

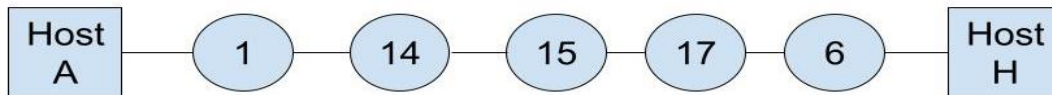
Evaluating Delays in Packet Switching Network

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Part1 – Understanding theoretical delay calculations.

1. What is the end-to-end packet delay in this store and forward subnet from Router1 to Router6?



Assume the following:

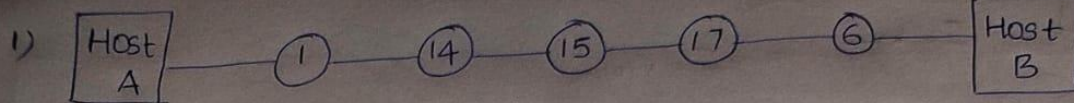
all links are of distance $d = 2.5\text{km}$.

Capacity of the link $R = 100\text{Mbps}$

Propagation speed $s = 200\text{m/microseconds}$

Queuing delay = Processing delay = 0

Packet size $L = 1000\text{ bytes}$



$$d = 2.5 \text{ km} = 2.5 \times 10^3 \text{ m}$$

$$R = 100 \text{ Mbps} = 10^8 \text{ bps}$$

Propagation speed $c = 200 \text{ m}/\mu\text{s} = 200 \text{ m}/10^{-6} \text{ s} = 2 \times 10^8 \text{ ms}^{-1}$

$$D_{\text{queue}} = D_{\text{processing}} = 0$$

$$L = 1000 \text{ bytes} = 8000 \text{ bits} = 8 \times 10^3 \text{ b}$$

(B) (b)

end to end delay \Rightarrow The links b/w router 1 to 6 are all same

$$\Rightarrow \text{Total delay} = \text{Delay}_{\text{link}} \times 4$$

$$\text{Delay} = D_{\text{transmission}} + D_{\text{propagation}} + \underbrace{D_{\text{queuing}} + D_{\text{processing}}}_0$$

$$= \frac{L}{R} + \frac{d}{c}$$

$$= \frac{8 \times 10^3}{10^8} + \frac{2.5 \times 10^3}{2 \times 10^8} = \frac{16 \times 10^3 + 2.5 \times 10^3}{2 \times 10^8}$$

$$= \frac{18.5 \times 10^3}{2 \times 10^8} = 9.25 \times 10^{-5} \text{ s}$$

$$= 92.5 \mu\text{s}$$

$$1 \text{ to } 6 \text{ end to end delay} = \text{delay} \times h$$

$$= \underline{\underline{3.70 \text{ Ms}}}$$

2. What is the end-to-end packet delay in this store and forward subnet from router 1 to router 6, under the scenario that when a packet from router 1 arrives at **router 15** there are 3 packets enqueued for the link to router 17?

- c. With the capture active, ping and traceroute the following three website URLs from a Windows command prompt:

Open a Windows command prompt

- 1) Domain name specified in the interface you had connected to internet.
- 2) www.amrita.edu

Note: When you ping the URLs listed, notice that the Domain Name Server (DNS) translates the URL to an IP address. Note the IP address received for each URL.

- d. You can stop capturing data by clicking the **Stop Capture** icon.

Step 1: Examining and analyzing the data from the remote hosts.

Review the captured data in Wireshark and examine the IP addresses of the two locations that you pinged.

