COMPUTER NETWORK CS-602 UNIT -04 DETAILED NOTES WITH EASY EXPLAINATION

TOPIC 1:- Network Layer

NEED, SERVICES PROVIDED AND DESIGN ISSUES

COMPLETE 14-MARK RGPV ANSWER (4–5 PAGES)

Introduction

OSI Model me **Network Layer** third layer hoti hai.

```
Application
Presentation
Session
Transport
----------------
Network Layer
----------------
Data Link
Physical
```

Network Layer ka main kaam source se destination tak data ko pahunchana hai.

Agar sender aur receiver alag-alag networks me ho to Data Link Layer kaafi nahi hoti.

Network Layer routing aur logical addressing provide karti hai.

What is Network Layer?

DEFINITION

Network Layer is the third layer of the OSI model responsible for routing, forwarding and logical addressing of packets across interconnected networks.

SIMPLE DEFINITION

Network Layer decide karti hai:

```
Data Kahan Jana Hai?

Kaunsa Route Lena Hai?

Destination Tak Kaise Pahuchna Hai?
```

Why Network Layer Needed?

Suppose:

```
Computer A
Delhi

↓

Computer B
Mumbai
```

Data ko destination tak pahunchne ke liye multiple routers cross karne pad sakte hain.

Without Network Layer:

```
No Route
No Address
No Delivery
```

With Network Layer:

```
Source
 ↓
Router
 ↓
Router
 ↓
Destination
```

Functions of Network Layer

1. LOGICAL ADDRESSING

IP Address provide karna.

---

2. ROUTING

Best path select karna.

---

3. PACKET FORWARDING

Packet ko next router tak bhejna.

---

4. FRAGMENTATION

Large packet ko chote packets me divide karna.

---

5. INTERNETWORKING

Different networks ko connect karna.

Network Layer Communication

```
Sender
   ↓
Network Layer
   ↓
Router
   ↓
Router
   ↓
Receiver
```

Need of Network Layer

⭐⭐⭐⭐⭐ Important

---

1. Communication Between Different Networks

Data Link Layer sirf local communication provide karti hai.

Network Layer:

```
LAN
 ↓
WAN
 ↓
Internet
```

communication possible banati hai.

---

2. Routing

Best route choose karti hai.

EXAMPLE

```
Delhi
 ↓
Mumbai
 ↓
Chennai
```

Shortest path choose kiya jayega.

---

3. Logical Addressing

Har device ko IP Address assign karti hai.

EXAMPLE

```
192.168.1.10
```

---

4. Congestion Handling

Traffic control karti hai.

---

5. Reliable Delivery

Destination tak packet pahunchati hai.

Services Provided by Network Layer

Network Layer upper layers ko services provide karti hai.

---

1. Connectionless Service

⭐⭐⭐⭐ Important

Definition

Data packets independently travel karte hain.

Connection establish nahi hota.

EXAMPLE

Internet Protocol (IP)

DIAGRAM

```
Packet 1
 ↓
Route A

Packet 2
 ↓
Route B
```

Characteristics

✔ Fast

✔ Flexible

✔ No Setup Required

---

2. Connection-Oriented Service

Definition

Communication se pehle connection establish hota hai.

DIAGRAM

```
Connection Setup
      ↓
Data Transfer
      ↓
Connection Release
```

EXAMPLE

Virtual Circuit Networks

Characteristics

✔ Reliable

✔ Ordered Delivery

✔ Error Recovery

Connectionless vs Connection-Oriented

Feature	**Connectionless**	**Connection-Oriented**
Connection Setup	No	Yes
Reliability	Low	High
Speed	Fast	Slower
Example	IP	Virtual Circuit

Design Issues of Network Layer

⭐⭐⭐⭐⭐ Very Important

Network Layer design karte waqt kuch important issues consider kiye jate hain.

---

1. Routing

Most Important Function

OBJECTIVE

Best path choose karna.

EXAMPLE

```
A
|
├ B
|
└ C

Destination D
```

Shortest route select karna.

---

2. Congestion Control

DEFINITION

Network traffic control karna.

EXAMPLE

```
Many Packets
      ↓
Congestion
      ↓
Slow Network
```

SOLUTION

Traffic management.

---

3. Addressing

Logical addresses assign karna.

Example:

```
IPv4

192.168.1.10
```

---

4. Quality of Service (QoS)

Different applications different requirements rakhti hain.

EXAMPLE

Video Call

```
Low Delay Required
```

EXAMPLE

Email

```
Delay Acceptable
```

---

5. Internetworking

Different networks connect karna.

EXAMPLE

```
LAN
 ↓
Internet
 ↓
WAN
```

---

6. Packet Fragmentation

Large packet ko small packets me divide karna.

EXAMPLE

```
Large Packet

↓

Packet 1
Packet 2
Packet 3
```

Network Layer Protocols

Important protocols:

IP

Internet Protocol

ICMP

Internet Control Message Protocol

IGMP

Internet Group Management Protocol

ARP

Address Resolution Protocol

Real-Life Example

Suppose tum courier bhejte ho.

ADDRESS

```
IP Address
```

ROUTE

```
Routing
```

DELIVERY

```
Packet Forwarding
```

TRAFFIC

```
Congestion Control
```

Exactly Network Layer bhi yehi kaam karti hai.

Complete Network Layer Flowchart

```
Application Data
        ↓
Network Layer
        ↓
Assign IP Address
```

```
        ↓
Select Route
        ↓
Packet Forwarding
        ↓
Destination
```

Advantages of Network Layer

✔ Logical Addressing

✔ Routing Support

✔ Inter-Network Communication

✔ Congestion Management

✔ Scalability

Disadvantages

✘ Complex Routing Algorithms

✘ Processing Overhead

✘ Congestion Possibility

One Minute Revision

```
Network Layer

↓

3rd Layer

Functions

↓

Routing

Forwarding

IP Addressing

Fragmentation

Congestion Control
```

```
Services

↓

Connectionless

Connection-Oriented

Design Issues

↓

Routing

QoS

Addressing

Congestion Control

Internetworking

Most Important

↓

Routing
IP Addressing
```

RGPV Examiner Keywords

```
Network Layer
Routing
Packet Forwarding
Logical Addressing
IP Address
Fragmentation
Congestion Control
QoS
Internetworking
Connectionless Service
Connection-Oriented Service
```

Most Expected Questions

7 MARKS

1. Define Network Layer.
2. Explain functions of Network Layer.
3. Explain services provided by Network Layer.

---

14 MARKS

1. Explain Network Layer with neat diagram.
2. Explain services provided by Network Layer.
3. Explain design issues of Network Layer.
4. Explain need and functions of Network Layer.

PYQ PROBABILITY: ★★★★★

🔥 **Network Layer Need + Services + Design Issues** direct 14-mark question ban sakta hai aur routing chapter ka foundation hai.

