limited | Adapts to changes |
| Scalability | Small networks | Large networks |
| Examples | Home networks | Enterprise networks |

### 7. Routing Protocols

Types of Routing Protocols

1. Distance Vector (RIP)

* Routers share entire routing tables with neighbours.
* Uses hop count as a metric.
* Slow convergence, not scalable.

1. Link State (OSPF)

* Routers exchange only network topology information.
* Uses Dijkstra’s Shortest Path Algorithm.
* Faster convergence and more scalable.

1. Path Vector (BGP)

* Used for internet-wide routing.
* Works between Autonomous Systems (AS).
* Used by ISPs and large networks.

### 8. IPv6 and Network Evolution

IPv6 was introduced to solve IPv4 exhaustion and improve network efficiency.

IPv6 Features

* 128-bit address space (compared to 32-bit in IPv4).
* Simpler packet header (faster processing).
* Better security (built-in IPsec encryption).
* Auto-configuration (devices can generate their own addresses).

IPv6 Address Format

* Written in hexadecimal, divided into eight groups (e.g., 2001:db8::1).
* Tunneling: IPv6 packets can be encapsulated in IPv4 to allow transition.

IPv6 Deployment

* Slow adoption (around 30% of traffic is IPv6).
* Dual-stack approach allows IPv4 and IPv6 to coexist.

### 9. Summary

* The Internet Layer enables communication across networks using IP.
* IP addressing and subnetting help structure the internet.
* Routing and forwarding determine how packets move between devices.
* NAT conserves IPv4 addresses and improves security.
* IPv6 provides a long-term solution to address exhaustion.