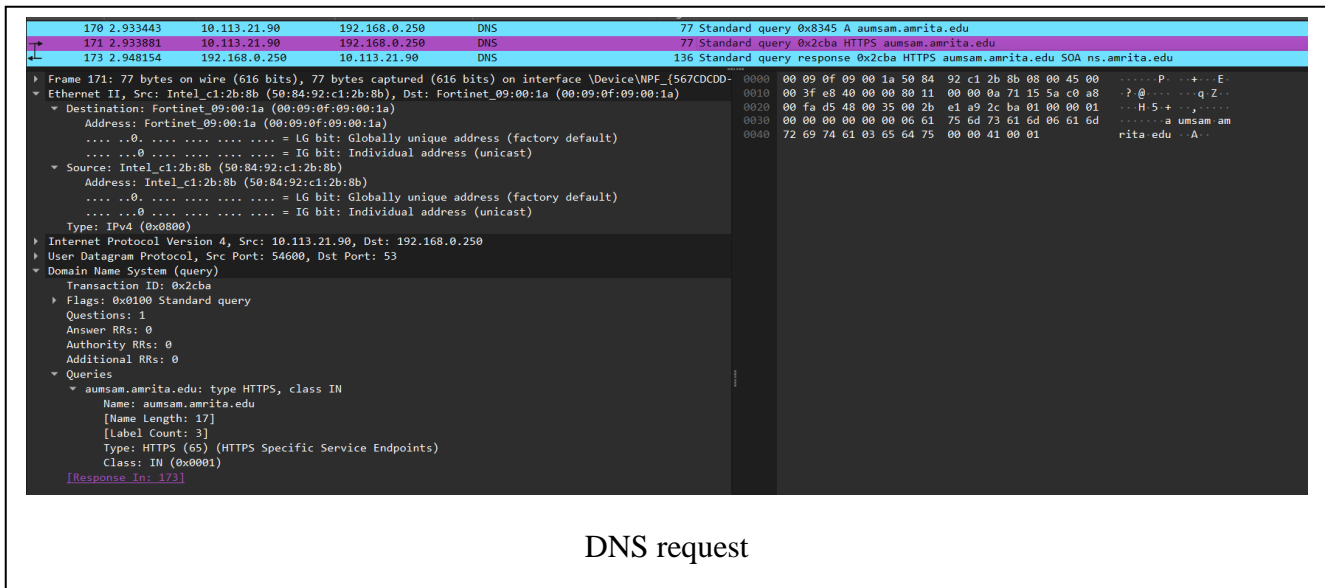
Questions:

IP address for **am.students.amrita.edu**: 192.168.0.252

How many Ping request and reply packets are captured?

Packets: Sent = 7, Received = 7.

Try to provide screenshots to show these details in the ICMP frames captured. Justify your answers.



The screenshot displays a Wireshark packet capture with three packets listed in the top pane. Packet 171 is a DNS Standard query for 'amsam.amrita.edu'. Packet 173 is the corresponding DNS Standard query response. The packet details pane for packet 171 is expanded, showing the Ethernet II header, Internet Protocol Version 4 header, User Datagram Protocol header, and Domain Name System (query) header. The query is for 'amsam.amrita.edu' with type 'HTTPS' and class 'IN'. The packet bytes pane shows the raw data of the packet.

DNS request

No.	Time	Source	Destination	Protocol	Length	Info	Raw
174	2.948154	192.168.0.250	10.113.21.90	DNS	93	Standard query response 0x8345 A aumsam.amrita.edu A 10.0.0.104	
▶ Frame 174: 93 bytes on wire (744 bits), 93 bytes captured (744 bits) on interface \Device\NPF_{567CDCDD-0000-50-84-92-c1-2b-8b}							
▶ Ethernet II, Src: Fortinet_09:00:1a (00:09:0f:09:00:1a), Dst: Intel_c1:2b:8b (50:84:92:c1:2b:8b)							
▶ Destination: Intel_c1:2b:8b (50:84:92:c1:2b:8b)							
Address: Intel_c1:2b:8b (50:84:92:c1:2b:8b)							
.....0..... = LG bit: Globally unique address (factory default)							
.....0..... = IG bit: Individual address (unicast)							
▶ Source: Fortinet_09:00:1a (00:09:0f:09:00:1a)							
Address: Fortinet_09:00:1a (00:09:0f:09:00:1a)							
.....0..... = LG bit: Globally unique address (factory default)							
.....0..... = IG bit: Individual address (unicast)							
Type: IPv4 (0x0800)							
▶ Internet Protocol Version 4, Src: 192.168.0.250, Dst: 10.113.21.90							
▶ User Datagram Protocol, Src Port: 53, Dst Port: 52716							
▶ Domain Name System (response)							
Transaction ID: 0x8345							
▶ Flags: 0x0180 Standard query response, No error							
Questions: 1							
Answer RRs: 1							
Authority RRs: 0							
Additional RRs: 0							
▶ Queries							
▶ aumsam.amrita.edu: type A, class IN							
Name: aumsam.amrita.edu							
[Name Length: 17]							
[Label Count: 3]							
Type: A (1) (Host Address)							
Class: IN (0x0001)							
▶ Answers							
▶ aumsam.amrita.edu: type A, class IN, addr 10.0.0.104							
Name: aumsam.amrita.edu							
Type: A (1) (Host Address)							
Class: IN (0x0001)							
Time to live: 600 (10 minutes)							
Data length: 4							
Address: 10.0.0.104							
[Request In: 170]							
[Time: 0.014711000 seconds]							

