



Tutor:

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**Tutorial: 1 hour**

- Discussion and solutions on tutorial problems.
- Q&A: your chance to ask technical questions.

**Lab: 1 hour**

- Group work:
- Form a group of 2 or 3 students each group.



## Lab Assessment:

**1 point each lab**, 10 points in total  
(week 1-5, 7-11).

Individually assessed based on lab  
performance – **Not attendance!**

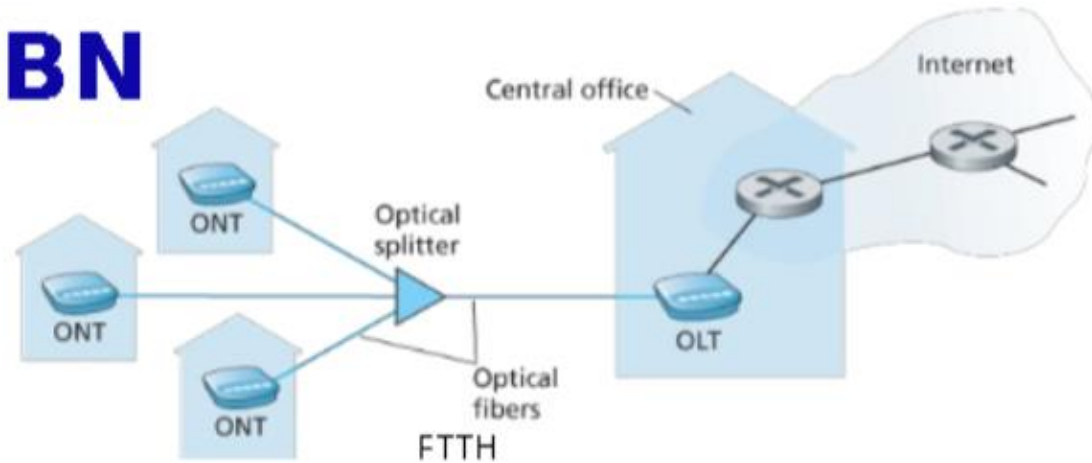
**(Understand, Operations, and Results)**

# Week 1. Q&A



Speak to the students next you  
😊 and get to know each other!

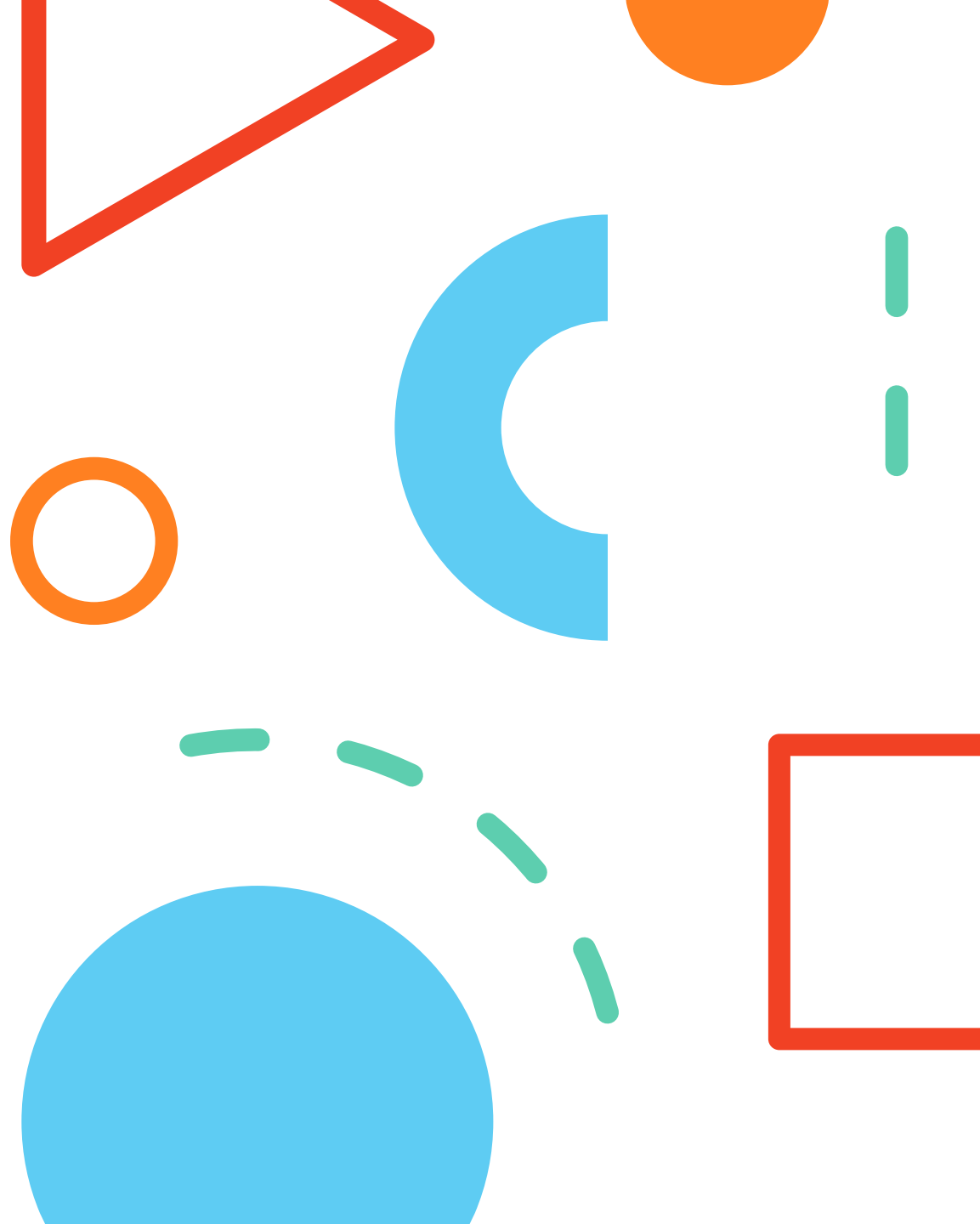
# What is NBN



- What Access technologies are used in NBN?
- What is FTTH?
- What are the data rates for each technology?
- How much \$ are they?
- Discuss Pros and Cons for each

**Discuss in your Tutorial Class**

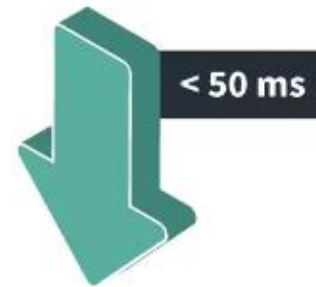
# Week 1. Tutorial problems and Solutions



# What's a ping?



Low ping is better than high ping.



