## COMPUTER NETWORKS

**CURRICULUM**

**Master of Applied Science**

| DEGREE REQUIREMENTS | | Credits |
|---|---|---|
| Master's Thesis | | (Milestone) |
| CN8811 | Multimedia Proc and Digtl Comm | 1 |
| CN8812 | LAN and WAN Switching | 1 |
| CN8813 | IP Protocols | 1 |
| CN8814 | Network Math and Simulations | 1 |
| CN8815 | Network Architectures | 1 |
| Two Elective credits | | 2 |

**Master of Engineering**

| DEGREE REQUIREMENTS | | Credits |
|---|---|---|
| CN8001 | Master's Project/Case Study | 2 |
| CN8810 | Intro to Computer Networks | 1 |
| CN8811 | Multimedia Proc and Digital Comm | 1 |
| CN8812 | LAN and WAN Switching | 1 |
| CN8813 | IP Protocols | 1 |
| CN8814 | Network Math & Simulations | 1 |
| CN8815 | Network Architectures | 1 |
| Four Elective credits | | 4 |

| Electives | | Credits |
|---|---|---|
| CN8002 | Directed Studies | 1 |
| CN8816 | Network Security | 1 |
| CN8817 | Wireless Networks | 1 |
| CN8819 | Multimedia Networks | 1 |
| CN8822 | Network Operating Systems | 1 |
| CN8824 | Server Networks | 1 |
| CN8825 | Network Design | 1 |
| CN8826 | Storage Networking | 1 |
| CN8827 | Data Center Computing | 1 |
| CN8828 | Cloud Computing | 1 |
| CN8831 | Adv Topics in Network Security | 1 |
| CN8841 | Content-Aware Networking | 1 |
| CN8861 | Network Management and Analytics | 1 |

**COURSE LISTING**

**Thesis**
The student is required to conduct advanced research on a topic chosen in consultation with the student's thesis supervisor. The student must submit the completed research in a thesis format to an examination committee and make an oral presentation of the research thesis, and the research results, to this committee. Through the thesis, the student is expected to furnish evidence of competence in research and a sound understanding of the specialty area associated with the research. This is a "Milestone." Pass/Fail

**CN8001 Project/Case Study**
The student will be required to analyze the performance of a network and either design a new network or an upgrade to an existing network. Some approved projects could be undertaken with collaborating external corporation(s) under the supervision of faculty advisor(s). Pass/Fail

**CN8002 Directed Studies**
A Directed Studies course is an elective in which a student in the Computer Networks MASc program can pursue independent research in a specific area under the guidance of a supervisor. Students are required to present the work of one term (not less than 90 hours in the form of directed research, tutorials and individual study) in an organized publication format. 1 Credit

**CN8810 Introduction to Computer Networks**
This course offers a general introduction to computer networks. It explores goals, services and problems with computer networks. Computer communication is examined using the seven-layer OSI model. The purpose of each layer is discussed both from conceptual and practical aspects. Topics include: OSI model, layered architecture, data link protocols, LAN protocols, WAN protocols and details of Internet protocol. There will be several lab projects to reinforce the topics discussed in the lectures. 1 Credit

**CN8811 Multimedia Processing and Digital Communication**
The course first covers the basic concepts in source and channel coding techniques. It subsequently introduces various aspects of multimedia processing. Topics include: sampling, quantization, PCM, DPCM, delta modulation, line coding, digital modulation, information theory on entropy, Huffman coding, Lempel Ziv coding, model-based coding, information theory on channel capacity, linear block codes, cyclic codes, convolutional codes, trellis code modulation, multimedia data compression standards, and multimedia information retrieval. Theoretical concepts will be re-enforced through some real-time experiments in the laboratory using Matlab and C. 1 Credit

**CN8812 LAN and WAN switching**
This course covers both LAN (Local-Area Network) and WAN (Wide-Area Network) switching technologies. It first covers Ethernet LAN switching and related topics such as spanning tree, VLAN, trunking, multicasting. Next, it studies advanced switching technologies: TRILL and FabricPath. The topics of cloud computing such as VXLAN and SDN will also be covered. The rest of the course covers the topics of Layer-2 VPNs (Virtual Private Networks). It first introduces MPLS and then focuses on PseudoWire, VPLS and EVPN. Prerequisite CN8810. 1 Credit

**CN8813 IP Protocols**
The course provides an in-depth coverage of the Internet protocols. It has two main focuses. First, it studies various interior gateway protocols: RIP, IGRP, Enhanced IGRP, and OSPF. It then concentrates on the protocols related to the Internet operations and management, such as ICMP, DHCP, DNS, and SNMP. Other topics include multicasting and IPv6. Prerequisite: CN 8810.
1 Credit

**CN8814 Network Mathematics and Simulations**
This course provides foundations in probability and random processes, and develops the understanding of Markov processes and the simulation of Markov Chains. The course also covers queuing systems and Monte Carlo simulation. Basic simulation and modeling techniques are then discussed, followed by output data analysis. The course concludes with various Computer Networks Simulation projects using OPNET. Prerequisite: CN8810. 1 Credit

**CN8815 Network Architectures**
This course covers the design aspects of large scale internets. It introduces the concept of route distribution and examines the use of Border Gateway Protocol (BGP) for interdomain routing. Multi-Protocol Label Switching (MPLS), an advanced datagram forwarding architecture, is also introduced, and its applications in Virtual Private Networks (VPNs) and traffic engineering are studied. Prerequisite: CN8813. 1 Credit

