Birla Institute of Technology & Science, Pilani
Department of Computer Science and Information Systems
First Semester 2017-2018
Advanced Computer Networks (CS G525)
Comprehensive Examination (CLOSE BOOK)

Duration: 3 Hrs **[Pilani & Hyd Campus]** **M.M: 70** **Date: 05/12/2017 (FN)**

Note: There are total 9 questions and all of them are compulsory. Attempt subparts of a question at one place. Be brief, but DO NOT omit necessary detail.

Q. 1 Internet Architecture Design **[2+3+3+2=10M]**

a) Why did the early Internet designers separate IP and TCP into two different protocols?

b) Give appropriate reasons to justify the following argument: "Congestion control is not persuadable to end-to-end implementation."

c) Why IP QoS deployment in the Internet has failed despite of IETF efforts (e.g., DiffServ, IntServ)?

d) Forwarding and routing planes are separated in Name Data Networking (NDN) architecture. What is the benefit of this separation?

Q.2 TCP Congestion Control **[4+3=7M]**

a) Suppose we use AIMD scheme with the same multiplicative decreasing factor (b_D) for both User 1 and User 2, but User 1's additive increasing factor (a_I) is half the additive increasing factor of User 2. Show the resource allocation convergence process with the help of a two phase plot similar to discussed in the class. Calculate the resource allocation convergence fairness value for this algorithm?

b)) In Snoop protocol, Base Station (BS) protects TCP sender (Fixed Host) from wireless losses by dropping duplicate ACKs and performs link layer retransmissions locally. It increases RTT of the connection due to more wireless losses. What is the impact of this on TCP throughput? Suggest one solution for this problem to improve Snoop protocol.

Q.3 IP Routing and Traffic Engineering **[4+4+2=10M]**

Assume that you wanted to design a routing protocol that took into account link loads and traffic costs and automatically adjusted the forwarding paths through the network to achieve Traffic Engineering. Consider the following two approaches to do this:

- Periodically collect the link loads, and tune the IGP link weights according to the objective function
- Periodically collect the link loads, compute the optimal flow assignment, and directly install flow table entries into routers corresponding to those flows.

a) Discuss the benefits and drawbacks to each of these two approaches.

b) The AS topology shown in Fig. 1 has eight ISPs represented by AS numbers AS 1 to AS 8 and six LANs named as A to F. Let's assume all ISPs import and export routes using BGP protocol's economic based policies. When two or more policy compliant path advertisements are received by an ISP, the path received from the least AS number is considered to import in the BGP routing table of that ISP.

Find the AS path followed to send traffic from:

i) C to D ii) A to B iii) F to E iv) B to C

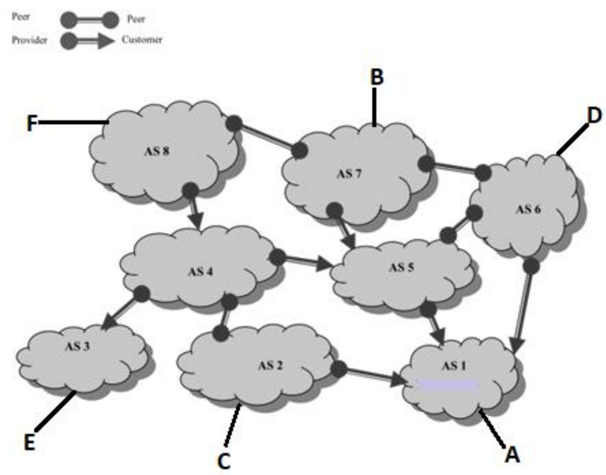

Fig. 1

c) Which of the BGP path attribute can be used by an ISP to route the traffic as per it's traffic engineering requirements and how?

Q.4 MPTCP Congestion Control **[3+3=6M]**

a) Consider an MPTCP implementation where each sub-flow independently increases its congestion window W_i by one packet per ACK received. The sub-flow experiencing the loss decreases its own window size by half. Each of the N sub-flows is using a path with RTT given by RTT_i. Assume each sub-flow receives one ACK per packet.

i) What is the total rate of increase in the sending rate of the MPTCP flow in terms of packets per second?

ii) How do this algorithm's increase and decrease in sending rate compare with regular single flow TCP?

b) Now let us consider a modified MPTCP protocol where each sub-flow increases aggregated congestion window of all N sub-flows (i.e. W_{total}) by one packet per ACK received. with the following algorithm. The sub-flow experiencing the loss decreases its own window size (i.e. W_i) by half.

Does this modified protocol use all paths efficiently and fair to other regular TCP flows? Explain.

Q.5 Overlay Networks **[6+2=8M]**

A web service provider deployed 16 servers (i.e., S_0, S_2, …. , S_{15}) for a web service to fulfill the load requirement. The provider wants to run its service for the clients using Internet Indirection Infrastructure (i3) overlay for balancing traffic load among the servers.

a) Design a Chord Distributed Hash Table (Chord-DHT) based i3 overlay architecture for this problem. Show your design with the help of a labelled diagram. Take suitable assumptions and mention them clearly in your solution like number of i3 server considered, number of bits used for identifiers (i.e., identifier space) etc.

b) How a client request is redirected to a least loaded server in your designed solution? Explain.

Q.6 Software Defined Networking **[3+1+3=7M]**

a) The OpenFlow table shown in Fig. 2 is of a device S1. The switch S1 is located in a network with two other devices S2 connected to port p2 and S3 connected to port p3. What flow rules needs to be added in the OpenFlow table of the S1 such that S1 acts as a switch connecting all devices in the network. Draw the table in your answer book and write the required flow entries.