**< 50 ms**

The lower your ping,  
the less lag time there

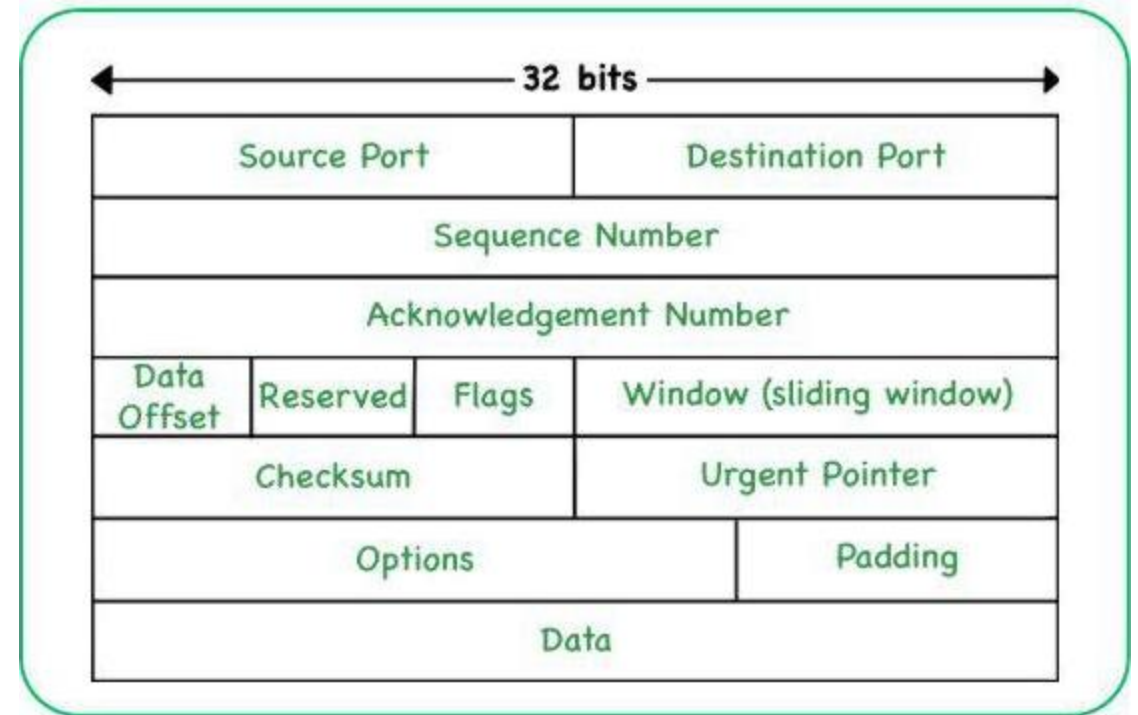


**> 100 ms**

The higher your ping,  
the more lag time there

# What is a packet?

- Packets are used to break down larger pieces of data into manageable chunks that can traverse the network more efficiently.
- They are individually routed through the network based on the destination address information in the header.
- Once they reach their destination, the packets are reassembled into the original data.



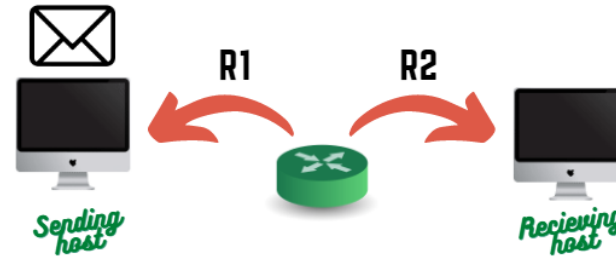


# OSI MODEL

7	Application Layer	Human-computer interaction layer, where applications can access the network services
6	Presentation Layer	Ensures that data is in a usable format and is where data encryption occurs
5	Session Layer	Maintains connections and is responsible for controlling ports and sessions
4	Transport Layer	Transmits data using transmission protocols including TCP and UDP
3	Network Layer	Decides which physical path the data will take
2	Data Link Layer	Defines the format of data on the network
1	Physical Layer	Transmits raw bit stream over the physical medium



## Problem 1:

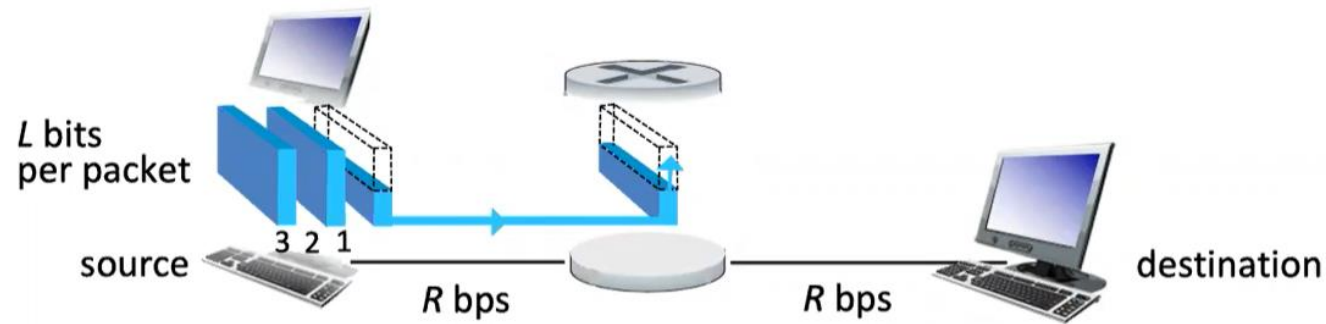


Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the **switch** and between the switch and the receiving host are  $R1$  and  $R2$ , respectively. Assuming that the switch uses **store-and-forward** packet switching, **what is the total end-to-end delay to send a packet of length  $L$ ? (Ignore queuing, propagation delay, and processing delay.)**

- Now assume packet length  $L=1500$  byte,  $R1=1\text{Mbps}$ ,  $R2=2\text{Mbps}$ , calculate the **end-to-end Delay**.
- Now assume packet length  $L=1200$  byte,  $R1=3\text{Mbps}$ ,  $R2=2\text{Mbps}$ , calculate the **end-to-end Delay**.

# Brief Explanation:

## Packet-switching: store-and-forward



- **Transmission delay:** takes  $L/R$  seconds to transmit (push out)  $L$ -bit packet into link at  $R$  bps
- **Store and forward:** entire packet must arrive at router before it can be transmitted on next link
- **End-end delay:**  $2L/R$  (above), assuming zero propagation delay (more on delay shortly)

### *One-hop numerical example:*

- $L = 10$  Kbits
- $R = 100$  Mbps
- one-hop transmission delay = 0.1 msec

## Solution 1:

At time  $t_0$  the sending host begins to transmit. At time  $t_1 = L/R_1$ , the sending host completes transmission, and the entire packet is received at the router (no propagation delay). Because the router has the entire packet at time  $t_1$ , it can begin to transmit the packet to the receiving host at time  $t_1$ . At time  $t_2 = t_1 + L/R_2$ , the router completes transmission, and the entire packet is received at the receiving host (again, no propagation delay). Thus, the end-to-end delay is  $L/R_1 + L/R_2$ .

a. Delay =  $1500 \cdot 8 / 1000000 + 1500 \cdot 8 / 2000000 = 0.018\text{s} = 18\text{ms}$

b. Delay =  $1200 \cdot 8 / 3000000 + 1200 \cdot 8 / 2000000 = 0.008\text{s} = 8\text{ms}$

## Problem 2:

$$d_{\text{end-to-end}} = N \frac{L}{R} \quad (1.1)$$

Gives a formula for the end-to-end delay of sending one packet of length  $L$  **by  $N$  links** of transmission rate  $R$ .

