ECE/CSC 570 : Computer Networks

HW1

Ans1- Conceptual Questions

Which of the OSI Layers or sub-layers handle the following:

a) Provide reliable, connection-oriented path between source and destination ⟶ Transport Layer

b) Determine alternate route for packets when the original route gets congested eg: routers on the path are dead ⟶ Network Layer

c) Determining which user 'owns' the wireless channel to the access point in 802.11b ⟶ Link Layer.

Ans 2- Network Latency

a) Given: Switching time = 10 μsec

To find: if switching time is a major factor in the response of a client-server system where client is in New York and server is in California.

Propagation Speed in Copper and Fiber = 2/3 × Speed in vaccuum

Assumptions: Distance between New York and California (San Francisco) is 4764×10^3 m

Speed of light in vaccuum = 3×10^8 m/s

Number of switches between New York and California = 50

Calculation: Speed in Copper/Fiber = $\frac{2}{3} \times (3 \times 10^8)$ m/s

$= 2 \times 10^8$ m/s

$$\text{Propagation delay} = \frac{\text{Distance b/w California and New York}}{\text{Speed in Copper/Fiber}}$$

$$= \frac{4764 \times 10^3 \text{ m}}{2 \times 10^8 \text{ m/s}} = 2382 \times 10^{-5} \text{ sec} = 0.02382 \text{ sec}$$

$= 23820$ μsec

Total Switching delay = 50 × 10 μsec
= 500 μsec

% contribution of switching delay in total delay = $\frac{500}{(23820+500)} \times 100$

$= \frac{500}{24320} \times 100$

$\approx 2\%$

Hence, switching time of 10 μsec is not a major factor in the response.

b) Given: Height of satellite = 40,000 km = 4×10^7 m
To find: Best case delay in response to a request.
Assumption: Speed of light in air = 299700 km/s
Calculation:
When the client sends request to the server, the request needs to go up to the satellite (40000 km), then from there needs to come down to the server (40000 km). Once the server has processed the request, the response needs to be returned back via the same route. Hence, total distance = 2 × (40000 + 40000) km
= 160000 km
= 16×10^7 m

Delay in Response = $\frac{\text{total distance}}{\text{Speed of light}} = \frac{16 \times 10^7 \text{ m}}{2997 \times 10^5 \text{ m/s}}$

$= \frac{1600}{2997}$ sec = 0.5339 sec
= 533.9 ms

Ans 3 - Network Protocol Stack

Layered Protocols → Protocol that has been separated into layered patterns where different protocols operate in different layers thus making the task of data transfer over the network as simple as possible.

Two reasons for using layered protocols:

i) They help in breaking a bigger problem into smaller pieces where each piece of the problem is handled separately in separate layer making the problem manageable.

ii) layering helps in easy maintainance and update of the system. In order to make changes, we do not break a big monolithic design. Instead, we make changes in the implementation of a specific layers service transparent to rest of system.

One possible disadvantage of using layered protocols:

i) Each layer adds its own set of header information in the packets which is mainly an overhead associated with each packet

Ans 4 - Network Metric Calculation

Given: System has n-layer protocol hierarchy.
Applications generate messages of length M bytes.
Each layer adds an h-byte header.

To find: What fraction of network bandwidth is filled with headers?

Calculation: Total message size : $M + hn$

Therefore, fraction of network bandwidth filled with headers $= \frac{nh}{(M+nh)}$

Ans 5- Given :-

Five routers connected in a point-to-point subnet. Designers may put a high-speed line, medium-speed line, low-speed line or no line. It takes 100 ms of time to generate and inspect each topology.

To find :- How long will it take to inspect all of them.

Calculation :-

Total number of lines $= \frac{n(n-1)}{2}$ where n = number of routers

Therefore, total number of lines $= \frac{5 * 4^2}{2} = 10$ lines.

Now, each line can take upto 4 different values.

