1. Summary… (10)

1A. Questions on reading assignments:

- In order to achieve interconnection across networks, IP makes certain assumptions about individual networks. What are these assumptions ? (Cerf-Kahn/Clark papers) (4)

Ans.
- Each network may have distinct ways of addressing
- Each network may accept data of different maximum size
- The success or failure of a transmission and its performance in each network is governed by different time delays in accepting, delivering, and transporting the data.
- Within each network, communication may be disrupted due to unrecoverable mutation of the data or missing data
- Status information, routing, fault detection, and isolation are typically different in each network.

Therefore,
- A common protocol is to be used between host's or processes in different networks and the interface between networks should take as small a role as possible in this protocol.
- The interface(gateway) between networks must play a central role in interconnection strategy that is routing data.
- Address information must be available in a standard format in every packet which arrives at the gateway.
- Network can transport a packet of reasonable size and a gateway may split a packet into two or more.

- Give 3 examples and clearly articulate why the end-to-end argument works in those examples (End-to-end paper) (4)

Ans.
Careful file transfer: The application program is required to perform the transfer must supply a file-transfer-specific, end-to-end reliability guarantee – a checksum to detect failures and a retry-commit plan. The data communication system's extraordinarily high reliability does not reduce the burden on the application program to ensure reliability.

Delivery guarantees: For the application, what is more important is whether or not the target host acted on the message than whether or not the message was delivered to the host. For this reason, the acknowledgment desired is an end-to-end one.

Secure Transmission of Data: The application end-to-end encryption obtains its required authentication check (the application level authentication check) and can handle key management to its satisfaction, and the data are never exposed outside the application.

Other examples:
Duplicate Message Suppression
Guaranteeing FIFO Message Deliver

Transaction Management

- Give four good reasons why the end-to-end argument is a good idea (do not cite examples – give general reasons). (End-to-end paper/Clark paper) (4)

Ans.

End-to-End saves the same functionality (e.g. reliability) from being provided redundantly

End-to-End makes the network functionality as simple as possible

End-to-End provides the application-level reliability

End-to-End enables communication to be more secure

Etc.

- Clark outlines an ordered list of goals (fundamental and second level goals), which was critical for the success and growth of the Internet. Consider any reordering or elimination of some of these goals, and suggest what implications it would have had on the design of the Internet. (4)

Ans.

Critical points:

Developing an effective technique for multiplexed utilization of existing interconnected networks

- A packet switched communication facility in which a number of distinguishable networks are connected together using packet communications processors called gateways which implement a store and forward packet forwarding algorithm

Continuing to supply communication service despite loss of networks or gateways (Survivability)

- The state information is gathered and stored at the endpoint of the net, at the entity which is utilizing the service of the network, not in the intermediate packet switching nodes of the network.

Supporting a variety of types of service at the transport service level.

- The datagram building block (“best effort”, IP)

Incorporating and utilizing a wide variety of networks (flexibility)

- A minimum set of assumptions about the function which the net will provide, such as transporting a packet or datagram of reasonable size without perfect reliability and having some suitable form of addressing.

Reordering:

If the accountability had been put as a first goal of the list, an architecture would have been much more suitable for commercial deployment. Similarly, the cost effectiveness would have been ranked higher for a commercial Internet architecture.

- Clark differentiates between services and building blocks. Explain this difference with an example. What does this say about building blocks which are used to support a wide variety of services ? (4)

Ans.
"Services" are corresponding to the transport layer protocol (e.g. TCP) while "Building blocks" are referred to as the network layer protocol (e.g. IP) which "Services" could be built upon. Clark says that a basic building block is needed and that should be the datagram in order to support a variety of types of services.

2. ***Addressing***:

- Analyze and comment on the structure of the following two MAC addresses:
  80:01:47:00:04:00 (3)
  40:01:54:00:00:01 (3)

Ans**.**

80:01:47:00:04:00
1000 0000 ... : G/L 1(Global) G/I 0(Unicast)

40: 01:54:00:00:01
0100 0000 …: G/L 0(Local) G/I 1(Multicast)

>>> According to different bit transmit order and IEEE standard,

80:01:47:00:04:00
|------OUI (Originally Unique ID)----|
0000 0001 : 1000 0000 : 1110 0010 : 0000 0000 : 0100 0000 : 0000 0000
|
Unicast

40:01:54:00:00:01
|-------OUI (Originally Unique ID)--|
0000 0010 : 1000 0000 : 0010 1010 : 0000 0000 : 0000 0000 : 1000 0000
|
Unicast

Ref) http://www.csci.csusb.edu/doc/mit_ethernet_numbers.txt
http://standards.ieee.org/regauth/oui/tutorials/lanman.html

- What are the network number, subnet number and host number for addresses 135.104.128.100, mask 255.255.192.0? Which class does this address belong to? (8)

Ans.