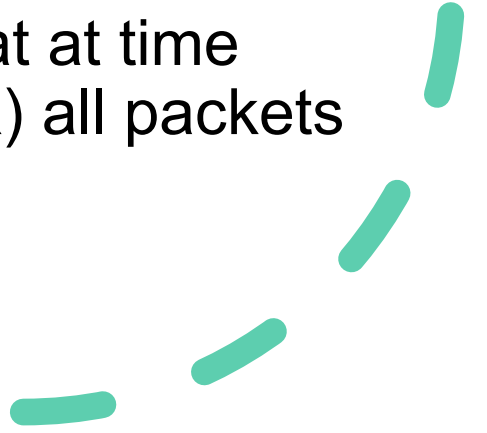
**Generalize** this formula for sending  **$P$  number packets back-to-back over the  $N$  links.**

## Solution 2:

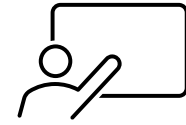
At time  $N^*(L/R)$  the first packet has reached the destination, the second packet is stored in the last router, the third packet is stored in the next-to-last router, etc.

At time  $N^*(L/R) + L/R$ , the second packet has reached the destination, the third packet is stored in the last router, etc.

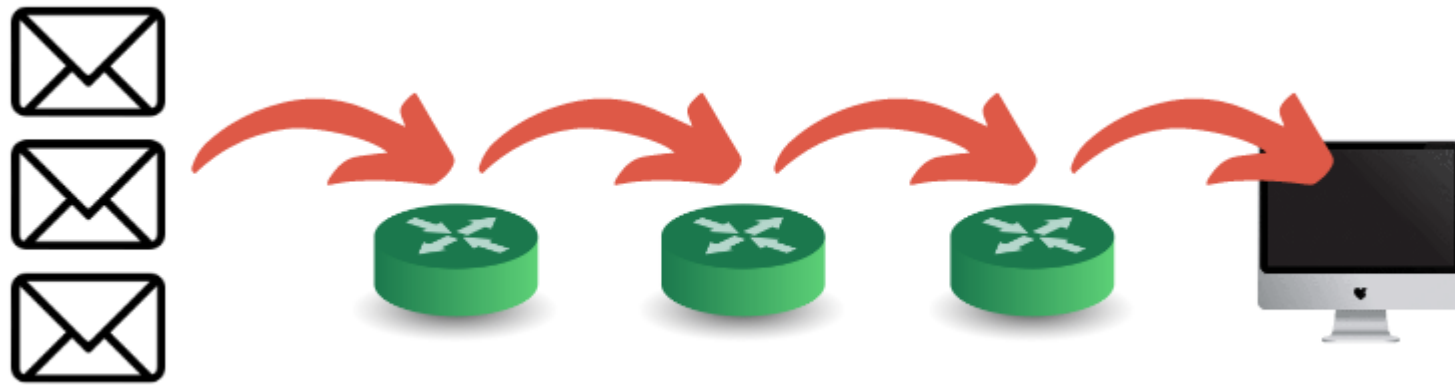
Continuing with this logic, we see that at time  $N^*(L/R) + (P-1)^*(L/R) = (N+P-1)^*(L/R)$  all packets have reached the destination.



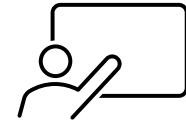
## P2 Explanation:



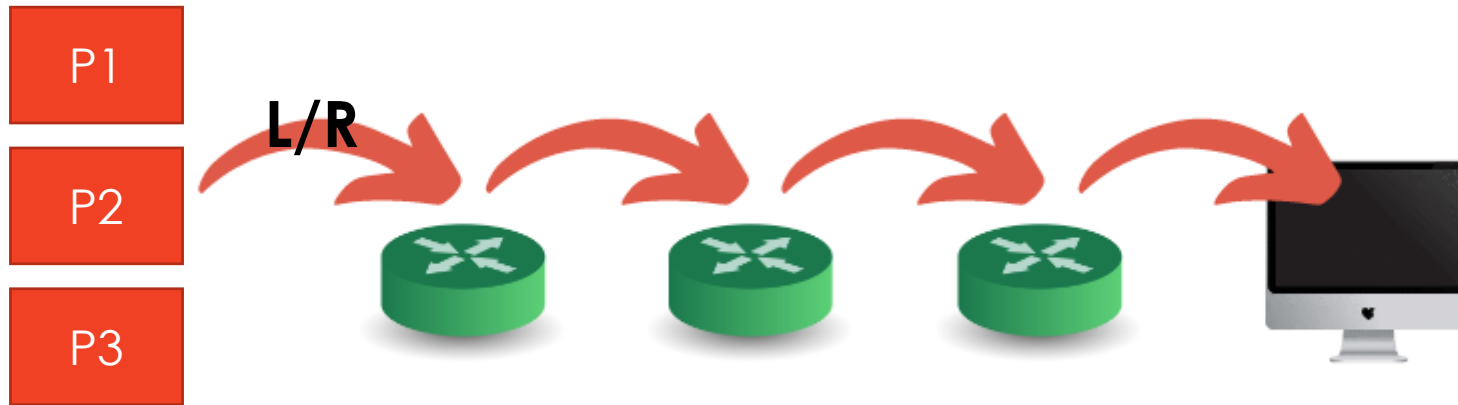
What is  $N$ ? in this example?



## P2 Explanation:

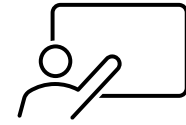


What is N? in this example?

