Network Layer

Unit: 3

Computer Networks

KCS 603

B Tech 6th Sem

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CSE Department

Content

- Evaluation Scheme
- Syllabus
- Branch wise syllabus
- Course Objective
- Course Outcome
- Program Outcome
- CO-PO Mapping
- PSO
- CO- PSO Mapping
- PEO
- Result analysis
- Paper template
- Prerequisites
- Introduction to subject
- Unit objective
- Network Layer
  - Topic Objective
  - Design issues of Network Layer
  - Functions of Network layer

Content

- Routing Algorithms
  - Topic Objective & Recap of previous topic
  - Types of Routing Algorithms
    - Non adaptive
    - Adaptive
- Congestion Control
  - Topic Objective & Recap of previous topic
  - Causes of congestion
  - Effects of Congestion
  - Congestion control techniques
- Internet as a connectionless protocol
- IPv4
- Video Links
- Quiz
- Weekly assignment
- MCQ
- Old Question papers

Content

- Expected Questions in University exams
- University question paper
- Summary
- Reference

Evaluation Scheme

SEMESTER- VI												
Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KCS601	Software Engineering	3	1	0	30	20	50		100		150	4
2	KIT601	Data Analytics	3	1	0	30	20	50		100		150	4
3	KCS603	Computer Networks	3	1	0	30	20	50		100		150	4
4	Deptt-Elective-III	Departmental Elective-III	3	0	0	30	20	50		100		150	3
5		Open Elective-I	3	0	0	30	20	50		100		150	3
6	KCS651	Software Engineering Lab	0	0	2				25		25	50	1
7	KIT651	Data Analytics Lab	0	0	2				25		25	50	1
8	KCS653	Computer Networks Lab	0	0	2				25		25	50	1
9	KNC601/ KNC602	Constitution of India, Law and Engineering / Indian Tradition, Culture and Society	2	0	0	15	10	25		50			
10		MOOCs (Essential for Hons. Degree)											
		Total	**0**	**3**	**6**							**900**	**21**

Syllabus

Unit	Topic
I	Introductory Concepts: Goals and applications of networks, Categories of networks, Organization of the Internet, ISP, Network structure and architecture (layering principles, services, protocols and standards), The OSI reference model, TCP/IP protocol suite, Network devices and components. Physical Layer: Network topology design, Types of connections, Transmission media, Signal transmission and encoding, Network performance and transmission impairments, Switching techniques and multiplexing.
II	Link layer: Framing, Error Detection and Correction, Flow control (Elementary Data Link Protocols, Sliding Window protocols). Medium Access Control and Local Area Networks: Channel allocation, Multiple access protocols, LAN standards, Link layer switches & bridges (learning bridge and spanning tree algorithms).
III	**Network Layer: Point-to-point networks, Logical addressing, Basic internetworking (IP, CIDR, ARP, RARP, DHCP, ICMP), Routing, forwarding and delivery, Static and dynamic routing, Routing algorithms and protocols, Congestion control algorithms, IPv6.**
IV	Transport Layer: Process-to-process delivery, Transport layer protocols (UDP and TCP), Multiplexing, Connection management, Flow control and retransmission, Window management, TCP Congestion control, Quality of service.
V	Application Layer: Domain Name System, World Wide Web and Hyper Text Transfer Protocol, Electronic mail, File Transfer Protocol, Remote login, Network management, Data compression, Cryptography – basic concepts.

Branch wise Applications

- Resource Sharing
- Server-Client model:
- Communication Medium:
- Access to remote information
- Person-to-person communication
- Electronic commerce
- Cloud-based Applications
- AI and Expert System
- Neural Networks and parallel programming
- Decision support and office automation systems etc.

Course Objective

To develop an understanding of

- To understand computer networking basics.
- To understand different components of computer networks.
- **To study and understand various protocols.**
- The standard models for the layered approach to communication between autonomous machines in a network.
- To study and understand the main characteristics of data transmission across various physical link types.

Course Outcome

At the end of the course, the student will be able

Course Outcomes (CO)	-	Bloom's Knowledge Level (KL)
C603.1	Explain basic concepts, OSI reference model, services and role of each layer of OSI model and TCP/IP, networks devices and transmission media, Analog and digital data transmission	K1, K2
C603.2	Apply channel allocation, framing, error and flow control techniques.	K3
C603.3	**Describe the functions of Network Layer i.e. Logical addressing, subnetting & Routing Mechanism**	**K2, K3**
C603.4	Explain the different Transport Layer function i.e. Port addressing, Connection Management, Error control and Flow control mechanism.	K2, K3
C603.5	Explain the functions offered by session and presentation layer and their Implementation.	K2, K3
C603.6	Explain the different protocols used at application layer i.e. HTTP, SNMP, SMTP, FTP, TELNET and VPN.	K2

Program Outcome

1. Engineering knowledge
2. Problem analysis
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and team work
10. Communication
11. Project management and finance
12. Life-long learning

CO-PO Mapping

The highlighted text shows the mapping of course outcome with PO mapping of this unit

					Computer Networks (KCS-603)				Year of Study: 2021-22			
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
C603.1	3	2	3	2	1	1					2	3
C603.2	3	3	2	2	3	2		1			1	3
C603.3	3	2	1		1	2		1	2		1	3
C603.4	2	2	1		1			1	1		1	3
C603.5	2	2	2		1						1	3
C603.6	2	1			3	2		3	1		1	3

Program Specific Outcomes

- **PSO1:** Work as a software developer, database administrator, tester or networking engineer for providing solutions to the real world and industrial problems.
- **PSO2:**Apply core subjects of information technology related to data structure and algorithm, software engineering, web technology, operating system, database and networking to solve complex IT problems.
- **PSO3:** Practice multi-disciplinary and modern computing techniques by lifelong learning to establish innovative career.
- **PSO4:** Work in a team or individual to manage projects with ethical concern to be a successful employee or employer in IT industry.

CO-PSO Mapping

The highlighted text shows the mapping of course outcome with PSO mapping of this unit

CO	PSO1	PSO2	PSO3	PSO4
C603.1	3	3	2	1
C603.2	3	3	2	1
C603.3	3	3	2	1
C603.4	3	3	1	1
C603.5	3	3	1	1
C603.6	3	3	1	1

Program Educational Objectives

- **PEO1:** able to apply sound knowledge in the field of information technology to fulfill the needs of IT industry.
- **PEO2:** able to design innovative and interdisciplinary systems through latest digital technologies.
- **PEO3:** able to inculcate professional and social ethics, team work and leadership for serving the society.
- **PEO4:** able to inculcate lifelong learning in the field of computing for successful career in organizations and R&D sectors.

Result Analysis

- Computer Networks Result of 2020-21: 96.97%
- Average Marks: 54.33

End Semester Question Paper Template

B TECH

(SEM-V) THEORY EXAMINATION 20__-20__

OBJECT ORIENTED SYSTEM DESIGN

Time: 3 Hours **Total Marks: 100**

Note: 1. Attempt all Sections. If require any missing data; then choose suitably.

SECTION A

1. Attempt all questions in brief. **2 x 10 = 20**

Q.No.	Question	Marks	CO
1		2	
2		2	
.		.	
10		2	

End Semester Question Paper Templates

SECTION B

2. Attempt any three of the following: 3 x 10 = 30

Q.No.	Question	Marks	CO
1		10	
2		10	
.		.	
5		10	

SECTION C

3. Attempt any one part of the following: 1 x 10 = 10

Q.No.	Question	Marks	CO
1		10	
2		10	

End Semester Question Paper Templates

4. Attempt any one part of the following: 1 x 10 = 10

Q.No.	Question	Marks	CO
1		10	
2		10	

5. Attempt any one part of the following: 1 x 10 = 10

Q.No.	Question	Marks	CO
1		10	
2		10	

6. Attempt any one part of the following: 1 x 10 = 10

Q.No.	Question	Marks	CO
1		10	
2		10	

End Semester Question Paper Templates

7. Attempt any one part of the following: 1 x 10 = 10

Q.No.	Question	Marks	CO
1		10	
2		10	

Prerequisite

- The student should have knowledge of
  - Networking
  - Layout of computer
  - Hardware
- The basic knowledge of C

Brief Introduction to Subject

- Computer network is a group of devices connected with each other through a transmission medium such as wires, cables etc.
- These devices can be computers, printers, scanners, Fax machines etc.
- The purpose of having computer network is to send and receive data stored in other devices over the network.

Network Layer(CO1)

Topic Objective

- The student will be able to understand the networking issues
- Functions of network layer and
- Services provided by the network layer

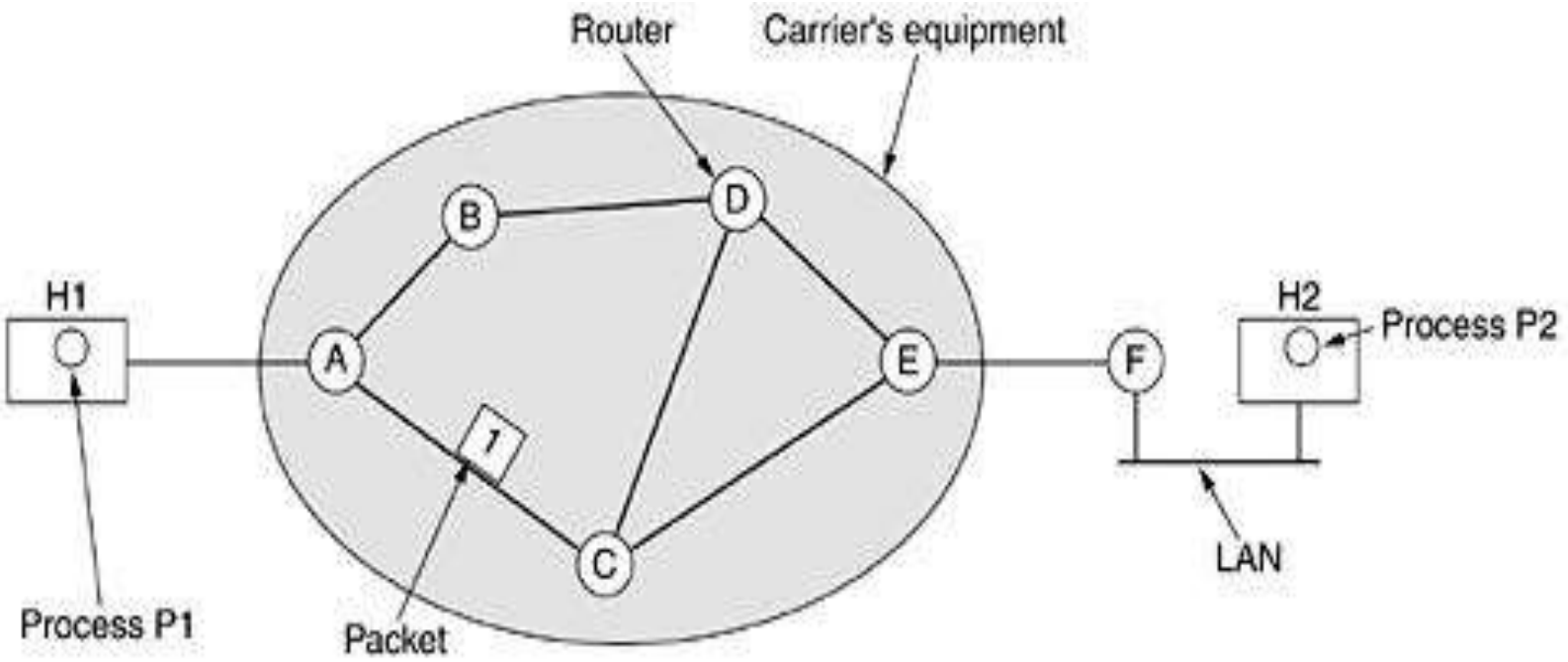
Network Layer(CO1)

- This is the third layer in OSI model in computer networking.
- Network layer provides support for end to end communication (helps to forward the packets from source to destination) by using routers and switches.
- Network layer manages the Quality of Services (QoS).
- The service provided by the network layer to the transport layer is called as **network service.**

Network Layer(CO2)

- Store – and – forward Packet Switching
- Services provided to the Transport Layer
- Implementation of connectionless Service
- Implementation of Connection-Oriented Service
- Comparison of Virtual-Circuit and Datagram Networks

