

1.

- a) The network layer can be decomposed into two interacting parts: the data plane and the control plane.
- b) The most important function that is implemented in the data plane is determining how datagrams arriving on a routers input links are forwarded to one of the routers output links.
- c) A router's forwarding table is configured by examining and using certain header values for packets to index these values into its forwarding table. The values stored in the table indicating the output link that a packet should be forwarded to.
- d) The internet's network layer provides a single service known as best-effort service. With this service, packets are neither guaranteed to be received in the order sent, nor is their delivery even guaranteed. There is also no guarantee on end-to-end delay nor is there minimal bandwidth guaranteed.
- e) The switch fabric connects the routers input ports to its output ports. It is essentially a network inside of a network router.
- f) The longest prefix matching rule helps the router find the longest matching entry in the table and forwards the packet to the link interface associated with the longest prefix match.
- g) The three switching techniques are switching via memory, via bus and via an interconnection network.
- h) Packets are typically dropped at a router when its memory is exhausted and can no longer store arriving packets in a queue.
- i) Priority queueing is classifying arriving packets into high or low priority classes. Two types of network traffic where one type could be deemed to have priority over the other would be packets carrying network management information, or real-time voice-over-IP packets receiving priority over non-real traffic like SMTP email packets.
- j) Work conserving queueing never allows the link to remain idle whenever there are packets, regardless of class, queued for transmission.

2.

- a) The two versions of IP in use today are IPv4 and IPv6.
- b) Assuming no options, if an IP datagram carries a TCP segment the header is 40 bytes.
- c) MTU stands for maximum transmission unit. The MTU places a hard limit on the length of an IP datagram. This is because each IP datagram is encapsulated within the link-layer frame for transport from one router to another.

- d) IP fragments datagrams because different link-layer protocols can have different MTUs. This can be a problem when a router receives a datagram from one link. The link that it needs to be forwarded to has a smaller MTU than the size of the IP datagram.
- e) The x bits in a CIDR address are network portion of the IP address and are called the prefix of the address.
- f) Before CIDR, the addressing scheme known as classful addressing was used; classful addressing limited the network portions of IP addresses to fixed lengths.
- g) IP addresses are managed by the Internet Corporation for Assigned Names and Numbers (ICANN). ICANN not only allocates IP addresses but they also managed the DNS root servers.
- h) DHCP stands for Dynamic Host Configuration Protocol.
- i) DHCP is often referred to as a plug-and-play or zeroconf protocol.
- j) A NAT translation table uses port numbers as well as IP addresses.

3.

- a) The goal of a routing algorithm is to determine good paths from senders to receivers.
- b) Algorithms with global state information are often referred to as link-state algorithms.
- c) A distance-vector algorithm is classified as a decentralized routing algorithm.
- d) A feasible solution to avoid oscillations would be to ensure that not all routers run the LS algorithm at the same time. This can be achieved by requiring each router to randomize the time it sends out a link advertisement.
- e) An autonomous system is a group of routers that are under the same administrative control.
- f) The OSPF protocol uses Dijkstra's algorithm.
- g) All AS's run the Border Gateway Protocol (BGP).
- h) BGP is an important protocol because it glues together the thousands of ISPs in the internet.
- i) For BGP the best router will be determined based on policy.
- j) IP-Anycast helps the DNS system direct DNS queries to the closest root DNS server.

4)

R1) The name of a network-layer packet is datagram. The fundamental difference between a router and a link-layer switch is that a router bases its forwarding decision on

header field values in the network-layer datagram, while link-layer switches base their forwarding decisions based on values in the fields of the link-layer frame.

R4) The role of the forwarding table in a router is to store certain header values to indicate the outgoing link interface that packets with those header values are to be forwarded to.

5)

R18) The hop limit field in the IPv6 header can be used to ensure that a packet is forwarded through no more than N routers.

R28) A “plug-and-play” or “zeroconf” protocol is a protocol with the ability to automate the network-related aspects of connecting a host into a network. This means that a network administrator does not have to manually configure these tasks.

6)

(P1) a)

router A

header	Output
H3	3
H1	1
H2	2
—	4

b) No, because the forwarding table does not take into account the sender, only the destination.

7)

(P7)

Destination Address Range	Link interface
[1100 0000, 1101 1111]	0
[1000 0000, 1011 1111]	1
[1110 0000, 1111 1111]	2
[0000 0000, 0111 1111]	3

8)

R8) False. With OSPF, a router broadcasts its routing information to all other routers in the autonomous system. The router broadcasts link-state information whenever there is a change in a link's state and periodically, regardless if anything has changed. This is done because the periodic updating of link state advertisements adds robustness to the link state algorithm.

9)

$x \Rightarrow z: \{x, z\}$
 $x \Rightarrow y: \{x, y\}$
 $x \Rightarrow v: \{x, v\}$
 $x \Rightarrow w: \{x, w\}$
 $x \Rightarrow t: \{x, v, t\}$
 $x \Rightarrow u: \{x, v, u\}$

10)

a)

b) Hello packets are sent to each functioning router interfaces and are used to discover and maintain neighbor relationships. Items contained in the packet include the interval between Hello packets sent out the interface as well as indicators for how often a neighbor must be heard from to remain active.