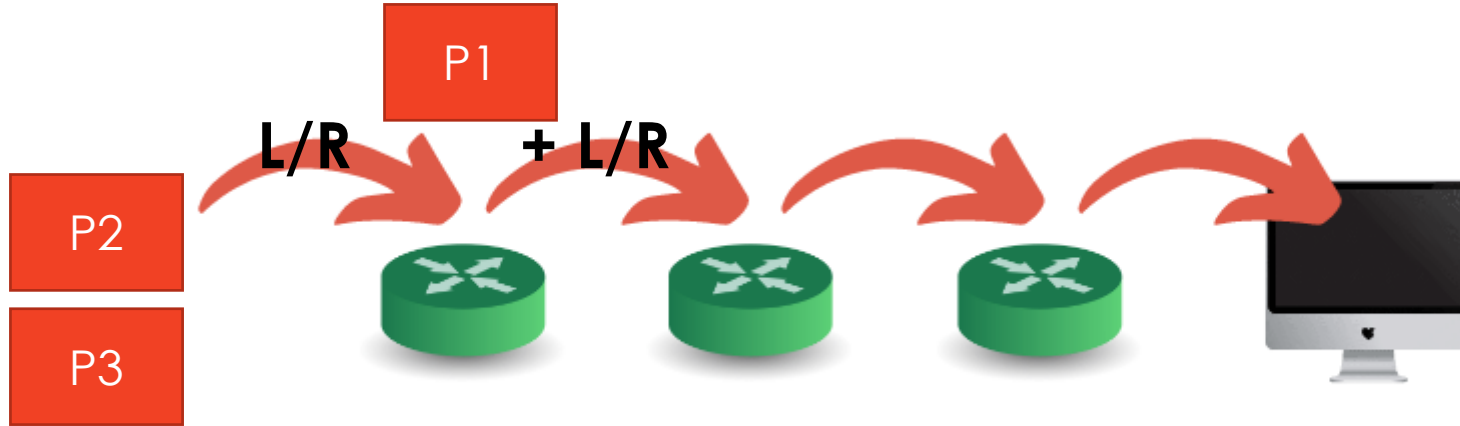




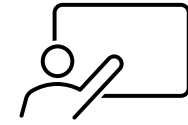
## P2 Explanation:



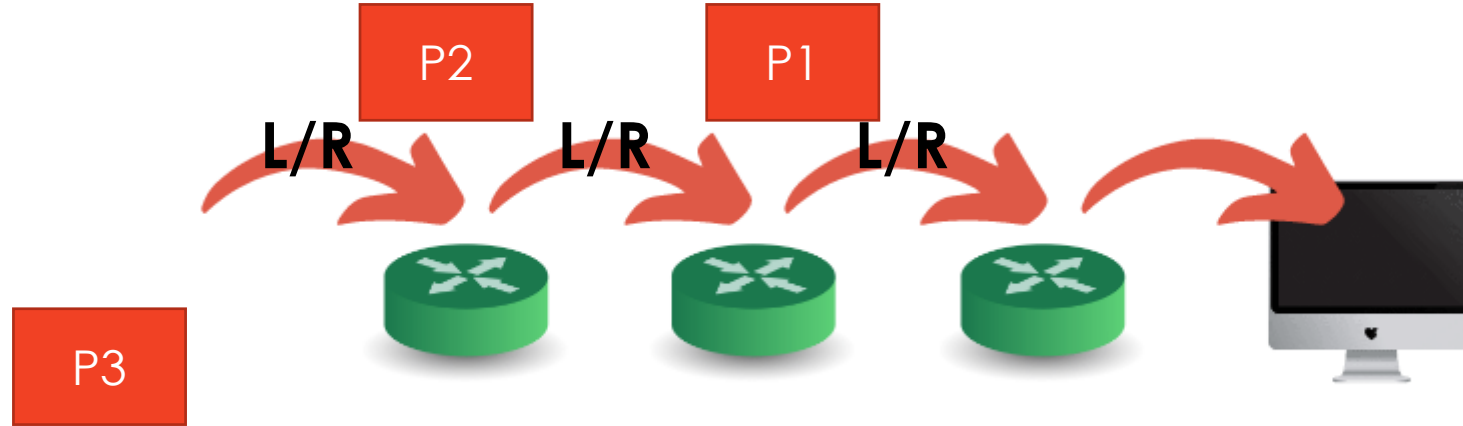
What is N? in this example?



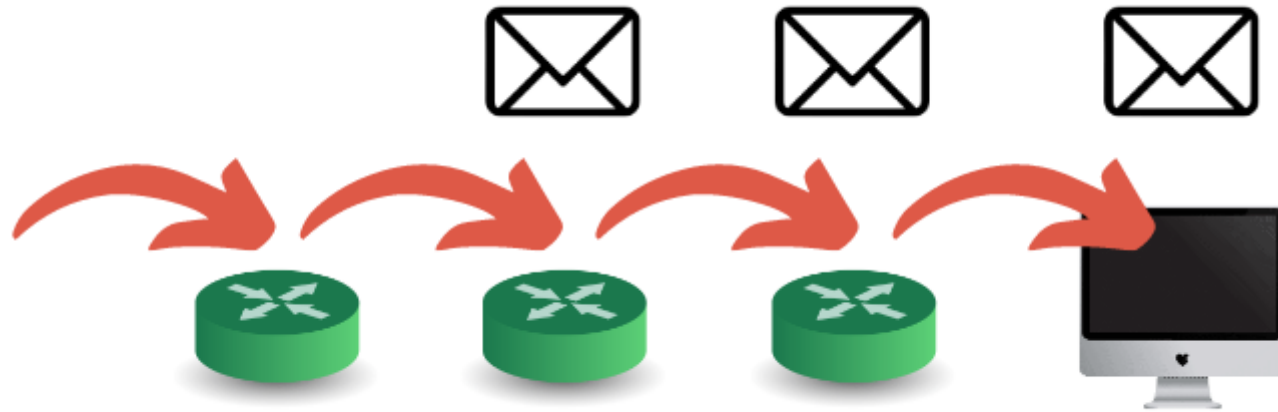
## P2 Explanation:



What is N? in this example?



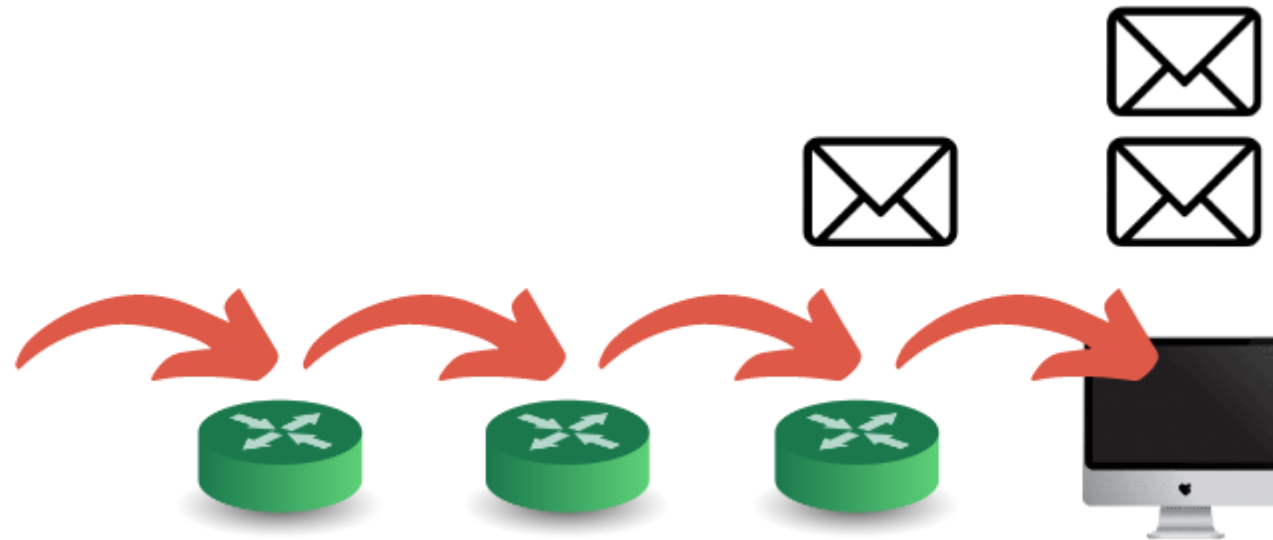
## P2 Explanation:



For the first packet to arrive its destination we will need:

$$N * L/R$$

## P2 Explanation:



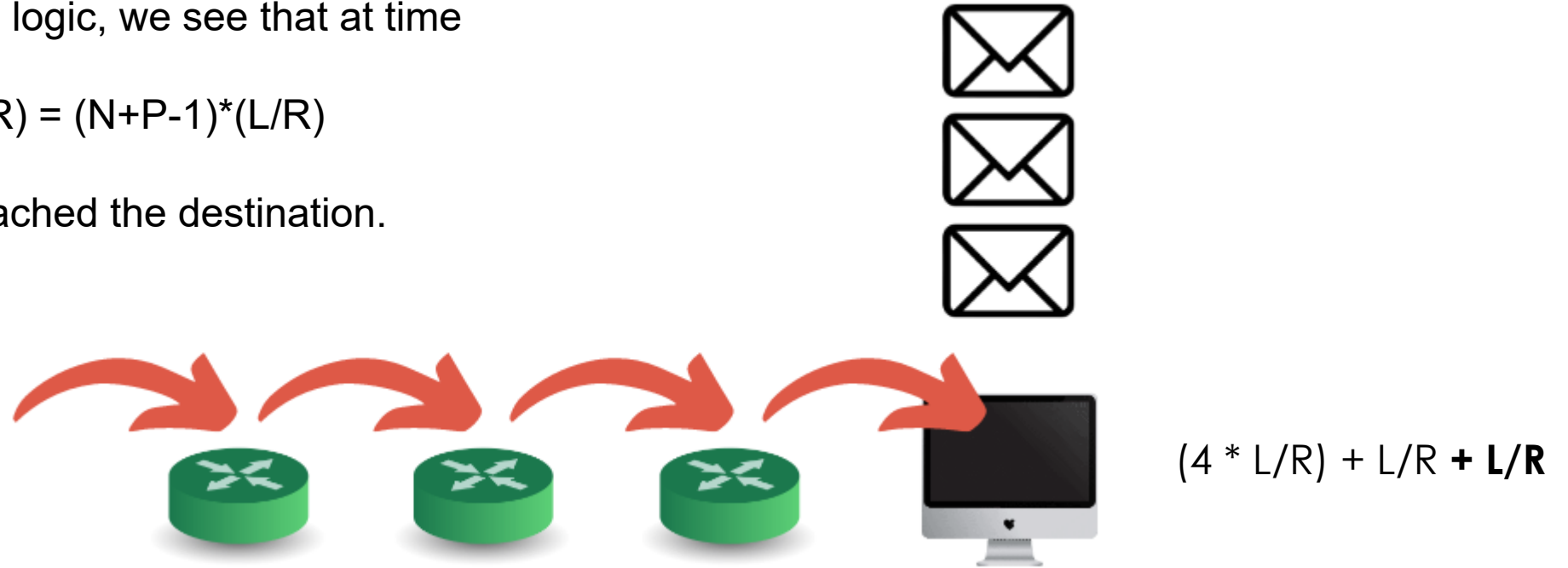
$$(4 * L/R) + L/R$$

## P2 Explanation:

Continuing with this logic, we see that at time

$$N * (L/R) + (P-1) * (L/R) = (N+P-1) * (L/R)$$

all packets have reached the destination.



The first part of the formula:  $N * (L/R)$

The second part of the formula:  $(P-1) * (L/R)$

[calculates the delay of when the first packet arrives to the destination]

[the delay of the remaining packets is calculated by this second part of the formula]

To double check, try and substitute the numbers of this topology into the formula:

$$P = 3$$

$$N = 4$$

$$4 * (L/R) + (3 - 1) * (L/R) = 6 * (L / R)$$

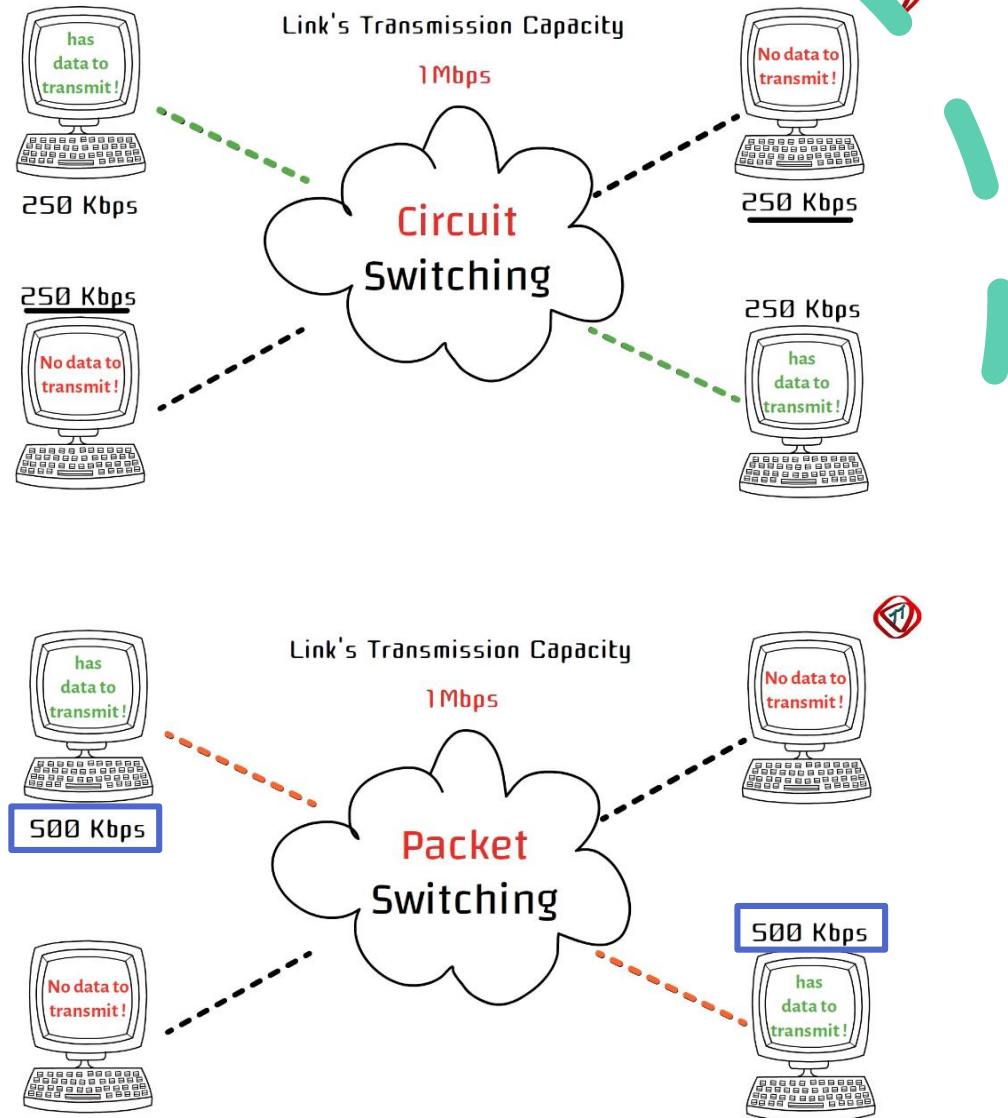


## Problem 3:

Consider an application that transmits data at a steady rate (for example, the sender generates an  $N$ -bit unit of data every  $k$  time units, where  $k$  is small and fixed). Also, when such an application starts, it will continue running for a relatively **long period of time**. Answer the following questions, briefly justifying your answer:

- a. Would a **packet-switched network** or a **circuit-switched** network be more appropriate for this application? Why?
- b. such applications as described above. Further-more, assume that the sum of the application data rates is **less than** the capacities of each and every link. Is some form of congestion control needed? Why?

Circuit-switched reserve a fixed bandwidth even if its not sending data.



Packet-switched does NOT reserve a fixed bandwidth when it does not need to use the route.

## Solution 3: (a)

a) A circuit-switched network would be well suited to the application, because the application involves long sessions with **predictable** smooth bandwidth requirements. Since the transmission rate is known and not bursty, bandwidth can be **reserved** for each application session without **significant waste**. In addition, the overhead costs of setting up and tearing down connections are paid off over the lengthy duration of a typical application session.



## Solution 3: (b)

b) In the worst case, all the applications simultaneously transmit over one or more network links. However, since each link has sufficient bandwidth to handle the sum of all of the applications' data rates, no congestion (very little queuing) will occur.

Given such generous link capacities, the network does not need congestion control mechanisms.



## Problem 8:

Suppose users share a **10 Mbps link**. Also suppose each user requires 200 kbps when transmitting, **but each user transmits only 10 percent of the time**.

(See the discussion of packet switching versus circuit switching in Section 1.3.)

- a. When **circuit switching** is used, how many users can be supported?
- b. For the remainder of this problem, suppose **packet switching** is used. Find the **probability** that a given user is transmitting.
- c. **Optional:** Suppose there are 120 users. Find the probability that at any given time, exactly  $n$  users are transmitting simultaneously. (Hint: Use the binomial distribution.)

10Mbps =  $10^8$  bits per seconds.

200Kbps = 200000 bits per seconds.

Divide those two the rate and the user's requirement together.

Link capacity / user transmission requirement

$10000000 / 200000 = 50$  users!

Solution 8:  
(a, b, and c)

10 / 100

a) 50 users can be supported.

b)  $p = 0.1$ .

c)  $\binom{120}{n} p^n (1 - p)^{120-n}$ .



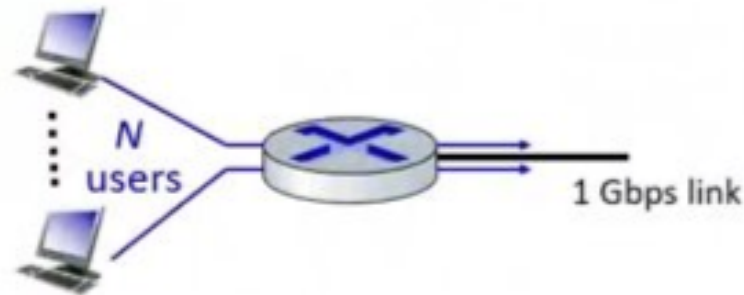
C) Suppose there are 120 users. Find the probability that at any given time, exactly  $n$  users are transmitting simultaneously. (Hint: Use the binomial distribution.)

## Packet switching versus circuit switching

*packet switching allows more users to use network!*

Example:

- 2 Mb/s link
- each user:
  - 1 Mb/s when "active"
  - active 20% of time, e.g. voice
- **circuit-switching:** 2 users
- **packet switching:** with 3 users, probability  $> 3$  active at same time is less than .008 \*



**Q:** how did we get value 0.008?

**A:**  $C(3,3)p^3(1-p)^{3-3}=0.2^3=0.008$

**Q:** what happens if 4 users ?

**ANSWER**

$$\text{c) } \binom{120}{n} p^n (1-p)^{120-n}$$

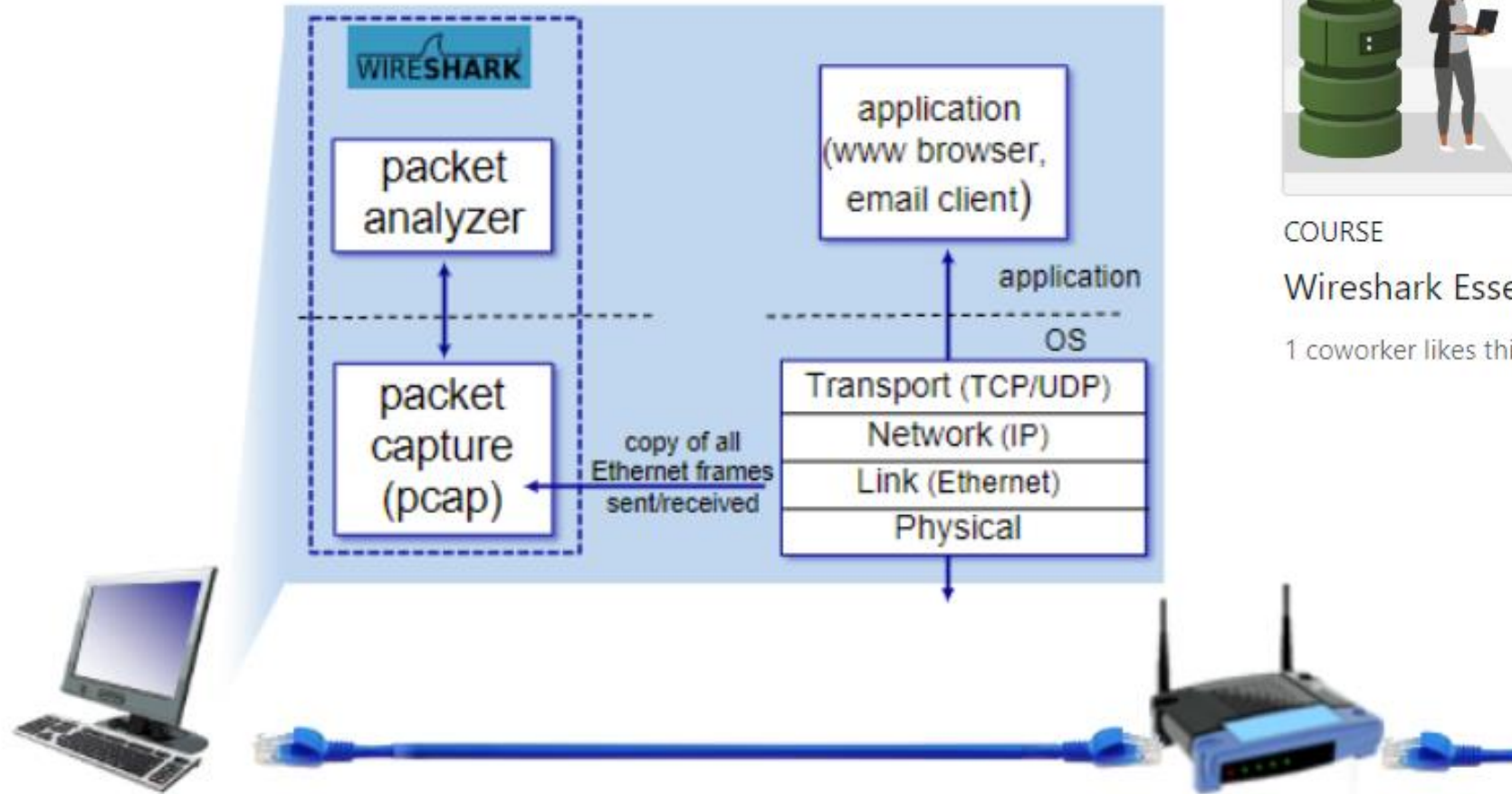
C) In the lecture we have been supplied a formula from which we can determine the probability. We can substitute the new values to complete the question.