DNS response

10.113.21.90	10.0.0.104	TCP	66 53193 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
10.113.21.90	224.0.0.251	IGMPv2	46 Membership Report group 224.0.0.251
10.0.0.104	10.113.21.90	TCP	66 443 → 53193 [SYN, ACK] Seq=0 Ack=1 Win=14600 Len=0 MSS=1460 SACK_PERM WS=128
Fortinet_09:00:1a	Intel_c1:2b:8b	ARP	60 Who has 10.113.9.48? Tell 10.113.0.1
10.113.21.90	10.0.0.104	TCP	54 53193 → 443 [ACK] Seq=1 Ack=1 Win=131328 Len=0

TCP 3 way handshake

178	2.967487	Fortinet_09:00:1a	Intel_c1:2b:8b	ARP	60	Who has 10.113.9.48? Tell 10.113.0.1	
▶ Frame 178: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{567CDCDD-0000-50-84-92-c1-2b-8b}							
▶ Ethernet II, Src: Fortinet_09:00:1a (00:09:0f:09:00:1a), Dst: Intel_c1:2b:8b (50:84:92:c1:2b:8b)							
▶ Address Resolution Protocol (request)							
Hardware type: Ethernet (1)							
Protocol type: IPv4 (0x0800)							
Hardware size: 6							
Protocol size: 4							
Opcode: request (1)							
Sender MAC address: Fortinet_09:00:1a (00:09:0f:09:00:1a)							
Sender IP address: 10.113.0.1							
Target MAC address: Xerox_00:00:00 (00:00:00:00:00:00)							
Target IP address: 10.113.9.48							

Address Resolution Protocol

10.113.21.90	10.0.0.104	TLSv1.2	799 Client Hello (SNI=aumsam.amrita.edu)
10.0.0.104	10.113.21.90	TLSv1.2	191 Server Hello, Change Cipher Spec, Encrypted Handshake Message
10.113.21.90	10.0.0.104	TLSv1.2	105 Change Cipher Spec, Encrypted Handshake Message
10.113.21.90	10.0.0.104	TCP	1514 53193 → 443 [ACK] Seq=797 Ack=138 Win=131072 Len=1460 [TCP segment of a reassembled PDU]
10.113.21.90	10.0.0.104	TLSv1.2	106 Application Data

Packet data captured

```
C:\Users\admin\Anuvind>ping am.students.amrita.edu
```

```
Pinging am.students.amrita.edu [192.168.0.252] with 32 bytes of data:  
Reply from 192.168.0.252: bytes=32 time=627ms TTL=126  
Reply from 192.168.0.252: bytes=32 time=580ms TTL=126  
Reply from 192.168.0.252: bytes=32 time=201ms TTL=126  
Reply from 192.168.0.252: bytes=32 time=13ms TTL=126
```

```
Ping statistics for 192.168.0.252:
```

```
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

