



BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

WORK INTEGRATED LEARNING PROGRAMMES

COURSE HANDOUT

Part A: Content Design

Course Title	Network Fundamentals for Cloud
Course No(s)	CC ZG503
Credit Units	4
Course Author	Nishit Narang
Version No	1.1
Date	07-Aug-2023

Course Objectives

No	Description
CO1	Understanding design and architectural choices for a data center network.
CO2	Understand enabling technologies, protocols, tools and services used for implementation of cloud networks.
CO3	Understanding cloud network performance and security challenges and methods to address them.

Learning Outcomes

No	Learning Outcomes
LO1	Design and implement a data center network.
LO2	Design and implement a virtual private cloud network in a public, hybrid or multi-cloud deployment model.
LO3	Learn performance optimization techniques and security methods for cloud networks.

Text Book(s)	
T1	Kurose James F and Keith W. Ross: Computer Networking: A Top-Down Approach, Pearson India, 6th Edition, 2013
T2	Lei Zhang, Le Chen. Cloud Data Center Network Architectures and Technologies, CRC Press 2021
T3	Dinesh G. Dutt. Cloud Native Data Center Networking: Architecture, Protocols and Tools, O'Reilly 2020
R1	Paul Goransson, Chuck Black. Software Defined Networks: A Comprehensive Approach, MK (Elsevier) 2014
R2	Ken Gray, Thomas D. Nadeau. Network Function Virtualization, MK (Elsevier) 2016
R3	Ronald L. Krutz, Russell Dean Vines. Cloud Security: A Comprehensive Guide to Secure Cloud



Computing, John Wiley & Sons, 2010

Other Reading Material

O1	Jupiter Rising: A Decade of Clos Topologies and Centralized Control in Google's Datacenter Network by Arjun Singh and Others
O2	A Scalable, Commodity Data Center Network Architecture by Mohammad Al-Fares, Alexander Loukissas and Amin Vahdat
O3	B4: Experience with a Globally-Deployed Software Defined WAN by Sushant Jain and Others
O4	Cloud Service Provider (AWS, Azure, GCP) Public Domain Technical Documentation

Suggested Pre-requisites:

It is suggested that students taking this course have a background or basic-level understanding of Computer Networks, even though the course shall cover some of the basic fundamental concepts.

Modular Structure

M1.Fundamentals of Networking

- 1.1 Network Topologies
- 1.2 TCP/IP Reference Model
- 1.3 Addressing Concepts
- 1.4 Routing and Switching Functions
- 1.5 VPNs and VLANs
- 1.6 Reliability in Data Transfer
- 1.7 Congestion Control, Flow Control and Traffic Engineering

M2.Software Defined Networking (SDN)

- 2.1 SDN Overview
- 2.2 Control Plane and Data Plane
- 2.3 SDN Architecture and Controllers
- 2.4 OpenFlow protocol
- 2.5 SD-WAN, SD-LAN, SDN Applications

M3.Network Function Virtualization (NFV)

- 3.1 NFV Overview
- 3.2 NFV-MANO Architectural Framework
- 3.3 NFV Use Cases

M4.Data Center Networks

- 4.1 Introduction to DCN
- 4.2 DCN Traffic Patterns
- 4.3 DCN Challenges
- 4.4 DCN Architecture and Technology Overview
- 4.5 DC Network Topologies
- 4.6 Underlay Networks Vs Overlay Networks
- 4.7 Multi-DC networks and Hybrid Cloud Networks
- 4.8 Routing Protocols for DCNs
- 4.9 SDN in the Data Center
- 4.10 Best Practices for DCN deployment

M5.Infrastructure Layer Networking Services

- 5.1 Virtual Private Cloud (VPC)



- 5.2 Network Load Balancing
- 5.3 Routing traffic between VMs
- 5.4 Cloud DNS
- 5.5 Cloud NAT
- 5.6 Cloud VPNs
- M6. Networking Services for Modern Applications
 - 6.1 API Gateways
 - 6.2 Application Load Balancers
 - 6.3 Content Delivery Networks
- M7. Container Networking
 - 7.1 Introduction to Containers
 - 7.2 Namespaces
 - 7.3 Virtual Ethernet Interfaces
 - 7.4 Single-host and Multi-host container networking
 - 7.5 Kubernetes Networking Example
- M8. Cloud Network Security
 - 8.1 Hypervisor Risks and Security Measures
 - 8.2 VM Secure Remote Access
 - 8.3 Network Segmentation
 - 8.4 Next Generation Firewalls, Access Security Brokers and Intrusion Prevention Systems
- M9. Cloud Network Performance and Optimization
 - 9.1 Traffic Monitoring (NetFlow) for East-West, North-South traffic flows
 - 9.2 Traffic Visualization
 - 9.3 Network Performance Measurements and Optimization

Part B: Contact Session Plan

Academic Term	Second Semester 2024 – 2025
Course Title	Network Fundamentals for Cloud
Course No	CC ZG503
Lead Instructor	NISHIT NARANG

Contact Session Plan

Session	Title	Topics	Reference
1	Fundamentals of Networking	Network Topologies	T1
		TCP/IP Reference Model	
		Addressing Concepts	
		Routing and Switching <ul style="list-style-type: none"> ● L2 Switches 	