**CN8816 Network Security**
This course covers the cryptographic algorithms and secure protocols, and their applications in security mechanisms for computer networks. The course introduces conventional encryption algorithms and Public Key Algorithm with integrity mechanism. Authentication mechanisms for OSI protocols and TCP/IP are also discussed, and their applications in Firewall and IDS (Intrusion Detection System) are studied using actual industrial (for example CISCO's) products. Prerequisite: CN8813. 1 Credit

**CN8817 Wireless Networks**
This course provides an overview of wireless networking, including wireless physical characteristics and mobility, wireless channel characteristics, signal propagation and multiplexing techniques. Specialized medium access protocols for TDMA and CDMA are then discussed, followed by an overview of the architecture of 3G systems (UMTS and CDMA2000). The course also discusses the IEEE 802.11 standard for wireless LAN, mobile routing techniques including Ad Hoc networking, mobile IP and roaming protocols, and wireless transport/TCP enhancements. The course also includes a design project of a small scale wireless network. Prerequisite: CN8813. 1 Credit

**CN8819 Multimedia Networks**
This course covers the concepts and design of multimedia networks. It first introduces the real-time transport protocols and various signaling protocols in multimedia-over-IP environments. A significant part of the course discusses the design and implementation of integrated voice/data networks. Different methods will be investigated to maintain the desirable voice quality performance. The course includes the following topics: Signaling system #7 (SS7), RTP and RTCP, multimedia signaling protocols such as H323, SIP, and MGCP, congestion control methods, and RSVP. Prerequisite: CN8813. 1 Credit

**CN8822 Network Operating Systems**
This course focuses on the issues surrounding network design using Unix and Microsoft Windows Operating Systems (OS). It explores the structure and networking capabilities of the OS's, introduces students to OS interprocess communication and client-server application design. The lab component focuses on network design, providing essential network services, and monitoring performance using Unix and Microsoft Windows servers. Prerequisite: CN8810. 1 Credit

**CN8824 Server Networks**
This course explores the technology required for a modern data center design. Three main areas of the design are examined: server-to-server/server-to-storage communication infrastructure, distributed computing environments including middleware, and distributed storage. Topics include: Fibre Channel, Infiniband, FICON, iSCSI communication protocols; high-performance computing, computer clusters and grid computing; storage area network (SAN) and storage virtualization techniques. The topics discussed in the lecture will be reinforced with the laboratory assignments requiring setting up and examining performance of various data center components. Prerequisite: CN8810. 1 Credit

**CN8825 Network Design**
This course presents the methods used for the design of various types of communication networks. The topics include: management and business perspectives on network design, estimation of traffic demand, network cost analysis, topological design, capacity assignment, routing, virtual network design, wireless network design, availability analysis and survivable network design. Prerequisite: CN8810. 1 Credit

**CN8826 Storage Networking**
The course objective is to explore the design and implementation of intelligent storage systems interconnected in Storage Area Network (SAN) infrastructure. The prevailing SAN technology with the focus on advanced SAN traffic engineering and management will be studied. The course also investigates the new SAN development trends driven by the data center virtualization and cloud computing, explores the storage and data networks relationship, and looks into the storage virtualization techniques and performance objectives. 1 Credit

**CN8827 Date Center Computing**
The objective of the course is to enable students design scalable, reliable and intelligent data center computing and virtualization solutions based on the latest technologies, including a comprehensive set of techniques for distributing computing resources and virtualization. It describes the data center unified computing and virtualization tools, explores the techniques for designing scalable data center architecture and explains how to evaluate existing data center solutions. Prerequisite: CN8824 and CN8826. 1 Credit

**CN8828 Cloud Computing**
The objective of the course is to introduce the purposes and architectures of different cloud types, and compare the advantages of cloud services to classical data center. The course would encompass virtualization technologies at compute, storage, network, desktop, and application levels as well as cloud building blocks. Prerequisite: CN8824 and CN8826. 1 Credit

**CN8831 Advanced Topics in Network Security**
Students of this course will obtain a firm understanding of the theory and applications of network security. Topics include: AAA mechanisms, secure policy manager, network secure management, Internet security and privacy, and web security. In addition, it covers wireless security fundamentals and addresses common risks and threats on wireless environment.
Prerequisite: CN8816. 1 Credit

**CN8841 Content-Aware Networking**
This course provides a focused perspective on the core technologies of the World Wide Web, and also state-of-the-art technologies of how to improve the web performance and how to build a content-aware and intelligent network. We focus on architectures, protocols, standards and devices (such as client, proxies, servers and load balancers) that constitute the web and deliver the content across the Internet. The course also covers web caching, content delivery networking, peer-to-peer networking, and multimedia streaming. Prerequisite: CN8810. 1 Credit

**CN8861 Network Management and Analytics**
This course gives an understanding of how to monitor and manage networks and services using data analytics and machine learning tools. It introduces management architecture, reference model, structure of management information (SMI), management information base (MIB). It also covers details on network management protocols such as SNMP, Syslog, NetFlow etc. Advanced topics such as policy-based network management, intent based network management and network data analysis using machine learning are also studied. Prerequisite: CN8810**.** 1 Credit

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