135.104.128.100/255.255.192.0

```
    |--network number--|    |-s-|    |----host number-----|
10  000111  .  01101000  .   10      000000  .  01100100
```

The first 2 bits: 10 → class B address (2)
Network number: 000111.01101000 (14bits) (2)
Subnet number: 10 (2bits) (2)
Host number: 000000.01100100 (13bits) (2)

- Why does the telephone network not have names and address resolution protocols like ARP? (7)

Ans.

The telephone network is a point-to-point network, which doesn't need ARP since there is no need of address mapping. The telephone network has only one level of (variable length) addresses.

- An organization has been assigned the network number 140.25.0.0 and it needs to create a set of subnets that supports upto 25 hosts on each subnet.
  A) What is a subnet mask you would use to do this ? (3)
  B) How many such subnets are possible ? (3)
  C) Given that you have 25 hosts on each subnet, how much of the address space is being wasted ? (3)

Ans.

A) To support 25 hosts, 255.255.225.224 should be used as a subnet mask.

B) 2046(=2048-2) subnets are possible.

C) Given the address space (00001 ~ 11110), the maximum number of hosts supported is 30. Therefore 5(=30-25) of the address space are wasted in each subnet.

3. ***Internetworking*** has two fundamental problems: ***heterogeneity and scaling.***

- Explain briefly how the IP addressing allows performance scaling ? Explain why bridges failed to solve the scaling problem without this mechanism. (6)

Ans.
IP splits its address into multiple parts such as network id, host id and subnet id. That is what is called '***hierarchical addressing***'. This address mechanism allows the interconnected networks to transfer (or route) IP packets more efficiently by using ***forwarding/filtering***. As a result, more efficiency enables the network scale.
On the contrary, bridges have functionality of forwarding and limited filtering, which connects collision domains. The limited filtering does not allow the network to scale.

- The split of address into a prefix and host part has a price: it introduces address allocation, configuration and mapping issues. List and briefly explain at least two issues related to each topic: address allocation, configuration, and address mapping issues. (9)

Ans.
Address allocation issues (3)
- Internal fragmentation which refers to wastage within an allocated block, due to the lack of effective use.
- External fragmentation which refers to wastage after blocks have been allocated, due to the different demand of address allocation.

Configuration issues (3)

- Variable subnet mask configuration
- Static splitting of the address space can cause the packets to take a non-optimal path to the destination.
- Arbitrary partitioning of the address space into two parts could mean that the route tables could be arbitrarily large. So we need additional management to ensure that the address space is manageable.
- Network migration or host mobility requires renumbering network ids.

Mapping issues (3)
- In overlay networks such as IP over ATM, the resolution that is the function of mapping one address or name to the other is a complex and fundamental internetworking problem.
- Several techniques are needed for resolution, such as snooping, table-based resolution, closed-form computation-based resolution and server-based resolution.

- Describe briefly the concepts introduced by IP to solve the heterogeneity problem.

Ans. (5)

The heterogeneity problem is caused by many different network protocols used in different networks. ***IP is an overlay model*** which all different networks are mapped to. Consequently, a common overlay protocol, IP, makes internetworking and hop-by-hop forwarding possible.

4. Concepts/Design/Performance:

- Describe the following concepts briefly: a "packet", "packet switching", "multiplexing", "statistical multiplexing". (6)

Ans.
Packet: The unit of data passed between IP and the network interface (e.g. IP datagram) (1)
Packet switching: A store-and-forward type transmission of packets with meta-data (header) (1)
Multiplexing: Sharing resources in the cost effective way. (2)
Statistical multiplexing: Sharing resources (or reducing resource requirements) with statistical knowledge of the system. (2)

- Why is packet switching fundamentally more efficient than circuit switching ? (6)

Ans.
While circuit switching could waste reserved resources if unused, packet switching has little chance of wasting resources since resources are shared in the way of multiplexing. Therefore, packet switching is more cost efficient than circuit switching.

- My program runs on a machine in 100s. Multiplication instructions are = 60% of the program. Designer M can improve speedup of multiply operations. I would like my program to run four times faster? How much speedup of multiply instructions should M achieve to allow me to reach my overall speedup goal? (8)

Ans.
Running time: 100s → 25s (4 times faster)
Performance affected by improvement: Multiplication (60%) = 60s
Performance unaffected: 40s

Using Amdahl's law, (2)

25 = 60/speed-up + 40 (4)

No solution for speed-up. (2)
It is impossible to run 4 times faster.