Therefore, number of topologies = (No. of values possible/line)$^{\text{Total no. of lines}}$

$= 4^{10} = 1048576$

Ans 6- Circuit and Packet Switching

Given :- Link Bandwidth = 6 Mbps

Total number of users = 30

Bandwidth per user = 400 Kbps

Probability of each user being active = 0.2

a) Circuit Switching :

$$\text{Number of supported users} = \frac{\text{Total link bandwidth}}{\text{Bandwidth required per user.}}$$

$$= \frac{6 \times 10^3 \text{ Kbps}}{4 \times 10^2 \text{ Kbps}} = \frac{60}{4} = 15 \text{ users}$$

b) Packet Switching :

Let X = number of active users

$$P(X=k) = \binom{n}{k} p^k (1-p)^{n-k}$$

where n = total number of users
k = number of active users
p = probability that user is active

Probability of k active users out of 30.

$$P(X=k) = \binom{30}{k} 0.2^k (1-p)^{(30-k)}$$

Average number of active users = np

$$= 30 \times 0.2 = 6$$

~~Probability that the link is overloaded~~

$$P(X>15) = \sum_{k=16}^{30} \binom{30}{k} 0.2^k (1-p)^{(30-k)}$$

Probability that the link is overloaded

$$P(X>15) = \sum_{k=16}^{30} \binom{30}{k} 0.2^k (1-0.2)^{(30-k)}$$

Ans 7 – Network Testing Tools

Part a)

```
C:\Users\sh160>ping www.duke.edu

Pinging duke.edu [152.3.72.197] with 32 bytes of data:
Reply from 152.3.72.197: bytes=32 time=47ms TTL=244
Reply from 152.3.72.197: bytes=32 time=93ms TTL=244
Reply from 152.3.72.197: bytes=32 time=46ms TTL=244
Reply from 152.3.72.197: bytes=32 time=53ms TTL=244

Ping statistics for 152.3.72.197:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 46ms, Maximum = 93ms, Average = 59ms
```

```
C:\Users\sh160>ping mit.edu

Pinging mit.edu [104.106.240.75] with 32 bytes of data:
Reply from 104.106.240.75: bytes=32 time=38ms TTL=51
Reply from 104.106.240.75: bytes=32 time=38ms TTL=51
Reply from 104.106.240.75: bytes=32 time=38ms TTL=51
Reply from 104.106.240.75: bytes=32 time=40ms TTL=51

Ping statistics for 104.106.240.75:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 38ms, Maximum = 40ms, Average = 38ms
```

```
C:\Users\sh160>ping berkeley.edu

Pinging berkeley.edu [35.163.72.93] with 32 bytes of data:
Reply from 35.163.72.93: bytes=32 time=126ms TTL=34
Reply from 35.163.72.93: bytes=32 time=116ms TTL=34
Reply from 35.163.72.93: bytes=32 time=122ms TTL=34
Reply from 35.163.72.93: bytes=32 time=121ms TTL=34

Ping statistics for 35.163.72.93:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 116ms, Maximum = 126ms, Average = 121ms
```

```
C:\Users\sh160>ping vu.nl

Pinging vu.nl [37.60.194.64] with 32 bytes of data:
Reply from 37.60.194.64: bytes=32 time=126ms TTL=236
Reply from 37.60.194.64: bytes=32 time=121ms TTL=236
Reply from 37.60.194.64: bytes=32 time=123ms TTL=236
Reply from 37.60.194.64: bytes=32 time=128ms TTL=236

Ping statistics for 37.60.194.64:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 121ms, Maximum = 128ms, Average = 124ms
```

