Network Layer Characteristics

Network Layer (OSI Layer 3) - allows **end devices** to exchange data across networks **(end-to-end)**

Types of Network Layer Protocols

1. Addressing Protocols - IPv4, IPv6
2. Routing Protocols - Open Shortest Path First (OSPF)
3. Messaging Protocols - Internet Control Message Protocol (ICMP)

Network Layer Protocols perform four basic operations

Protocols	Operations
Addressing Protocols - IPv4, IPv6	[1] Addressing end devices with **unique IP address for identification** on the network
	IP packets are [2] encapsulated by the sender with both source and destination IP addresses.
Routing Protocols - Open Shortest Path First (OSPF)	[3] Routing - The router selects the best path and directs IP packets PDU toward the destination host **End-to-end** - data travels **directly** between the sender and recipient **Hop-to-hop** - data travels **through multiple intermediary routers** before reaching the destination
	IP packets are [4] de-encapsulated by the destination by checking the IP header. If it matches, pass the IP packet to the transport layer as segment PDU

Network Layer vs Transport Layer (OSI Layer 4)

Network Layer	Transport Layer
Cares about the metadata of data (packet structure and process used to carry data (routing, addressing, packet forwarding)	Cares about data's integrity (**sequencing**) and order (**segmentation**)
Specify packet structure and processing used to carry the data	Manages the data transport (**tracking and managing flow of IP packets**) between the processes running on each host
Addressing Protocol, Routing protocol	Transmission Control Protocol (TCP)

3. Media Independent: IP packets can travel over various media types like copper, fiber, or wireless.

   *IP packets are **not limited to any particular medium** as the data link layer is responsible for taking an IP packet and preparing it for transmission over different kinds of communications medium. However, there is a maximum size of the PDU that each medium can transport*

   a. **Maximum Transmission Unit (MTU)**: the **largest size of the PDU** that each medium can transport
   b. Communication Between Layers: The **data link layer informs the network layer** of the **MTU** value
   c. Packet Size Determination: The **network layer decides how large packets** can be **based on the MTU**
   d. **Fragmentation**: Routers may **split IPv4 packets** if moving them to a medium with a smaller MTU but this may cause **latency**.
      i. *IPv6 packets cannot be fragmented*

Limitations of IPv4

1. IPv4 address depletion - increasing of new IP-enabled devices, always-on connections, and the potential growth of less-developed regions have increased the need for more addresses
2. Lack of end-to-end connectivity - NAT allows multiple devices to share a single public IPv4 address but hides internal addresses, complicating end-to-end connectivity.
3. Increased network complexity - NAT, while extending IPv4's lifespan, adds complexity, latency, and troubleshooting difficulties.