Syllabus Template **FF No. : 654**

CS3052::Computer Networks

Credits: 4 **Teaching Scheme Theory: 2 Hours/Week**
Tutorial: 1 Hours/Week
Lab: 2 Hours/Week

Course Prerequisites: Operating System, Theory of Computer Science

Course Objectives:
1. To learn the data communication model, signal generation, data encoding, digital modulation and demodulation required for wired and wireless communication networks.
2. To learn the physical layer which includes transmission mediums, physical layer devices, transmission modes and topologies, performance issues for intranet and internetworks.
3. To learn multiple access schemes and wide area network connectivity for intranet and internetworks.
4. To learn IP protocol and routing algorithms for packet switching service framework used in intranet and internetworks.
5. To learn TCP and UDP protocol to provide quality of service over packet switching service framework used for intranet and internetworks.
6. To learn to select, design, develop, analyze and evaluate client server solutions for societal requirements at large.

Course Relevance:
The key technology of the information age is communications. Data communications and networking is a truly global area of study, both because the technology enables global communication over telephone lines and Internet. Data communication and networking is the backbone of all IT infrastructures in the world. These technologies and applications often emerge in communication within countries of countries and spread rapidly around the world.

Section 1: Topics/Contents

Unit-I Data Communication, Networking Fundamentals, Physical Layer
04 Hours
Communication Model: Source, Transmitter, Transmission System, Receiver, Destination, Data Terminal Equipment (DTE), Data Communication Equipment (DCE). Transmission Configurations: Point to Point and Multipoint. Transmission Modes: Synchronous and Asynchronous. Transmission Methods: Serial and Parallel. Communication Modes: Simplex, Half Duplex, and Full Duplex. Line Coding: Unipolar NRZ, Polar NRZ, NRZ Inverted, Bipolar Encoding, Manchester Encoding, Differential Manchester Encoding. Modulation: Analog Modulation: Amplitude, Frequency, Phase.

Pulse Modulation Techniques: PCM, PAM, PWM, PPM. Digital Modulation: ASK, FSK, MSK, GMSK, PSK, BPSK, PSK, QAM, CPM, OFDM and multicarrier modulations.
Networking Fundamentals: Types of Computer Networks: LAN, MAN, WAN, PAN, Internet, internet and Intranet. Network Architectures: Client-Server; Peer To Peer. Network Architecture Modes: Infrastructure and Ad-hoc mode. Network Topologies: Mesh, Star and Hierarchical. Reference Models: OSI, TCP/IP. Design Issues for Layers. Is ATM still used? Is ISDN dying? Is Frame Relay outdated? Is SNA still present in the Market?
Physical Layer: Transmission Mediums: Air, Water, Vacuum, Coaxial, Cat5, Cat5e, Cat6, Cat6a, Cat7, Cat8, OFC - Single and Multicore. Networking Devices Wired and Wireless: NIC, Repeater, Bridge, Switch, Modem, Router, Gateways and Access Point.

Unit-II Logical Link Control
06 Hours
Logical Link Control: Design Issues: Services to Network Layer, Framing, Error Control: Parity Bits, Hamming Codes and CRC. Flow Control Protocols: Unrestricted Simplex, Stop and Wait, Sliding Window Protocol, WAN Connectivity: PPP and HDLC. PPPoE, PPPoA. Is DOCSIS used in 2023? Do we use DSL line in 2023? Do we use coaxial cable in 2023? Is PPP still used?