TOPIC:-2 Routing Algorithms

LEAST COST ROUTING, DIJKSTRA'S ALGORITHM AND BELLMAN-FORD ALGORITHM

COMPLETE 14-MARK RGPV ANSWER (5–6 PAGES)

Introduction

Network Layer ka sabse important function hai:

```
Routing
```

Jab data source se destination tak travel karta hai to uske paas kai possible routes ho sakte hain.

Example:

```
A
| \
|  \
B   C
|   |
D---E
```

A se E tak jaane ke liye multiple paths available hain.

Network Layer ko decide karna hota hai:

```
Sabse Best Route Kaunsa Hai?
```

Isi process ko **Routing** kehte hain.

What is Routing?

DEFINITION

Routing is the process of selecting the best path for data transmission from source to destination.

SIMPLE DEFINITION

Data ko destination tak pahunchane ke liye best route choose karna Routing kehlata hai.

What is Routing Algorithm?

DEFINITION

A Routing Algorithm is a method used by routers to determine the optimal path for forwarding packets.

OBJECTIVES OF ROUTING ALGORITHMS

✔ Shortest Path

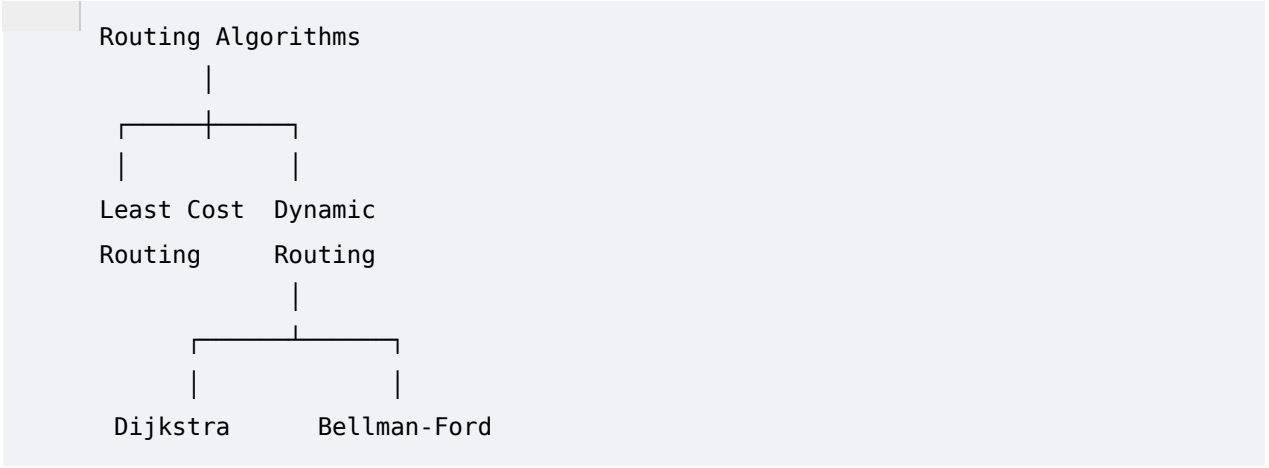
✔ Minimum Cost

✔ Minimum Delay

✔ Maximum Throughput

✔ Reliable Delivery

Types of Routing Algorithms



Least Cost Routing Algorithm

⭐⭐⭐⭐ Important

Definition

Least Cost Routing selects the route having the minimum total cost between source and destination.

Cost May Represent

DISTANCE

DELAY

BANDWIDTH USAGE

TRAFFIC

HOP COUNT

Example

```
A ----2---- B

A ----5---- C

B ----1---- D

C ----3---- D
```

Find Route A → D

ROUTE 1

```
A → B → D

Cost = 2 + 1

= 3
```

ROUTE 2

```
A → C → D

Cost = 5 + 3

= 8
```

BEST ROUTE

```
A → B → D

Cost = 3
```

Advantages

✔ Simple

✔ Efficient

✔ Better Performance

Dijkstra's Algorithm

⭐⭐⭐⭐⭐ Most Important

Definition

Dijkstra's Algorithm is a shortest path routing algorithm that finds the minimum-cost path from a source node to all other nodes in a network.

Developed By

```
Edsger Dijkstra
```

Principle

At every step:

```
Choose Nearest Node
```

Example Network

```
      2
  A-----B
  |     |
4 |     | 1
  |     |
  C-----D
      3
```

Find shortest path from A.

Step 1

Source Node:

```
A = 0
```

Others:

```
B = ∞

C = ∞

D = ∞
```

Step 2

Visit A

```
A → B = 2

A → C = 4
```

Table:

Node	**Cost**
A	0
B	2
C	4
D	∞

Step 3

Choose smallest value

```
B = 2
```

Visit B

Update:

```
B → D = 1

Total Cost

= 2 + 1

= 3
```

Table:

Node	Cost
A	0
B	2
C	4
D	3

Step 4

Choose next smallest

```
D = 3
```

Final Result

Node	Shortest Distance
A	0
B	2
C	4
D	3

Dijkstra Flowchart

```
Start
  ↓
Choose Source
  ↓
Assign Costs
  ↓
```

```
Select Minimum Cost Node
  ↓
Update Neighbors
  ↓
All Nodes Visited?
  ↓
Stop
```

Advantages

✔ Fast

✔ Accurate

✔ Widely Used

✔ Best for Link-State Routing

Disadvantages

✘ Complex for Large Networks

✘ Requires Complete Network Information

Applications

- OSPF Routing Protocol
- GPS Navigation
- Network Routing

Bellman-Ford Algorithm

⭐⭐⭐⭐⭐ Most Important

Definition

Bellman-Ford Algorithm is a routing algorithm that calculates shortest paths using distance vectors and can handle changing network conditions.

Principle

Each router maintains:

```
Distance Vector Table
```

and exchanges information with neighbors.

Formula

```
D(x)

=

Minimum

[C(x,v) + D(v)]
```

Where:

```
C(x,v)

=

Cost from x to v
```

Working

STEP 1

Every router knows distance to neighbors.

STEP 2

Exchange routing tables.

STEP 3

Update shortest path.

STEP 4

Repeat until stable.

Example

```
A --1-- B --2-- C
```

Initially:

Router	Distance
A	0
B	1

C	∞

After Update:

```
A → B → C

Cost

=

1 + 2

=

3
```

Bellman-Ford Diagram

```
Router A
   |
Distance Table
   |
Exchange
   |
Router B
```

Advantages

✔ Distributed Algorithm

✔ Dynamic Updates

✔ Simple Implementation

Disadvantages

✘ Slow Convergence

✘ Count-to-Infinity Problem

✘ More Overhead

Dijkstra vs Bellman-Ford

⭐⭐⭐⭐⭐ Most Important Comparison

Feature	Dijkstra	Bellman-Ford
Type	Link State	Distance Vector
Information	Complete Network	Neighbor Information
Speed	Fast	Slow
Complexity	High	Low
Convergence	Faster	Slower
Used In	OSPF	RIP
Routing Table Exchange	No	Yes

Real-Life Example

Suppose tum Gwalior se Bhopal jana chahte ho.