Store-and-Forward Packet Switching



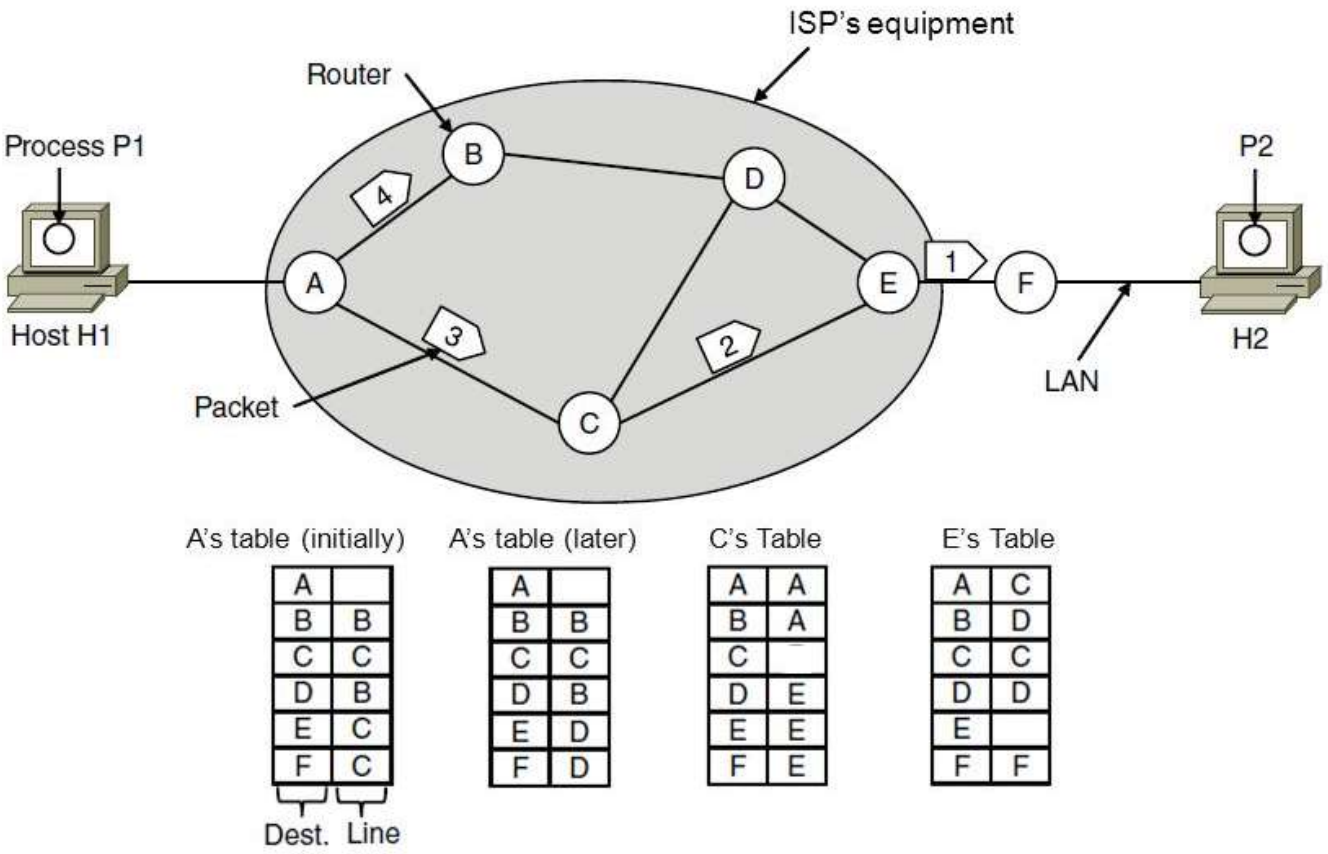
Network Layer

Services provided to the Transport Layer

- The services should be independent of the router technology
- The transport layer should be shielded from the number, type, and topology of the routers present
- The network addresses made available to the transport layer should use a uniform numbering plan, even across LANs and WANs.

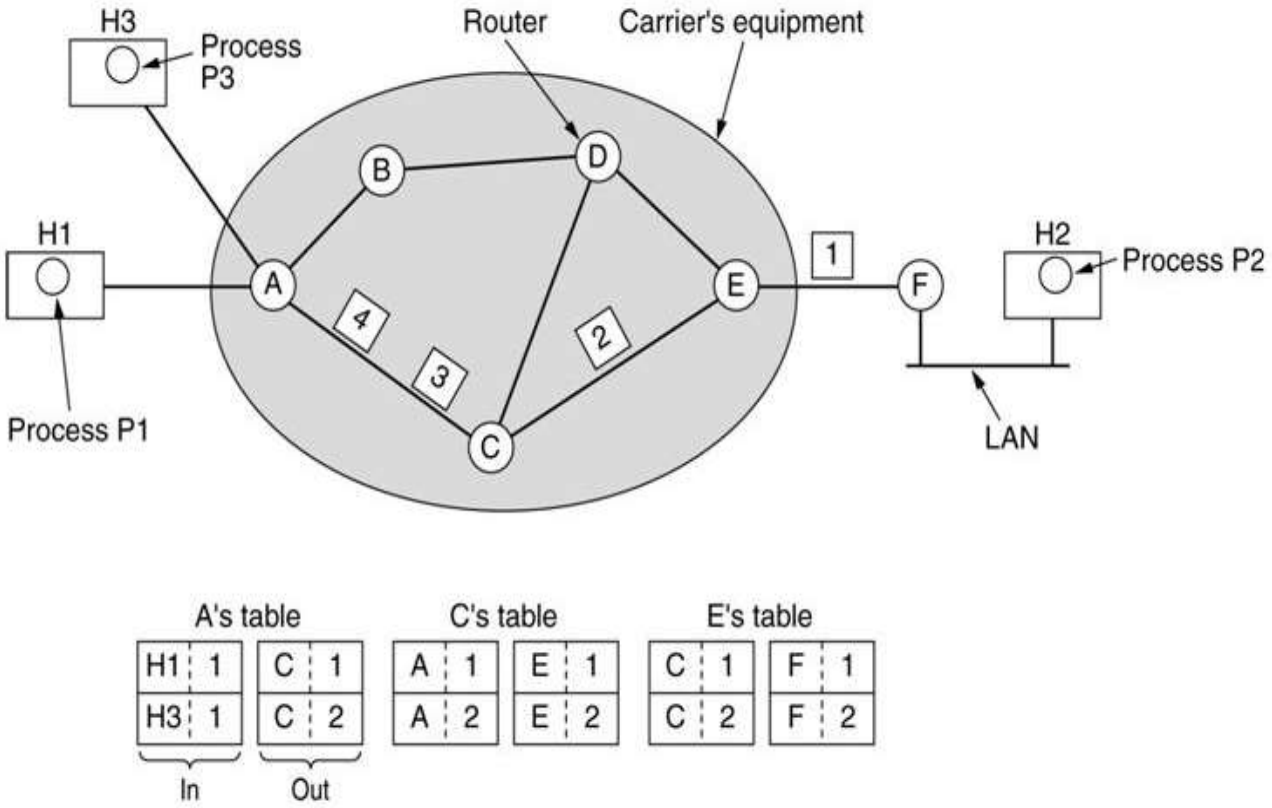
Network Layer

Implementation of connectionless Service



Network Layer

Implementation of Connection-Oriented Service



Comparison of Virtual-Circuit and Datagram Networks

Issue	Datagram network	Virtual-circuit network
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

Network Layer design issue(CO5)

- Reliability
- Scalability
- Addressing
- Error Control
- Flow Control
- Resource Allocation
- Statistical Multiplexing
- Routing
- Security

Functions of Network Layer(CO1)

Routing –

- transferring packets received from the Data Link Layer of the source network to the Data Link Layer of the correct destination
- Involves decision making at each intermediate node on where to send the packet next so that it eventually reaches its destination.
- The node which makes this choice is called a router.
- For routing we require some mode of addressing which is recognized by the Network Layer.

Functions of Network Layer

Inter-networking –

- The network layer is the same across all physical networks (such as Token-Ring and Ethernet).
- the packets that arrive at the Data Link Layer of the node which connects these two physically different networks, would be stripped of their headers and passed to the Network Layer.

Functions of Network Layer

Congestion Control –

- If the incoming rate of the packets arriving at any router is more than the outgoing rate.
- If suddenly, packets begin arriving on many input lines and all need the same output line, then a queue will build up.
- If there is insufficient memory to hold all of them, packets will be lost.
- Another reason for congestion are slow processors.
- Similarly, low-bandwidth lines can also cause congestion.

Routing Algorithms(CO3)

Topic Objective

- To understand the basics of routing
- Various adaptive and non adaptive routing algorithms
- Implementation of the algorithms

Recap of previous topic

- Network layer provides unreliable transmission of data
- Provides services to transport layer
- Error and flow control

Routing Algorithms(CO3)

Routing is the process of forwarding of a packet in a network so that it reaches its intended destination.

- Correctness:
- Simplicity:
- Robustness:
- Stability:
- Fairness:
- Optimality:

Routing Algorithms

Types

- Optimality Principle
- Shortest Path Routing
- Flooding
- Distance Vector Routing
- Link State Routing
- Hierarchical Routing
- Broadcast Routing
- Multicast Routing

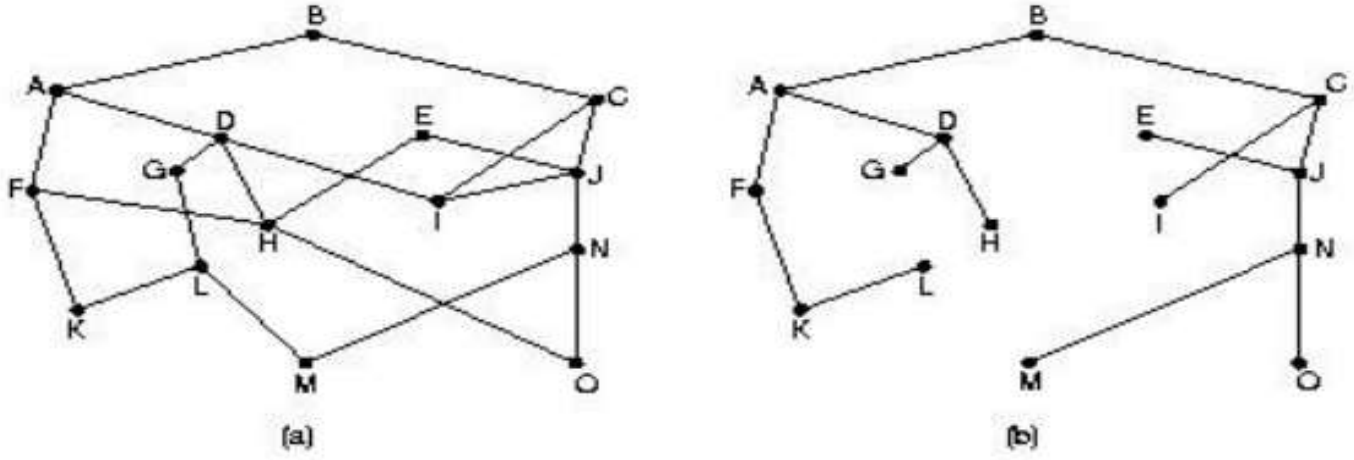
Types of Routing Algorithms(CO5)

- Non-adaptive (Static)
  - Do not use measurements of current conditions
  - Static routes are downloaded at boot time
- Adaptive Algorithms
  - Change routes dynamically
  - Gather information at runtime
    - locally
    - from adjacent routers
    - from all other routers
  - Change routes
    - Every delta T seconds
    - When load changes
    - When topology changes

Types of Routing Algorithms-Non adaptive(CO4)

The Optimality Principle

- If router j is on the optimal path from i to k, then the optimal path from j to k also falls along the same route.
- The set of optimal routes to a particular node forms a sink tree.
- Sink trees are not necessarily unique
- Goal of all routing algorithms – Discover sink trees for all destinations