Unit-III Medium Access Control
04 Hours
Medium Access Control: Channel Allocation: Static and Dynamic, Multiple Access Protocols: Pure and Slotted ALOHA, CSMA, WDMA. Legacy Standard : 10 Mbps IEEE 802.3 Standard(Ethernet), Wiring Schemes and Frame Formats, CSMA/CD, Binary Exponential Back-off Algorithm. High Speed Ethernet Standards: Fast, Gigabit and 10Gigabit (Focus must be on Gigabit Networks). Wireless Standards: Radio Spectrum, Frequency Hopping (FHSS) and Direct Sequence (DSSS), IEEE 802.11a/b/g/n/ac, IEEE 802.15, IEEE 802.15.4 and IEEE 802.16 Standards, CSMA/CA, Introduction of Infrastructure and Data Processing Unit (IPU and DPU)

Section2: Topics/Contents

Unit-IV Network Layer
06 Hours
Network Layer: Switching Techniques: Circuit, Message and Packet Switching. Logical Addressing: IPv4 and IPv6, Subnetting, NAT, CIDR. Network Layer Protocols: IP, ICMP, Routing Protocols: Distance Vector, Link State, and Path Vector. Routing in Internet: RIP, OSPF, BGP, Congestion control and QoS, MPLS, Mobile IP, Routing in MANET: AODV, DSR

Unit-V Transport Layer
04 Hours
Transport Layer: Services: Berkeley Sockets, Addressing, Connection Establishment, Connection Release, Flow control and Buffering, Multiplexing. HTH Layer Protocols:

TCP, TCP, TCP Timer management, UDP. Quality of Service: TCP Congestion Control. Traffic Shaping: AIMD. QUIC Protocol, Real Time Support Protocols: Real Time Transport protocol (RTP), Stream Control Transmission Protocol (SCTP), Quality of Service (QoS), Differentiated services, TCP and UDP for Wireless

Unit-VI Application Layer
04 Hours
Application Layer: Address Resolution: Domain Name System (DNS). WWW: Hyper Text Transfer Protocol (HTTP1.1/1.2/2.0) and HTTPS with SSL. Web Service. Email: SMTP, MIME, POP3 and Webmail. File Transfer: FTP, Dynamic Logical Addressing: Dynamic Host Control Protocol (DHCP), Custom packet generation, Design, development and evaluation of scalable enterprise application using communication and service frameworks.

List of Tutorials (13):

Unit-I Data Communication, N/w Fundamentals and Phy Layer
1) Examples and analysis of Encoding Methods: Unipolar NRZ, Polar NRZ, NRZ Inverted, Bipolar Encoding, Manchester Encoding, Differential Manchester Encoding
2) Line coding, Channel Encoding and modulations Techniques: used in IEEE 802.3 standard and its extensions, IEEE 802.11 standards and its extensions for 100 Mbps, 1 GbE, 1 Gbps, 2.5 Gbps, 5 Gbps, 10 Gbps, 25Gbps, 40 Gbps, 100 Gbps networks. Chanel Encodings in 3G, 4G and 5G Mobile Networks
Unit-II Logical Link Control
3) Examples on Network Performance parameters: RTT, Delay, Bandwidth, Throughput and efficiency
Unit-III Medium Access Control:
4) PHY and MAC Layer IEEE 802.3 Standards For Copper: Overview of 10 Mbps Ethernet, Fast Ethernet, GbE -Gigabit Ethernet, 2.5 Gigabit Ethernet, 5 Gigabit Ethernet, 10 Gigabit Ethernet, 25 Gigabit Ethernet,40 Gigabit Ethernet, 100 Gigabit Ethernet
5) PHY and MAC Layer IEEE 802.3 Standards For Optical Fiber: 100 Mbps Fast Ethernet, GbE -Gigabit Ethernet, 2.5 Gigabit Ethernet, 5 Gigabit Ethernet, 10 Gigabit Ethernet, 25 Gigabit Ethernet,40 Gigabit Ethernet, 100 Gigabit Ethernet
6) PHY and MAC Layer IEEE 802.11 Wireless LAN Standards: IEEE 802.11, Wi-Fi 1/IEEE 802.11a, Wi-Fi 2/IEEE 802.11b, Wi-Fi 3/IEEE 802.11g, Wi-Fi 4/IEEE 802.11n, Wi-Fi 5/IEEE 802.11ac, IEEE 802.11ad (WiGig), IEEE 802.11ah (HaLow), Wi-Fi 6/IEEE 802.11ax, Wi-Fi 6/IEEE 802.11ay, Wi-Fi 6/IEEE 802.11by, Wi-Fi 7/IEEE 802.11be
Unit-IV Network Layer:
7) Examples of Network Layer Logical Addressing
(a) Classful IP and CIDR: Subnetting, IP Prefixes
(b) NAT Mapping: Public to Private IP and Port Mapping
(c) Packet Delivery in Internetwork: Packets traversing through different sub-networks with different MTU and Speeds
(d) Packet Dropping Probabilities of Routers

