Q1: You are given a list of possible answers below. Select the most appropriate answer **(a-nn)** and fill in the blank for each of the questions. **[20 marks]**

a) CD	b) Requires complex storage and retrieval mechanisms of data
c) Decentralization and scalability	d) Inaccessibility due to IP address changes
e) Dynamic web page generation	f) By measuring time to each router for delay insights
g) Store user preferences for personalization	h) Upgrading the access link
i) MX record	j) Rc, Rs, R/N (N is the number of connections)
k) User tracking across websites	l) The TCP connection is closed
m) Data corruption leads to out-of-order packets	n) Simplifies complex network device design
o) CNAME record	p) Frequent database updates causes bottlenecks
q) Complexity in decentralized security and privacy	r) To associate a domain name with an IP range
s) Minimizing latency	t) By pinging destination server for latency measurement
u) PTR Record	v) Calculate distance between source and destination
w) R, router count, bandwidth calculation	x) By sending packets with increasing TTL values
y) Improved performance	z) Routing variations lead to arrival time differences
aa) Store all domain name and IP mappings	bb) Devices from different manufacturers can communicate seamlessly
cc) Manually configure device settings	dd) To direct queries to appropriate TLD servers
ee) Client waits for server initiation	ff) Enables modularity and specialization
gg) Stores domain ownership information	hh) GET
ii) Edge connects users, core handles high-speed data	jj) Maping a hostname to another hostname
kk) Reliance on a single server	ll) Videos

mm) Multiple users have varying bandwidth needs	nn) End to End

Note: Multiple answers and crossing/overwriting will result in zero (0) marks.

S.No.	Question	Answer
1.	What is the primary difference between the network "edge" and the network "core"?	ii
2.	Assuming a reliable connection, why is the order in which packets arrive at their destination potentially different from the order they were sent?	z
3.	Why might a network administrator choose packet switching over circuit switching?	mm
4.	What does the term "interoperability" imply in the context of network protocols?	bb
5.	What would be the “best” reason for layers being important in networking?	ff
6.	How does traceroute accomplish measurement of “real” internet delays?	x
7.	The per-connection throughput is limited by the minimum of three factors. What are these three factors?	j
8.	How does the traceroute program “help” in understanding network delays?	f
9.	What is a key characteristic of peer-to-peer (P2P) architecture compared to traditional client-server models?	c
10.	What is one significant challenge associated with managing peer-to-peer (P2P) networks?	q
11.	What is the “primary” purpose of an HTTP cookie?	g
12.	In a non-persistent HTTP connection, what happens after a client sends a request and receives a response?	l
13.	Which statement best describes the challenge of maintaining state in a stateless protocol like HTTP?	b
14.	Which of the following web content types is LEAST likely to benefit from caching?	e
15.	What FTP command is used to retrieve a file from a remote server?	hh
16.	Which solution would be more suitable for an institution with a large number of users accessing frequently updated content?	h

17.	What type of DNS record is used to specify the mail server for a domain?	i
18.	What is the primary function of the root servers in the DNS hierarchy?	dd
19.	What is the purpose of CNAME records in DNS?	jj
20.	What is a potential consequence of outdated DNS cache entries?	d

Q2: [10 marks]

You are using a computer system at FAST NUCES Islamabad lab to access your university email through the webmail interface at mail.nu.edu.pk. The email system involves various protocols and services. Users can send and receive emails, synchronize across devices, and handle large attachments through this system. You are tasked to understand the scenario and answer how all these components interact to provide seamless email service.

i. When you type http://mail.nu.edu.pk/ into the browser, what would be the first application layer protocol that would be used to handle your request?

DNS is the first protocol used to resolve domain name to IP address

ii. After that your web browser request the webmail interface page which message and application layer protocol does it use?

HTTP (Hypertext Transfer Protocol)

HTTP GET request message

iii. You compose a new email and send it using a webmail interface, which protocols are used to transfer your email from the sender to the receiver?

1. **HTTP**: to send the email from the webmail interface to the mail server and
2. **SMTP**: to forward the email to the recipient's mail server.
3. **IMAP:** is used by the recipient to retrieve the email from the mail server.

iv. When sending an email to an external domain (e.g., student@example.com), how does the sender email server determine to which mail server it shall send the email?

The sender's email server performs a **DNS (Domain Name System) lookup** to find the **MX (Mail Exchange)** records associated with the recipient's domain (example.com). which provides the address of the mail server responsible for receiving emails for that domain.

v. How does the webmail server use cookies to maintain your session after you log in, and which method is used to set these cookies?

The webmail server sets **session cookies** once you log in to maintain your authenticated session. The method used to set these cookies is through the **Set-Cookie** header in the HTTP response sent by the server to your browser.

vi. What would the Link layer do with packet received from upper layer, more specifically what critical information would the Link layer add?

The Link layer the packet into a **frame** by adding critical information, including:

1. **MAC addresses**
2. **Frame Check Sequence (FCS)**

vii. If the recipient's mail server is temporarily unavailable, what does the sending mail server do with the email?

Sending mail server **queues** the email and **retries delivery at regular intervals.**

viii. Using email client (e.g., Outlook), the client needs to retrieve your latest emails. Which application layer protocol is used for this purpose, and what is its primary function?

IMAP (Internet Message Access Protocol) – is used **by the recipient** to download or sync the email and synchronize your email across multiple devices and keeps a copy of the email on the server.

ix. If you are downloading a large file attachment from an email using webmail, and the server uses FTP for this purpose, how does the FTP protocol handle this download?