OpenFlow Table S1							
Switch port	MAC src	MAC dst	IP src	IP dest	TCP sport	TCP dport	Action

Fig. 2

b) Assume switch S1 receives an OSPF routing packet from switch S2. How this packet will be handled by the switch S1?

c) Assume that the routing packet arrived at switch S1 results into a change in the output port for the large number of flows (these flows are sharing same output port). This requires controller to send a separate FLOW_MOD command to the switch for each flow affected by this routing change. Does Openflow provide a way to perform this task in more efficient manner? If yes, explain.

Q.7 Router Queuing Algorithms **[2+2+4=8M]**

Studies advocate that most of the Internet traffic (i.e., 80%) is carried by only small number of connections (i.e., long flows 20%). The remaining large amount of connections (i.e., 80%) carrying small amount of traffic (i.e., short flows 20%). In a fair network environment, short flows expect relatively fast service than long flows.

Answer the following questions based on above mentioned Internet traffic dynamics.

a) How does FIFO+DropTail router handle the above mentioned mix of short and long flows traffic? In particular, comment on transmission rate attained by short and long flows.

b) Why RED queuing algorithm fails to provide fairness (i.e., better transmission rate) to short flows at the bottleneck link? Explain.

c) Suggest a modified RED algorithm to improve transmission rate for short flows at the bottleneck links.

Q.8 Data Center Networks **[3+5=8M]**

The data center topology shown in Fig. 3 have two root switches (i.e., R1, R2) and three leaf switches (i.e., A, B, C). The numbers stated above each link represents the total bandwidth of that link in Gbps. There is a UDP traffic flow of 30 Gbps routed via R1 between switch A and C shown by thick line in the fig.

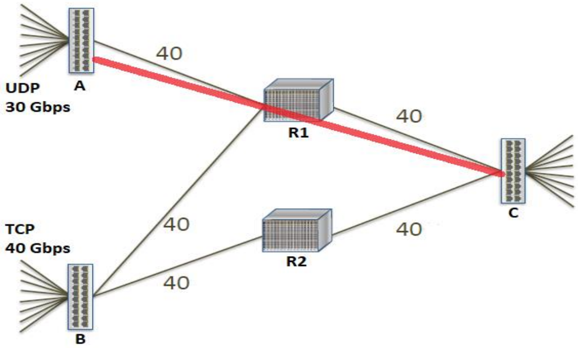

Fig. 3

Let us assume a TCP traffic flow requirement of 40 Gbps is arrived between switch B and C. This traffic flow can be distributed over two equal cost paths available between switch B and C for achieving load balancing.

a) What will be the traffic distribution over these two paths when we use each of the following traffic distribution algorithms?

i) Equal Cost Multipath Routing

ii) Local congestion aware traffic distribution

iii) Global congestion aware traffic distribution

b) Consider the Data Center network fat-tree topology shown in the Fig. 4. The IP addresses are assigned to the devices as per the rules mentioned below:

Core switches: 10.*k.j.i* (i, j from [1, (k/2)])

Aggregation layer switches: 10.*pod.switch.1*

Hosts: 10.*pod.switch.ID* (ID from [2, k/2+1])

Take following assumptions:

Core switches are numbered from 0 to 3 from left to right.

Hosts are numbered 0 to 3 from left to right in each pod

Aggregation layer switches are numbered from 0 to 3 (0 and 1 in bottom layer from left to right, 2 and 3 in upper layer from left to right).

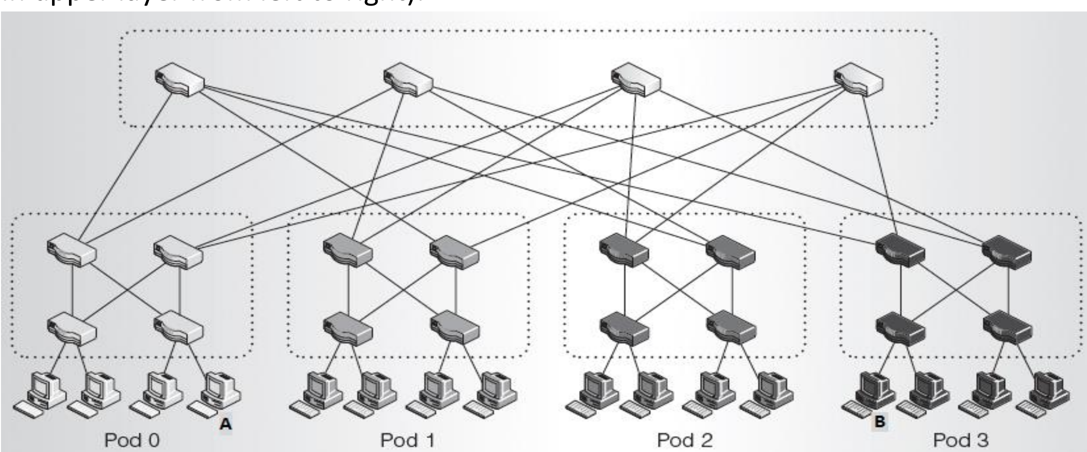

Fig. 4

i) Which path will be followed to send the data from host A to B (marked in the fig) as per the two level routing method discussed in the class? Show the routing table of one of the aggregation layer switches in pod 3 and pod 0. Use your own convention to assign port numbers (0 to 3) to the switch ports.

ii) How this two level routing is different from the traditional subnet based IP routing? Explain with a suitable example.

Q.9 Delay Tolerant Networking **[3+3=6M]**

a) Analyze the Retiring Replicant Congestion Control (RRCC) and Buffer Space Advertisement algorithms for the Buffer space utilization.

b) Describe one application scenario for that Message Ferry based routing protocol is more suitable than replication based protocols.

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