8) Examples of Network Layer Routing
(a) Shortest Path and Spanning Tree
(b) Dijkstra's Algorithm
(c) Distance Vector Routing
(d) Link State Routing
(e) ECMP

Unit-V Transport Layer
9) Examples of Transport Layer
(a) TCP Connection Establishment: SYN and ACK, Normal Packets
(b) Flow Control: Calculating Optimal Size of Sliding Window
(c) Cumulative ACK scheme
(d) Smoothed RTT
(e) Slow Start and Additive Increase
Unit-VI Application Layer:
10) Examples of Application Layer
(a) DNS: URL Domain Processing
(b) Performance of HTTP1.0 and HTTP1.1
(c) CDN--------

List of Practical's (Minimum Six):

Unit-I Data Communication Networking Fundamentals and Physical Layer:
1) Write a program in C++/JAVA to implement - Unipolar NRZ, Polar NRZ, NRZ Inverted, Bipolar Encoding, Manchester Encoding and Differential Manchester Encoding.
2) Setting up small computer networks and Hands on networking commands:
Set up a small wired and wireless network of 2 to 4 computers using Hub/Switch/Access point. It includes installation of LAN Cards, Preparation of Cables/ Installation and Configuration of Access Point, Assigning unique IP addresses and use of ping utility. Hands on for network commands - ping, pathping, ipconfig/ifconfig, arp, netstat, nbtstat, nslookup, route, traceroute/tracert, nmap.
Unit-II and III MAC and Logical Link Layer
3) Write a program for error detection and correction for 7/8 bits ASCII codes using Hamming Codes or CRC. Demonstrate the packets captured traces using Wireshark Packet Analyzer Tool for peer to peer mode.(50% students will perform Hamming Code and others will perform CRC). Further extend it to real implementation of CRC over Ethernet standard.
4) Write a program to simulate Go back N and Selective Repeat Modes of Sliding Window Protocol in peer to peer mode and demonstrate the packets captured traces using Wireshark Packet Analyzer Tool for peer to peer mode. Further extend it to real implementation of Flow Control over TCP protocol.
Unit-IV Network Layer

5) Write a program to find the shortest path using Dijkstra Equation for Link State Routing Protocol which is used by Open Shortest Path First Protocol (OSPF) in the Internet for the network flow provided by instructor.

Unit-V Transport Layer

6) Write a program using TCP Berkeley socket primitives for wired /wireless network for following
a. Say Hello to Each other
b. File transfer
c. Calculator (Arithmetic)
d. Calculator (Trigonometry)
Demonstrate the packets captured traces using Wireshark/Fiddler for traffic analysis tool in peer to peer mode.
7) Write a program using UDP Berkeley Sockets for wired/wireless network to enable file transfer (Script, Text, Audio and Video one file each) between two machines. Demonstrate the packets captured traces using Wireshark/Fiddler for traffic analysis tool in peer to peer mode.

Unit-VI Application Layer
8) Understanding protocol stack of Intranet
a) Analyze packet formats of Ethernet, IP, TCP and UDP captured using Wireshark/Fiddler for traffic analysis tool in peer to peer mode for wired and wireless networks.
b) Use any tool for custom packet generation (Packet Sender Tool) or write your own code for packet generation and analyze the packets.
9) Develop a client-server using C++ or JAVA to demonstrate the behavior of HTTP1.0, HTTP1.1, HTTP1.2 and HTTP2.0 protocols along with all success and error messages. Use Firefox as client browser.

