Approval: 12th Senate Meeting

Course number	: CS 549
Course name	: Computer Networks Analysis
Credits	: 3 - 0 - 0 - 3
Prerequisites	: IC 210 Probability, statistics and random variables or equivalent CS 310 Introduction to Communicating and Distributed Processes MA 651 Optimization Techniques or the consent of the instructor.
Intended for	: BTech CSE & EE, MTech/MS/PhD in the area.
Elective/Core	: Discipline elective for BTech CSE and EE, free elective for others
Semester	**:** Any

Preamble: The proposed course offers a first formal introduction to performance analysis of different components of computer networks. It revisits some of the modules students have learned in *Introduction to Communicating and Distributed Processes* (CS 310) and provides an analytical framework for them. To understand this analytical framework some basic knowledge of probability, random processes (IC 210) and optimization techniques (MA 651) is required. This course aims at introducing students to introductory queuing theory, stochastic analysis of computer networks and different aspects of network economics.

Objective: In today's world Internet and communication technology have become part and parcel of our life. This course will introduce analytical frameworks for some of the underlying technologies and principles that make the Internet work. After a brief review of some of the basic concepts of random processes, the course will discuss how data traffic in a network is modeled. Some simple results from *Queuing theory* will be introduced in that process. Following that, the course intends to explore several routing algorithms. When multiple devices are connected to an access point, multi-access communication mechanisms ensure that each of those devices get the requested packets satisfying some fairness criteria. This course will present several such multi-access communication schemes. The course will then delve into the economic aspects of modern computer networks. Finally, if time permits, the course will touch upon some of the advanced topics, e.g., Content Distribution Network (CDN), Voice over IP (VoIP). On completion of this course, students will

1. Get a feel for processes and phenomena unique to Networks.
2. Get an analytical understanding how files (data) are transferred from a server to a client over the Internet.
3. Get acquainted with an analytical framework for the computer networks. Develop technical intuition for the layered and decentralized architecture of the Internet.
4. Be familiar with the design and analysis of different routing and MAC protocols.
5. Get an understanding of how data packets are routed over the Internet.
6. Get a firm grasp of the basics ideas and tools of Queuing theory, and also know their limitations.
7. Get a conceptual understanding of schemes for multiple access, flow and congestion control etc.

Modules: The topics to be covered are:

Introduction to computer networks (2 Lectures) A brief history and introduction to Internet, Review of networking and layering

Delay models in computer network (10 Lectures) Brief review of Random processes, Introduction to Markov chains and Queueing theory, Traffic models, deterministic and stochastic analysis; Delay modeling using Queuing theory: Little's law, M/M/1, M/M/m, M/M/m/m, M/G/1 queuing systems, priority queuing

Routing algorithms and their analysis (10 Lectures) Algorithms for shortest path routing - Dijkstra's Algorithm, Bellman-Ford Algorithm and Generalized Dijkstra's Algorithm, Optimal routing

Multiaccess communication and its analysis (10 Lectures) Slotted multi-access and the ALOHA system, Carrier sensing multiple access slotted ALOHA, Local Area Networks: Carrier Sense Multiple access with Collision Detection (CSMA/CD) and Ethernet: Slotted CSMA/CD, unslotted CSMA/CD and IEEE 802 standards, Link scheduling and Network capacity

Network economics (6 Lectures) Economic models for ISPs, price for QoS, Usage-based prices, Congestion prices, Market Dynamics, Revenue Maximization

Advanced topics (4 Lectures) Mobile IP, Multimedia streaming, VoIP, Content Distribution Networks, Software-defined networking and network function virtualization

Textbooks:

1. *Data networks*, D. Bertsekas, and, R. G. Gallager, 1992, Prentice-hall
2. *Communication networking: an analytical approach*, Anurag Kumar, D. Manjunath, and Joy Kuri.. Elsevier, 2004.

Additional References:

1. *High performance Communication networks*, J. Walrand, and P. P. Varaiya, Morgan Kaufmann Publishers In; 2nd Revised edition edition (25 October 1999)
2. *Stochastic networks*, F. Kelly, and E. Yudovina, 2014, Cambridge University press
3. *Network algorithmics*: an interdisciplinary approach to designing fast networked devices, G. Varghese, 2004, Morgan Kaufmann
4. *Notes for ECE 567 Communication network analysis*, B. Hajek, 2006, University of Illinois, www.ifp.illinois.edu/~hajek/Papers/networkanalysis.html
5. *Computer networking: a top-down approach*, J. F. Kurose, and K. F. Ross, 2010, Pearson
6. *Networks*, P. Whittle, 2004, Cambridge University press
7. *Control techniques for complex networks*, S. Meyn, , 2010, Cambridge University press