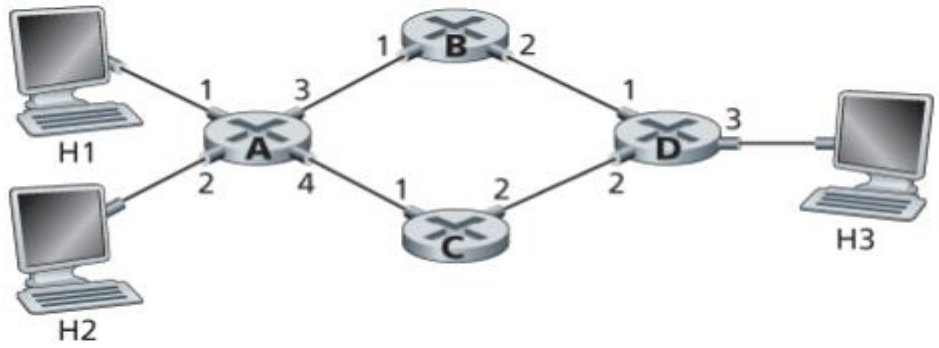
P1. Consider the network below.

a. Show the forwarding table in router A, such that all traffic destined to host H3 is forwarded through interface 3.

b. Can you write down a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4? (Hint: This is a trick question.)



Solution:

a) To forward all datagrams destined to host H3 via interface 3, the forward table of router A should have an entry such as Destination Address: H3, Link Interface: 3.

b) No, because forwarding rule is only based on destination address not source address.

P5. Consider a datagram network using 32-bit host addresses. Suppose a router has four links, numbered 0 through 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Link Interface
11100000 00000000 00000000 00000000 through 11100000 00000000 11111111 11111111	0
11100000 00000001 00000000 00000000 through 11100000 00000001 11111111 11111111	1
11100000 00000010 00000000 00000000 through 11100001 11111111 11111111 11111111	2
otherwise	3

a. Provide a forwarding table that has five entries, uses longest prefix matching, and forwards packets to the correct link interfaces.

b. Describe how your forwarding table determines the appropriate link interface for datagrams with destination addresses:

11111000 10010001 01010001 01010101

11100000 00000000 11000011 00111100

11100001 10000000 00010001 01110111

Solution:

a) The prefix to represent the first range of addresses is 11100000 00000000 while the one for the second range is 11100000 0000001. The third range would be represented by the prefix 1110000 since it includes the remaining addresses in the range between 11100000 00000000 00000000 00000000 and 11100001 11111111 11111111 11111111. Note that the addresses belonging to the first or second prefix will be sent over link 0 or 1 even though they are included into the third entry by the longest prefix matching algorithm.

Even though the four entries with "otherwise" are sufficient to forward datagrams to appropriate links as required in the problem statement, since the problem asks five entries the fifth entry would be any prefix that is not overlapped with the previous three entries, for example like 1110001. Finally the forward table would be like the below.

Prefix Match	**Link Interface**
11100000 00000000	**0**
11100000 00000001	**1**
1110000	**2**
1110001	**3**
otherwise	**3**

b)

1) Since no prefixes in the forward table are matched, this datagram would be forwarded over li nk interface 3.

2) Since the first entry is the longest prefix matching with this address, this datagram would be s ent over link interface 0.

3) Since the third entry is the longest prefix matching with this address, this datagram would be delivered over link interface 2.

P14. Consider sending a 1600-byte datagram into a link that has an MTU of 500 bytes. Suppose the original datagram is stamped with the identification number 291. How many fragments are generated? What are the values in the various fields in the IP datagram(s) generated related to fragmentation?

Solution:

The maximum size of payload in each fragment = 480 (because there are 20 bytes IP he ader). Thus the number of required fragments = $\left\lceil \frac{1600-20}{480} \right\rceil =$

4 where ⌈ ⌉is a ceiling operator. Each fragment will have identification number 291. E ach fragment except the last one will be of size 500 bytes (including IP header). The las t datagram will be of size 160 bytes (including IP header). The offsets of the 4 fragment s will be 0, 60, 120, and 180. Each of the first 3 fragments will have flag=1; the last fra gment will have flag=0.

P20. Consider again the SDN OpenFlow network shown in Figure 4.30. Suppose that the desired forwarding behavior for datagrams arriving from hosts h3 or h4 at s2 is as follows:

- any datagrams arriving from host h3 and destined for h1, h2, h5 or h6 should be forwarded in a clockwise direction in the network;
- any datagrams arriving from host h4 and destined for h1, h2, h5 or h6 should be forwarded in a counter-clockwise direction in the network.

Specify the flow table entries in s2 that implement this forwarding behavior.

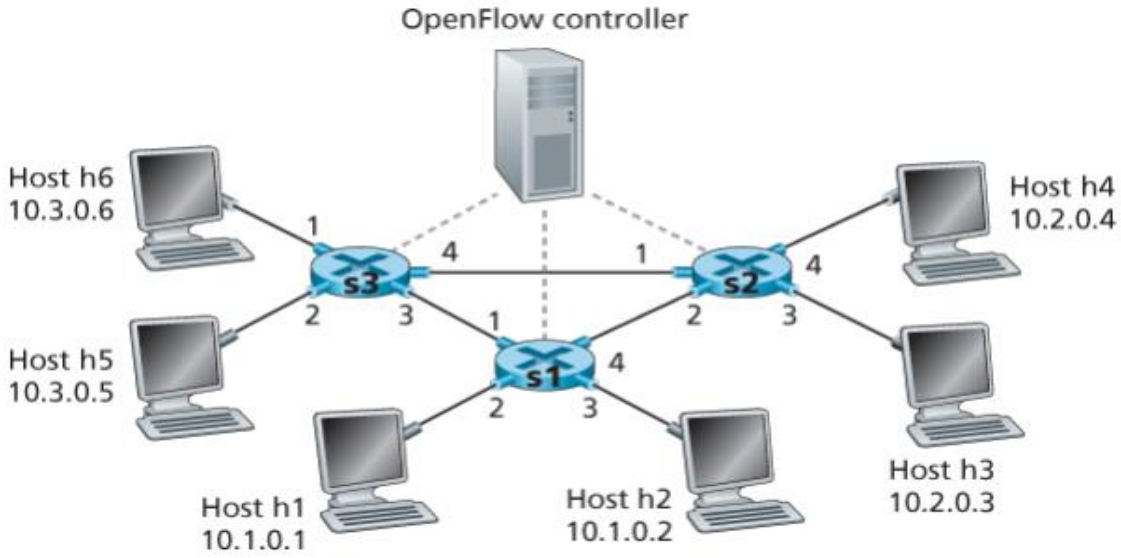


Figure 4.30 OpenFlow match-plus-action network with three packet switches, 6 hosts, and an OpenFlow controller

Solution:

S2 Flow Table	
Match	**Action**
Ingress Port = 3; IP Dst = 10.1.*.*	**Forward (2)**
Ingress Port = 3; IP Dst = 10.3.*.*	**Forward (2)**
Ingress Port = 4; IP Dst = 10.1.*.*	**Forward (1)**
Ingress Port = 4; IP Dst = 10.3.*.*	**Forward (1)**