List of Course Project areas:
1. Simulation of modulation and demodulation for digital telephone lines
2. Simulation of modulation and demodulation for 100 Mbps Ethernet Network
3. Simulation of modulation and demodulation for Gigabit Ethernet Network
4. Simulation of modulation and demodulation for 10Gigabit Ethernet Networks
5. Simulation of modulation and demodulation for 3G for mobile networks
6. Simulation of modulation and demodulation for 4G mobile networks
7. Develop a tool fox for line encoding methods
8. Develop a tool fox for modulation and demodulation methods
9. Design and deploy TCP based Multithreaded HTTP client server for accessing student activity data in the institute.
10. Design and deploy TCP based Multithreaded FTP client server to share institute level notices.
11. Design and deploy UDP based Multithreaded TFTP client server for your class

12. Design and deploy TCP based Multithreaded SMTP and POP3 mail client server for your campus.
13. Design and deploy TCP based Multithreaded Chat client server for your class.
14. Design and deploy UDP based Multithreaded Chat client server for your class.
15. Design and deploy UDP based Multithreaded Audio Conferencing client server for computer engineering department.
16. Design and deploy UDP based Multithreaded Video Conferencing client server for computer department
17. Implementation of RIP/OSPF/BGP using Packet Tracer
18. Simulation of AODV routing protocol using Packet Tracer/ NS3/OMNet ---------

List of Group Discussion Areas:
1. Energy-Efficient Architectures For Communication System
2. Satellite Communication System
3. Data Communication in Software Defined Networks
4. Cognitive Radios for Future Communication Frameworks
5. Fast Ethernet (Encoding Framing, Modulation, Multiplexing, Diameter etc)
6. Gigabit Ethernet (Encoding Framing, Modulation, Multiplexing, Diameter etc)
7. 10G Ethernet (Encoding Framing, Modulation, Multiplexing, Diameter etc)
8. IEEE 802.11b protocol based on HR-DSSS for wireless physical layer standard
9. IEEE 802.11g protocol based on ERP-OFDM for wireless physical layer standard
10. IEEE 802.11n protocol based on HT-OFDM for wireless physical layer standard
11. IEEE 802.11ac protocol based on VHT-OFDM for wireless physical layer standard

List of Home Assignment Areas:
Design:
1. Design a communication framework for irrigation system
2. Design a communication framework for automated car
3. Design a communication framework for smart city applications
4. RIP Routing Protocol for Intranet in VIT campus
5. OSPF Routing Protocol for Internet on India
6. BGP Routing Protocol for Asia continent

Case Study:
1. WiTricity technology for industrial applications
2. Multiple access schemes implemented in 4G mobile networks
3. RFCs for wired TCP based reliable communication
4. RFCs for wireless TCP based reliable communication
5. RFCs for SSL Certificates

Blog:
1. Journey of line encoding methods
2. Journey of modulation techniques
3. Internet Logical Addressing

4 Internet Routing Protocols
5. Applications Layer Protocols

Survey
1. Analogy to digital transformations on communication systems
2. Routing protocols for MANET
3. IEEE 802.1 Physical layer standard for Internet
4. IEEE 802.15.4 standard for IoT applications
5. IEEE 802.11 Wireless Standards for Wi-Fi

Assessment Scheme: Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Bloom's Taxonomy.

Assessment scheme covers following aspects of Modified Blooms Taxonomy:

L2 Understanding, L3 Apply, L3 Design, L3 Apply, L4 Analyze and L5 Evaluate

Laboratory Continuous Assessment: 100 Marks converted to 10 Marks
Home Assignments: 100 Marks converted to 20 Marks
Course Project: End Semester Examination: 100 Marks converted to 20 Marks
Theory: End Semester Examination (Written): 60 Marks converted to 30 Marks
Comprehensive Viva Voce: End Semester Examination: 100 Marks converted to 20 Marks

Text Books: ***(As per IEEE format)***
1. Andrew S. Tanenbaum, "Computer Networks",5th Edition, PHI, ISBN 81-203-2175-8.
2. Kurose, Ross "Computer Networking a Top Down Approach Featuring the Internet", Pearson; 6th edition (March 5, 2012), ISBN-10: 0132856204
3. Frouzan B., "Data Communications and Networking", 5th edition, Tata McGraw- Hill, Publications, 2006