FTP handles it by: Establishing a **control connection** on **port 21** to manage commands (e.g., authentication, file request). Opening a separate **data connection** on **port 20** (for active mode) or a dynamic port (for passive mode) to transfer the file.

x. How does the university provide email addresses in its domain (e.g., @nu.edu.pk) while using Gmail as the backend service, and what are the benefits of this setup?

The university likely uses **G Suite (Google Workspace)** for Education, which allows organizations to use Google's Gmail service while maintaining a **custom domain** (e.g., @nu.edu.pk). In this case, the university's DNS records are configured to point **MX records** to Gmail's servers, ensuring emails sent to @nu.edu.pk are processed through Gmail. (Scalability, Security, Seamless Integration)

Q3: Differentiate the following. **[10 marks]**

i. Circuit Switching vs. Packet Switching

Circuit Switching establishes a dedicated communication path between two parties for the duration of the conversation (e.g., traditional phone calls). It provides a constant data rate but is less efficient, as resources are reserved even when not in use.

Packet Switching divides data into packets that are sent independently across the network, allowing for more efficient use of resources. It's the basis for most modern networks, like the internet, as it allows multiple users to share the same network paths.

ii. POP3 vs. IMAP

POP3 (Post Office Protocol 3) downloads emails from a server to a local device and usually deletes them from the server afterward. This means emails are stored locally, limiting access from multiple devices.

IMAP (Internet Message Access Protocol) allows users to access emails directly on the server without downloading them, keeping messages synchronized across multiple devices. Emails remain on the server unless explicitly deleted, offering better flexibility for multi-device use.

iii. RTT vs. TTL

RTT (Round-Trip Time) is the time it takes for a data packet to travel from the source to the destination and back. It measures network latency and helps assess the speed of a connection.

TTL (Time to Live) is a field in a packet that specifies the maximum number of hops (routers) the packet can pass through before being discarded. It prevents packets from circulating indefinitely in the network.

iv. IP Spoofing vs. Packet Sniffing

IP Spoofing involves creating IP packets with a false source address to impersonate another device on the network. This technique is often used in attacks, such as Denial of Service (DoS), to mislead the recipient about the true origin of the traffic.

Packet Sniffing is the process of intercepting and analyzing data packets traveling over a network. This technique can be used for legitimate purposes, such as network monitoring and troubleshooting, or maliciously to capture sensitive information like passwords or private data.

v. Persistent vs. Non-Persistent Connection

Persistent Connection allows multiple requests and responses to be sent over a single TCP connection without needing to establish a new connection for each request.

Non-Persistent Connection establishes a separate TCP connection for each request and closes it after the response is received.

Q4: [10 marks]

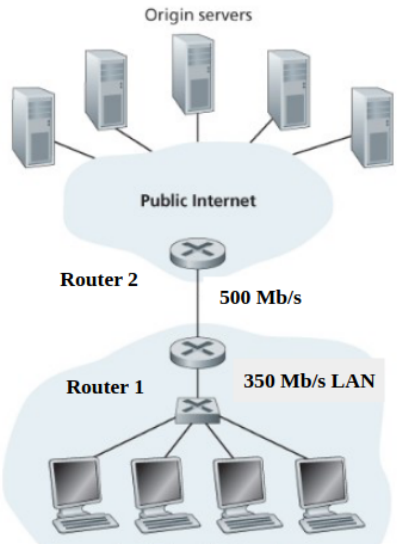
Consider that you are working on one of the lab systems of MEDIX software house having a LAN network with 350 Mb/s transmission rate to institutional Router 1, for which there is an institutional network connected to the Internet.

Suppose that the average object size is 250,000 bits and that the average request rate from the Lab's browsers to the origin servers is 35 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side (Router 2) of the access link forwards an HTTP request until it

receives the response is 2.5 seconds on average. Model the total average response time as the sum of the average access delay (that is, the delay from Router 2 to Router 1) and the average Internet delay.

i. Find the total average response time. **[4]**

ii. Now suppose that a web cache is installed on the MEDIX Lab network's LAN. Suppose that the miss rate is 0.7. Find the total response time (considering that the **response time from the cache is 0.01 sec**) **[6]**



a) Find the total average response time.

L= 250, 000 Bits

R = 500 * 10^6 bits/ sec

a= 35

Cache response = 0.01 sec

Internet delay = 2.5 sec

Average Transmission Delay = Ttrans = L / R = 0.25 * 10^6 / 500 * 10^6

= 0.0005 sec

Traffic Intensity on the access Link = Ttrans * a = (0.0005) * 35 = 0.0175

The average access delay is = Ttrans / (1-Traffic intensity) = 0.0005 / (1- 0.0175)

= 0.0005 sec

Final average response time = 0.0005 + 2.5 = 2.5005 sec

b) with installed cache

The average access delay is (70 % for cache miss)

Average Access delay = (0.0005 sec) / [1 – (0.7) (0.0175)] = 0.0005 seconds

Average Response Time = 0.0005 sec + 2.5 sec =2.5005 sec

For Cache Hit (30 %)

The response time is approximately .01 sec if the request is satisfied by the cache

Average Access delay = 0.3 * 0.01 =0.003 sec

Final Average Response Time = (0.3)(0.01) + (0.7) (2.5005) = 1.75335 sec

Thus, the average response time has been reduced from 2.5005 sec to 1.75335 sec