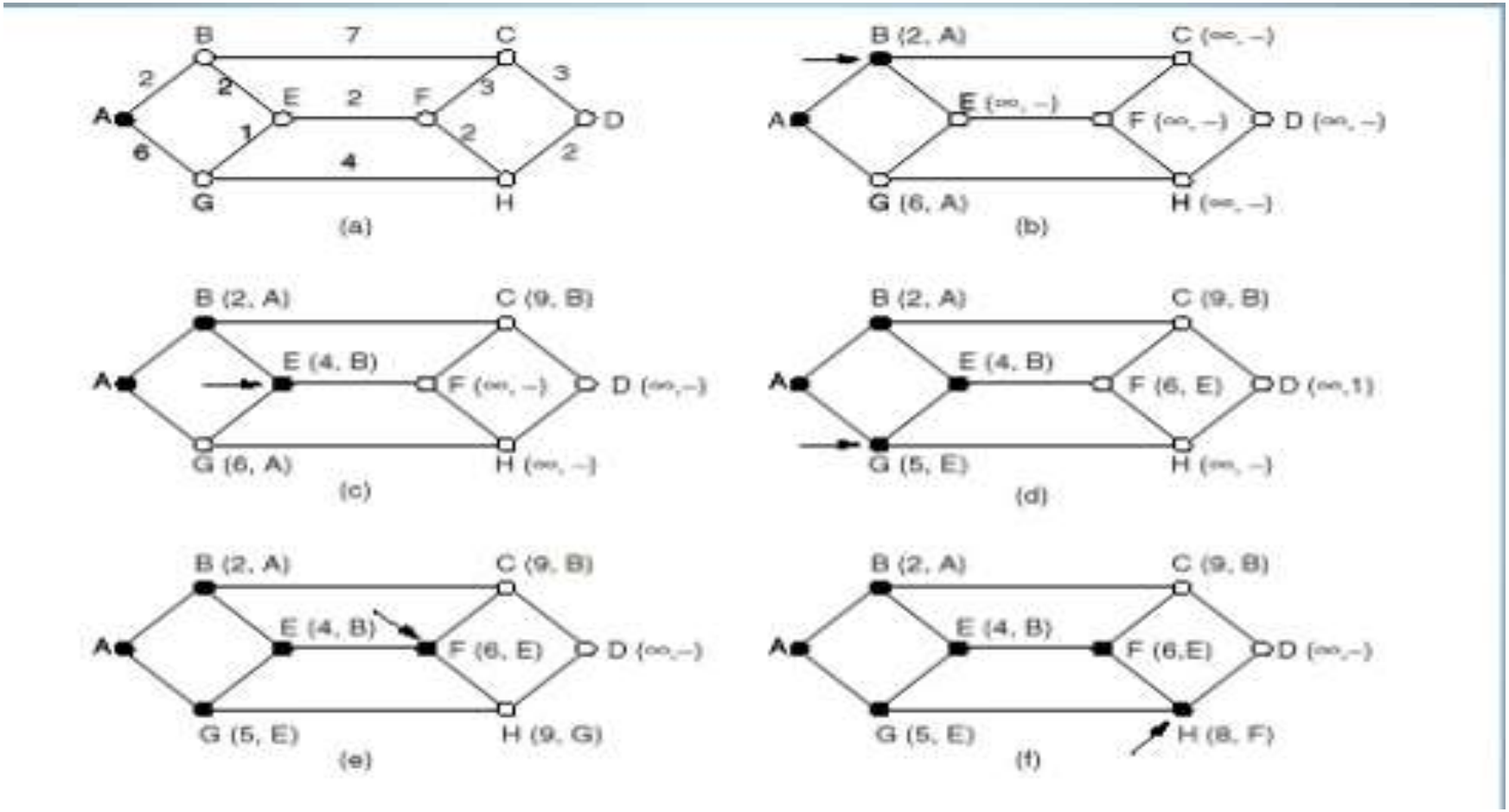
Types of Routing Algorithms-Non Adaptive(CO4)

Shortest Path Routing

- Given a network topology and a set of weights describing the cost to send data across each link in the network
- Find the shortest path from a specified source to all other destinations in the network.
- Shortest path algorithm first developed by E. W. Dijkstra Shortest Path Routing (a non-adaptive routing algorithm)

Types of Routing Algorithms-Non Adaptive(CO5)

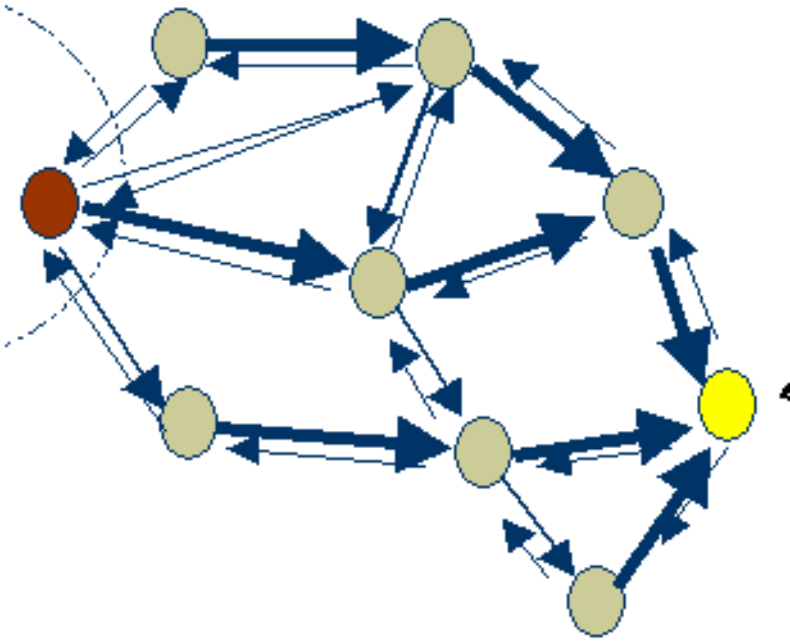
Example for shortest path routing



Types of Routing Algorithms-Non Adaptive(CO4)

Flooding

- No network information is required
- Packet send by node to every neighbor
- Incoming packets retransmitted on every link without incoming link
- Eventually a numbers of copies will arrives at destination
- Each packet is uniquely numbered so duplicate can be discarded
- Nodes can remember packets already forwarded to keep network load in bounds
- All nodes are visited – All possible routes are tried



Types of Routing Algorithms-Non Adaptive

Selective Flooding – Flood only in the direction of the destination

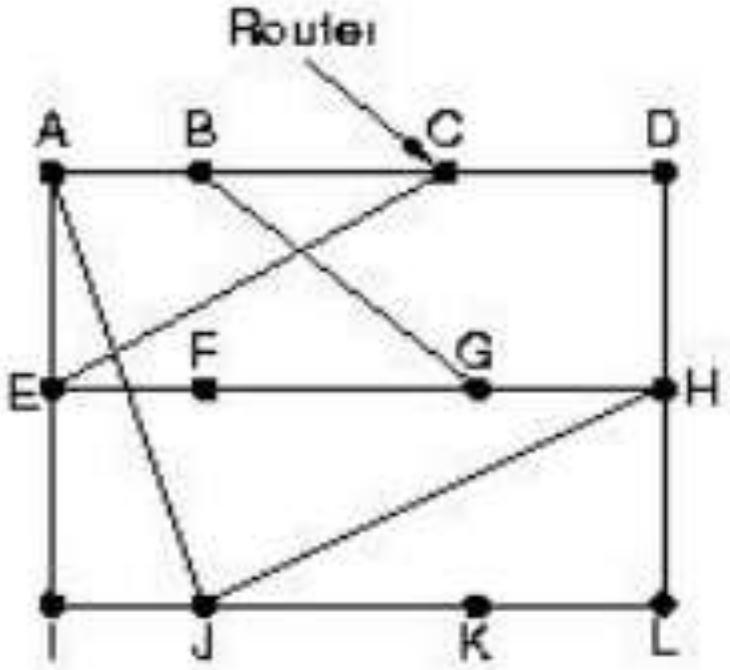
- To prevent packets from looping forever, each router decrements a hop count contained in the packet header.
- Whenever the hop count decrements to zero, the router discards the packet.
- To reduce looping even further:
  1. Add a sequence number to each packet's header.
  2. Each router maintains a private sequence number. When it sends a new packet, it copies the sequence number into the packet, and increments its private sequence number.
  3. For each source router S, a router:
     a) Keeps track of the highest sequence number seen from S.
     b) Whenever it receives a packet from S containing a sequence number lower than the one stored in its table, it discards the packet.
     c) Otherwise, it updates the entry for S and forwards the packet on Non-Adaptive Algorithm

Types of Routing Algorithms- Adaptive(CO1,CO5)

Distance Vector Routing

1. Each router maintains a table (vector) giving the best known distance to a destination and the line to use for sending there. Tables are updated by exchanging information with neighbors.
2. Each router knows the distance (cost) of reaching its neighbors (e.g. send echo requests).
3. Routers periodically exchange routing tables with each of their neighbors.
4. Upon receipt of an update, for each destination in its table, a router:
   – Compares the metric in its local table with the metric in the neighbor's table plus the cost of reaching that neighbor. – if the path via the neighbor has a lower cost, the router updates its local table to forward packets to the neighbor.

Types of Routing Algorithms- Adaptive



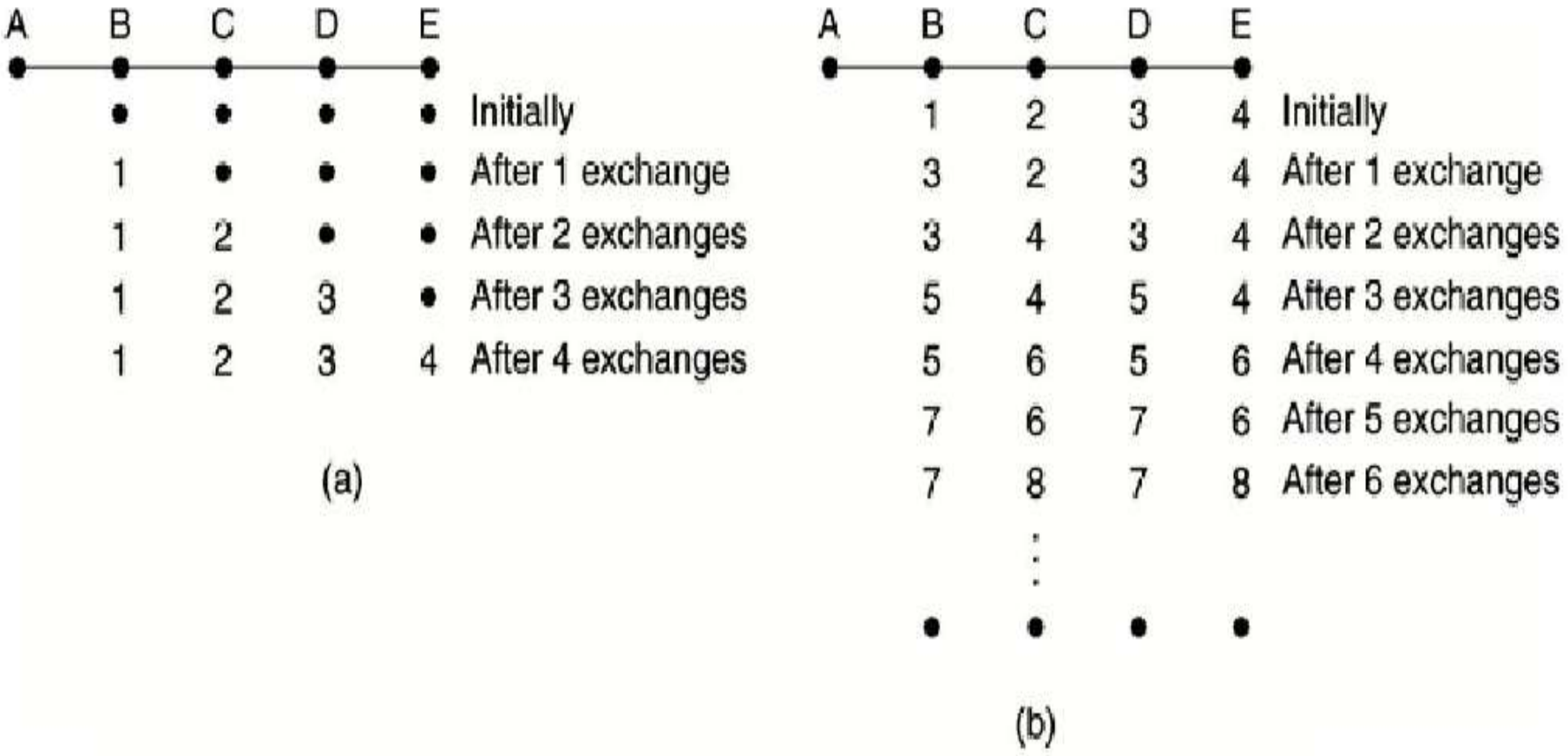
New estimated delay from J

To	A	I	H	K	New estimated delay from J	Line
A	0	24	20	21	8	A
B	12	36	31	28	20	A
C	25	18	19	36	28	I
D	40	27	8	24	20	H
E	14	7	30	22	17	I
F	23	20	19	40	30	I
G	18	31	6	31	18	H
H	17	20	0	19	12	H
I	21	0	14	22	10	I
J	9	11	7	10	0	—
K	24	22	22	0	6	K
L	29	33	9	9	15	K
	JA delay is 8	JI delay is 10	JH delay is 12	JK delay is 6	New routing table for J	

Vectors received from J's four neighbors

Types of Routing Algorithms- Adaptive

The count –to – infinity Problem



Types of Routing Algorithms- Adaptive

Distance Vector Routing

- This algorithm was used in the original ARPANET.
- Unfortunately, it suffers from the problem: good news travels quickly, bad news travels slowly (count-to-infinity problem).
- The fundamental problem with the old Arpanet algorithm is that it continues to use `old' information that is invalid, even after newer information becomes available.

