Indian Institute of Technology Kharagpur

Internet Routing Protocols – Part I

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Lecture 7: Internet routing protocols – Part I

On completion, the student will be able to:

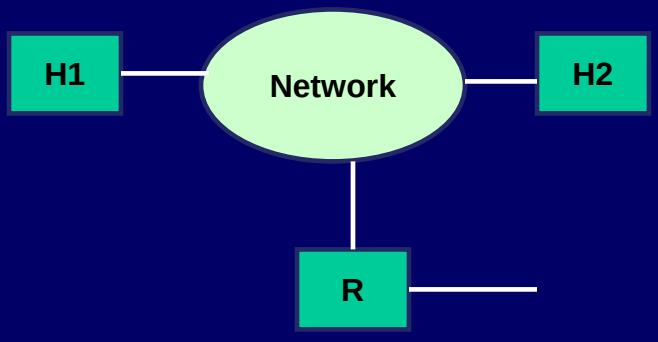
1. Explain the operation of an IP router.
2. Understand the various routing methods.
3. Interpret the various fields in a typical routing table.
4. Explain the basic concept of an autonomous system (AS).
5. Explain the working of the RIP and OSPF protocols for dynamically updating the routing tables.

Connection Options

1. Connection-oriented
   - Network layer protocol first makes a connection.
   - All packets delivered as per the connection.
2. Connection-less
   - Network layer protocol treats each packet independently.
   - No relationship between packets.

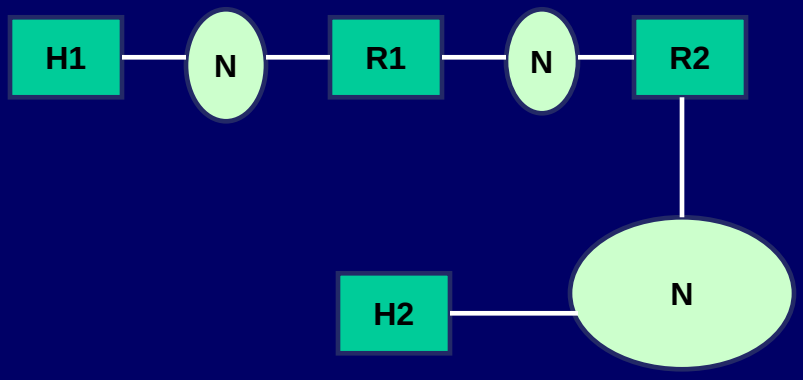
Packet Delivery Options

1. Direct Delivery
   - Host-to-host
   - Router-to-host



2. Indirect Delivery

- Through one or more routers.

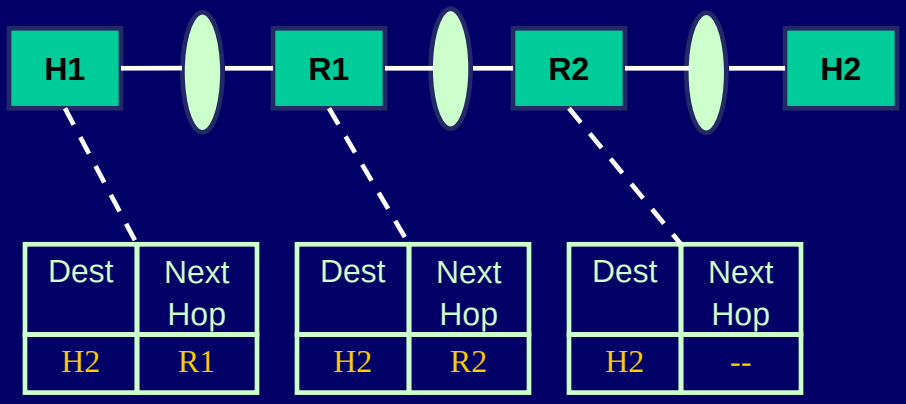


Routing Methods

- Several alternatives possible:
  a) Next-hop routing
  b) Network-specific routing
  c) Host-specific routing
  d) Default routing

