## Approval: 9th Senate Meeting

**Course Name**: Cloud Networking

**Course Number**: CS548

**Credits** 3-0-0-3

**Prerequisites**: CS 406 Computer Networks, CS 310 Introduction to Computing Distributed Processes, CS5 47 Network Management Systems, or the instructor's consent

**Intended for**: UG/PG

**Elective/Core**: Elective

**Semester**: 6th and 8th Semester

**Course Preamble:** In this cloud networking course, we will see what the network needs to do to enable cloud computing. We will explore in-depth the challenges for cloud networking – how do we build a network infrastructure that provides the agility to deploy virtual networks on a shared infrastructure, that enables both efficient transfer of big data and low latency communication, and that enables applications to be federated across countries and continents?
This course places an emphasis on both operations and design rationale – i.e., how things work and why they were designed this way. This course takes a look inside what has become the critical communications infrastructure for many applications today.

## Course Objectives

After you complete this course, you will be able to:

- Understand the network stack of a cloud network – network virtualization, physical interconnection of servers, routing, congestion control, and application-level techniques.
- Emulate a (small) cloud network and evaluate its performance.
- Write simple software-defined networking applications.
- Engineer networked applications for higher performance and reliability.
- Energy Efficient Cloud Networking
- Follow the latest research in cloud networking.

## Course Modules

**Module 1:** (3 contact Hours)

Cloud Networking Introduction.

**Module 2:** (7 contact Hours)

[a] Application and traffic patterns - how web search works, data center traffic , implication on networking [b] Physical network structure - Big Switch Approach, FAT tree network etc

**Module 3:** (12 contact hours)

[a] Routing and traffic engineering - STP( spanning tree), link stat protocol, Transparent Interconnection of Lots of Links, OSPF over IP, Border Gateway Protocol in the Data Center, distributed congestion aware load balancing for data centers.

[b] Host virtualization - Server Virtualization, networking VMs, Improving networking performance, packet processing on CPUs, Open vSwitch.

[c] Congestion control - Feedback control loop, Basic Congestion control Loop, Problems with TCP, Data Center TCP, Explicit Congestion Notification.

**Module 4:** (8 contact hours)

[a] Introduction to SDN architecture - Software-defined Networks, evaluation of SDN, flexible data planes, logically centralized control.

[b] Network virtualization - Network virtualization in VL2, Network virtualization in VMware NSX (VL2 Physical topology, Routing in VL2, Routing Implementation, end-end example).

**Module 5:** (10 contact hours)

[a] Inter-data center networking- Large online services work, Traditional WAN approach and problems.

[b] Content Distributed Networks

[c] Application layer techniques

**Module 6:** (3 contact Hours)

Green Cloud Networking. Energy efficient Optimization Technology, Nano Data Center.

**Textbook:**


1. G Varghese, Network Algorithmics, 1st Edition An Interdisciplinary Approach to Designing Fast Networked Devices, 2014
2. 2. Lee Chao, Cloud Computing Networking: Theory, Practice, and Development, CRC Press, August 2015.
3. 3. William Stallings, Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, Addison Wesley, Oct 2015.
4. 4. Ken Gray, Thomas Nadeau**,** SDN - Software Defined Networks, O'Reilly Media, August, 2013.


## References:

There will be a selection of readings and resources available to you for this course. Some of these will be required, while others will be optional for you to explore further.


1. Use of BGP for Routing in Large-Scale Data Centers, online https://www.ietf.org/id/draft-ietf-rtgwg-bgp-routing-large-dc-07.txt

2. RFC, TCP Congestion Control (This is an RFC, i.e., "Request for Comments."). (online) https://www.ietf.org/id/draft-ietf-rtgwg-bgp-routing-large-dc-07.txt, https://tools.ietf.org/html/rfc5681
3. Mohammad Alizadeh et. al., CONGA: Distributed Congestion-Aware Load Balancing for Datacenters, SIGCOMM'14, August 17–22, 2014, Chicago, IL, USA.
4. Ben Pfaff et. al., The Design and Implementation of Open vSwitch, 12th USENIX Symposium on Networked Systems Design and Implementation (NSDI '15).May 4–6, 2015, Oakland, CA, USA
5. Ankit Singla et.al, Towards a Speed of Light Internet, ACM Hotnets , Oct. 2014, LA, USA 2014
6. Latency: The New Web Performance Bottleneck, By Ilya Grigorik on July 19, 2012