Date: 18th Aug 2020

FIRST SEMESTER 2020-2021
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:	**VIRENDRA SINGH SHEKHAWAT**
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Course web page:	http://nalanda.bits-pilani.ac.in
	Microsoft Teams Code to Join the course: r899637

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 the 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 projects, 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:

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 Outcomes
M1	**Internet Architecture & Principles:** Overview of network building blocks, Design Philosophy of DARPA Internet, End-to-End Design Principle, layers and protocols, Internet design: Challenges and Solutions	✓ To understand the Internet Design Philosophy and it's limitation in today's context. ✓ To learn the pitfalls in existing design and solutions.
M2	**Software Defined Networks (SDNs):** SDN Architecture and Components**,** SDN Controller, Network Programmability, Network Function Virtualization (NFV), SDN Frameworks, Use cases for traffic monitoring & managment, bandwidth scheduling and monitoring.	✓ To learn about centralized control vs. distributed control of the network. ✓ To learn about network functions, virtualization and architectural principles of SDNs ✓ To understand technical challenges and potential issues arising in SDN deployment.
M3	**Network Traffic Control & Management:** Congestion control principles, TCP congestion control, IP routing: Intra-domain (OSPF/RIP) and Inter-domain (BGP), Adaptive Routing, Multipath and QoS Routing, Traffic Engineering Principles.	✓ To understand the network traffic control and management mechanisms used in the Internet. ✓ To learn about different routing protocols and performance issues ✓ To learn about different TE solutions and their applicability in different context
M4	**Wireless & Mobile Networks:** Wireless Networks fundamentals, WiFi, Mobile IP and Micro Mobility Protocols, TCP for Wireless Networks, Multi-hop Wireless Networks	✓ To understand wireless networks & node mobility issues in IP network and solutions ✓ To understand data dissemination approaches in mobile Adhoc networks
M5	**Overlay & Data Center Networks:** Overlay Network Applications & Protocols: P2P Networks, Distributed searching systems based on DHTs, Data Center Architectures, Load balancing, and Congestion Control	✓ To learn about overlay architecture and its applications like content searching, content distribution, file sharing, real time content sharing, content caching etc. ✓ To learn about data center architecture design and performance measurements

Lecture Plan:

Lect. No.	Topics	Reading List/References
M1: Internet Design & Architecture		
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 [Saltzer 1984]
4	Challenges for the current Internet design, Next generation Internet architectures	Tussle in Cyberspace: Defining Tomorrow's Internet [Clark 2005] A Survey of the Research on Future Internet Architectures [Jianli Pan 2011]
5	Case Study of Future Internet Design Project: Named Data Networking (NDN)	NDN Project Technical Report [Zhang 2010]
M2: Software Defined Networks		
6	Challenges in Legacy Network, Software Defined Networking (SDN) Evolution, SDN Architecture	Software Defined Networking: The New Norm of Networks, White Paper [ONF 2012]
7-8	OpenFlow Protocol Basics, Use of Mininet to Emulate Network	OpenFlow: Enabling Innovation in Campus Networks [N Mckeown 2008]
9-10	SDN Controllers and Network Operating System, Case Study: POX Controller	Ten Things to Look for in an SDN Controller [https://www.necam.com]
11-12	SDN Applications: Network Utilization Monitoring	FlowSense: Monitoring Network Utilization with Zero Measurement Cost [Curtis Yu 2013]
13	Achieving Network Flexibility using P4: Programming	P4: Programming Protocol-Independent Packet Processors [Bosshart 2014]
M3: Network Traffic Control & Management		
14-15	Congestion Control Principles, TCP Congestion Control Models, Congestion Control Algorithms Design and Analysis	Congestion Avoidance and Control [Jacobson 1988] Analysis of Increase and Decrease Algorithms for Congestion Avoidance in Computer Networks [Raj Jain 1989]
16-18	Modern Internet Congestion Control: The QUIC Transport Protocol Design and Analysis, BBR Congestion Control Algorithm	The QUIC Transport Protocol: Design and Internet-Scale Deployment [Adam 2017] BBR: Congestion-Based Congestion Control [Cardwell 2016]

19-21	Congestion Control at Routers: Queuing Algorithms (e.g. FIFO, FQ, RED, BLUE etc.)	Random Early Detection Gateways for Congestion Avoidance [Sally Floyd 1993] The BLUE Active Queue Management Algorithms [Feng 2002]
22-23	Internet Congestion Control using Multipath TCP protocol: Design principles and performance analysis	How Hard Can It Be? Designing and Implementing a Deployable Multipath TCP [Raiciu 2012]
24-25	Intra domain Routing and Interdomain Routing, Border Gateway Protocol (BGP)- Performance and Security Issues with BGP Routing	BGP Routing Policies in ISP Networks [Caesar 2005] Some Foundational Problems in Inter domain Routing [Feamster 2004]
M4: Wireless & Mobile Networks		
26-27	Wireless Networks Characteristics, Wi-Fi Network Fundamentals	Class Notes
28-29	TCP Performance Issues in Wireless Links: Problems and Solutions	A Comparison of Mechanisms for Improving TCP Performance over Wireless Links [Balakrishanan 1996]
30-31	Mobility Management Principles, IP Mobility Solutions	Mobility in IP Networks: From Link Layer to Application Layer Protocols and Architectures [Johnson 2010]
32-33	Wireless Mesh Architecture for High Performance Internet Access	Architecture and Evaluation of an Unplanned 802.11b Mesh Network [Bicket 2002]
M5: Overlay & Data Center Networks		
34-35	Lookup Problem in P2P Overlay Networks, Scalable P2P Lookup Service for Internet Applications using Chord Protocol	Chord: A Scalable Peer-to-peer Lookup Service for Internet Applications [Stoica 2001]
36-38	Data Center Network Architectures and Evolution of Google Data Center Network Architecture	A Scalable, Commodity Data Center Network Architecture [Al-Fares 2008] Jupiter Rising: A Decade of Clos Topologies and Centralized Control in Google's Datacenter Network [Arjun Singh 2015]
39-40	Congestion aware Load balancing for Data Center Networks.	CONGA: Distributed Congestion-Aware Load Balancing for Datacenters [Alizadeh 2014]

Evaluation Scheme:

EC No.	Evaluation Component	Duration (mints.)	Weightage (%)	Date & Time	Nature of Component
1.	Test-1	30	10	14-09-2020	Close Book
2.	Test-2	30	10	14-10-2020	Close Book
3.	Test-3	30	15	18-11-2020	Close Book
4.	Assignment	--	10	NA	Open Book
4.	Project	--	20	NA	Open Book
5.	Comprehensive Examination	2.0	35	05-12-2020	To be announced

Take home lab sheets will be made available on the course page for hands-on learning. All students are required to install the following tools Tools/Software in their laptops to perform the lab exercises, assignment and project work.

- **gcc compiler for c/c++ programming**
- **Network Protocol Simulation - ns-3**
- **SDN Network Simulation – [Mininet + Openflow + POX]**

Makeup Policy: There will be no makeup exam for project and assignment. Makeup for other components will be given only in genuine cases as per the CSIS department makeup policy guidelines. In all cases prior permission from the Instructor-In-Charge is must.
Consultation Hour: M W F 6:00 – 7:00 PM
Notices: Notices regarding the course will be displayed **ONLY** on the course page on LMS NALANDA/MS Teams.

Instructor-in-charge
CS G525