		<ul style="list-style-type: none"> • L3 Switches • Routers 	
2	Fundamentals of Networking	Routing and Switching <ul style="list-style-type: none"> • L2 Traffic Forwarding - Spanning Tree Protocol • L3 Routing - IGP vs EGP; Link-state vs Distance-vector vs Path-vector routing; • Routing Protocols - OSPF and BGP 	T1
3	Fundamentals of Networking	VLAN Concepts	T1
		Virtual Private Network (VPN) Concepts	
		Reliable Data Transfer, Congestion Control, Flow Control and Traffic Engineering	
4	Software Defined Networking	Traditional Switch Architecture	R1, T3
		Autonomous and Dynamic Forwarding Tables	
		The Need for Programmable Networks	
		Introduction and history of SDN	
		Network Abstraction and Virtualization	
5	Software Defined Networking	Control Plane and Data Plane of Network Switches	R1, O3
		Distributed Vs Centralized Control Planes	
		SDN Architecture and Controllers	
		OpenFlow Protocol	
		SD-WAN, SD-LAN, SDN Applications	
6	Network Function Virtualization	NFV Overview	R2, T3
		NFV-MANO Architectural Framework	
		NFV Use Cases	
7	Data Center Networks	Introduction to Data Center Networks (DCN)	T2
		DCN Traffic Patterns <ul style="list-style-type: none"> • Typical DC Applications and their traffic patterns • Differences between DCN and WAN traffic profiles/volumes 	
		DCN Challenges <ul style="list-style-type: none"> • Bandwidth Oversubscription in DC Networks 	



		<ul style="list-style-type: none"> DC Network Cost and Scalability DC Cooling and Cabling Challenges TCP challenges and need for DCTCP 	
8	Data Center Networks	DCN Physical Architecture	T2, O1, O2
		Service Models of Cloud DCNs	
		DC Network Topologies <ul style="list-style-type: none"> Access/Edge-aggregation-core 3-tier structures Spine-Leaf Architecture / Clos Networks / Fat-Trees Modular and scalable DCN topologies using commodity nodes (case study) 	
		Underlay Vs Overlay Networks <ul style="list-style-type: none"> Introduction to Overlay Networks VXLAN Basics and Concepts Constructing an Overlay Network in a DC 	
9	Data Center Networks	Multi-DC networks and Hybrid Cloud Networks	T2, O3
		Routing Protocols for DCNs <ul style="list-style-type: none"> L2 Routing - TRILL as an enhancement to STP OSPF-based Routing in DCNs ECMP and BGP Routing in Large-scale DCs 	
10	Data Center Networks	SDN in the Data Center <ul style="list-style-type: none"> Virtualized Multi-tenant Data Center SDN Solutions for DCN SDN Use Cases in the Data Center 	R1, T2, O2, O3
		Best Practices for DCN Deployment	
11	Infrastructure Layer Networking Services	Virtual Private Cloud (VPC)	O4,T3
		Network Load Balancing	
		Routing Traffic between Virtual Machines <ul style="list-style-type: none"> Hypervisor-based Virtual Switch SR IOV Open vswitch (OVS) Trade-off between flexibility (OVS) and performance (SR IOV) 	
12	Infrastructure Layer Networking Services	Cloud DNS	O4
		Cloud NAT	
		Cloud VPNs	



		Use of Infrastructure Layer Networking Services in Hybrid and Multi-cloud deployments: Examples	
13	Networking Services for Modern Applications	API Gateways	O4
		Application Load Balancers	
		Content Delivery Networks	
14	Container Networking	Introduction to Containers	T3
		Concept of Namespaces	
		Need for Virtual Ethernet Interfaces	
		Single-host and Multi-host Container Networking	
		Kubernetes Networking Example	
15	Cloud Network Security	Introduction to Cloud Network Security	R3
		Hypervisor Risks and Security Measures	
		VM Secure Remote Access	
		Network Segmentation	
		Next Generation Firewalls, Access Security Brokers and Intrusion Prevention Systems	
16	Cloud Network Performance and Optimization	Network Observability	T3
		Traffic Monitoring for East-West, North-South traffic flows	
		Traffic Visualization	
		Network Performance Measurements and Optimization	

Evaluation Scheme:

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

No	Name	Type	Duration	Weight	Day, Date, Session, Time
EC-1	Quiz-I	Online	-	5%	February 17-27, 2025
EC-1	Quiz-II	Online	-	5%	April 1-10, 2025
EC-1	Assignment-I	Online	-	10%	May 1-10, 2025
EC-1	Assignment-II	Online	-	10%	To be announced
EC-2	Mid-Semester Test	Closed Book	2 hours	30%	22/03/2025 (AN)
EC-3	Comprehensive Exam	Open Book	2 ½ hours	40%	24/05/2025 (AN)



Syllabus for Mid-Semester Test (Closed Book): Topics in Session Nos. 1 to 8
Syllabus for Comprehensive Exam (Open Book): All topics (Session Nos. 1 to 16)

Important links and information:

Elearn portal: <https://elearn.bits-pilani.ac.in>

Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.

Evaluation Guidelines:

1. EC1 consists of two assignments. Announcements will be made on the portal, in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.