DIJKSTRA

Google Maps poore road network ko dekhkar shortest route choose karega.

BELLMAN-FORD

Har city apne neighboring city se poochkar route decide karegi.

Memory Trick

DIJKSTRA

```
D = Direct Knowledge
```

Complete Network Information

BELLMAN-FORD

```
B = By Neighbors
```

Neighbor Information

One Minute Revision

```
Routing
↓
Best Path Selection

Least Cost Routing
↓
Minimum Cost Route

Dijkstra
↓
Shortest Path

Link State

Fast

OSPF

----------------

Bellman-Ford
↓
Distance Vector

Neighbor Based

Slow

RIP

Most Important
↓
Dijkstra vs Bellman-Ford
```

RGPV Examiner Keywords

```
Routing Algorithm
Shortest Path
Least Cost Routing
Dijkstra Algorithm
Bellman-Ford Algorithm
Link State Routing
Distance Vector Routing
```

```
Cost Metric
Routing Table
Distance Vector
OSPF
RIP
```

Most Expected Questions

7 MARKS

1. Define Routing Algorithm.
2. Explain Least Cost Routing.
3. Explain Dijkstra Algorithm.
4. Explain Bellman-Ford Algorithm.

---

14 MARKS

1. Explain Dijkstra Algorithm with example.
2. Explain Bellman-Ford Algorithm with example.
3. Compare Dijkstra and Bellman-Ford.
4. Explain Least Cost Routing Algorithm.

PYQ PROBABILITY: ★★★★★

🔥 **Dijkstra Algorithm**, **Bellman-Ford Algorithm**, and **their comparison** are among the most frequently asked 14-mark questions in RGPV Unit-4.

TOPIC 3:- Hierarchical Routing, Broadcast Routing and Multicast Routing

COMPLETE 14-MARK RGPV ANSWER (4–5 PAGES)

Introduction

Pichle chapter me humne routing algorithms (Dijkstra, Bellman-Ford) padhe.

Ab question aata hai:

```
Data Kisko Bhejna Hai?
```

Network me data transmission 3 tarah se ho sakta hai:

```
Routing Types
      |
  ┌───┼───┐
```

```
 |    |    |
Hierarchical
Broadcast
Multicast
```

Ye teeno Network Layer ke important routing techniques hain.

---

1. Hierarchical Routing

⭐⭐⭐⭐ Important

Problem with Large Networks

Suppose Internet me lakho routers hain.

```
Router1
Router2
Router3
...
Router100000
```

Agar har router sab routers ki information store kare:

❌ Huge Routing Table

❌ High Memory Usage

❌ Slow Routing

Solution

Hierarchical Routing

Definition

Hierarchical Routing is a routing technique in which routers are divided into regions or groups to reduce routing table size and improve efficiency.

Simple Definition

Pure network ko chote-chote groups me divide kar diya jata hai.

Diagram

```
Network

          Internet
```

```
                |

        ----------------------
        |          |          |

    Region 1   Region 2   Region 3

        |          |          |

    R1 R2 R3   R4 R5 R6   R7 R8 R9
```

Working

STEP 1

Network ko regions me divide karo.

STEP 2

Har router apne region ki detail rakhega.

STEP 3

Dusre regions ke liye sirf summary information rakhega.

Example

Suppose:

```
Region A

A1
A2
A3

Region B

B1
B2
B3
```

A1 ko B2 tak packet bhejna hai.

A1 ko sirf itna pata hoga:

```
Go to Region B
```

Region B ke andar ka route B routers handle karenge.

Advantages

✔ Small Routing Tables

✔ Better Scalability

✔ Faster Routing

✔ Less Memory Required

Disadvantages

✘ Route Sometimes Longer

✘ Complex Design

Applications

- Internet Routing
- Large WAN Networks
- ISP Networks

Broadcast Routing

⭐⭐⭐⭐⭐ Most Important

Definition

Broadcast Routing is a routing technique in which a packet is sent from one source to all nodes in the network.

Simple Definition

Ek sender data network ke sabhi devices ko bhejta hai.

Diagram

```
        Source
          |

   ------------------

   |    |    |    |

   A    B    C    D
```

Example

```
School Notice

↓

All Students
```

Need of Broadcast Routing

Used when:

✔ Network Announcement

✔ Routing Updates

✔ ARP Request

✔ Emergency Messages

Methods of Broadcast Routing

---

1. Unicast Broadcasting

Sender individually sabko message bhejta hai.

EXAMPLE

```
A → B

A → C

A → D
```

PROBLEM

Bandwidth Waste

---

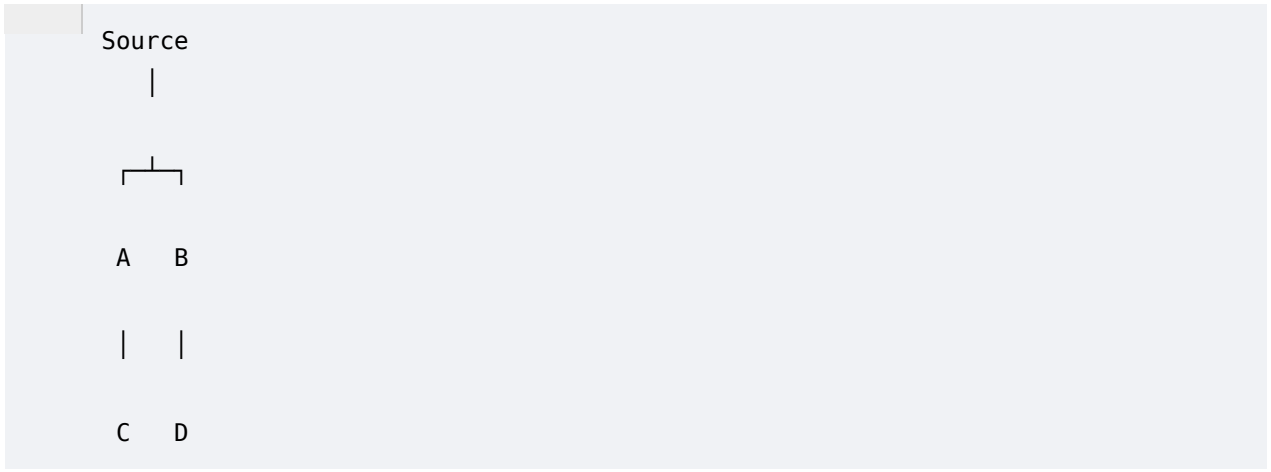
2. Flooding

Most Important

Definition

Every router packet ko apne sab neighbors ko forward karta hai.

Diagram



Working

Source packet bhejta hai.

Har router packet ko sab directions me forward karta hai.