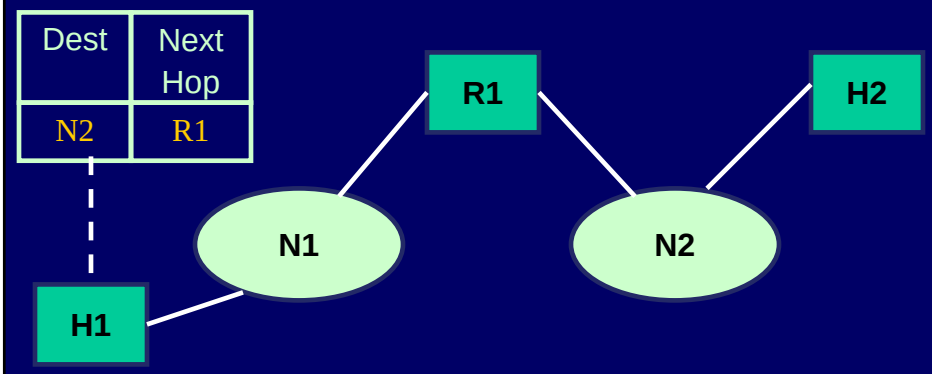
a) Next-hop routing

- Routing tables based on next hop.



b) Network-specific routing

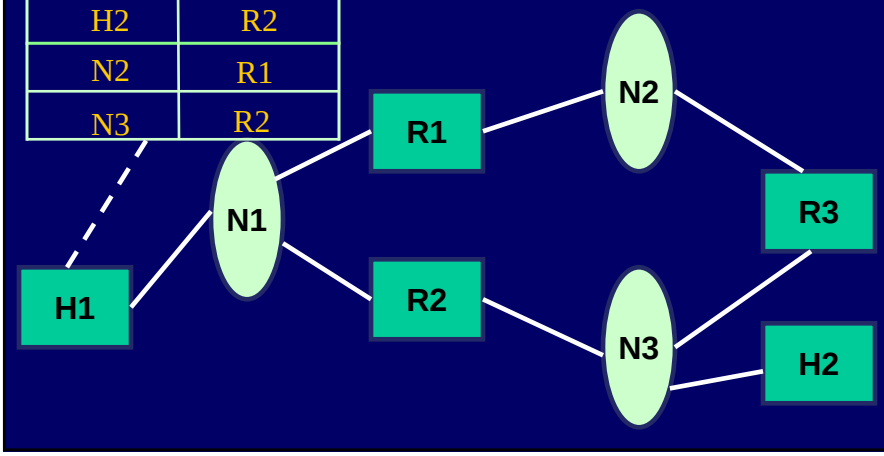
- Routing table based on destination network address.



c) Host-specific routing

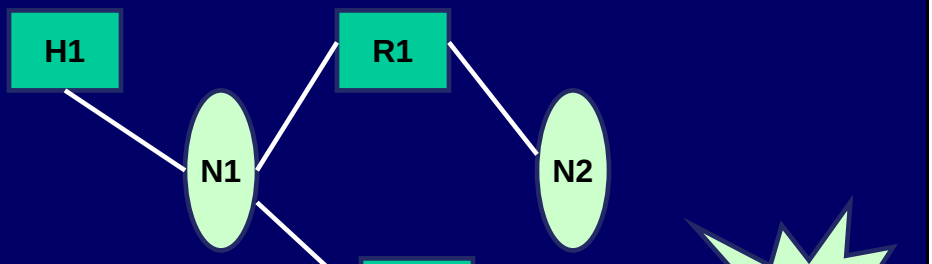
- Can specify the address of a host.

Dest	Next Hop
H2	R2
N2	R1
N3	R2



d) Default routing

- Follow a default path if no match found.



