Tutorial questions for Chapter 1.

Expected time to complete: 2 weeks or less.

Simple questions:

Pease answer the following questions:

1. What is internet? Briefly define it with one or two sentences.

The internet is a **network of networks**, where billions of hosts are connected to networks, which are connected to ISPs. These ISPs are interconnected to form the internet as we know it.

2. What are the examples of hosts? List 3-4 examples of hosts.

A host is an end system, that may be a computer or a device which communicates with other hosts over a network. Ex: computers, smartphones, IoT devices, routers, servers (basically any device on the network that has an IP)

3. Briefly define the meaning of a protocol in computer network.

Protocols define **the format, order of messages sent and received** among network entities, and **actions taken on message transmission, receipt, errors or other states** (for example congestion, loss, disconnect).

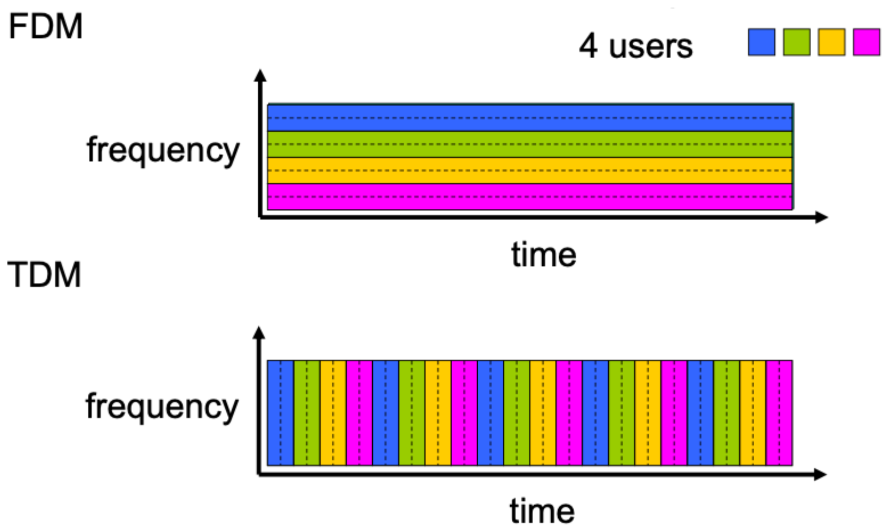
4. What are the differences between packet switching and circuit switching? Explain at least two differences between them.

Packet switching	Circuit Switching
A block of data is split into pieces (packets) and addressed individually and switched at routers to the final destination where there are assembled into the original data block.	The circuit pathways are connected from sender to receiver to form a dedicated reserved pathway for the data similar to a pipeline. The data block flows along this pipeline.
• Packets arrive out of order • Uses less resources • Is more resilient as it can take least congested pathways • Lost packets require smaller re-transmissions • Can result in high jitter	• Packets come in order • The whole pathway is reserved • A broken pathway results in the whole connection needing to be re-established • Path establishment is an expensive (time, cpu) • Very little jitter and guaranteed performance

5. What is the difference between FDM and TDM?

Frequency Division Multiplexing – The available bandwidth is separated into frequency bands (slots) that do not overlap, each carrying an individual signal. (All senders get a smaller sperate sub range to use simultaneously)

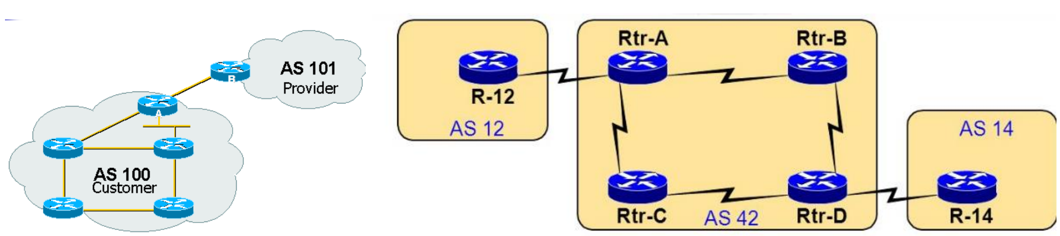
Time Division Multiplexing – The signals are sent over the available bandwidth according to time divisions, that dictate when to start sending and stop sending a signal. (The whole channel is allocated fully to each sender for a small time slice, over and over)



6. What are the three types of autonomous systems in computer networking?

AS : is a portion of a large internetwork that is under a given administrative authority (Ex: UQ)

- Stub AS : AS is connected to only one other AS. (Ex: AS100)
- Transit AS : Connected to more than one other AS. Can be used for transit traffic between autonomous systems (Ex: AS42)
- Multi-homed AS : Connected to more than one other AS but does not let transit traffic from another AS pass through itself. An example might be a corporate network with several Internet connections to different ISPs.