Types of Routing Algorithms- Adaptive

Link State Routing

- The `old' Arpanet routing algorithm was replaced in 1979.
- Problems with old algorithm included:

1. High-priority routing update packets were large, adversely affecting traffic.

2. Network was too slow in adapting to congestion, too fast to react to minor changes.

3. Average queue length was used to estimate delay. – This works only if all lines have the same capacity and propagation delay.d – Doesn't take into account that packets have varying sizes.

Types of Routing Algorithms- Adaptive

Link State Routing

1.) Discover your neighbors and learn their addresses.

2.) Measure the cost (delay) to each neighbor.

3.) Construct a packet containing all this information

4.) Send this packet to all other routers.

5.) Compute the shortest path to every other router.

Types of Routing Algorithms- Adaptive

Link State Routing

1. Discovering Your Neighbors

- Send “Hello” packet on each point-to-point line. Destination node replies with its address.

2. Measure the cost (delay) to each neighbor.

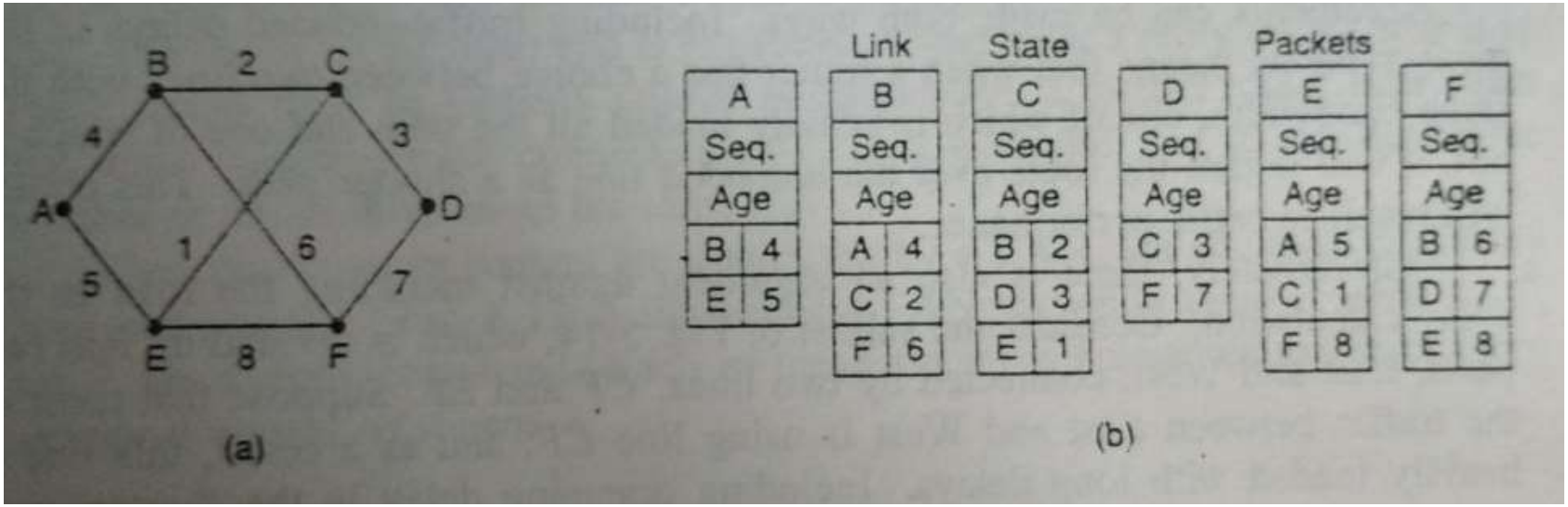
- Send an “ECHO” packet over the line.
- Destination is required to respond to “ECHO” packet immediately.
- Measure the time required for this operation

Types of Routing Algorithms- Adaptive

Link State Routing

3. Building Link State Packets

- Build a packet containing all the data

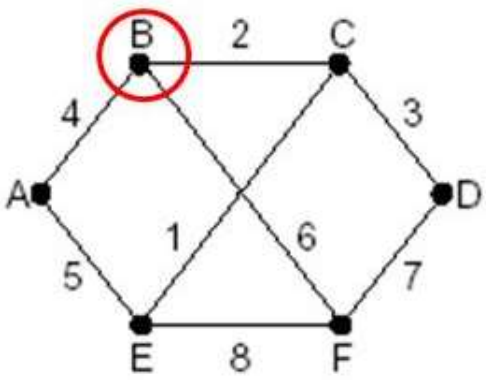


Types of Routing Algorithms- Adaptive

Link State Routing

4.Distributing the Link State Packets

- Use selective flooding
- Sequence numbers prevent duplicate packets from being propagated
- Lower sequence numbers are rejected as obsolete



Source	Seq.	Age	Send flags A	Send flags C	Send flags F	ACK flags A	ACK flags C	ACK flags F	Data
A	21	60	0	1	1	1	0	0	
F	21	60	1	1	0	0	0	1	
E	21	59	0	1	0	1	0	1	
C	20	60	1	0	1	0	1	0	
D	21	59	1	0	0	0	1	1	

Types of Routing Algorithms- Adaptive

Link State Routing

5. Computing the New Routes

- Dijkstra's Shortest Path algorithm is used to determine the shortest path to each destination.

Types of Routing Algorithms- Adaptive

Hierarchical Routing

- One of the fundamental issues regarding routing is scaling.

a) As a network becomes larger, the amount of information that must be propagated increases, and the routing calculation becomes increasingly expensive.

b) Obviously, there are limits to how big a network can be.

Hierarchical routing is an approach that hides information from far-away nodes, reducing the amount of information a given router needs to perform routing:

- Divide the network into regions, with a router only knowing the details of how to route to other routers in its region.

a) In particular, a router does not know about the internal topology of other regions.

b) Gateway is a router that knows about other regions.

Types of Routing Algorithms- Adaptive

Hierarchical Routing

A node in each region is designated as an entry point, and the entry point knows how to reach the entry points in all the other regions.

When traffic flows from A to B, it actually follows the path

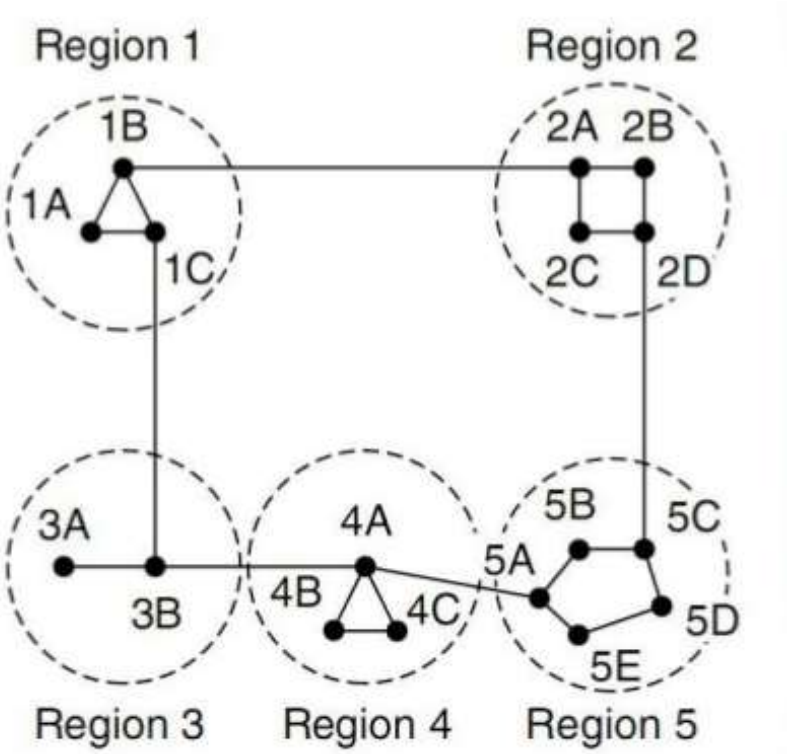
A - AENTRY - BENTRY - B,

where AENTRY and BENTRY are the entry points to the respective regions.

- Advantage: Scaling. Each router needs less information (table space) to perform routing.
- Disadvantage: Sub optimal routes. The average path length increases because there may be a shorter path that bypasses the entry points, but we don't use it.

Types of Routing Algorithms- Adaptive

Hierarchical Routing



Full table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

Hierarchical table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

Types of Routing Algorithms- Adaptive

Broadcast Routing

- Sending a packet to all destinations simultaneously is known as broadcasting.
- There are several ways to implement broadcasting:
- For Broadcast Networks:

1. The implementation is trivial: designate a special address as the `all hosts address'.

- For non broadcast Networks:

1. Send a unicast packet to each destination. However, this approach makes poor use of resources.

2. Flood packets to all nodes. Flooding generates many packets and consumes too much bandwidth.

Types of Routing Algorithms- Adaptive

Broadcast Routing

- For non broadcast Networks:

3. Use multi-destination routing:

a) Each packet contains a list (or bitmap) of all destinations, and when a router forwards a packet across two or more lines, it splits the packet and divides the destination addresses accordingly.

b) This approach is similar to sending uni-cast packets, except that we don't send individual copies of each messages.

c) However, the copy operations slow down the ability of a router to process many packets.

Types of Routing Algorithms- Adaptive

Broadcast Routing

- For non broadcast Networks:

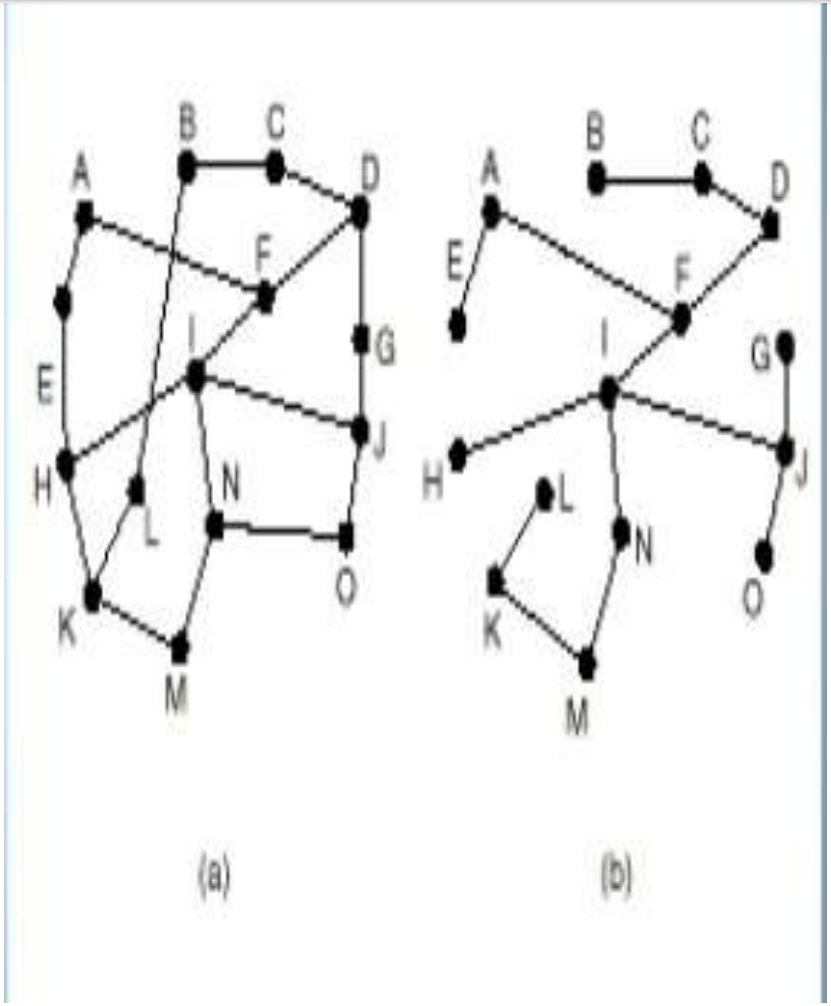
4. Use a spanning tree.