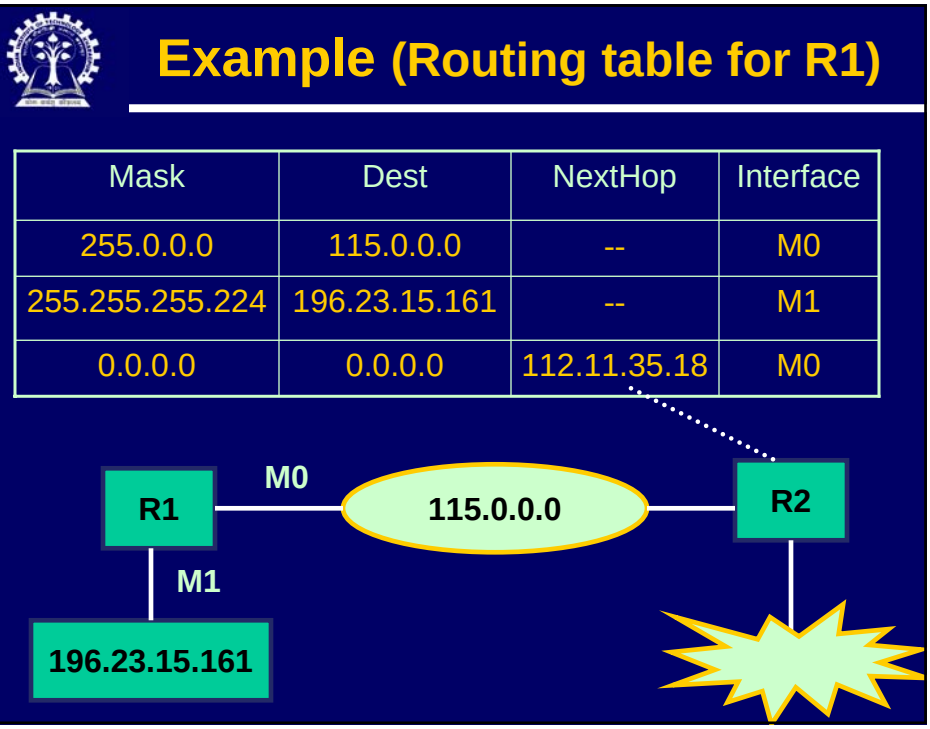
Dest	Next Hop
N2	R1
Default	R2

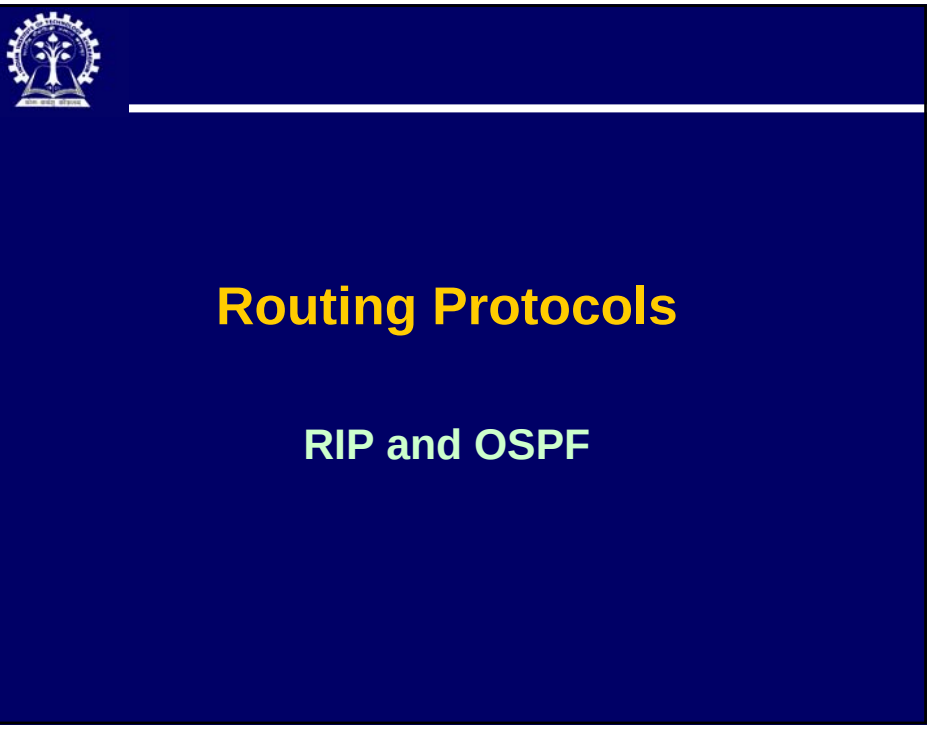
Types of Routing Table

1. Static
   - Contains information inserted manually.
   - Does not change with time.
2. Dynamic
   - Updated periodically depending on network condition.
   - Uses protocols like RIP, OSPF, BGP, etc.

Typical Fields in a Routing Table

- Subnet mask
- Destination IP address
- Next hop address
- Flags
  - U : router is up and running
  - G : destination is in another network
  - H : host-specific address
  - D : added by redirection
  - M : modified by redirection
- Interface