Advantage

✔ Guaranteed Delivery

Disadvantage

✘ Duplicate Packets

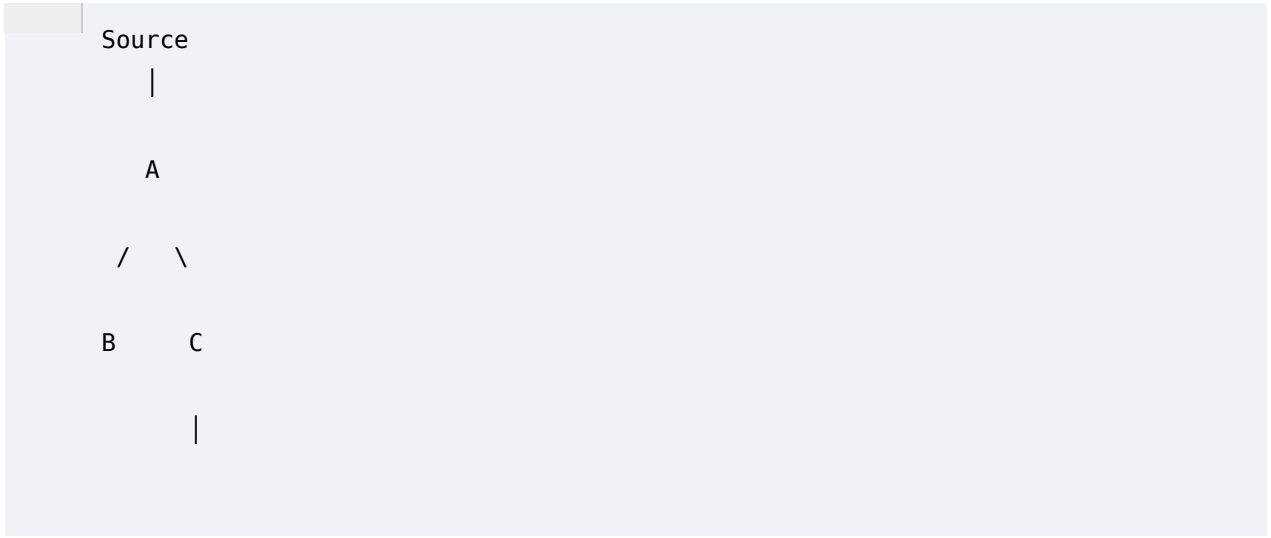
✘ Congestion

---

3. Spanning Tree Broadcast

Network me spanning tree create ki jati hai.

Diagram



```
        D
```

Packet sirf tree branches me travel karega.

Advantage

✔ No Duplicate Packet

✔ Efficient

Applications of Broadcast Routing

- ARP Requests
- DHCP
- Routing Updates
- Emergency Alerts

Multicast Routing

⭐⭐⭐⭐⭐ Very Important

Definition

Multicast Routing is a routing technique in which packets are delivered only to a selected group of receivers.

Simple Definition

Data sirf interested users ko bheja jata hai.

Diagram

```
Source
   |

----------------

|      |      |

A      B      C

       |
```

```
        D
```

Suppose:

Only B and D want data.

Transmission:

```
Source

↓

B

↓

D
```

Example

Live IPL Streaming

Sab internet users ko stream nahi bheji jati.

Sirf viewers ko bheji jati hai.

Working

STEP 1

Multicast Group Create

STEP 2

Interested Users Join Group

STEP 3

Sender Group Address par Data bhejta hai.

STEP 4

Only Group Members Data Receive karte hain.

Multicast Tree

```
Source

   |
```

```
      A

     / \

    B   C

        |

        D
```

Group Members:

```
    B

    D
```

Advantages

✔ Bandwidth Saving

✔ Efficient Delivery

✔ Less Network Traffic

✔ Better Performance

Disadvantages

✘ Complex Management

✘ Group Maintenance Required

Applications

- Video Conferencing
- Online Classes
- IPTV
- Live Streaming
- Stock Market Feeds

Broadcast vs Multicast

⭐⭐⭐⭐⭐ RGPV Favorite

Feature	**Broadcast**	**Multicast**

Delivery	All Devices	Selected Group
Traffic	High	Low
Bandwidth Usage	More	Less
Efficiency	Lower	Higher
Example	ARP	Live Streaming

Hierarchical vs Broadcast vs Multicast

Feature	**Hierarchical**	**Broadcast**	**Multicast**
Purpose	Routing Efficiency	Send to All	Send to Group
Routing Table	Reduced	Normal	Group Based
Traffic	Medium	High	Low
Scalability	High	Low	High

Real-Life Example

HIERARCHICAL ROUTING

```
India

↓

States

↓

Cities

↓
```

```
Areas
```

BROADCAST ROUTING

```
Principal Announcement

↓

Entire College
```

MULTICAST ROUTING

```
Only CSE Students

↓

Placement Notice
```

One Minute Revision

```
Hierarchical Routing
↓

Network Divided Into Regions

Advantages
↓

Small Routing Table

----------------

Broadcast Routing
↓

One To All

Methods
↓

Flooding

Spanning Tree
```

```
----------------

Multicast Routing
↓

One To Many

Selected Group

Applications
↓

Video Streaming
Online Classes

Most Important
↓

Broadcast vs Multicast
```

RGPV Examiner Keywords

```
Hierarchical Routing
Regions
Routing Table
Broadcast Routing
Flooding
Spanning Tree
Multicast Routing
Multicast Group
Bandwidth Saving
Network Efficiency
One-to-All
One-to-Many
```

Most Expected Questions

7 MARKS

1. Explain Hierarchical Routing.
2. Explain Broadcast Routing.
3. Explain Multicast Routing.
4. Differentiate Broadcast and Multicast.

---

14 MARKS

1. Explain Hierarchical Routing with diagram.
2. Explain Broadcast Routing and its methods.
3. Explain Multicast Routing with diagram.
4. Compare Broadcast Routing and Multicast Routing.

PYQ PROBABILITY: ★★★★☆

🔥 **Broadcast Routing, Flooding, Multicast Routing and Broadcast vs Multicast** bahut frequently exams me pooche jaate hain.

TOPIC 4:- IP Addressing

IP ADDRESS, CLASSES OF IP ADDRESS, NETWORK ID, HOST ID AND SUBNET MASK

COMPLETE 14-MARK RGPV ANSWER (5–6 PAGES)

Introduction

Network Layer ka sabse important function hai:

```
Logical Addressing
```

Har device ko network me identify karne ke liye ek unique address diya jata hai jise **IP Address** kehte hain.

Jaise:

```
Har ghar ka address hota hai

Waise hi

Har computer ka IP Address hota hai
```

What is IP Address?

DEFINITION

IP Address (Internet Protocol Address) is a unique logical address assigned to a device connected to a network.

SIMPLE DEFINITION

IP Address ek unique number hota hai jo network me kisi device ki identity batata hai.

Example

```
192.168.1.10
```

Why IP Address Needed?

Suppose:

```
Computer A

Computer B

Computer C
```

A ko B ko data bhejna hai.

Bina address ke possible nahi hoga.

IP Address Format

IPv4 Address:

```
192.168.1.10
```

---

32 Bits

```
11000000.10101000
00000001.00001010
```

Structure of IP Address

IP Address do parts me divide hota hai:

```
IP Address

     |

  ┌──┴──┐

Network  Host
ID       ID
```

Network ID

Network ko identify karta hai.