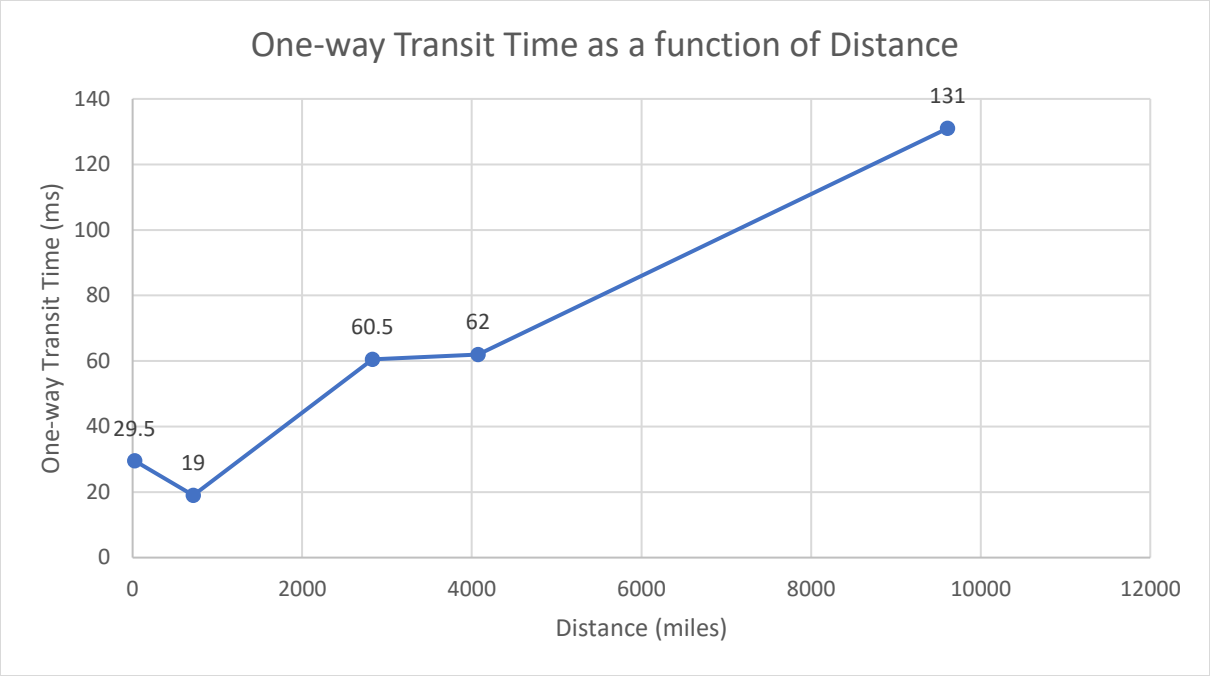
```
C:\Users\sh160>ping usyd.edu.au

Pinging usyd.edu.au [129.78.5.11] with 32 bytes of data:
Reply from 129.78.5.11: bytes=32 time=261ms TTL=234
Reply from 129.78.5.11: bytes=32 time=259ms TTL=234
Reply from 129.78.5.11: bytes=32 time=254ms TTL=234
Reply from 129.78.5.11: bytes=32 time=275ms TTL=234

Ping statistics for 129.78.5.11:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 254ms, Maximum = 275ms, Average = 262ms
```

Table showing websites, distance of their servers from NCSU and one-way transit time

Websites	Distance (miles)	One-way Transit Time (ms)
Duke University, Durham (duke.edu)	24	29.5
Cambridge, MA (mit.edu)	715	19
Berkeley, CA (berkeley.edu)	2830	60.5
Vrije University, Amsterdam (vu.nl)	4072	62
Sydney, Australia (usyd.edu.au)	9610	131



Part b) Traceroute to MIT (USA)

```
C:\Users\sh160>tracert mit.edu

Tracing route to mit.edu [23.218.67.189]
over a maximum of 30 hops:

  1     2 ms     1 ms     1 ms  www.routerlogin.com [192.168.1.1]
  2     2 ms     8 ms     1 ms  smdf-bbdis-c6k-1.ncstate.net [152.7.64.1]
  3     1 ms     1 ms     1 ms  vl2935-itcore.ncstate.net [152.1.6.137]
  4     2 ms     2 ms     2 ms  ncsugw-gi2-1.ncstate.net [152.1.6.70]
  5     4 ms     3 ms     4 ms  rtp7600-gw-to-ncsu-gw-1.ncren.net [128.109.18.109]
  6     5 ms     5 ms     4 ms  et-3-3-0.582.rtsw.rale.net.internet2.edu [198.71.47.221]
  7    10 ms     9 ms    10 ms  ae-1.4079.rtsw.wash.net.internet2.edu [162.252.70.121]
  8    10 ms    10 ms    10 ms  eeq-exchange.tr01-asbnva01.transitrail.net [206.126.236.45]
  9    13 ms    13 ms    13 ms  equinix-iad11.netarch.akamai.com [206.126.236.102]
 10    10 ms    10 ms    10 ms  a23-218-67-189.deploy.static.akamaitechnologies.com [23.218.67.189]

Trace complete.
```

1st hop -> 192.168.1.1 (Local Router / DNS Server)
2nd hop -> 152.7.64.1 (ISP - North Carolina State University)
3rd hop -> 152.1.6.137 (ISP - North Carolina State University)
4th hop -> 152.1.6.70 (ISP - North Carolina State University)
5th hop -> 128.109.18.109 (ISP – MCNC)
6th hop -> 198.71.47.221 (ISP – Internet2 [INTER-395])
7th hop -> 162.252.70.121 (ISP – Internet2 [INTER-395])
8th hop -> 206.126.236.45 (ISP – Equinix, Inc. [EQUINIX])
9th hop -> 206.126.236.102 (ISP - Equinix, Inc. [EQUINIX])
10th hop -> 23.218.67.189 (ISP – Akamai Technologies, Inc. [AKAMAI])