# Week 1 Lab. PC Guide

Follow Lab PC Guide to configure Lab PC.

Enable the 'FEIT' adapter in the 'network and internet sharing' center for internet c

# Week 1 Lab: Wireshark Intro



LinkedIn course



COURSE

Wireshark Essential Training

1 coworker likes this



# Wireshark Interface

**Red Box Shows Wireshark is Running**

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

**1. Filter Toolbar**

No.	Time	Source	Destination	Protocol	Info
1827	8.598721	192.168.1.101	74.125.200.94	TCP	49246->443 [ACK] Seq=3161453776 Ack=3708602291 Win=4150 Len=0 TSval=595569656 TSecr=3513932058
1828	8.599091	192.168.1.101	74.125.200.94	TLSv1.2	Application Data
1829	8.631177	216.58.220.46	192.168.1.101	TCP	443->49251 [ACK] Seq=1298278402 Ack=1710850208 Win=371 Len=0 TSval=1704563776 TSecr=595569582
1830	8.644211	74.125.200.94	192.168.1.101	TCP	443->49246 [ACK] Seq=3708602291 Ack=3161453776 Win=547 Len=0 TSval=3513932109 TSecr=595569629
1831	8.658656	216.58.196.132	192.168.1.101	TCP	443->49249 [ACK] Seq=2905517011 Ack=521756204 Win=366 Len=0 TSval=1415568817 TSecr=595569630
1832	8.696484	74.125.200.94	192.168.1.101	TCP	443->49246 [ACK] Seq=3708602291 Ack=3161453845 Win=547 Len=0 TSval=3513932161 TSecr=595569656
1833	8.697547	216.58.220.46	192.168.1.101	TCP	443->49251 [ACK] Seq=1298278402 Ack=1710850277 Win=371 Len=0 TSval=1704563842 TSecr=595569642
1834	9.846595	192.168.1.101	216.239.98.121	TCP	443->49251 [ACK] Seq=1030802300 Ack=360272818 Win=4096 Len=0 TSval=595570899 TSecr=3031662643
1835	10.201531	216.239.98.121	192.168.1.101	TCP	443->49246 [ACK] Seq=360272818 Ack=1030802301 Win=173 Len=0 TSval=3031667578 TSecr=595570899
1836	11.798841	192.168.1.101	111.221.29.129	SSL	
1837	12.045607	111.221.29.129	192.168.1.101	TCP	443->65343 [ACK] Seq=41277483 Ack=1149722157 Win=7875 Len=0 TSval=212941084 TSecr=595572845
1838	12.045684	192.168.1.101	111.221.29.129	SSL	Continuation Data
1839	12.125740	111.221.29.129	192.168.1.101	TLSv1.2	Application Data
1840	12.125803	192.168.1.101	111.221.29.129	TCP	65343->443 [ACK] Seq=1149722228 Ack=41277616 Win=4091 Len=0 TSval=595573171 TSecr=212941102
1841	13.933007	192.168.1.101	17.253.26.253	NTP	NTP Version 4, client
1842	14.297892	17.253.26.253	192.168.1.101	NTP	NTP Version 4, server
1843	16.342582	fe80::1	ff02::1	ICMPv6	Router Advertisement from 94:fb:b2:b8:df:d8

**2. Packet List Pane**

Frame 1: 89 bytes on wire (712 bits), 89 bytes captured (712 bits)

Ethernet II, Src: 28:cf:e9:1e:df:a9 (28:cf:e9:1e:df:a9), Dst: 94:fb:b2:b8:df:d8 (94:fb:b2:b8:df:d8)

Internet Protocol Version 4, Src: 192.168.1.101 (192.168.1.101), Dst: 192.168.1.1 (192.168.1.1)

User Datagram Protocol, Src Port: 49940 (49940), Dst Port: 53 (53)

Domain Name System (query)