7. What are the reasons to use layering for Internet protocol stack (e.g., TCP/IP)? Briefly discuss how (in)efficient it will be if the information represented in internet protocol stack (TCP/IP) stack is represented in one layer.

In TCP/IP each layer is defined according to a specific function to perform. All layers work collaboratively to transmit the data from one layer to another. Thus, layers facilitate :

- Understanding and dealing with well-defined, specific part of a large and complex system
- One or more protocol standards can be developed at each layer

- As the functions of each layer are well defined, standards can be developed independently and simultaneously for each layer. This speed up the standards-making process
- Simplification for modularity for vendors, developers and users and
- Interoperability (ex: TCP or UDP, Fibre or Cable)
- Ease of changing implementation of the service provided by the layer
- Ease of Incorporation of new technologies (such as Wi-Fi when they arrive) and standards
- As long as the layer provides the same service to the layer above it and uses the same services from the layer below it, the remainder of the system remains unchanged when a layer's implementation is changed."

Calculation questions:

8. Please show an example of how to calculate packet transmission delay with your own numbers.

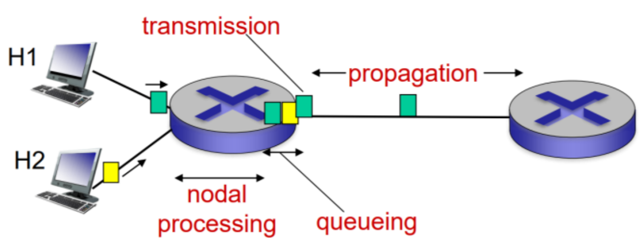
Packet transmission delay is the

$d_{trans} = time\ needed\ to\ transmit\ L - bit\ packet\ into\ link = \frac{L\ (bits)}{R\ (bits/sec)} = \frac{8 * 2}{5} = 3.2$ s

Therefore, for a packet of 2 bytes (16 bits) to be sent on a link of rate 5 bits/sec, 3.2 sec would be the resulting packet transmission delay.

[Based on **Introduction 1-18** in "Chap1 - Computer Networks & the Internet"]

9. Define a nodal delay with four sources of packet delay in an equation; show an example with numbers that generated by your own.



$$\boxed{d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}}$$

If

d_{proc}, time taken by the first router to process each packet, is 2 secs.
d_{queue}, is not applicable since there is no queuing at the out link of the first router.

L , packet size, 8 bits
R, rate of transmission, is 4 bits/sec

$$d_{trans} = \frac{L}{R} = \frac{8\ bits}{4\ bits/sec} = 2\ secs$$

d , $length\ of\ the\ link\ between\ the\ two\ routers\ is,\ 2000m$
$s, propogation\ speed\ is, 2x10^8 m/s$

$$d_{proc} = \frac{d}{s} = 1x10^{-5}s$$
$$Therefore,\ d_{nodal} = 2 + 0 + 2 + 0.00001 = 4.00001\ s$$

The nodal delay may be different if there are more packets to be sent across the link (this may result in packets waiting their turn to be put on the link, this $d_{queue} \neq 0$) , between the two routers, but for one packet under those conditions, d_{nodal} is 4.00001 seconds.

10. Quantitative Comparison of Packet Switching and Circuit Switching
(Refer to the slide [01_COMNET1_Chap1 – sup]):
Consider the two scenarios below: A circuit-switching scenario in which Ncs users, each requiring a bandwidth of 15 Mbps, must share a link of capacity 250 Mbps. A packet-switching scenario with Nps users sharing a 250 Mbps link, where each user again requires 12 Mbps when transmitting, but only needs to transmit 25 percent of the time.

a. When circuit switching is used, what is the maximum number of circuit-switched users that can be supported? Explain your answer.

When circuit switching is used, $\frac{250\text{Mbps}}{15\text{Mbps}} = 16.6667 \approx 16\ users$ can be supported at a time.

b. For the remainder of this problem, suppose packet switching is used. Suppose there are 45 packet-switching users (i.e., Nps = 45). Can this many users be supported under circuit-switching? Explain.

No, because under circuit switching, each one of the 45 users will need to be allocated 15Mbps, or an aggregate of 675 Mbps (much more than 250 Mbps link size).

c. What is the probability that a given (specific) user is transmitting, and the remaining users are not transmitting?

- The probability that a specific user is transmitting, ρ, is the percent of the time it is transmitting, i.e. 0.25.
- The probability that a specific user is not busy is (1 - ρ).
- The probability that the Nps - 1 users are not transmitting is $(1-\rho)^{Nps-1}$.
- Thus, the probability that one user is transmitting, and the other users are not transmitting is, $\rho^1(1-\rho)^{45-1} = 0.25 * 0.75^{44} = 7.954916e-7$

Ans - 7.954916e-7

d. What is the probability that one user (any one among the 45 users) is transmitting, and the remaining users are not transmitting? When one user is transmitting, what fraction of the link capacity will be used by this user?