If the network can be reduced to a tree

a) (There's only one path between any two pairs of routers), copy a packet to each line of spanning tree except the one on which it arrived.

b) Works only if each router understands the same spanning tree.

c) Uses the minimum number of packets necessary



Types of Routing Algorithms- Adaptive

Broadcast Routing

- For non broadcast Networks:

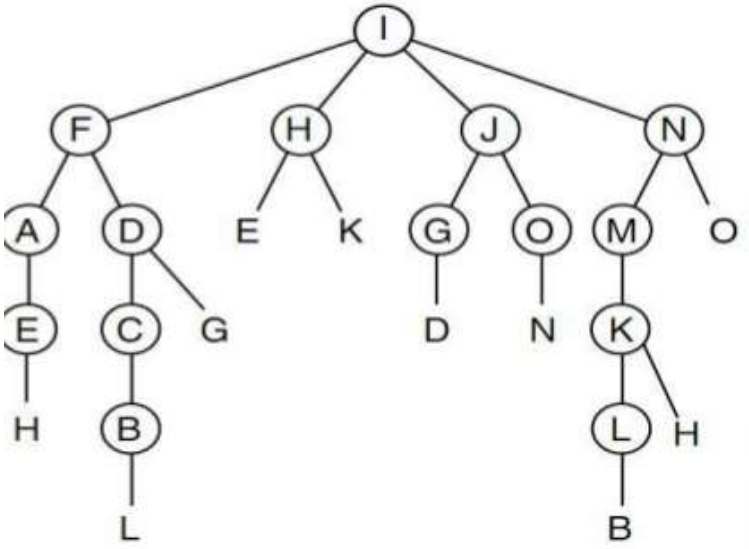
5. Reverse Path Forwarding (RPF):

a) Use a sink tree (assume sink/source trees are the same).

b) If a packet, originating from X, arrives on a line of the sink tree leading to X, the packet is traveling along the shortest path, so it “must” be the first copy we've seen.

c) Copy the packet to all outgoing lines of the sink tree. If the packet arrives on another line, assume that the packet is a copy - it didn't arrive on the shortest path - and discard it.

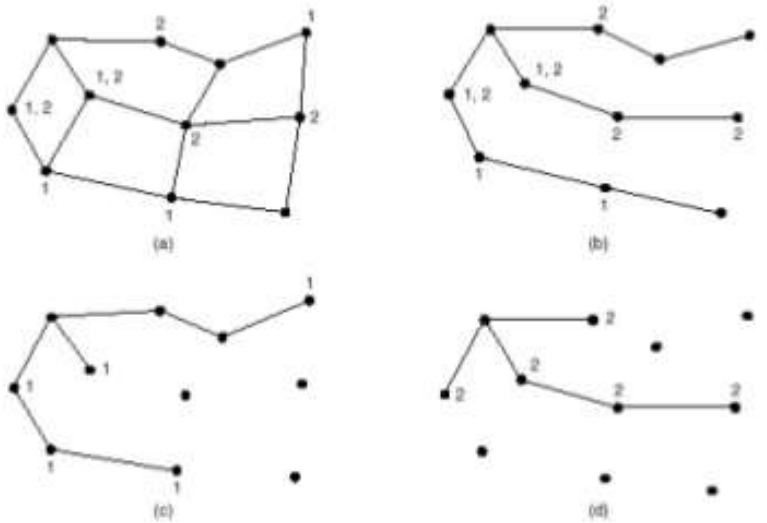
RPF is easy to implement and makes efficient use of bandwidth.



Types of Routing Algorithms- Adaptive

Multicast Routing

- A method to broadcast packets to well- defined groups
- Hosts can join multicast groups. – They inform their routers – Routers send group information throughout the subnet
- Each router computes a spanning tree for each group.
- The spanning tree includes all the routers needed to broadcast data to the group



Congestion control Algorithms(CO4)

Topic Objective

- To understand the basics of Congestion
- Various Congestion control algorithms
- Usage of the algorithms

Recap of previous topic

- Concept of Routing
- Usage of various routing algorithms

Congestion Control Algorithms(CO4)

- As Internet can be considered as a Queue of packets, where transmitting nodes are constantly adding packets and some of them (receiving nodes) are removing packets from the queue.
- So, consider a situation where too many packets are present in this queue (or internet or a part of internet), such that constantly transmitting nodes are pouring packets at a higher rate than receiving nodes are removing them.
- This degrades the performance, and such a situation is termed as Congestion. Main reason of congestion is more number of packets into the network than it can handle.

Congestion Control Algorithms

- When the number of packets dumped into the network is within the carrying capacity, they all are delivered, expect a few that have too be rejected due to transmission errors .
- As traffic increases too far, the routers are no longer able to cope, and they begin to lose packets. This tends to make matter worse.
- At very high traffic, performance collapse completely, and almost no packet is delivered

Causes of Congestion

- Congestion can occur due to several reasons.
- if all of a sudden a stream of packets arrive on several input lines and need to be out on the same output line, then a long queue will be build up for that output. If there is insufficient memory to hold these packets, then packets will be lost (dropped) .
- If router have an infinite amount of memory even then instead of congestion being reduced, it gets worse; because by the time packets gets at the head of the queue, to be dispatched out to the output line, they have already timed-out.
- All the packets will be forwarded to next router up to the destination, all the way only increasing the load to the network more and more.
- Finally when it arrives at the destination, the packet will be discarded, due to time out, so instead of been dropped at any intermediate router (in case memory is restricted) such a packet goes all the way up to the destination, increasing the network load throughout and then finally gets dropped there.
- Slow processors also cause Congestion. If the router CPU is slow at performing the task .

Effects of Congestion

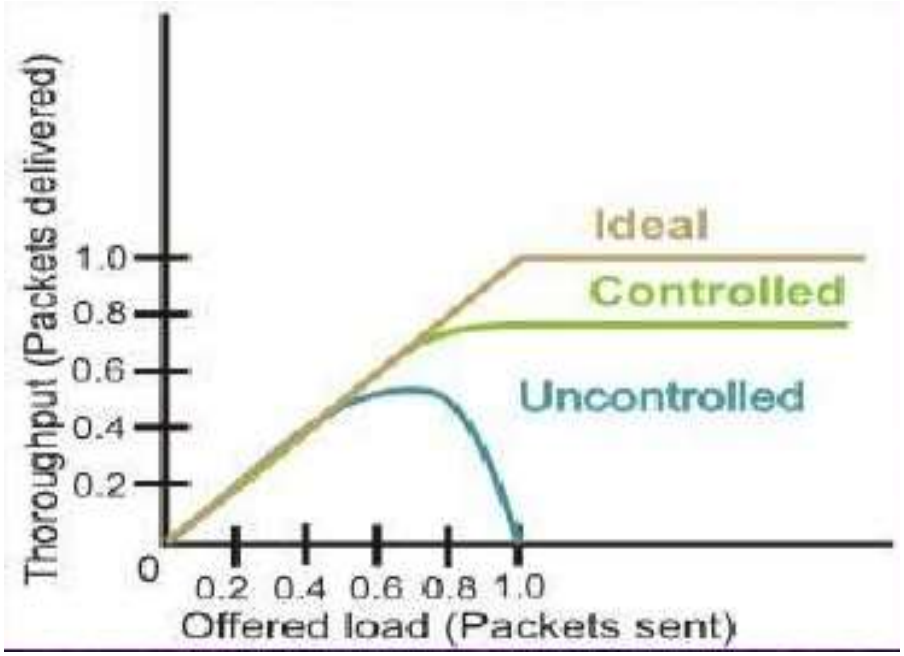
Congestion affects two vital parameters of the network performance .

1. Through put
2. Delay

- Initially throughput increases linearly with offered load, because utilization of the network increases.
- However, as the offered load increases beyond certain limit, say 60% of the capacity of the network, the throughput drops.
- If the offered load increases further, a point is reached when not a single packet is delivered to any destination, which is commonly known as deadlock situation

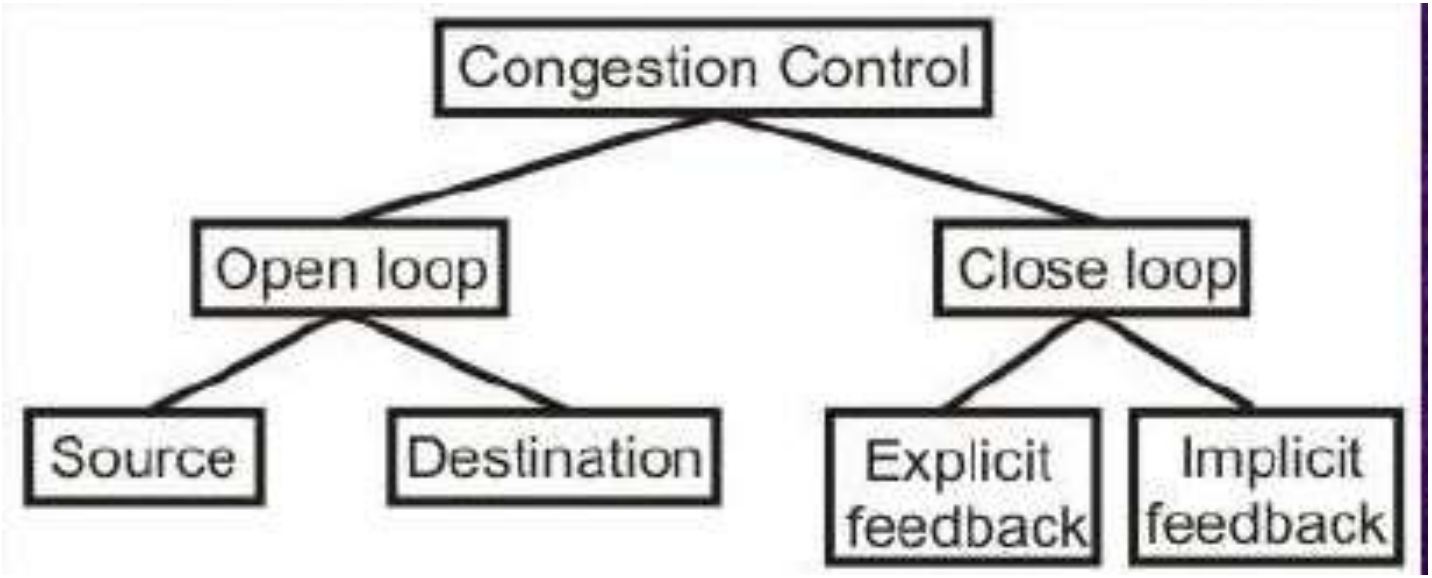
Effects of Congestion

- The ideal one corresponds to the situation when all the packets introduced are delivered to their destination up to the maximum capacity of the network.
- The second one corresponds to the situation when there is no congestion control.
- The third one is the case when some congestion control technique is used. This prevents the throughput collapse, but provides lesser throughput than the ideal condition due to overhead of the congestion control technique



Congestion Control Techniques

- Open loop: Protocols to prevent or avoid congestion, ensuring that the system never enters a Congested State.
- Close loop: Protocols that allow system to enter congested state, detect it, and remove it.