Host ID

Network ke andar device ko identify karta hai.

Example

```
192.168.1.10
```

Network:

```
192.168.1
```

Host:

```
10
```

Classes of IP Address

⭐⭐⭐⭐⭐ Most Important

IPv4 me total 5 classes hoti hain.

```
Class A

Class B

Class C

Class D

Class E
```

Class A

Range

```
1.0.0.0

to

126.255.255.255
```

First Bit

```
0
```

Format

```
N . H . H . H
```

Network:

```
8 Bits
```

Host:

```
24 Bits
```

Example

```
10.20.30.40
```

Diagram

```
| Network | Host | Host | Host |
```

Class B

Range

```
128.0.0.0

to

191.255.255.255
```

First Bits

```
10
```

Format

```
N . N . H . H
```

Network:

```
16 Bits
```

Host:

```
16 Bits
```

Example

```
172.16.10.5
```

Class C

⭐⭐⭐⭐⭐ Most Important

Range

```
192.0.0.0

to

223.255.255.255
```

First Bits

```
110
```

Format

```
N . N . N . H
```

Network:

```
24 Bits
```

Host:

```
8 Bits
```

Example

```
192.168.1.100
```

Class D

Range

```
224.0.0.0

to

239.255.255.255
```

Use

```
Multicasting
```

Class E

Range

```
240.0.0.0

to

255.255.255.255
```

Use

```
Research
Experimental
```

IP Class Summary Table

Class	**Range**	**Purpose**
A	1–126	Large Networks
B	128–191	Medium Networks
C	192–223	Small Networks

D	224–239	Multicast
E	240–255	Research

Network ID

⭐⭐⭐⭐ Important

Definition

Network ID network ko identify karta hai.

Example

```
192.168.1.10
```

Network ID:

```
192.168.1.0
```

Purpose

Same network ke devices identify karna.

Host ID

⭐⭐⭐⭐ Important

Definition

Host ID network ke andar specific device ko identify karta hai.

Example

```
192.168.1.10
```

Host ID:

```
10
```

Network ID vs Host ID

Network ID	Host ID
Network Identify	Device Identify
Common for Devices	Unique for Device
Routing Purpose	Communication Purpose

Subnet Mask

⭐⭐⭐⭐⭐ Most Important

Definition

Subnet Mask is a 32-bit number used to separate Network ID and Host ID.

Example

```
IP Address

192.168.1.10

Subnet Mask

255.255.255.0
```

Binary Form

```
11111111.11111111
11111111.00000000
```

Working

```
1 → Network Part

0 → Host Part
```

Example

```
IP
```

```
192.168.1.10

Mask

255.255.255.0
```

Result:

```
Network

192.168.1.0
```

Common Subnet Masks

Subnet Mask	CIDR
255.0.0.0	/8
255.255.0.0	/16
255.255.255.0	/24

Classful Addressing Diagram

```
Class A

N H H H

------------

Class B

N N H H

------------

Class C

N N N H
```

Advantages of IP Addressing

✔ Unique Identification

✔ Routing Support

✔ Network Communication

✔ Scalability

✔ Global Connectivity

Disadvantages

✘ IPv4 Address Exhaustion

✘ Configuration Complexity

✘ Security Issues

Real-Life Example

Suppose:

```
City = Network ID

House Number = Host ID
```

Example:

```
Gwalior = Network

House No. 10 = Host
```

Exactly same concept.

Memory Trick

CLASSES

```
A B C D E

Large
Medium
Small
Multicast
Experimental
```

RANGE TRICK

```
A = 1-126

B = 128-191

C = 192-223

D = 224-239

E = 240-255
```

One Minute Revision

```
IP Address
↓

Logical Address

32 Bits

------------

Parts

↓

Network ID

Host ID

------------

Classes

↓

A
B
C
D
E

------------
```

```
Subnet Mask

↓

255.255.255.0

------------

Most Important

↓

Class C

Subnet Mask

Network ID
```

RGPV Examiner Keywords

```
IP Address
IPv4
Logical Address
Network ID
Host ID
Subnet Mask
Class A
Class B
Class C
Class D
Class E
CIDR
Addressing
Routing
```

Most Expected Questions

7 MARKS

1. Define IP Address.
2. Explain Classes of IP Address.
3. Explain Network ID and Host ID.
4. Explain Subnet Mask.

---

14 MARKS

1. Explain IP Addressing with classes.
2. Explain Class A, B, C, D and E addresses.
3. Explain Network ID and Host ID with examples.
4. Explain Subnet Mask with working.

PYQ PROBABILITY: ★★★★★

🔥 **IP Addressing, Classes of IP Address, Subnet Mask, Network ID and Host ID** are among the most repeated and highest-scoring topics in Unit-4.

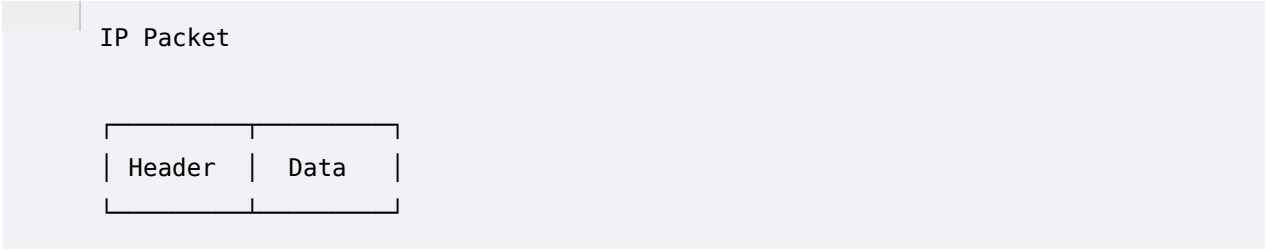
TOPIC:- 5 IPv4 Header Format, Packet Forwarding, Fragmentation and Reassembly

COMPLETE 14-MARK RGPV ANSWER (5–6 PAGES)

Introduction

Network Layer me data ko **Packet** ke form me transmit kiya jata hai.

Har packet ke saath kuch control information bhi bheji jati hai jise **Header** kehte hain.



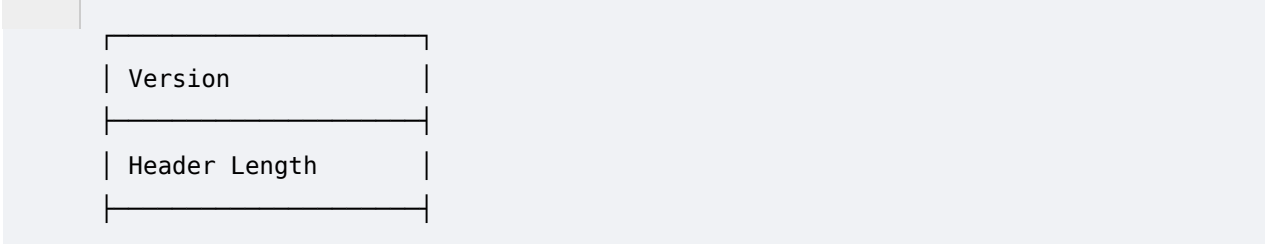
IPv4 packet structure, forwarding aur fragmentation Network Layer ke sabse important topics hain.