- The probability that exactly one (*any* one) of the *Nps* users is busy is *Nps* times the probability that a given specific user is transmitting and the remaining users are not transmitting (our answer to (c) above), since the one transmitting user can be any one of the *Nps* users.
- Therefore, the fraction of the link used when a user is using the link (and the remaining users aren't transmitting) is,
  - $Nps.\rho^1.(1-\rho)^{Nps-1} = 45 * 0.25^1 * 0.75^{44} = \ 0.00003579712$

e. What is the probability that any 25 users (of the total 45 users) are transmitting and the remaining users are not transmitting? (Hint: you will need to use the binomial distribution).

- Using the formula $\rho^n(1-\rho)^{Nps-n}$ we can find the probability that n specific users are transmitting and $Nps - \ n$ users are not.
- To find the probability that any n (25 in this case) out of the 45 possible users, are transmitting is $\mathrm{choose}(45, \mathrm{n}) * \rho^n(1-\rho)^{Nps-n}$
  - $\mathrm{c}(45{,}25) * \rho^{25}(1-\rho)^{45-25} = c(45{,}25) * 0.25^{25} * 0.75^{20} =$ 0.00000892826

f. What is the probability that more than 25 users are transmitting?

The probability that more than 25 users are transmitting is

$$\sum_{i=26}^{45} \mathrm{choose}(45, \mathrm{n}) * \rho^n(1-\rho)^{Nps-n} = 0.0000029686$$

g. Comment on what this implies about the number of users supportable under circuit switching and packet switching.

- With packet switching, more than thrice the number of users can be accommodated on the same link (with capacity of 250Mbps) as compared to circuiting switching, with a small probability of collisions. This is given that packet switching users are using 12 Mbps of the link 25% of the time and circuit switching users are using 15Mbps.
- In packet switching 26-45 users my transmit at the same time with a probability of 2.9686x10^-6. In circuit switching, only 16 users may be accommodated at a time.

Practice questions

11. Run a traceroute program (Windows or linux) for a specific site (e.g., google.com) and find the information highlighted on the page 1-49 of the slide [01_ COMNET1_Chap1].

Traceroute: *www.telstra.net* to *www.tum.de*

3 delay measurements from telstra.net to gigabitethernet3-3…melbourne.telstra.net

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 1  gigabitethernet3-3.exi1.melbourne.telstra.net (203.50.77.49)  0.302 ms  0.266 ms  0.244 ms
 2  bundle-ether3-100.exi-core10.melbourne.telstra.net (203.50.80.1)  2.987 ms  1.418 ms  2.242 ms
 3  bundle-ether12.chw-core10.sydney.telstra.net (203.50.11.124)  14.107 ms  14.410 ms  12.359 ms
 4  bundle-ether1.oxf-gw11.sydney.telstra.net (203.50.6.93)  13.608 ms  12.286 ms  13.109 ms
 5  bundle-ether1.sydo-core03.sydney.reach.com (203.50.13.98)  13.359 ms  14.286 ms  12.734 ms
 6  i-10403.sydo-core04.telstraglobal.net (202.84.222.130)  14.361 ms  12.407 ms  12.735 ms
 7  i-10604.1wlt-core02.telstraglobal.net (202.84.141.225)  155.528 ms  154.704 ms  153.903 ms
 8  i-93.tlot02.bi.telstraglobal.net (202.84.253.86)  154.526 ms  153.705 ms  153.779 ms
 9  8-3-2.edge1.LosAngeles6.Level3.net (4.68.70.69)  153.277 ms
10  ae-1-5.bar1.Hamburg1.Level3.net (4.69.142.209)  297.623 ms  297.578 ms  297.562 ms
11  195.122.181.62 (195.122.181.62)  298.318 ms  298.619 ms  297.946 ms
12  cr-han2-be3.x-win.dfn.de (188.1.144.38)  302.434 ms  302.236 ms  302.312 ms
13  cr-fra2-be12.x-win.dfn.de (188.1.144.133)  307.188 ms  307.345 ms  307.565 ms
14  cr-gar1-be6.x-win.dfn.de (188.1.145.230)  316.055 ms  315.608 ms  315.932 ms
15  kr-gar188-0.x-win.dfn.de (188.1.37.90)  316.178 ms  315.728 ms  316.056 ms
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Trans-oceanic link

Note: (via https://www.tolaris.com/2008/10/09/identifying-undersea-fibre-and-satellite-links-with-traceroute/)

1 ms – within your LAN

25 ms – cable service in Telstra to servers located in Sydney

90 ms – typical home DSL in the US to google.com

100-150 ms – transoceanic cable

600-2000 ms – typical VSAT remote to hub link

You are encouraged to bring up any problems and discuss on Piazza.