Reference Books: ***(As per IEEE format)***
1. Matthew S. Gast "802.11 Wireless Networks", O'Reilly publications; 2nd Edition.
2. C. Siva Ram Murthy and B. S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols" Prentice Hall, 2004
3. Holger Karl and Andreas Willing, "Protocols and Architectures for Wireless Sensor Networks", Wiley, ISBN: 0-470-09510-5

MOOCs Links and additional reading material:
www.nptelvideos.in, www.coursera.com, www.udemy.com
Course Outcomes:
The student will be able to –
1. Select line encoding, modulation, topology, essential components of physical layer, data transmission rates to design computer networks.
2. Estimate reliability issues based on error control, flow control and pipelining by using bandwidth, latency, throughput and efficiency.

3. Propose mechanisms for server channel allocation in wired and wireless computer networks
4. Develop Client-Server architectures and prototypes by the means of correct standards, protocols and technologies
5. Analyze data flow between peer to peer in an IP network using Application, Transport and Network Layer Protocols
6. Compare sustainable engineering practice indicating the scientific purpose and utility of communication frameworks and standards.

CO-PO Map:

CO	Program Outcomes (PO)												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
1	3	**2**			**2**									3		
2	3	2	**2**		2									3		
3	2	3	3	**2**		2	3							3		2
4	3	3	3	2	1	**2**	3	3	3				3	3	2	
5	3	3		2	3							**3**		3		
6	3	3		2						3		3		**3**		
Avg	**2.84**	**2.67**	**2.67**	**2.0**	**2**	**2**	**3**	**3**	**3**	**3**	**0**	**3**	**3**	**3**	**2**	**2**

Attainment Levels: 1, 5, 3, 4, 2, 4

CO Attainment levels:

Weights for attainment levels: L1 - Easy-0.75 L2 - Comfortatble-0.7 L3 – Medium – 0.65
L4 – Somewhat difficult – 0.6 L5 – Difficult – 0.55

CO1 – L1, CO2 – L5, CO3 – L3, CO4 – L4, CO5 – L2 and CO6 – L4

Future Course Mapping:

High Speed Networks, Wireless Networks, Mobile Networks, Network Security, Cyber Security

Job Mapping:

Network Engineer, Network Stack Developers, Application Developer

CN Lab Submission:

1) Write a program in C++/JAVA to implement - Unipolar NRZ, Polar NRZ, NRZ Inverted, Bipolar Encoding, Manchester Encoding and Differential Manchester Encoding.

2) Setting up small computer networks and Hands on networking commands:
Set up a small wired and wireless network of 2 to 4 computers using Hub/Switch/Access point. It includes installation of LAN Cards, Preparation of Cables/ Installation and Configuration of Access Point, Assigning unique IP addresses and use of ping utility. Hands on for network commands - ping, pathping, ipconfig/ifconfig, arp, netstat, nbtstat, nslookup, route, traceroute/tracert, nmap.

3) Write a program to simulate Go back N and Selective Repeat Modes of Sliding Window Protocol in peer to peer mode and demonstrate the packets captured traces using Wireshark Packet Analyzer Tool for peer to peer mode. Further extend it to real implementation of Flow Control over TCP protocol.

4) Write a program to find the shortest path using Dijkstra Equation for Link State Routing Protocol which is used by Open Shortest Path First Protocol (OSPF) in the Internet for the network flow provided by instructor.

5) Develop a client server using TCP Berkeley socket primitives to transfer a file in peer to peer and client server mode.

Demonstrate the packets captured traces using Wireshark Packet Analyzer Tool for peer to peer mode.

6) Develop a client server using UDP Berkeley socket primitives for chat application in peer to peer and client server mode.

Demonstrate the packets captured traces using Wireshark Packet Analyzer Tool for peer to peer mode.