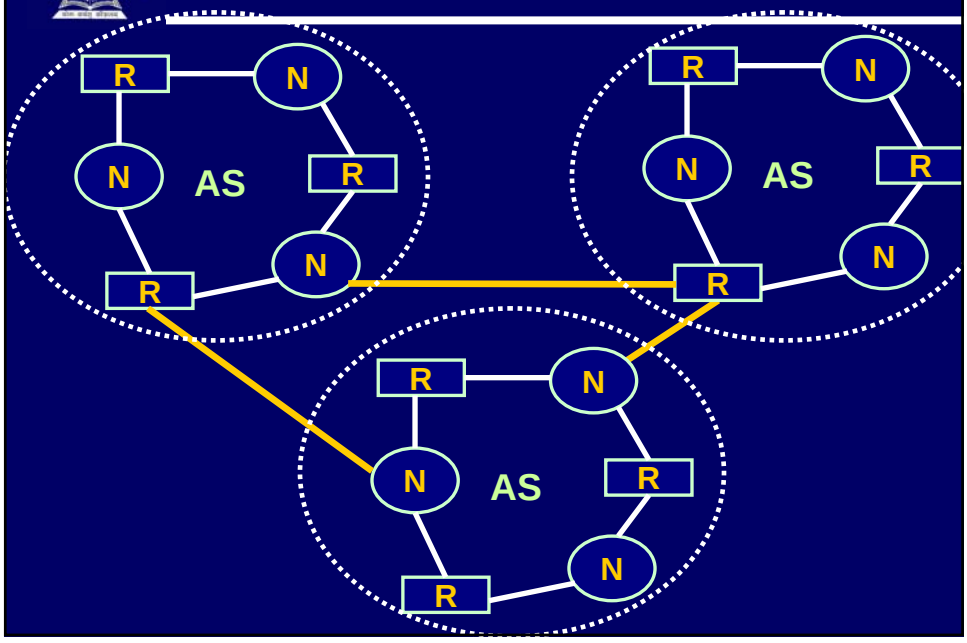

Example (Routing table for R1)
Mask
Dest
NextHop
Interface
255.0.0.0
115.0.0.0
--
M0
255.255.255.224
196.23.15.161
--
M1
0.0.0.0
0.0.0.0
112.11.35.18
M0
R1
115.0.0.0
R2
M1
196.23.15.161


Routing Protocols
RIP and OSPF

Routing Protocols

- Two classes of protocols:
  1. Interior
     - Routing Information Protocol (RIP)
     - Open Shortest Path First (OSPF)
  2. Exterior
     - Border Gateway Protocol (BGP)

Autonomous Systems



- **What is an AS?**
  - **A set of routers and networks managed by a single organization.**
  - **The routers within the AS exchange information using a common routing protocol.**
  - **The AS graph is connected (in the absence of failure).**

- **Which class of protocols to use?**
  - **Use interior router protocols to exchange information between routers within an AS.**
  - **Use exterior routing protocol to pass exchange routing information between routers in different AS's.**

Routing Information Protocol (RIP)

- Routers within an autonomous system exchange messages.
  - Distance vector routing using hop count.
  - Table entries updated using values received from neighbors.
  - Maintain timers to detect failed links.
  - Used in first generation ARPANET.

Problems

- Slow convergence for larger networks.
- If a network becomes inaccessible, it may take a long time for all other routing tables to know this.
  - After a number of message transfers.
- Routing loops may take a long time to be detected.
  - Counting to infinity problem.
- Too much bandwidth consumed by routing updates.

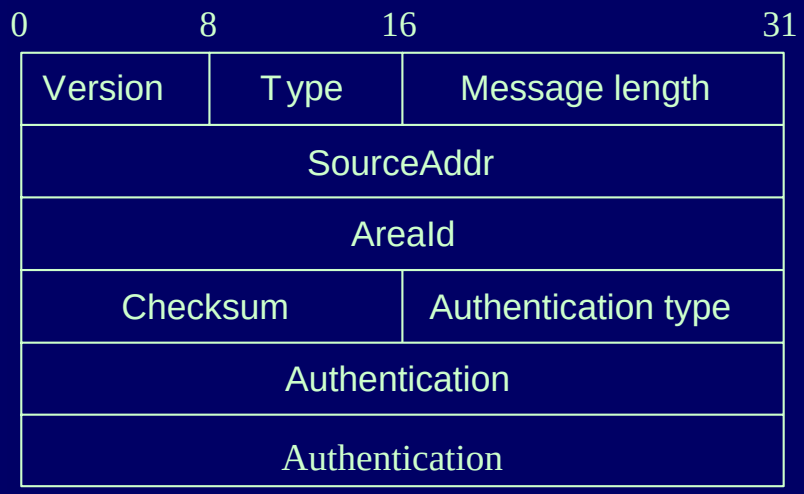
Open Shortest Path First (OSPF)

- Widely used as the interior router protocol in TCP/IP networks.
- Basic concept:
  - Computes a route that incurs the least cost.
    - User configurable: delay, data rate, cost, etc.
  - Each router maintains a database.
    - Topology of the autonomous system to which the router belongs.
    - Vertices and edges.

- Two types of vertices:
  - Router
  - Network
- Two types of (weighted) edges:
  - Two routers connected to each other by direct point-to-point link.
  - A router is directly connected to a network.
- A router calculates the least-cost path to all destination networks.
  - Using Dijkstra's algorithm.
  - Only the next hop to the destination is used in the forwarding process.

