

EE 580 Network Systems: Modelling & Analysis

Theory Assignment 1

Assigned: August 25, 2023

Due: August 31, 2023

You must write your answers by hand, scan and upload in Moodle.

1. Search the web and pick an interesting article about any network that you come across in real life. Write a short essay about what you learned from this article. Your essay must answer the following questions
 - (a) What is the article about? When have you come across this network/ when do think you would come across such a network?
 - (b) What kind of interconnectivity do you see in this network? For eg. (a) each node connected to every other node ? (b) clusters of nodes connected to each other, and a few inter-cluster connections? (c) arbitrary connections?
 - (c) What interesting thing did you learn about this network?

Do not just write the answers to the above questions. Write an essay that revolves around these answers. Cite the chosen article appropriately.

2. The Internet runs over two central protocols: the Transmission Control Protocol (TCP) for end-to-end network communication and the Internet Protocol (IP) for routing packets and for host-to-gateway or gateway-to-gateway communication. The congestion control mechanism in TCP is based on conserving the number of packets in the loop from the sender to the receiver and back to the sender. The sending rate is increased exponentially when there is no congestion, and it is dropped to a low level when there is congestion. Congestion is detected by the TCP source when packets get dropped at the router due to excessive queueing. Instead of varying the sending rate, TCP varies its window size, *i.e.* number of packets sent per round-trip time—total time elapsed between the instant a packet is sent from the sender to the instant when an acknowledgement is received at the sender indicating that the receiver has received the packet. Consider a TCP source that increases its sending window by 1 packet per round-trip time for every successful delivery and slashes it down to half the current window size for every packet that is dropped. Assume that the probability that a packet is dropped before it reaches the destination is p .

Using this information answer the following:

- (a) Draw a block diagram representing this process of congestion control in the Internet.
- (b) Write a mathematical model for the expected rate of change in sending window.

- (c) Find a condition that ensures that the sending window remains constant in time.

This is an exercise in mathematical modelling, not on TCP, and all the information about TCP required for the model is stated above. Any additional assumptions made must be written down clearly.

3. Suppose you have a network of 10 sensors. Each sensor updates its observation using the averaging algorithm (average of its own and its neighbours' observations) every k^{th} instant, $k \in \{1, 2, 3, \dots\}$. What would you do if you were to find the vector of the observations at $k = 10$?
4. Derive the mathematical expression for the trajectory $x(k)$ for the system

$$x(k+1) = \begin{bmatrix} 1 & 1/2 \\ 1/2 & 1/3 \end{bmatrix} x(k).$$

Comment on the convergence properties of the system.

5. Consider the matrix

$$A = \begin{bmatrix} -2 & -1 & -3 \\ 4 & 3 & 3 \\ -2 & 1 & -1 \end{bmatrix}$$

Find the eigenvalues of A . Write down the algebraic and geometric multiplicity of each of the eigenvalues. Write down the Jordan normal form of A . Using the Jordan blocks comment if A is convergent/semiconvergent.