Congestion Control Techniques(CO5)

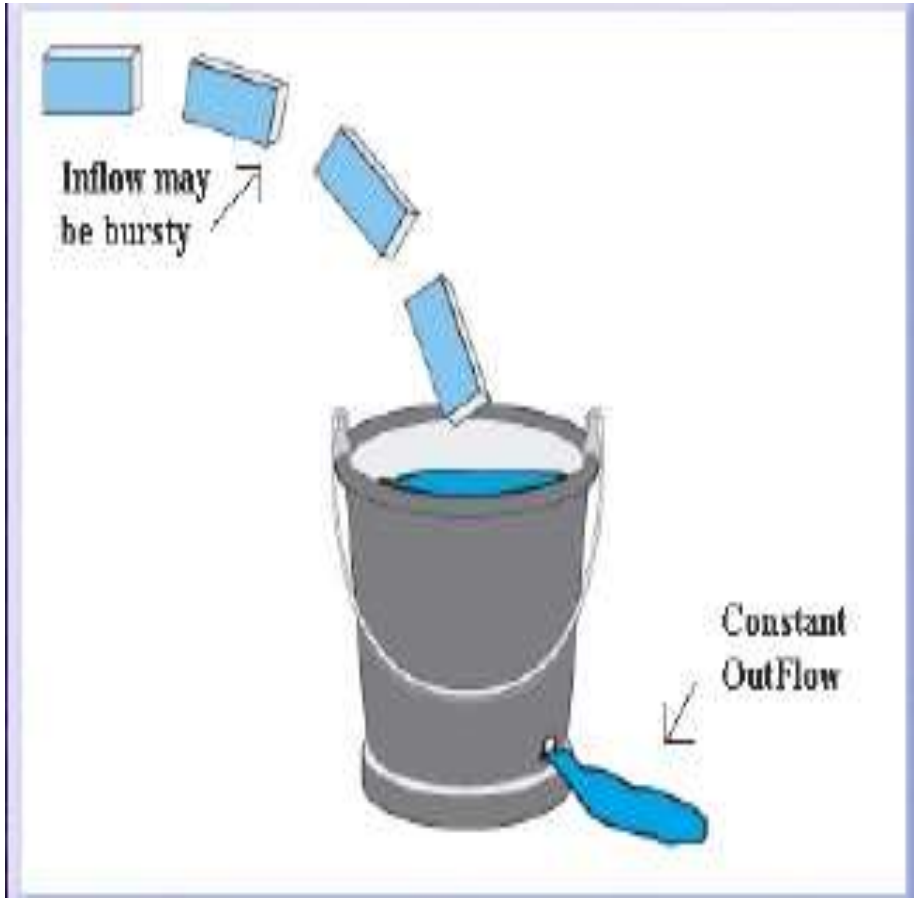
Open Loop Approach

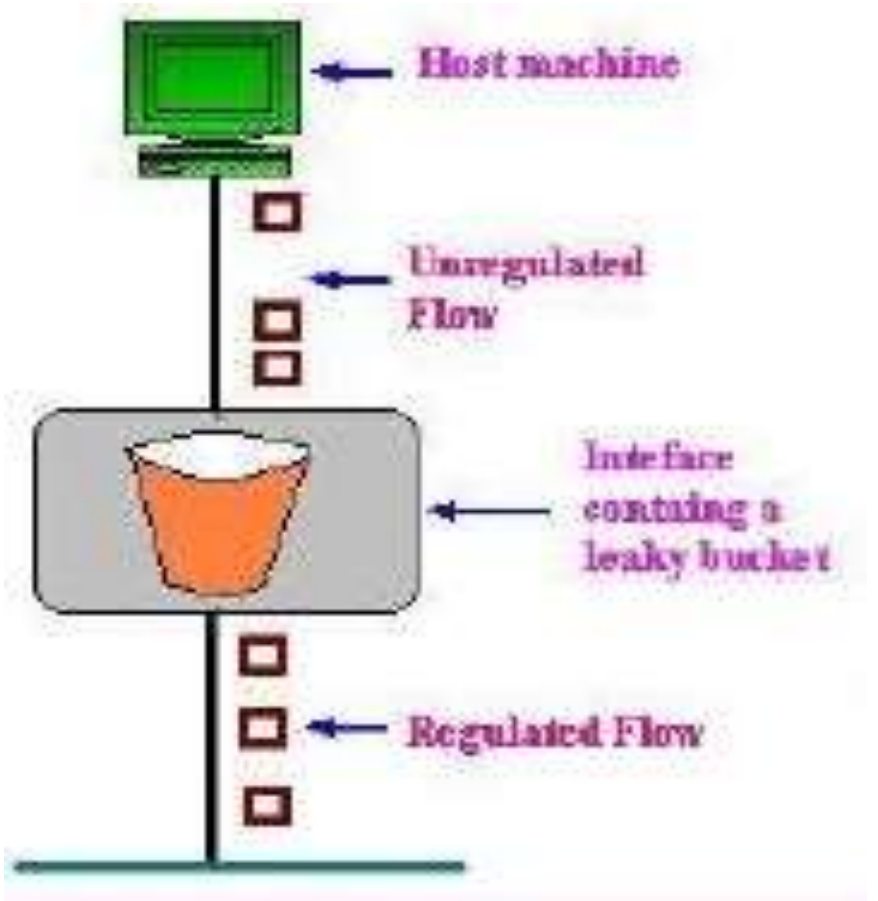
1.Leaky Bucket Algorithm

Consider a Bucket with a small hole at the bottom, whatever may be the rate of water pouring into the bucket, the rate at which water comes out from that small hole is constant. Once the bucket is full, any additional water entering it spills over the sides and is lost . The same idea of leaky bucket is applied to packets. When the host has to send a packet, the packet is thrown into the bucket. The bucket leaks at a constant rate, meaning the network interface transmits packets at a constant rate

Congestion Control Techniques

Leaky Bucket Algorithm





Congestion Control Techniques

Open Loop Approach

2.Token Bucket Algorithm

For many applications it is better to allow the output to speed up somewhat when a larger burst arrives than to loose the data. In this algorithm leaky bucket holds token, generated at regular intervals.

In regular intervals tokens are thrown into the bucket.

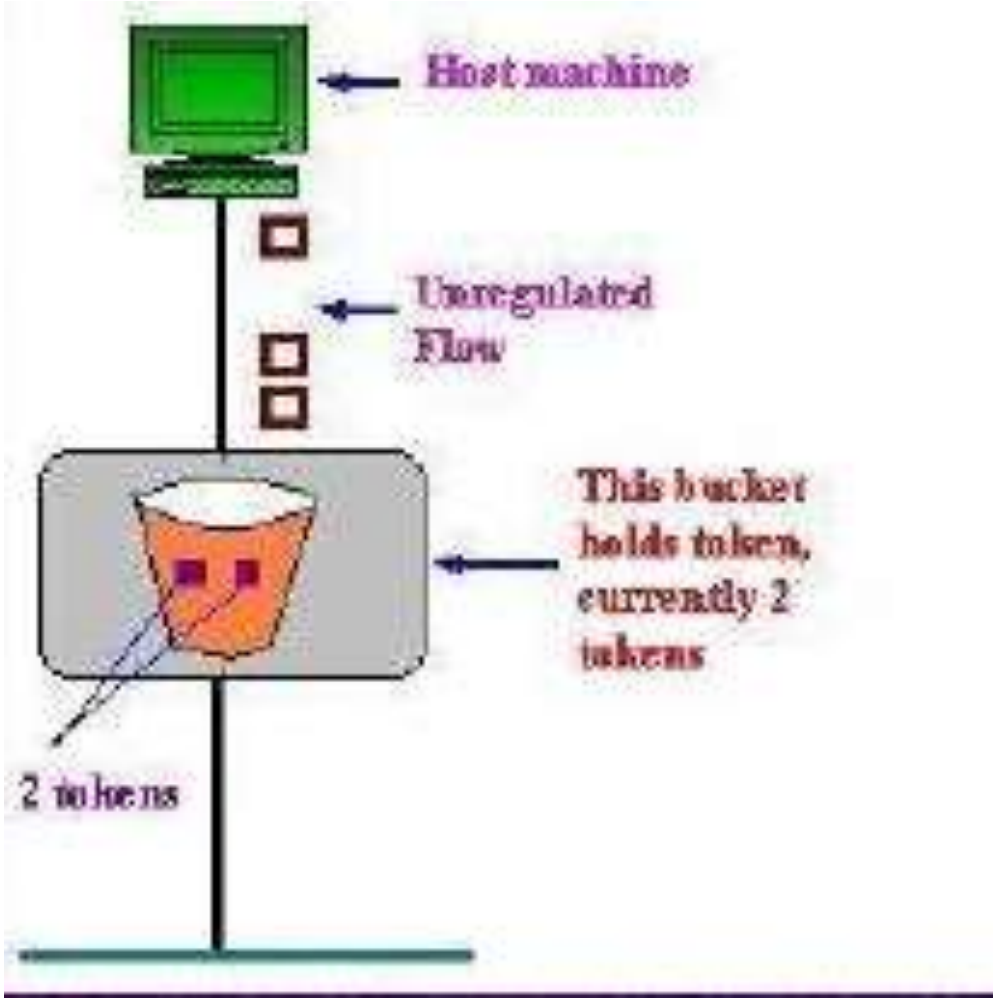
The bucket has a maximum capacity.

If there is a ready packet, a token is removed from the bucket, and the packet is send.

If there is no token in the bucket, the packet cannot be send.

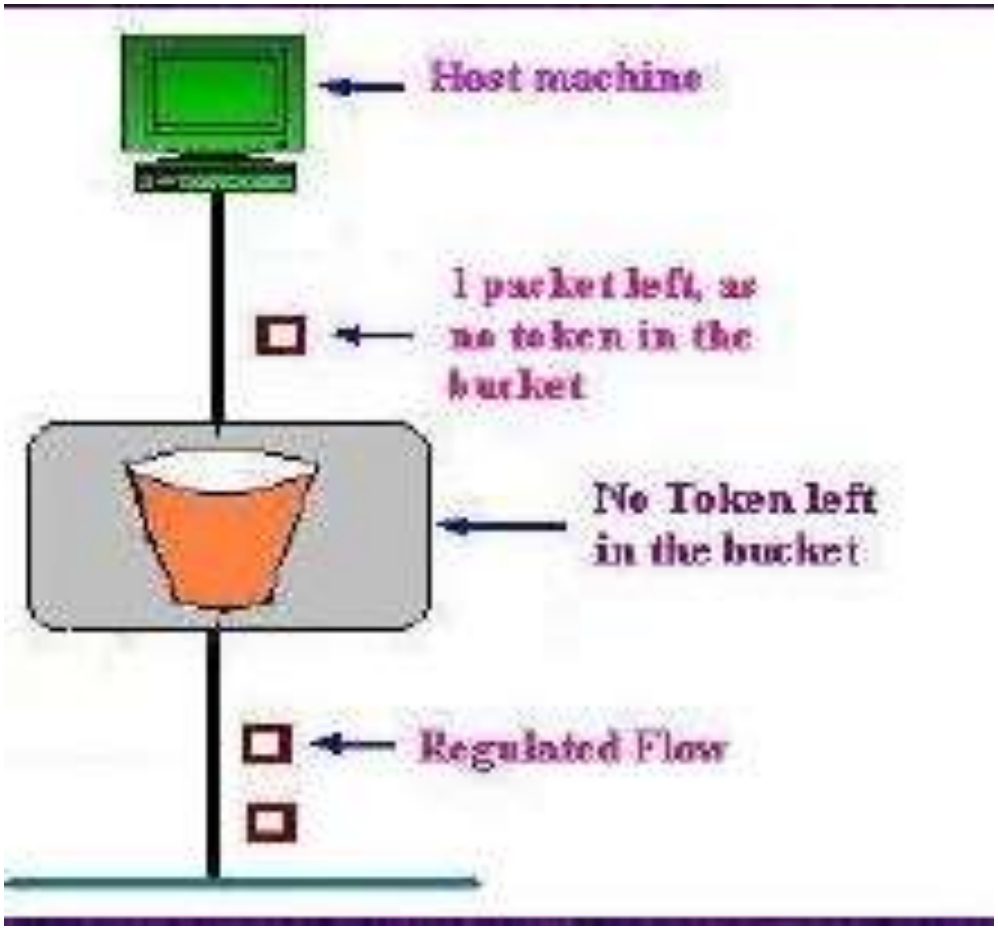
Congestion Control Techniques

Token Bucket Algorithm – a bucket has two tokens and three packets to be delivered



Congestion Control Techniques

Token Bucket Algorithm – after two tokens consumed for two packets and left with one packet to be delivered



Congestion Control Techniques

Congestion control in virtual Circuit

- Admission control is one such closed-loop technique, where action is taken once congestion is detected in the network.
- Simpler one “Do not set-up new connections, once the congestion is signalled. This type of approach is often used in normal telephone networks. When the exchange is overloaded, then no new calls are established. “
- Another approach “To allow new virtual connections, but route these carefully so that none of the congested router (or none of the problem area) is a part of this route”

Congestion Control Techniques

Choke Packet Technique

- Each router monitors its resources and the utilization at each of its output line.
- There is a threshold set by the administrator, and whenever any of the resource utilization crosses this threshold and action is taken to curtail down this.
- For Example, when source A receives a choke packet with destination B at first, it will curtail down the traffic to destination B by 50%, and if again after a fixed duration of time interval it receives the choke packet again for the same destination, it will further curtail down the traffic by 25% more and so on