- At steady state
  - All routers know the same network topology.
  - "Hello" packets sent every 10 seconds (configurable) to neighbors.
  - Link State Advertisement (LSA) flooded initially from each router.
  - Absence of "Hello" packet for 40 seconds indicate failure of neighbour.
    - Causes LSA to be flooded again.
  - LSAs re-flooded every 30 minutes anyway.

OSPF Header Format



- **Packet types :**
  - **1 : Hello (check if neighbor is up)**
  - **2 : Database Description (synchronize database at beginning)**
  - **3 : Link State Request (request specific LSA)**
  - **4 : Link State Update (LSAs flooded)**
  - **5 : Link State Acknowledgement (flooded LSAs are explicitly ack'ed – reliable flooding)**

- **Authentication type:**
  - **Cleartext**
  - **Encrypted (MD5 Hash, others possible)**

End of Lecture 7

SOLUTIONS TO QUIZ QUESTIONS ON LECTURE 6

Quiz Solutions on Lecture 6

1. For the subnet mask 255.255.192.0, how many hosts per subnet are possible?
   - 11111111 11111111 11000000 00000000
   - 14 bits available for host addresses.
   - Number of hosts possible is $2^{14}-2=16382$.

2. In classful addressing, if we are using the subnet mask 255.255.192.0, which address class does it correspond to?
   - Either Class A or Class B.

Quiz Solutions on Lecture 6

3. What is the subnet address if the destination IP address is 144.16.34.124 and the subnet mask is 255.255.240.0 ?

34 :: 0010 0010
240:: 1111 0000
AND:: 0010 0000
Subnet address will be
144.16.32.0

Quiz Solutions on Lecture 6

4. What is the natural mask for a class C network?

   255.255.255.0

5. Using simple subnets, is it possible to divide a network into unequal sized subnets?

   No. Simple subnets can only divide a network into equal-sized subnets.

Quiz Solutions on Lecture 6

6. For an IP address 10.17.5.122 and subnet mask 255.255.128.0, what is the subnet address? How many hosts per subnet are possible?

   Subnet address = 10.17.5.122 AND
   255.255.128.0
   = 10.17.0.0

   There are 15 bits in the host portion.

   Hosts per subnet = 2^{15}-2 = 32766.

Quiz Solutions on Lecture 6

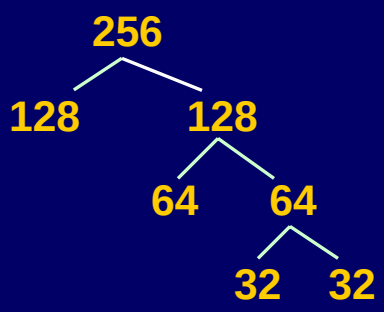
7. Among multiple network classes and subnets, which alternative imposes more burden on the external router?

   Multiple network classes.

Quiz Solutions on Lecture 6

8. Using VLSM, give a scheme to split a class C address into four subnets where the number of hosts required are:

   100, 55, 20, 30



Quiz Solutions on Lecture 6

9. If the number of hosts required are 100, 50, 50 and 20, can VLSM be used?

   Not possible. The last subdivision of 50 and 20 cannot be done.

10. Can the following be the beginning addresses in CIDR based addressing?

144.16.192.32/28	---	YES
10.17.18.42/28	---	NO
188.15.170.55/28	---	NO
200.0.100.80/28	---	YES

Divisible by 16

Quiz Solutions on Lecture 6

11. For a CIDR address of the form W.X.Y.Z/20, what is the maximum number of hosts possible in the network?

    Number of bits in host part = 32-20 = 12.

    So, number of hosts possible = 2^{12}-2 = 4094

Quiz Solutions on Lecture 6

12. Which of the following can be the starting address of a CIDR block that contains 512 addresses?

144.16.24.128	---	NO
144.16.75.0	---	NO
144.16.24.0	---	YES
144.16.0.0	---	YES

QUIZ QUESTIONS ON LECTURE 7

Quiz Questions on Lecture 7

1. What is a connection-oriented protocol?
2. What is a connectionless protocol?
3. What is the difference between direct and indirect packet delivery options?
4. How is the default route specified in the routing table?
5. What is the problem if we use only host-specific routing and no network-specific routing?

Quiz Questions on Lecture 7

6. What do the G and U flags in the routing table signify?
7. What is the difference between interior and exterior routing protocols?
8. What is an autonomous system?
9. How do routers update information in RIP?
10. How to routers compute path in OSPF?
11. Which paths do the packets follow in OSPF?