Traceroute to ETH Zurich (Europe)

```
C:\Users\sh160>tracert ethz.ch

Tracing route to ethz.ch [129.132.19.216]
over a maximum of 30 hops:

  1     3 ms     2 ms   541 ms  www.routerlogin.com [192.168.1.1]
  2     3 ms     3 ms   329 ms  smdf-bbdis-c6k-1.ncstate.net [152.7.64.1]
  3     3 ms     3 ms     3 ms  vl2935-itcore.ncstate.net [152.1.6.137]
  4     3 ms     2 ms     3 ms  ncsugw-gi2-1.ncstate.net [152.1.6.70]
  5     6 ms     4 ms     5 ms  rtp7600-gw-to-ncsu-gw-1.ncren.net [128.109.18.109]
  6     6 ms     4 ms     6 ms  et-3-3-0.613.rtsw.rale.net.internet2.edu [198.71.46.185]
  7    11 ms    10 ms    54 ms  ae-1.4079.rtsw.wash.net.internet2.edu [162.252.70.121]
  8   156 ms    99 ms    98 ms  internet2-gw.mx1.lon.uk.geant.net [62.40.124.44]
  9   104 ms    95 ms   100 ms  ae6.mx1.lon2.uk.geant.net [62.40.98.37]
 10   113 ms   201 ms   201 ms  ae5.mx1.par.fr.geant.net [62.40.98.179]
 11   109 ms   203 ms   201 ms  ae5.mx1.gen.ch.geant.net [62.40.98.182]
 12   208 ms   202 ms   201 ms  swice1-100ge-0-3-0-1.switch.ch [62.40.124.22]
 13   203 ms   201 ms   202 ms  swiCE4-B4.switch.ch [130.59.36.70]
 14   109 ms   202 ms   201 ms  swiBE3-100GE-0-1-0-1.switch.ch [130.59.37.145]
 15   207 ms   203 ms   201 ms  swiBF1-100GE-0-0-0-1.switch.ch [130.59.39.78]
 16   116 ms   201 ms   200 ms  swiEZ3-100GE-0-1-0-0.switch.ch [130.59.37.6]
 17   211 ms   204 ms   201 ms  rou-gw-lee-tengig-to-switch.ethz.ch [192.33.92.1]
 18   212 ms   201 ms   201 ms  rou-fw-rz-rz-gw.ethz.ch [192.33.92.169]
 19   209 ms   201 ms   201 ms  www.ethz.ch [129.132.19.216]

Trace complete.
```

1st hop -> 192.168.1.1 (Local Router / DNS Server)
2nd hop -> 152.7.64.1 (ISP - North Carolina State University)
3rd hop -> 152.1.6.137 (ISP - North Carolina State University)
4th hop -> 152.1.6.70 (ISP - North Carolina State University)
5th hop -> 128.109.18.109 (ISP – MCNC)
6th hop -> 198.71.46.185 (ISP – Internet2 [INTER-395])
7th hop -> 162.252.70.121 (ISP – Internet2 [INTER-395])
8th hop -> 62.40.124.44 (ISP - GEANT Operations)
9th hop -> 62.40.98.37 (ISP - GEANT Operations)
10th hop -> 62.40.98.179 (ISP – GEANT Operations)
11th hop -> 62.40.98.182 (ISP - GEANT Operations)
12th hop -> 62.40.124.22 (ISP - GEANT Operations)
13th hop -> 130.59.36.70 (ISP – RIPE Network Coordination Centre [RIPE])
14th hop -> 130.59.37.145 (ISP - RIPE Network Coordination Centre [RIPE])
15th hop -> 130.59.39.78 (ISP - RIPE Network Coordination Centre [RIPE])
16th hop -> 130.59.37.6 (ISP - RIPE Network Coordination Centre [RIPE])
17th hop -> 192.33.92.1 (ISP - RIPE Network Coordination Centre [RIPE])
18th hop -> 192.33.92.169 (ISP – RIPE Network Coordination Centre [RIPE])
19th hop -> 129.132.19.216 (ISP - RIPE Network Coordination Centre [RIPE])