IPv4 Packet Format

DEFINITION

IPv4 Packet consists of Header and Data. Header contains control information required for routing and delivery.

IPv4 Packet Structure



```
| Type of Service     |
├─────────────────────┤
| Total Length        |
├─────────────────────┤
| Identification      |
├─────────────────────┤
| Flags               |
├─────────────────────┤
| Fragment Offset     |
├─────────────────────┤
| TTL                 |
├─────────────────────┤
| Protocol            |
├─────────────────────┤
| Header Checksum     |
├─────────────────────┤
| Source IP Address   |
├─────────────────────┤
| Destination IP Addr |
├─────────────────────┤
| Options             |
├─────────────────────┤
| Data                |
└─────────────────────┘
```

Important Header Fields

⭐⭐⭐⭐⭐ Very Important

---

1. VERSION

IP version batata hai.

Example:

```
IPv4 = 4
```

---

2. HEADER LENGTH

Header ka size batata hai.

Minimum:

```
20 Bytes
```

---

3. TOTAL LENGTH

Pure packet ka size.

```
Header + Data
```

---

4. TTL (TIME TO LIVE)

⭐⭐⭐⭐⭐ Important

Packet network me kitni der tak survive karega.

PURPOSE

Infinite looping prevent karna.

EXAMPLE

```
TTL = 64
```

Har router par:

```
TTL = TTL - 1
```

TTL = 0

↓

Packet discard

---

5. PROTOCOL FIELD

Upper layer protocol identify karta hai.

Example:

```
TCP = 6

UDP = 17

ICMP = 1
```

---

6. SOURCE ADDRESS

Sender ka IP Address.

---

7. DESTINATION ADDRESS

Receiver ka IP Address.

Packet Forwarding

⭐⭐⭐⭐ Important

Definition

Packet Forwarding is the process of moving packets from one router to another until they reach the destination.

Working

STEP 1

Packet router par arrive karta hai.

STEP 2

Router destination IP check karta hai.

STEP 3

Routing table lookup karta hai.

STEP 4

Best route select karta hai.

STEP 5

Packet next router ko forward kar deta hai.

Diagram

```
Source
   |
Router 1
   |
Router 2
   |
Router 3
   |
Destination
```

Example

```
Gwalior
 ↓
Bhopal
 ↓
Indore
 ↓
Mumbai
```

Har city ek router ki tarah kaam kar rahi hai.

Packet Forwarding Flowchart

```
Receive Packet
       ↓
Check Destination
       ↓
Routing Table Lookup
       ↓
Select Route
       ↓
Forward Packet
```

Fragmentation

⭐⭐⭐⭐⭐ Most Important

Why Fragmentation Needed?

Har network ka MTU (Maximum Transmission Unit) different hota hai.

Example:

```
Network A

MTU = 1500 Bytes

Network B

MTU = 500 Bytes
```

Agar packet:

```
1200 Bytes
```

ka hai to Network B me direct nahi ja sakta.

Solution

Fragmentation

Definition

Fragmentation is the process of dividing a large IP packet into smaller packets called fragments.

Diagram

Types of Fragmentation

---

1. TRANSPARENT FRAGMENTATION

Fragmentation aur reassembly same network ke andar hoti hai.

---

2. NON-TRANSPARENT FRAGMENTATION

Fragments destination tak travel karte hain.

Internet me mostly ye use hoti hai.

Fragmentation Fields

IDENTIFICATION

Same packet ke fragments identify karta hai.

FLAGS

Fragmentation control.

MORE FRAGMENT (MF)

```
1 = More Fragments
```

```
0 = Last Fragment
```

FRAGMENT OFFSET

Fragment ki position batata hai.

Example

Suppose:

```
Data = 2400 Bytes

MTU = 1000 Bytes
```

Fragments:

```
Fragment 1 = 1000

Fragment 2 = 1000

Fragment 3 = 400
```

Advantages of Fragmentation

✔ Supports Different Networks

✔ Efficient Transmission

✔ MTU Compatibility

Disadvantages

✘ Overhead Increase

✘ More Processing

✘ Delay Increase

Reassembly

⭐⭐⭐⭐⭐ Important

Definition

Reassembly is the process of combining fragments back into the original packet at the destination.

Working

STEP 1

Fragments receive hote hain.

STEP 2

Identification field check hoti hai.

STEP 3

Fragment Offset check hota hai.

STEP 4

Original packet reconstruct hota hai.

Diagram

```
Fragment 1

Fragment 2

Fragment 3

      ↓

Reassembly

      ↓

Original Packet
```

Fragmentation vs Reassembly

Fragmentation	**Reassembly**
Packet Divide	Packet Combine
Router Side	Destination Side
Smaller Packets	Original Packet
Before Transmission	After Reception

Real-Life Example

Suppose tum 300-page book courier karna chahte ho.

FRAGMENTATION

Book ko 3 packets me divide kar diya.

```
Part 1

Part 2

Part 3
```

REASSEMBLY

Receiver teeno parts combine kar deta hai.

```
Complete Book
```

Complete Network Flow

```
Data
 ↓
IPv4 Header Added
 ↓
Packet Created
 ↓
Router
 ↓
Fragmentation
 ↓
Transmission
 ↓
Destination
 ↓
Reassembly
 ↓
Original Data
```

One Minute Revision

```
IPv4 Packet
↓

Header + Data
```

```
Important Fields
↓

Version

TTL

Protocol

Source IP

Destination IP

----------------

Packet Forwarding
↓

Routing Table

Next Hop

----------------

Fragmentation
↓

Large Packet

↓

Small Fragments

----------------

Reassembly
↓

Combine Fragments

Most Important
↓

TTL
```

```
Fragmentation

IPv4 Header
```

RGPV Examiner Keywords

```
IPv4 Packet
IPv4 Header
TTL
Protocol Field
Packet Forwarding
Routing Table
Fragmentation
MTU
Identification
Flags
Fragment Offset
Reassembly
Source Address
Destination Address
```

Most Expected Questions

7 MARKS

1. Explain IPv4 Header.
2. Explain Packet Forwarding.
3. Explain Fragmentation.
4. Explain Reassembly.

---

14 MARKS

1. Explain IPv4 Header Format with neat diagram.
2. Explain Packet Forwarding process.
3. Explain Fragmentation and Reassembly with diagram.
4. Explain IPv4 packet structure.

PYQ PROBABILITY: ★★★★★

🔥 **IPv4 Header Format** and **Fragmentation & Reassembly** are among the most repeated 14-mark questions in RGPV Computer Networks.