Congestion Control Techniques

Choke Packet Technique

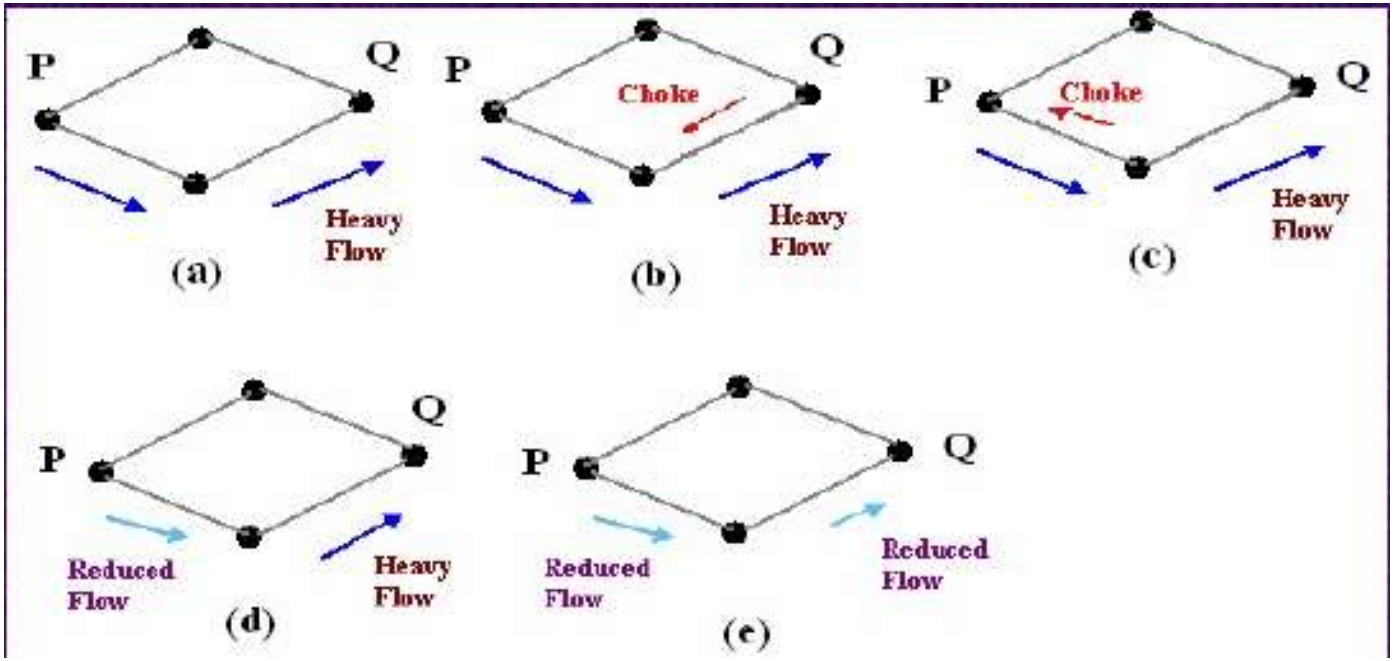
(a) Heavy traffic between nodes P and Q,

(b) Node Q sends the Choke packet to P,

(c) Choke packet reaches P,

(d) P reduces the flow and send a reduced flow out,

(e) Reduced flow reaches node



Congestion Control Techniques

Hop-by-Hop Choke Packets

- This technique is an advancement over Choked packet method.
- At high speed over long distances, sending a packet all the way back to the source doesn't help much, because by the time choke packet reach the source, already a lot of packets destined to the same original destination would be out from the source.
- Hop-by-Hop Choke packets are used.
- the choke packet affects each and every intermediate router through which it passes by.
- Here, as soon as choke packet reaches a router back to its path to the source, it curtails down the traffic between those intermediate routers. intermediate nodes must dedicate few more buffers for the incoming traffic as the outflow through that node will be curtailed down immediately as choke packet arrives it, but the input traffic flow will only be curtailed down when choke packet reaches the node which is before it in the original path.

Congestion Control Techniques

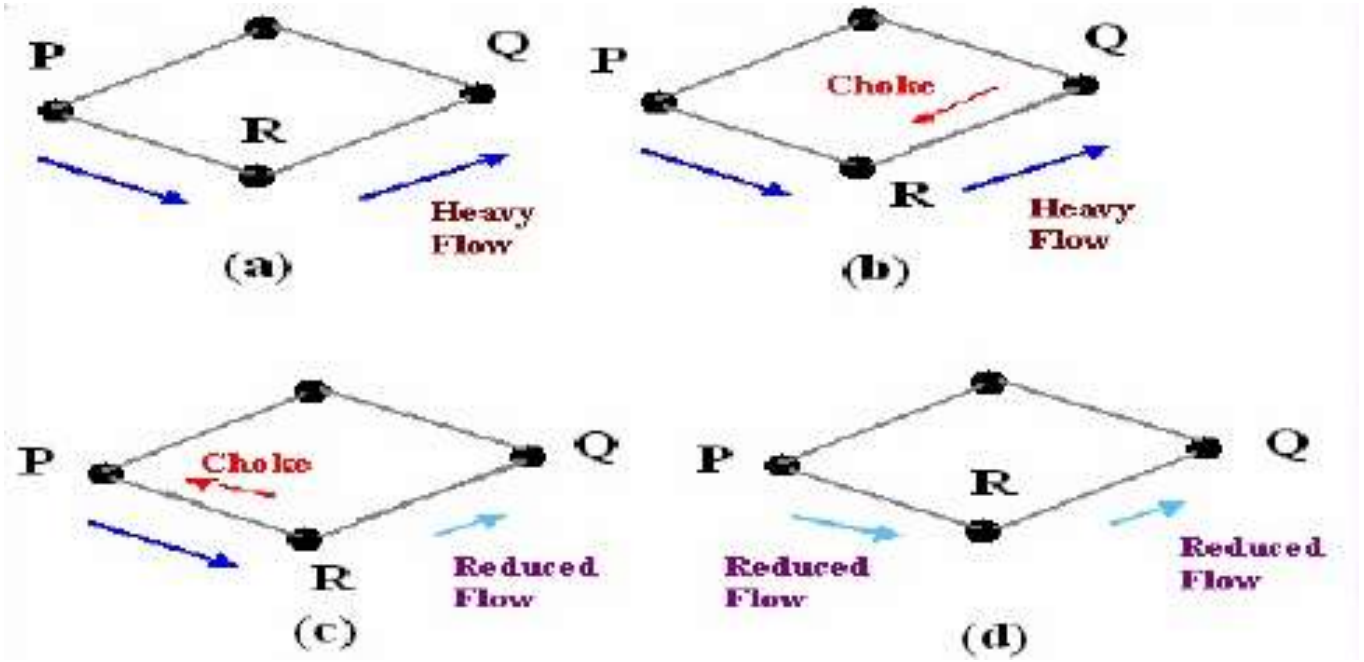
Hop-By-Hop

a) Heavy traffic between nodes P and Q,

(b) Node Q sends the Choke packet to P,

(c) Choke packet reaches R, and the flow between R and Q is curtail down,

(d)Choke packer reaches P, and P reduces the flow out



Congestion Control Techniques

Load Shedding

- one of the simplest and more effective techniques.
- whenever a router finds that there is congestion in the network, it simply starts dropping out the packets.
- There are different methods by which a host can find out which packets to drop.
- choose the packets randomly which has to be dropped.
- For many applications, some packets are more important than others. So, sender can mark the packets in priority classes to indicate how important they are. If such a priority policy is implemented than intermediate nodes can drop packets from the lower priority classes and use the available bandwidth for the more important packets.

Internet as a connectionless protocol(CO3)

- The connectionless network services are also known as datagrams.
- The internet at the network layer works as packet-switched network.
- Internet routes the packets by using universal address defined in the network layer.
- In connectionless service, the network layer protocol operates each packet independently.
- The internet is built from several heterogeneous networks. So, it is not possible to create a connection between the source and destination, before knowing the nature of the network.

Internet as a connectionless protocol(CO3)

Addressing Scheme

- IP addresses are of 4 bytes and consist of :
  i) The network address- network on which the host resides
  ii) The host address - identifies the particular host on the given network
- A fixed size for each of these would lead to wastage or under-usage that is either there will be too many network addresses and few hosts in each
- or there will be very few network addresses and lots of hosts

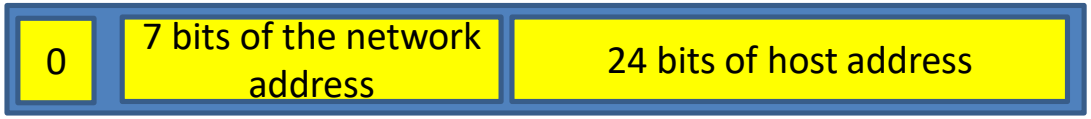
Internet as a connectionless protocol

Addressing

- **Large Networks :** 8-bit network address and 24-bit host address.
- **Medium Networks :** 16-bit network address and 16-bit host address.
- **Small networks :** 24-bit network address and 8-bit host address.

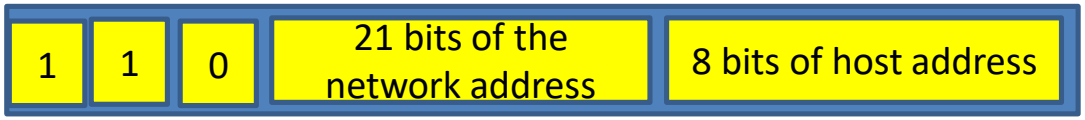
Internet as a connectionless protocol

Class A – For large networks



Class B - For medium networks

Class C - For small networks



Class D - For multi-cast messages (multi-cast to a "group" of networks)

Class E - Currently unused, reserved for potential uses in the future

IPv4(CO3)

- The **Internet Protocol version 4 (IPv4)** is a connectionless protocol which is used for delivery mechanism (used by TCP/ IP protocols).
- The IPv4 is an unreliable protocol, but to make it reliable IPv4 is paired with a reliable protocol such as TCP.
- The IPv4 uses the datagram approach which means, that each datagram is handled independently and each datagram can follow the different route to the destination. Due to this, the datagrams sent from the same source to the same destination can reach at any order while some may get lost.

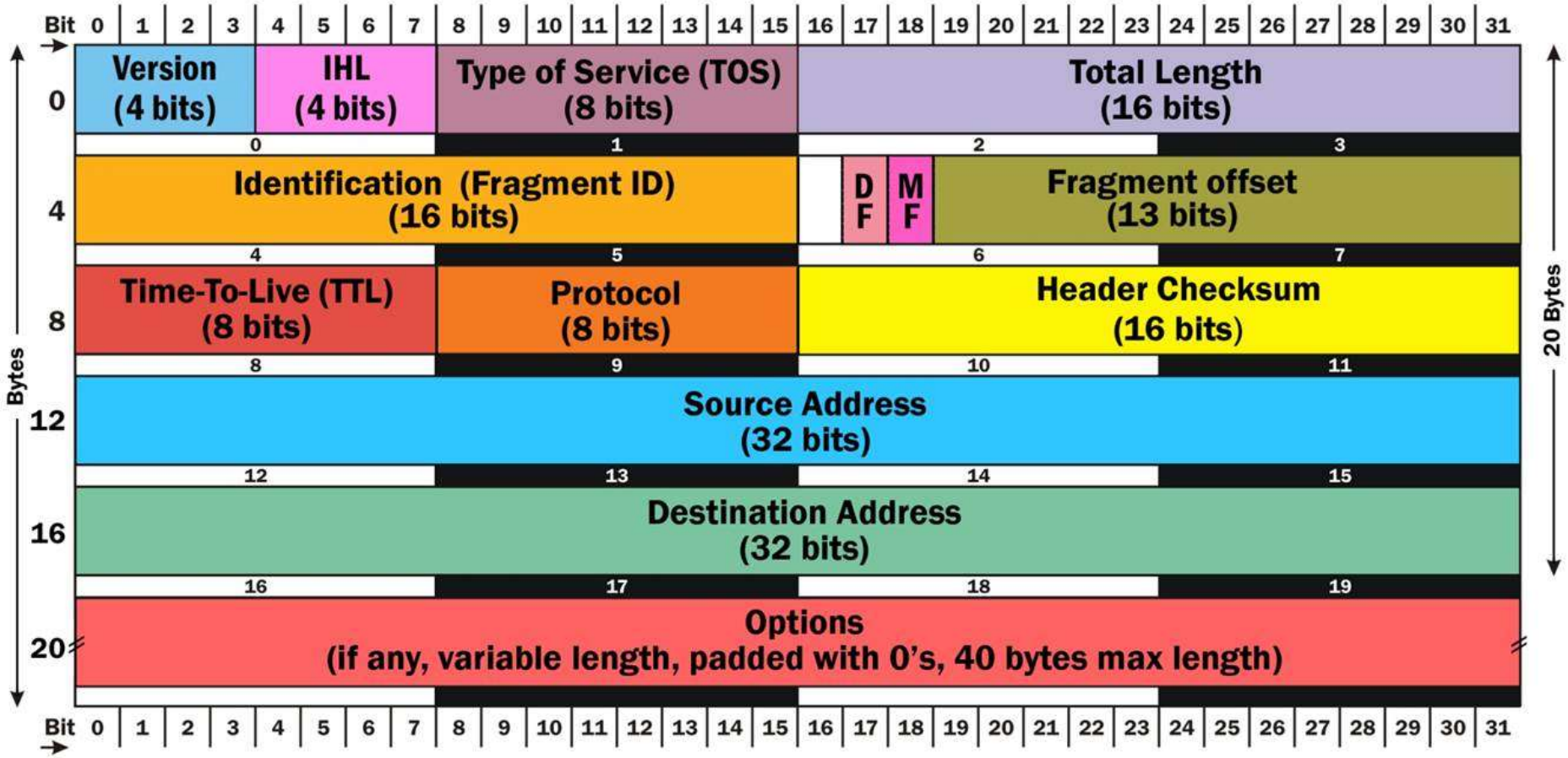
IPv4

- Datagrams
  - Packets in the IPv4 layer are called as datagrams.
  - A datagram is a variable- length packet consists of header and data.
  - The size of header is 20 to 60 bytes, which is essential for routing and delivery.
- Fragmentation
  - The data travels through the different networks. Each router first decapsulates the IPv4 datagram from the received frame, then process it and again encapsulates in the another frame.
  - The format and the size depends on the protocol used by the physical network through which it is going to travel.
- Maximum Transfer Unit
  - When a datagram is encapsulated in a frame, the total size of the datagram should be less than maximum size, which is defined or restricted by the hardware and software used in the network.

