



Date: 02/08/2016

**FIRST SEMESTER 2016-2017**  
**COURSE HANDOUT (PART II)**

In addition to Part I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

**Course No.:** CS G525  
**Course Title:** Advanced Computer Networks  
**Instructor(s):** **VIRENDRA S SHEKHAWAT (Pilani Campus)**  
**Abhishek Thakur (Hyderabad Campus)**  
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**Course web page:** <http://nalanda.bits-pilani.ac.in>

**Note: This course is being offered in multi-campus mode (Pilani-Hyd) via Tele-Presence**

**Course Description:**

This is a graduate level course on computer networking and assumes a student has a basic understanding of computer network concepts. This course is a topic based course which primarily covers topics from Internet Architecture, Internet Congestion Control, Software Defined Networking, Delay Tolerant Networks, Wireless Networking, Quality of Service & Traffic Engineering, Network Performance & Management, Overlay Networks and Network Applications. Around 30 research papers/articles/case studies will be discussed on different aspects of computer networking. This course will introduce students to the basic design principles on which today's Internet is based upon along with the current and emerging research topics in computer networking area. In addition, this course will cover some recent proposals to improve network performance, functionality and scalability. This course will provide plenty of opportunity for learning by doing through project, assignments and laboratory exercises.

**Scope and Objectives:**

- To understand the state of the art in network protocols, network architecture, and networked systems.
- To develop a strong understanding of the core concepts of computer networks
- To get practice of reading the research papers and critically understanding the research of others
- To engage ourselves in networking research

**Prescribed Text Book**

There is no prescribed text book for this course. The course contents will be covered through several research papers. Students can consider following text books to refresh their basics on networking:



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i) Kurose James F and Keith W. Ross: Computer Networking: A Top-Down Approach Featuring the Internet

ii) L. Peterson and B. Davie, Computer Networks: A Systems Approach

*Note: Several technical papers/articles from the literature will be assigned throughout the semester. These papers/articles will be made available to the students through the course page.*

Module No.	Topics	Learning Objectives
M1	<b>Internet Design &amp; Architecture:</b> Overview of network building blocks, Network architecture, layers and protocols, Internet design: Challenges and Solutions	<ul style="list-style-type: none"><li>✓ To understand the Internet Design Philosophy.</li><li>✓ To learn the pitfalls in existing design and solutions.</li><li>✓ To understand future Internet design approaches for catering emerging application requirements.</li></ul>
M2	<b>Network Traffic Control &amp; Management:</b> Congestion control principles, TCP congestion control, TCP performance in Wireless Networks, IP routing: Intra-domain (OSPF/RIP) and Inter-domain (BGP), Adaptive Routing, Multipath and QoS Routing, Traffic Engineering Principles, MPLS Routing.	<ul style="list-style-type: none"><li>✓ To understand the network traffic control and management mechanisms used in the Internet.</li><li>✓ To learn about different routing protocols and performance issues</li><li>✓ To learn about different traffic engineering solutions and their applicability in different context</li></ul>
M3	<b>Software Defined Networks (SDNs):</b> SDN Controllers, Network Programmability, Network Function Virtualization, SDN Frameworks, Use cases for traffic monitoring & classification, bandwidth scheduling and monitoring.	<ul style="list-style-type: none"><li>✓ To learn about centralized control vs. distributed control of the network.</li><li>✓ To learn about network functions, virtualization and architectural principles of SDNs</li><li>✓ To understand technical challenges and potential issues arising from applying SDNs</li></ul>
M4	<b>Delay Tolerant Networks (DTNs):</b> Delay Tolerant Network Architecture, DTN Routing Protocols, Congestion Control in DTNs, DTN Application(s): e.g. Message Dissemination in Vehicular Networks, Adhoc Network for Disaster Rescue Management, Multimedia Content Delivery Network	<ul style="list-style-type: none"><li>✓ To learn about challenged/opportunistic networks and their applicability.</li><li>✓ To learn about the modified network architecture which enables data transfers under delay and disruptions conditions.</li><li>✓ To learn, how to leverage such networks to connect the IP network for data transfer.</li></ul>





M5	<b>Overlay Networks &amp; Applications:</b> Overlay Network Applications & Protocols: P2P Networks, Content Distribution Networks (CDNs), Distributed searching systems based on DHTs, Resilient Overlay Networks, P2P Overlays for Delay Tolerant Networks	✓ To learn about overlay architecture and its applications like content searching, content distribution, file sharing, real time content sharing, resilient routing, content caching etc.
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**Lecture Plan:**

Lect. No.	Topics	Reading List
<b>M1: Internet Design &amp; Architecture</b>		
0	Introduction to the course, Course plan and administration	NA
1	Internet architecture and design principles	The Design Philosophy of The DARPA Internet Protocols [Clark 1988]
2-3	Internet Layering, Functionality Implementation (like Recovery from crashes, security, reliability etc.) at lower layers vs. Higher layers	End-to-End Argument in System Design [J H Saltzer 1984]
4-5	Next generation Internet design and challenges	Tussle in Cyberspace: Defining Tomorrow's Internet [Clark 2005] A Survey of the Research on Future Internet Architectures [Jianli Pan 2011]
6	Case Study of Future Internet Design Project: Named Data Networking (NDN)	NDN Project Technical Report [Zhang 2010]
<b>M2: Network Traffic Control &amp; Management</b>		
7-8	Congestion Control Principles, TCP Congestion Control Models, Congestion Control Algorithm Design and Analysis	Congestion Avoidance and Control [Jacobson 1988] Analysis of Increase and Decrease Algorithms for Congestion Avoidance in Computer Networks [Raj Jain 1989]
9	Congestion Control at Routers: Queuing Methods (e.g. RED, FQ, CSFQ etc.)	Random Early Detection Gateways for Congestion Avoidance by Sally Floyd 1993
10-11	Multipath TCP protocol: Design principles, Load Balancing using Multipath TCP	How Hard Can It Be? Designing and Implementing a Deployable Multipath TCP [Raiciu 2012]
12-13	TCP Performance Issues in Wireless Links: Problems and Solutions	A Comparison of Mechanisms for Improving TCP Performance over Wireless Links [Balakrishnan 1996]
14-15	Internet Routing Basics: Intra domain Routing and Interdomain Routing, Border Gateway	BGP Routing Policies in ISP Networks [Caesar 2005]