TOPIC 6:- ICMP (Internet Control Message Protocol)

NEED, WORKING, MESSAGE TYPES AND APPLICATIONS

COMPLETE 14-MARK RGPV ANSWER (4–5 PAGES)

Introduction

Internet Protocol (IP) ek **connectionless protocol** hai.

IP sirf packets deliver karne ki koshish karta hai, lekin ye nahi batata:

- Packet destination tak pahucha ya nahi
- Route available hai ya nahi
- Network congested hai ya nahi

Isi problem ko solve karne ke liye **ICMP (Internet Control Message Protocol)** use kiya jata hai.

What is ICMP?

DEFINITION

ICMP (Internet Control Message Protocol) is a Network Layer protocol used for error reporting and diagnostic functions in IP networks.

SIMPLE DEFINITION

ICMP network me errors aur status information communicate karne ke liye use hota hai.

Why ICMP Needed?

Suppose:

```
Computer A
     ↓
Router
     ↓
Destination Not Found
```

IP packet deliver nahi ho paya.

Ab sender ko kaise pata chalega?

SOLUTION

ICMP Message

```
Router
   ↓
ICMP Error Message
   ↓
Sender
```

Functions of ICMP

1. ERROR REPORTING

Network errors report karta hai.

---

2. NETWORK DIAGNOSTICS

Network testing me help karta hai.

---

3. ROUTE INFORMATION

Route related information provide karta hai.

---

4. CONGESTION REPORTING

Traffic problems batata hai.

Position of ICMP

```
Application Layer

Transport Layer

Network Layer
   |
  ┌─┴─┐
  |IP |
  |ICMP|
  └─┬─┘

Data Link Layer

Physical Layer
```

ICMP Packet Format

```
+----------------+
| Type           |
+----------------+
| Code           |
```

```
+----------------+
| Checksum       |
+----------------+
| Data           |
+----------------+
```

Fields of ICMP Packet

TYPE

Message ka type batata hai.

CODE

Type ke andar specific reason batata hai.

CHECKSUM

Error detection ke liye.

DATA

Additional information.

Working of ICMP

STEP 1

Sender packet bhejta hai.

STEP 2

Router ya destination packet process karta hai.

STEP 3

Agar problem aaye:

ICMP message generate hota hai.

STEP 4

ICMP sender ko error report karta hai.

Flowchart

```
Send Packet
     ↓
Destination Reach?
   /      \
 Yes      No
  ↓        ↓
Success   Generate ICMP
```

```
                ↓
          Send Error
```

ICMP Message Types

⭐⭐⭐⭐⭐ Most Important

ICMP messages do categories me divide hote hain:

```
ICMP Messages
      |
  ┌───┴────┐
  |        |
Error   Query
Messages Messages
```

---

1. Error Reporting Messages

Network errors batate hain.

DESTINATION UNREACHABLE

MEANING

Destination tak packet nahi pahunch saka.

EXAMPLE

```
Server Down

↓

Destination Unreachable
```

TIME EXCEEDED

⭐⭐⭐⭐ Important

Packet ka TTL zero ho gaya.

EXAMPLE

```
TTL = 0

↓

Packet Discard
```

REDIRECT MESSAGE

Router better route suggest karta hai.

EXAMPLE

```
Current Route
      ↓
Not Best Route
      ↓
Redirect
```

SOURCE QUENCH

(Network Congestion Message)

MEANING

Traffic kam karne ko bolta hai.

---

2. Query Messages

Information obtain karne ke liye.

ECHO REQUEST

Ping command use karti hai.

ECHO REPLY

Ping ka response.

Ping Working

⭐⭐⭐⭐⭐ Most Important

What is Ping?

Ping network connectivity test karta hai.

Working

```
Computer A

Echo Request
      ↓

Computer B

Echo Reply
```

```
        ↓

    Computer A
```

Example

```
ping google.com
```

Result:

```
Reply Received
```

Network working.

Traceroute

⭐⭐⭐⭐ Important

Definition

Traceroute source se destination tak ka route find karta hai.

Working

TTL values use karta hai.

EXAMPLE

```
Computer
   ↓
Router 1
   ↓
Router 2
   ↓
Router 3
   ↓
Destination
```

Traceroute sab routers ki information show karta hai.

Common ICMP Message Types

Type	**Purpose**

Echo Request	Ping Request
Echo Reply	Ping Response
Destination Unreachable	Destination Error
Time Exceeded	TTL Expired
Redirect	Better Route
Source Quench	Congestion Control

Advantages of ICMP

✔ Error Reporting

✔ Network Monitoring

✔ Troubleshooting

✔ Connectivity Testing

✔ Route Discovery

Disadvantages of ICMP

✘ Security Risks

✘ Can Be Misused

✘ Additional Traffic

Real-Life Example

Suppose tum courier bhejte ho.

SUCCESSFUL DELIVERY

```
Courier Delivered
```

No issue.

ADDRESS WRONG

```
Address Not Found
```

Delivery company notification bhejegi.

Exactly:

```
ICMP Destination Unreachable
```

ROAD CLOSED

```
Alternative Route Suggested
```

Exactly:

```
ICMP Redirect Message
```

ICMP vs IP

ICMP	**IP**
Error Reporting	Data Delivery
Diagnostic Tool	Packet Transfer
Control Information	User Data
Supports IP	Main Protocol

One Minute Revision

```
ICMP
↓

Internet Control Message Protocol

Purpose
↓

Error Reporting

Diagnostics

----------------

Message Types

↓
```

```
Error Messages

Query Messages

----------------

Important Messages

↓

Destination Unreachable

Time Exceeded

Redirect

Echo Request

Echo Reply

----------------

Applications

↓

Ping

Traceroute

Most Important

↓

Ping

TTL

Destination Unreachable
```

RGPV Examiner Keywords

```
ICMP
Internet Control Message Protocol
```

```
Error Reporting
Diagnostics
Echo Request
Echo Reply
Ping
Traceroute
Destination Unreachable
TTL
Time Exceeded
Redirect Message
```

Most Expected Questions

7 MARKS

1. Define ICMP.
2. Explain ICMP message format.
3. Explain Ping.
4. Explain Traceroute.

---

14 MARKS

1. Explain ICMP with diagram.
2. Explain working of ICMP.
3. Explain ICMP message types.
4. Explain Ping and Traceroute using ICMP.

PYQ PROBABILITY: ★★★★☆

🔥 **ICMP**, **Ping**, **Traceroute**, **Destination Unreachable**, and **Time Exceeded** are frequently asked questions in RGPV Unit-4.

TOPIC 7:- Comparative Study of IPv4 and IPv6

FEATURES, ADDRESS FORMAT, HEADER FORMAT, ADVANTAGES AND COMPARISON

COMPLETE 14-MARK RGPV ANSWER (5–6 PAGES)

Introduction

Internet ke shuruaati dino me **IPv4 (Internet Protocol Version 4)** use kiya gaya tha.

Lekin Internet users ki sankhya bahut tezi se badhne lagi.

Result:

```
IPv4 Addresses

↓

Insufficient
```

IPv4 ke paas limited addresses the.