IPv4

- **IPv4** - **Packet Structure**. Internet Protocol being a layer-3 protocol (OSI) takes data Segments from layer-4 (Transport) and divides it into **packets**.
- IP **packet** encapsulates data unit received from above layer and add to its own **header** information.
- The encapsulated data is referred to as IP Payload.

IPv4


Bit 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Version (4 bits)
IHL (4 bits)
Type of Service (TOS) (8 bits)
Total Length (16 bits)
Identification (Fragment ID) (16 bits)
DF
MF
Fragment offset (13 bits)
Time-To-Live (TTL) (8 bits)
Protocol (8 bits)
Header Checksum (16 bits)
Source Address (32 bits)
Destination Address (32 bits)
Options (if any, variable length, padded with 0's, 40 bytes max length)
0
4
8
12
16
20
Bytes
20 Bytes

IPv4

- The *Header Length* field (4 bits) indicates how long the header is, in 32 bit "words".
- The *Type of Service* field (8 bits implement a fairly simple QoS (Quality of Service).
- The *Total Length* field (16 bits) contains the total length of the packet, including the packet header, in bytes.
- The *Identification (Fragment ID)* field (16 bits) identifies which fragment of a once larger packet this one is, to help in reassembling the fragmented packet later.
- The next three bits are flags related to fragmentation. The first is reserved and must be zero.

IPv4

- The next bit is the **DF** (Don't Fragment) flag. If DF is set, the packet cannot be fragmented (so if such a packet reaches a part of the network that can't handle one that big, that packet is dropped).
- The third bit is the **MF** (More Fragments) flag. If MF is set, there are more fragments to come. Unfragmented packets of course have the MF flag set to zero.

IPv4

- The *Fragment Offset* field (13 bits) is used in reassembly of fragmented packets. It is measured in 8 byte blocks. The first fragment of a set has an offset of 0.
- If you had a 2500 byte packet, and it was fragmented into chunks of 1000 bytes or less, you would have three fragments as follows:

Fragment ID	MF Flag	Total Length	Data Size	Offset
1	1	1020	1000	0
2	1	1020	1000	125
3	0	520	500	250

IPv4

The *Time To Live (TTL)* field (8 bits) is to prevent packets from being shuttled around indefinitely on a network.

The *Header Checksum* field (16 bits).

The *Source Address* field (32 bits) contains the IPv4 address of the sender

The *Destination Address* field (32 bits) contains the IPv4 address of the recipient

Options (0 to 40 bytes)

IPv4

IPv4 is well designed, but has some shortfalls, which are listed below:

- The real-time audio and video transmission should properly work on the Internet. This type of transmission needs minimum delay strategies and reservation of the resources, which are not provided in IPv4.
- Encryption and authentication facility is not provided in the IPv4.
- Address depletion problem.

Faculty Video Links, Youtube & NPTEL Video Links and Online Courses Details

Youtube/other Video Links

https://www.youtube.com/watch?v=5ZuP5qjbKSI

https://www.youtube.com/watch?v=dINbkkxHY4U

https://www.youtube.com/watch?v=ZYIdYIt7W_g

https://www.youtube.com/watch?v=V4QYffX9v60

Glossary questions

1. Admission control is a _____ technique
2. Network layer provides support for _____communication
3. The service provided by the network layer to the transport layer is called as _____.
4. If the incoming rate of the packets arriving at any router is more than the outgoing rate then _____ occurs
5. _____algorithm was used in the original ARPANET.
6. For Large Networks Addressing _____ bit network address and ____ bit host address are used.
7. The connectionless network services are also known as _____.
8. The internet at the network layer works as _____ network.

Weekly Assignment

1. What is congestion? Give principles of congestion control? CO3
2. Difference between logical and physical address? CO3
3. Name any two congestion control algorithms. CO1
4. In distance vector routing, demonstrate the contents of table with a suitable example CO3
5. Analyze the different methods used to overcome the disadvantage with flooding and explain any one method. CO1
6. When we will go for hierarchical routing? For N router subnet explain the requirements of optimal number of routers. CO3

Weekly Assignment

7. Why there was a need of moving from IPv4 to IPv6? What are the major goals of IPv6 ? CO3

8. With the given IP-address, how will you extract its net-id and host-id? CO3

9. What is unicast routing? Discuss unicast routing protocols. CO3

10. Given the IP address 180.25.21.172 and the subnet mask 255.255.192.0, what is the subnet address ? CO3

MCQ

1. A router is used in the _____layer.

A. Physical
B. Datalink
C. Network
D. Transport

2. IP protocol is the

A. Interconnected protocol
B. Inter-transmission protocol
C. Internet protocol
D. Inter protocol

MCQ

3. What is the minimum header size of IP packet acceptable?

A. 8 bytes
B. 20 bytes
C. 24 bytes
D. 32 bytes

4. Which of the following is a Network support layer?

A. Transport layer
B. Data link layer
C. Session layer
D. Application layer

MCQ

5. Network congestion occurs
A. Router has infinite amount of memory
B. Insufficient memory
C. Slow processors
D. All of the above

6. What is the address size of IPv6
A. 16 bit
B. 32 bit
C. 64 bit
D. 128 bit

MCQ

7. Which of the following is not the design issue of the network layer
A. Reliability
B. Addressing
C. Presentation
D. Routing

8. All routing algorithms goals to design a _____ for all destinations
A. Sink tree
B. Heap
C. Both A & B
D. None

Old Question Papers

- 18-19
- https://drive.google.com/open?id=17OUMNnX0kFDc9UB8tx8qd8zyEj7lCD5P
- 17-18
- https://drive.google.com/open?id=1oFmw__qC7wdUP85gUkKbkohZvd9Vopm_
- 16-17
- https://drive.google.com/open?id=1eDrOkj2wVsxdTZPb7-A78YuYn16HC1ob
- 15-16
- https://drive.google.com/open?id=1ljNxmZP1_pl10rbxJvK6xB1ybG7AMuqU
- 14-15
- https://drive.google.com/open?id=1tjERKPwEA9icWcQTBZQnKUq_ttqBDeo5

Expected Questions for University Exam

- What is meant by fragmentation ? CO4
- Write a note on Leaky bucket algorithm CO5
- What are Unicast and multicast routing algorithms with suitable diagram CO2
- Draw the diagram of IP header and explain the various fields in it CO3
- Compare and contrast IPv4 with IPv6 CO3

Question paper of University Exam

Printed Pages: 02 Sub Code: RCS601

Paper Id: 110262 Roll No.

B.TECH
(SEM-VI) THEORY EXAMINATION 2018-19
COMPUTER NETWORK

Time: 3 Hours ***Total Marks: 70***

Note: 1. Attempt all Sections. If require any missing data; then choose suitably.

SECTION A

1. Attempt *all* questions in brief. 2 x 7 = 14

a. What are header and trailers and how do they get added and removed?

b. A large FDDI ring has 100 stations & a token rotation time of 40msec. The token holding time is 10msec. What is the maximum achievable efficiency of the ring?

c. What is the difference between network layer delivery and the transport layer delivery?

d. If a class B network on the Internet has a subnet mask of 255.255.248.0, what is the maximum number of hosts per subnet?

e. What is count-to-infinity problem?

f. What is the difference between a user agent (UA) and a mail transfer agent (MTA)?

g. What is time-to-live or packet lifetime?

Question paper of University Exam

SECTION B

2. Attempt any *three* of the following: 7 x 3 = 21

a. Define topology and explain the advantage and disadvantage of Bus, Star and Ring topologies.

b. A channel has a bit rate of 20 kbps. The stop and wait protocol with frame size 4500 bits is used. The delay for error detection and sending ACK by the receiver is 0.25 seconds because of a fault. Find the maximum efficiency of the channel if the destination is 30000km away and the speed of the propagation of the signal is $2.8X10^8$ m/s. Find the decrease in efficiency due to the fault.

c. What is unicast routing? Discuss unicast routingprotocols.

d. Explain about the TCP header and working of TCP protocoland differentiate between TCP and UDP with frameformat.

e. (i) How is TFTP different from FTP?
(ii)What three functions can SNMP performto manage network devices?

SECTION C

3. Attempt any *one* part of the following: 7 x 1 = 7

(a) What is OSI Model? Explain the functions; protocols andservices of each layer?

(b) Encode the data-stream 10011010 using the following encoding scheme:
(i) Unipolar
(ii) Bipolar NRZ-L
(iii) Bipolar NRZ-I
(iv) RZ

Question paper of University Exam

(v) Manchestor
(vi) Differential Manchestor
(vii) AMI

4. Attempt any *one* part of the following: 7 x 1 = 7

(a) A slotted ALOHA network transmits 400-bit frames on a shared channel of 400 kbps. What is the throughput if the system (all stations together) produces –
(i) 1000 frames per second
(ii) 500 frames per second
(iii) 250 frames per second

(b) Explain ARQ Error Control technique, in brief.

5. Attempt any *one* part of the following: 7 x 1 = 7

(a) Write advantages of Next-generation IPV6 over IPV4.

(b) The IP network 200.198.160.0 is using subnet mask 255.255.255.224. Design the subnets.

6. Attempt any *one* part of the following: 7 x 1 = 7

(a) The following is the dump of a TCP header in hexa decimal format:
05320017 00000001 00000000 500207FF 00000000
(i) What is the sequence number?
(ii) What is the destination port number?
(iii) What is the acknowledgment number?

Question paper of University Exam

(iv) What is the window size?

(b) What do you understand by Quality of service, parameters? List various Quality of service parameters.

7. Attempt any *one* part of the following: 7 x 1 = 7

(a) (i) How is the BOOTP different from DHCP?
(ii) What is the purpose of the Domain Name System? Discuss the three main divisions of the domain name space.

(b) Write short notes on any two:
(i) SMTP
(ii) TELNET
(iii) HTTP

Summary

- Understanding of Network structure and Architecture.
- The layout of OSI reference model and TCP/IP model.
- Various Network Topology Design used .
- The different Networking.
- Physical Layer and types of Transmission Media.
- Overview of ISDN and Terminal Handling.

Summary

- Understood the concept of Point - to Point Networks,
- The problems related to routing and various algorithms
- Congestion control Internetworking concepts
- IP frame format
- The Use of IP packet and the use of IP address to understand the networking concepts

Text Books

1. Behrouz Forouzan, “Data Communication and Networking”, McGraw Hill

2. Andrew Tanenbaum “Computer Networks”, Prentice Hall.

3. William Stallings, “Data and Computer Communication”, Pearson.

References

1. Forouzen, "Data Communication and Networking", TMH
2. A.S. Tanenbaum, Computer Networks, Pearson Education
3. W. Stallings, Data and Computer Communication, Macmillan Press
4. Gary R.Wright,W.Richard Stevens "TCP/IP Illustrated,Volume2 The Implementation" Addison-Wesley
5. Michael A. Gallo and William M. Hancock "Computer communucation and Networking Technology" Cengage Learning
6. Bhavneet Sidhu, An Integrated approach to Computer Networks, Khanna Publishing House
7. Anuranjan Misra, “Computer Networks”, Acme Learning
8. G. Shanmugarathinam, ”Essential of TCP/ IP”, Firewall Media

Thank You