```
Approximate round trip times in milli-seconds:
```

```
    Minimum = 13ms, Maximum = 627ms, Average = 355ms
```

10.113.21.90	192.168.0.252	ICMP	106 Echo (ping) request id=0x0001, seq=236/60416, ttl=1 (no response found!)
10.113.0.1	10.113.21.90	ICMP	134 Time-to-live exceeded (Time to live exceeded in transit)
0.0.0.0	239.255.255.250	IGMPv2	46 Membership Query, specific for group 239.255.255.250
10.113.21.90	192.168.0.252	ICMP	106 Echo (ping) request id=0x0001, seq=237/60672, ttl=1 (no response found!)
10.113.0.1	10.113.21.90	ICMP	134 Time-to-live exceeded (Time to live exceeded in transit)
Fortinet_09:00:1a	Intel_c1:2b:8b	ARP	60 Who has 10.113.22.45? Tell 10.113.0.1
10.113.21.90	192.168.0.252	ICMP	106 Echo (ping) request id=0x0001, seq=238/60928, ttl=1 (no response found!)
10.113.0.1	10.113.21.90	ICMP	134 Time-to-live exceeded (Time to live exceeded in transit)
10.113.21.90	192.168.0.250	DNS	83 Standard query 0xdcf4 PTR 1.0.113.10.in-addr.arpa

Ping Request and response

537 10.098513	10.113.21.90	192.168.0.252	ICMP	106 Echo (ping) request id=0x0001, seq=239/61184, ttl=2 (reply in 538)
538 10.103961	192.168.0.252	10.113.21.90	ICMP	106 Echo (ping) reply id=0x0001, seq=239/61184, ttl=126 (request in 537)
541 10.108058	10.113.21.90	192.168.0.252	ICMP	106 Echo (ping) request id=0x0001, seq=240/61440, ttl=2 (reply in 542)
542 10.112887	192.168.0.252	10.113.21.90	ICMP	106 Echo (ping) reply id=0x0001, seq=240/61440, ttl=126 (request in 541)
544 10.117554	10.113.21.90	192.168.0.252	ICMP	106 Echo (ping) request id=0x0001, seq=241/61696, ttl=2 (reply in 545)
545 10.121453	192.168.0.252	10.113.21.90	ICMP	106 Echo (ping) reply id=0x0001, seq=241/61696, ttl=126 (request in 544)
832 16.594376	10.113.21.90	192.168.0.252	ICMP	74 Echo (ping) request id=0x0001, seq=242/61952, ttl=128 (reply in 834)
834 16.599252	192.168.0.252	10.113.21.90	ICMP	74 Echo (ping) reply id=0x0001, seq=242/61952, ttl=126 (request in 832)
882 17.609832	10.113.21.90	192.168.0.252	ICMP	74 Echo (ping) request id=0x0001, seq=243/62208, ttl=128 (reply in 884)
884 17.614536	192.168.0.252	10.113.21.90	ICMP	74 Echo (ping) reply id=0x0001, seq=243/62208, ttl=126 (request in 882)
922 18.645150	10.113.21.90	192.168.0.252	ICMP	74 Echo (ping) request id=0x0001, seq=244/62464, ttl=128 (reply in 926)
926 18.668604	192.168.0.252	10.113.21.90	ICMP	74 Echo (ping) reply id=0x0001, seq=244/62464, ttl=126 (request in 922)
975 19.680606	10.113.21.90	192.168.0.252	ICMP	74 Echo (ping) request id=0x0001, seq=245/62720, ttl=128 (reply in 977)
977 19.690859	192.168.0.252	10.113.21.90	ICMP	74 Echo (ping) reply id=0x0001, seq=245/62720, ttl=126 (request in 975)

7 Request and 7 replies captured

```
C:\Users\admin\Anuvind>ping amrita.edu
```

```
Pinging amrita.edu [15.197.141.123] with 32 bytes of data:  
Reply from 15.197.141.123: bytes=32 time=33ms TTL=249  
Reply from 15.197.141.123: bytes=32 time=91ms TTL=249  
Reply from 15.197.141.123: bytes=32 time=47ms TTL=249  
Reply from 15.197.141.123: bytes=32 time=46ms TTL=249
```

```
Ping statistics for 15.197.141.123:
```

```
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

```
Approximate round trip times in milli-seconds:
```

```
    Minimum = 33ms, Maximum = 91ms, Average = 54ms
```