Is problem ko solve karne ke liye **IPv6 (Internet Protocol Version 6)** develop kiya gaya.

What is IPv4?

DEFINITION

IPv4 is the fourth version of Internet Protocol that uses 32-bit addresses for communication over networks.

EXAMPLE

```
192.168.1.10
```

What is IPv6?

DEFINITION

IPv6 is the sixth version of Internet Protocol that uses 128-bit addresses and provides a much larger address space than IPv4.

EXAMPLE

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

Need for IPv6

PROBLEMS WITH IPV4

✔ Limited Address Space

✔ Security Issues

✔ Complex Configuration

✔ No Built-in Security

SOLUTION

IPv6

Address Size Comparison

IPV4

```
32 Bits
```

Total Addresses:

```
2^32

=

4.3 Billion
```

IPV6

```
128 Bits
```

Total Addresses:

```
2^128
```

Approximately:

```
340 Undecillion Addresses
```

Practically Unlimited

IPv4 Address Format

```
192.168.1.10
```

STRUCTURE

```
8 Bit . 8 Bit . 8 Bit . 8 Bit
```

EXAMPLE

```
11000000.10101000.
00000001.00001010
```

IPv6 Address Format

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

STRUCTURE

```
16 Bit : 16 Bit : 16 Bit
```

HEXADECIMAL REPRESENTATION

Uses:

```
0-9

A-F
```

IPv4 Header Format

⭐⭐⭐⭐ Important

```
+----------------+
| Version        |
+----------------+
| Header Length  |
+----------------+
| TOS            |
+----------------+
| Total Length   |
+----------------+
| TTL            |
+----------------+
| Protocol       |
+----------------+
| Checksum       |
+----------------+
| Source Address |
+----------------+
| Destination    |
+----------------+
```

HEADER SIZE

```
20–60 Bytes
```

IPv6 Header Format

⭐⭐⭐⭐ Important

```
+----------------+
| Version        |
+----------------+
| Traffic Class  |
```

```
+----------------+
| Flow Label     |
+----------------+
| Payload Length |
+----------------+
| Next Header    |
+----------------+
| Hop Limit      |
+----------------+
| Source Address |
+----------------+
| Destination    |
+----------------+
```

HEADER SIZE

```
Fixed

40 Bytes
```

Key Features of IPv6

⭐⭐⭐⭐⭐ Most Important

---

1. Huge Address Space

```
128-bit Addressing
```

---

2. Built-in Security

Uses:

```
IPSec
```

---

3. Auto Configuration

Devices automatically IP obtain kar sakte hain.

---

4. Better Routing

Routing tables smaller ho jati hain.

---

5. No NAT Required

Direct end-to-end communication.

---

6. Better QoS

Real-time applications ke liye better support.

IPv4 vs IPv6

⭐⭐⭐⭐⭐ RGPV Favorite Question

Feature	**IPv4**	**IPv6**
Full Form	Internet Protocol Version 4	Internet Protocol Version 6
Address Size	32 Bit	128 Bit
Address Format	Decimal	Hexadecimal
Example	192.168.1.10	2001:db8::1
Address Space	4.3 Billion	Very Large
Header Size	Variable	Fixed
Security	Optional	Built-in IPSec
Configuration	Manual/DHCP	Auto Configuration
NAT	Required	Not Required
QoS Support	Limited	Better
Broadcast	Supported	Not Supported
Multicast	Supported	Supported
Routing	Less Efficient	More Efficient

IPv4 Advantages

1. WIDELY USED

2. SIMPLE IMPLEMENTATION

3. LARGE EXISTING INFRASTRUCTURE

4. EASY CONFIGURATION

IPv4 Disadvantages

1. LIMITED ADDRESS SPACE

2. SECURITY WEAKNESS

3. NAT DEPENDENCY

4. SCALABILITY ISSUES

IPv6 Advantages

1. UNLIMITED ADDRESS SPACE

2. BETTER SECURITY

3. BETTER ROUTING

4. AUTO CONFIGURATION

5. NO NAT REQUIRED

6. IMPROVED PERFORMANCE

IPv6 Disadvantages

1. MIGRATION COST

2. COMPATIBILITY ISSUES

3. COMPLEX ADDRESS FORMAT

IPv4 to IPv6 Migration

Methods:

```
Dual Stack

Tunneling

Translation
```

Dual Stack

Device IPv4 aur IPv6 dono support karta hai.

```
IPv4
  +
IPv6
```

Real-Life Example

Suppose:

IPV4

```
Small Hostel
```

```
Limited Rooms
```

IPV6

```
Huge Smart City

Unlimited Houses
```

Memory Trick

ADDRESS SIZE

```
IPv4

↓

32

IPv6

↓

128
```

Remember:

```
4 → 32

6 → 128
```

ADDRESS FORMAT

```
IPv4

Dots

(.)
```

```
IPv6

Colons

(:)
```

One Minute Revision

```
IPv4
↓
32 Bit
4.3 Billion Addresses
Example
192.168.1.1
----------------
IPv6
↓
128 Bit
Huge Address Space
Example
2001:db8::1
----------------
Advantages
↓
Security
Auto Configuration
No NAT
----------------
Most Important
↓
```

```
IPv4 vs IPv6
Header Comparison
Address Comparison
```

RGPV Examiner Keywords

```
IPv4
IPv6
32-bit Address
128-bit Address
IPSec
Auto Configuration
NAT
Address Space
Header Format
QoS
Dual Stack
Tunneling
```

Most Expected Questions

7 MARKS

1. Define IPv4 and IPv6.
2. Explain IPv6 features.
3. Explain IPv4 header.
4. Explain IPv6 header.

---

14 MARKS

1. Compare IPv4 and IPv6.
2. Explain IPv6 features in detail.
3. Explain IPv4 and IPv6 header formats.
4. Explain need for IPv6.

PYQ PROBABILITY: ★★★★★

🔥 **IPv4 vs IPv6 Comparison** is one of the most repeated RGPV Computer Networks questions and often comes directly for **14 marks**.

✅ UNIT 4 COMPLETE

Covered Topics:

- Network Layer: Need, Services, Design Issues
- Least Cost Routing

- Dijkstra Algorithm
- Bellman-Ford Algorithm
- Hierarchical Routing
- Broadcast Routing
- Multicast Routing
- IP Addressing
- IPv4 Header Format
- Packet Forwarding
- Fragmentation & Reassembly
- ICMP
- IPv4 vs IPv6

Highest Priority for Exam:

1. Dijkstra Algorithm ⭐⭐⭐⭐⭐
2. Bellman-Ford Algorithm ⭐⭐⭐⭐⭐
3. IP Addressing ⭐⭐⭐⭐⭐
4. IPv4 Header ⭐⭐⭐⭐⭐
5. Fragmentation & Reassembly ⭐⭐⭐⭐⭐
6. IPv4 vs IPv6 ⭐⭐⭐⭐⭐
7. ICMP ⭐⭐⭐⭐