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Question 1

The three main switching fabric architectures are memory-based, bus-based, and interconnection network-based. These switching fabric architectures are used within routers and switches to control how fast and efficiently data packets are transferred from source to destination. These architectures are responsible for a router's throughput, latency, scalability, and efficiency. Memory-based switching utilizes a memory-based system where incoming packets are stored in memory. The switch then reads the packet from memory and forwards it to the output port. An analogy for this architecture would be if there was a pharmacy with one pharmacist. Customers will bring their prescriptions, and the pharmacist will put them into the system. When the pharmacist has time, they will go get the medication and give it to the correct person. Since there is only one pharmacist, the customers must wait in line if it gets too congested. This type of system can be effective in administrative buildings with light network traffic. Bus-based switching is where the input and output are in a shared channel. The input ports can place packets into this channel and the output ports are able to listen and take packets that are meant for them. An analogy for this architecture would be if there was a group chat that only allowed one person to text at a time, the others in the group chat would have to wait and listen. This type of system would be effective in student dormitories as it can handle bursty traffic and if there are not too many users transmitting at the same time. Lastly, interconnection network-based switching is an architecture that utilizes a multi-stage switching fabric to provide parallel paths between input and output ports. It allows multiple packets to be sent at the same time without interference. An analogy for this architecture would be a team using walkie-talkies that use different channels for different conversations. Every person can talk to each other on a different frequency. This type of system would be effective for research labs due to the high-volume transfers.

For a medium sized university, I believe the bus-based architecture would work the best because of its ability to handle bursty data. A solution for Head-Of-Line Blocking to address HOL blocking, a hybrid between priority scheduling and weighted fair queuing could work. Priority scheduling could be used to minimize delays for critical traffic. WFQ on the other hand will allow fair bandwidth to lower priority traffic during peak traffic. In a research article proposed by students from the University of Science and Technology of China, they implemented an approximate WFQ packet scheduling algorithm named SQ-EWFQ which is effective for bursty TCP traffic to address excessive packet drops.

Network neutrality is something to consider when implementing a queuing system. The university must prioritize based on application instead of user. This is allocating bandwidth for the correct requirements. The university must also conduct regular audits to ensure the prioritized applications are prioritized correctly for its purpose. These methods would balance the needs for high throughput, fairness, and low latency for a university campus.

Sources

Chen, Wei, et al. "Enhancing fairness for approximate weighted fair queueing with a single queue." *IEEE/ACM Transactions on Networking*, vol. 32, no. 5, Oct. 2024, pp. 3901–3915, https://doi.org/10.1109/tnet.2024.3399212.

Question 2

The router forwarding simulator for this assignment was to show how packet forwarding works and uses principles such as longest prefix matching, packet scheduling algorithms and having head-of-line blocking detection. Longest prefix matching seems like the standard for packet forwarding as it makes sures that the data is taking a specific available path therefore minimizing latency and maximizing the total throughput. In this simulator, a longer IP address is prioritized over a more general IP address and makes sure that the most precise route is taken. The implementation of the ROUTER_ID was essential to the priority scheduling portion. It allows higher priorities for those who need it for specific operational needs such as administrators or network operators. The use of priority scheduling and weighted fair queuing (WFQ) is to represent the traffic strategies used in enterprise and ISP networks. It is important that these strategies meet the Quality of Service (QoS) standard. This hybrid approach is effective when there is high traffic as it prevents lower-priority traffic from being starved.

Question 3

a) If AS2 wants to implement policy-based routing where it refuses to carry transit traffic between AS1 and AS4 but allows traffic to/from AS3, explain in detail:

    a. What BGP mechanisms would be used to implement this policy

        i. For this, you may want to implement some kind of route or path filtering that filters out the routes between as1 and as4. You may also implement a local preference adjustment which if control is needed, as2 can set a low preference between as1 and as4.

b. How path advertisements would flow through the system

   i. The routes from AS3 can be advertised by AS1 and AS4 allowing full transit. Routes from AS1 and AS4 would have to go to AS3 and cannot do directly to each other.

c. The specific attributes in BGP that would enable this routing policy

   i. The use of AS-Path filtering to block AS1 and AS4, the use of no export, and the preferences.

d. What entries would appear in the forwarding tables of routers in AS2

Destination prefix	Next hop	path	notes
Prefix from as1	as3	As1 as3	allowed
Prefix from as as4	as3	As4 as3	allowed
Prefix from as as3	as1	As3 as1	allowed
Prefix from as as3	as4	As3 as4	allowed
Prefix from as as1	blocked		No trasit
Prefix from as as4	blocked		No transit

b) AS2 decision implement policy-based routing where it refuses to carry transit traffic between AS1 and AS4 will cause the users in AS1 and AS4 to experience delays, packet loss, and other service disruptions. In this case, Network Neutrality should apply here as they are selectively blocking traffic which violates the network neutrality principles.

border routers AS1

destination	next	AS path
AS3	A2r1	1a2b3c
AS4	blocked	N/A
AS2	A2r1	1a2b

border router in AS2

AS1	A1r1	2b1a
AS3	A3r1	2b3c
AS4	A4r1	2b4c

border router in AS4

AS3	A2r1	4c2b3c
AS1	blocked	N/A
AS2	A2r1	4c2b

c)

d)