1158	23.230741	10.113.21.90	3.33.154.67	ICMP	74 Echo (ping) request	id=0x0001, seq=246/62976, ttl=128 (reply in 1160)
1160	23.252842	3.33.154.67	10.113.21.90	ICMP	74 Echo (ping) reply	id=0x0001, seq=246/62976, ttl=249 (request in 1158)
1224	24.251275	10.113.21.90	3.33.154.67	ICMP	74 Echo (ping) request	id=0x0001, seq=247/63232, ttl=128 (reply in 1226)
1226	24.274440	3.33.154.67	10.113.21.90	ICMP	74 Echo (ping) reply	id=0x0001, seq=247/63232, ttl=249 (request in 1224)
1271	25.286842	10.113.21.90	3.33.154.67	ICMP	74 Echo (ping) request	id=0x0001, seq=248/63488, ttl=128 (reply in 1273)
1273	25.309509	3.33.154.67	10.113.21.90	ICMP	74 Echo (ping) reply	id=0x0001, seq=248/63488, ttl=249 (request in 1271)
1314	26.321996	10.113.21.90	3.33.154.67	ICMP	74 Echo (ping) request	id=0x0001, seq=249/63744, ttl=128 (reply in 1315)
1315	26.345300	3.33.154.67	10.113.21.90	ICMP	74 Echo (ping) reply	id=0x0001, seq=249/63744, ttl=249 (request in 1314)

4 request and 4 replies captured

```
C:\Users\admin\Anuvind>tracert amrita.edu
```

Tracing route to amrita.edu [15.197.141.123]
over a maximum of 30 hops:

```

 1      4 ms      4 ms      3 ms  10.113.0.1
 2     11 ms     32 ms     5 ms  static.ill.117.193.77.225.bsnl.in [117.193.77.225]
 3      9 ms     10 ms     4 ms  117.193.162.46
 4      *        337 ms    216 ms  117.216.207.122
 5     76 ms     32 ms      *      99.82.177.212
 6      *        *        *      Request timed out.
 7      *        *        *      Request timed out.
 8      *        *        *      Request timed out.
 9     87 ms     57 ms    136 ms  52.93.19.131
10     35 ms      *    136 ms  52.93.19.50
11     46 ms     28 ms     47 ms  a572ab1d134af1b1e.awsglobalaccelerator.com [15.197.141.123]

```

Trace complete.

10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=250/64000, ttl=1 (no response found!)
10.113.0.1	10.113.21.90	ICMP	134 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=251/64256, ttl=1 (no response found!)
10.113.0.1	10.113.21.90	ICMP	134 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=252/64512, ttl=1 (no response found!)
10.113.0.1	10.113.21.90	ICMP	134 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=253/64768, ttl=2 (no response found!)
123.63.2.1	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=254/65024, ttl=2 (no response found!)
123.63.2.1	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=255/65280, ttl=2 (no response found!)
123.63.2.1	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=256/1, ttl=3 (no response found!)
122.15.45.170	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=257/257, ttl=3 (no response found!)
122.15.45.170	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=258/513, ttl=3 (no response found!)
122.15.45.170	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=259/769, ttl=4 (no response found!)
182.19.108.198	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=260/1025, ttl=4 (no response found!)
182.19.108.198	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=261/1281, ttl=4 (no response found!)
182.19.108.198	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=262/1537, ttl=5 (no response found!)
99.83.90.14	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=263/1793, ttl=5 (no response found!)
99.83.90.14	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=264/2049, ttl=5 (no response found!)
52.93.19.47	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=275/4865, ttl=9 (no response found!)
52.93.19.47	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=276/5121, ttl=9 (no response found!)
52.93.19.47	10.113.21.90	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=277/5377, ttl=10 (no response found!)
52.93.19.46	10.113.21.90	ICMP	182 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=278/5633, ttl=10 (no response found!)
52.93.19.46	10.113.21.90	ICMP	182 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=279/5889, ttl=10 (no response found!)
52.93.19.46	10.113.21.90	ICMP	182 Time-to-live exceeded (Time to live exceeded in transit)	
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=280/6145, ttl=11 (reply in 6859)
3.33.154.67	10.113.21.90	ICMP	106 Echo (ping) reply	id=0x0001, seq=280/6145, ttl=249 (request in 6858)
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=281/6401, ttl=11 (reply in 6863)
3.33.154.67	10.113.21.90	ICMP	106 Echo (ping) reply	id=0x0001, seq=281/6401, ttl=249 (request in 6862)
10.113.21.90	3.33.154.67	ICMP	106 Echo (ping) request	id=0x0001, seq=282/6657, ttl=11 (reply in 6866)
3.33.154.67	10.113.21.90	ICMP	106 Echo (ping) reply	id=0x0001, seq=282/6657, ttl=249 (request in 6864)

IP address for amrita.edu: 15.197.141.123

How many Ping request and reply packets are captured?

Packets: Sent = 4, Received = 4.