	Protocol (BGP)- Performance Issues with Policy based Routing	Some Foundational Problems in Interdomain Routing [Feamster 2004]
16-17	Internet Traffic Engineering (TE) as Route Optimization, Achieving QoS/Traffic Engineering with IP Routing Protocols	Traffic Engineering with Traditional IP Routing Protocols [Bernard 2002] Making Intra-Domain Routing Robust to Changing and Uncertain Traffic Demands: Understanding Fundamental Tradeoffs [David 2003]
18-19	Multicast Routing Protocols, A Framework for Scalable Multicast Routing	A Reliable Multicast Framework for Light-weight Sessions and Application Level Framing [S Floyd 1995]
<b>M3: Software Defined Networks</b>		
20	Software Defined Networking (SDN): Centralized and Distributed Control and Data Planes, SDN Architecture	Software Defined Networking: The New Norm of Networks, White Paper, [ <a href="https://www.opennetworking.org">https://www.opennetworking.org</a> 2012]
21-22	OpenFlow: Protocol to Program the Networks	OpenFlow: Enabling Innovation in Campus Networks [N Mckeown 2008]
23-24	SDN Controller: Framework to control and Manage Network, Case Study: Open Daylight Controller/Ryu Controller	Ten Things to Look for in an SDN Controller [ <a href="https://www.necam.com">https://www.necam.com</a> ]
25-26	SDN Applications: Network Function Virtualization, Network Topology Abstraction, Network Statistics, Traffic Monitoring	FlowSense: Monitoring Network Utilization with Zero Measurement Cost [Curtis Yu 2013] Class Notes + Lab Session
<b>M4: Delay Tolerant Networks</b>		
27-28	History of Delay Tolerant Networking (DTN), DTN Architecture, Bundle Protocol	A Delay-Tolerant Network Architecture for Challenged Internets [Kevin Fall 2003]
29-30	Routing in DTNs: Taxonomy and Design, Replication Based Routing Protocols, Open Issues and Challenges	Routing in a Delay Tolerant Network [Sushant Jain 2004] Routing in Delay/Disruption Tolerant Networks: A Taxonomy, Survey and Challenges [Yue Cao 2013]
31-32	Congestion Control in DTN Networks	Retiring Replicants: Congestion Control for Intermittently-Connected Networks [N Thompson 2010] Using Buffer Space Advertisements to Avoid Congestion in Mobile Opportunistic DTNs [J Lakkakorpi 2011]





<b>M5: Overlay Networks &amp; Applications</b>		
33	Overlay Networks: Advantages and Challenges, Resilient Overlay Networks (RON)	Resilient Overlay Networks [2001]
34	Lookup Problem in P2P Networks, Scalable P2P Lookup Service for Internet Applications, Chord Protocol	Chord: A Scalable Peer-to-peer Lookup Service for Internet Applications [Stoica 2001]
35-36	DNS and Naming System, DNS and CDN, HTTP and CDN Case Study: Akamai CDN	The Akamai Network: A Platform for High Performance Internet Applications [Nygren 2011]
37-38	An overlay approach to decouple sender and receiver to generalize the Multicast, Anycast and Mobility	Internet Indirection Infrastructure [Stoica 2002]
39-40	Mobile P2P Overlay Networks for DTNs: Challenges, Prophet Based Information Retrieval, Ad-hoc Storage Overlay System	Performance Evaluation of Content-Based Information Retrieval Schemes for DTNs [M.Chuah 2009] Ad-hoc Storage Overlay System (ASOS): A Delay-Tolerant Approach in MANETs [Yang 2006]
41	Review and Thanks Giving!!!	NA

**Evaluation Scheme:**

EC No.	Evaluation Component	Duration (hrs)	Weightage(%)	Date & Time	Nature of Component
1.	Mid Semester Test	1.5	20	-	Close Book
2.	Project/Assignment/Seminar*	NA	35		Open Book
3.	Comprehensive Examination	3	35	12/12 FN	Close Book
4.	Classroom Discussions/Quizzes/Discussion Forum on NALANDA	NA	10		Open Book

\*Details will be announced in the class.

**Makeup Policy:** There will be no makeup exam for project/assignments and online quizzes. Makeup for written exam components will be given only in genuine cases as per the CSIS department makeup policy guidelines. In all cases prior intimation must be given to the Instructor.

**Chamber Consultation Hour (Pilani Campus) : TBA (Hyderabad Campus) : TBA**

**Notices:** Notices regarding the course will be displayed **ONLY** on the course page on LMS NALANDA.  
**Instructor-in-charge**



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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani  
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CS G525



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