**3. Packet Details Pane**

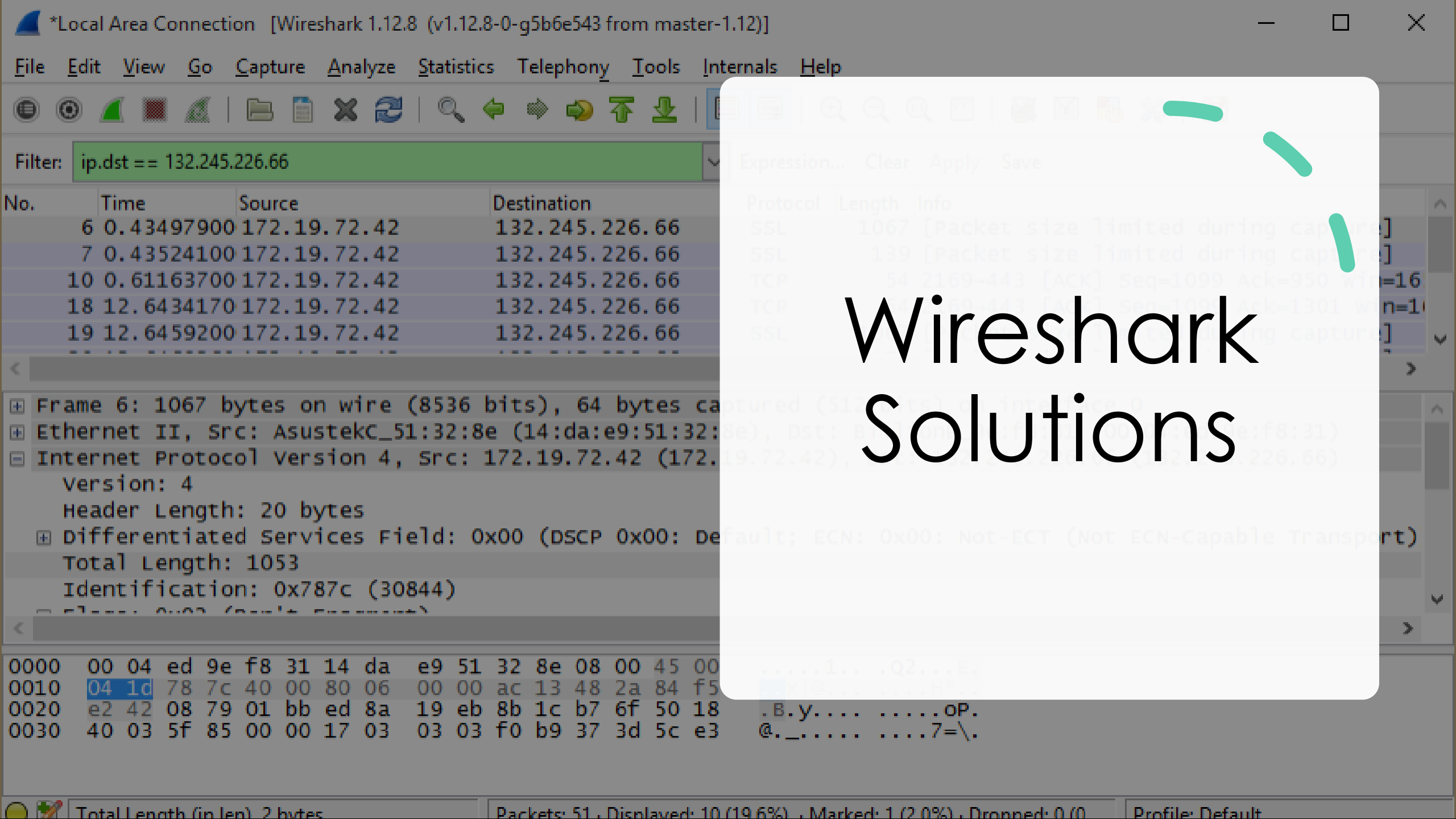
0000 94 fb b2 b8 df d8 28 cf e9 1e df a9 08 00 45 00 .....(.....E.  
0010 00 4b db ee 00 00 ff 11 5b fc c0 a8 01 65 c0 a8 .....K.....[.....e.  
0020 01 01 c3 14 00 35 00 37 95 bc 07 bf 01 00 00 01 .....5.7.....  
0030 00 00 00 00 00 00 07 70 61 67 65 61 64 32 11 67 .....p agead2.g  
0040 6f 6f 67 6c 65 73 79 6e 64 69 63 61 74 69 6f 6e oogle syn dication  
0050 03 63 6f 6d 00 00 01 00 01 .....com.....

**4. Packet Byte Pane**



# What to hand in:

1. List 3 different protocols that appear in the protocol column in the unfiltered packet-listing window in step 7 above.
2. How long did it take from when the HTTP GET message was sent until the HTTP OK reply was received? (By default, the value of the Time column in the packet-listing window is the amount of time, in seconds, since Wireshark tracing began. To display the Time field in time-of-day format, select the Wireshark *View* pull down menu, then select *Time Display Format*, then select *Time-of-day*.)
3. What is the Internet address of the gaia.cs.umass.edu (also known as www-net.cs.umass.edu)? What is the Internet address of your computer?
4. Print the two HTTP messages (GET and OK) referred to in question 2 above. To do so, select *Print* from the Wireshark *File* command menu, and select the “*Selected Packet Only*” and “*Print as displayed*” radial buttons, and then click OK.

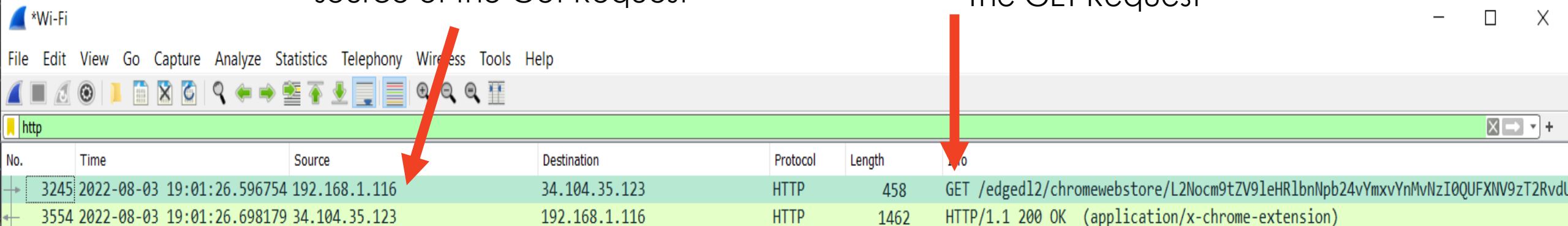


# Wireshark Solutions

# HTTP

Our laptop address, is the source of the Get Request

The GET Request

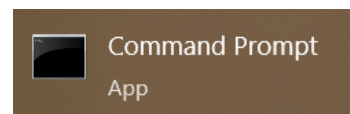


The screenshot shows the Wireshark interface with a packet capture on the 'http' filter. Two packets are visible: a GET request (No. 3245) and its corresponding 200 OK response (No. 3554). Red arrows point from the text labels to the relevant parts of the packets.

No.	Time	Source	Destination	Protocol	Length	Info
3245	2022-08-03 19:01:26.596754	192.168.1.116	34.104.35.123	HTTP	458	GET /edgedl2/chromewebstore/L2Nocm9tZV9leHRlbnNpb24vYmxvYnMvNzI0QUFXNV9zT2RvdU...
3554	2022-08-03 19:01:26.698179	34.104.35.123	192.168.1.116	HTTP	1462	HTTP/1.1 200 OK (application/x-chrome-extension)

Time

The OK Response



```
Wireless LAN adapter Wi-Fi:

Connection-specific DNS Suffix  . : 
Link-local IPv6 Address . . . . . : fe80::7440:6219:9d7b:f1b5%11
IPv4 Address. . . . . : 192.168.1.116
Subnet Mask . . . . . : 255.255.255.0
Default Gateway . . . . . : 192.168.1.1
```

**Bonus trick:** open the command prompt in your PC. And type **ipconfig** you will get to see your IP address