M. Sc. Program – Courses Outline

1400501 Operating System

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Graduate Standing

Objective: This course is intended to cover basic concepts underlying operating systems.

Course Outline:

- Review of computer architecture, layered design process and thread models, thread implementation and management, scheduling
- Context switching, saving state, thread creation and termination, deadlock
- Thread coordination, mutual exclusion, other synchronization paradigms
- Inter-process communication, messages, buffering issues, priority, one-to-many communication
- Address space and low level memory management, stack and heap segments, hardware support
- Interrupt and exception handling, dispatching
- Device independent I/O, generic device interface
- Low level device detail, driver design, begin virtual memory
- Virtual memory concepts, segmentation and paging, hardware support
- File systems, disk model, separation of naming/indexing/access mechanisms, protection
- Network interface and inter-machine communication, relation to hierarchy
- Real time issues, clock management, real time processing

1400502 Design & Analysis of Algorithms

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Graduate Standing

Objective: The course provides fundamental knowledge regarding the design and analysis of computer algorithms and also provides tools to analyze and compare the performance of algorithms. Learn to prove the correctness of algorithms and emphasize classes of problems that can be solved by computers.

Course Outline: Basic techniques for designing and analyzing algorithms: dynamic programming, divide and conquer, balancing. Upper and lower bounds on time and space costs, worst case and expected cost measures. A selection of applications such as disjoint set union/find, graph algorithms, search trees, pattern matching. The polynomial complexity classes P, NP, and co-NP; intractable problems.

1400503 Computer Architecture

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Graduate Standing

Objective: The course Objective: is to provide detailed information of advanced computer architecture along with distributed systems, limitations, memory organization, and engineering necessary for the design of computer systems.

Course Outline: This course first reviews the fundamental concepts in computer architecture. The fundamental concepts consist of two main parts: (1) *What* to do and (2) *How* to do. Consequently, Instruction-set architecture (ISA) describes *what* the computer does while the computer organization describes *how* the ISA is implemented. After studying the fundamental concepts, this course covers the innovative features of computer architectures such as pipelining, superscalar processing, vector and SIMD processing, Thread-level parallelism and cache memory systems.

1400508 Research Seminar I

Credit Hrs. 0, Contact Hrs. 3

Prerequisite: Graduate Standing

Objective: Research Seminar allow students to interact and learn from latest research trends in computing field from Researchers in the college and guest speakers.

Course Outline: Research Seminar allow students to interact and learn from latest research trends in computing field from Researchers in the college and guest speakers.

Course Contents: Recent Articles

1400509 Research Seminar ll

Credit Hrs. 0, Contact Hrs. 3

Prerequisite: Graduate Standing

Objective: Research Seminar allow students to interact and learn from latest research trends in computing field from Researchers in the college and guest speakers.

Course Outline: Research Seminar allows students to interact and learn from latest research trends in computing field from Researchers in the college and guest speakers.

1400510 Information security

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Student must have taken an undergraduate course in Information Security or related field

Objective: Provide an overview of information security: confidentiality, integrity, and availability.

Course Outline:

- Introduces the concept of information security.
- Discusses need for organizational policy to define required services such as confidentiality, authentication, integrity, non-repudiation, access control, and availability, and mechanisms to implement those services.
- Covers different types of security including physical security, computer security, and network security; common threats to and attacks against information systems, including accidental damage, identity theft, malicious software, and "spam"; and defensive measures.

1400511 Cryptography and Secure Communication

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400510

Objective: This course introduces the basic concepts of cryptography. Various cipher systems Various cipher systems are presented. Case studies of use of cryptographic methods in communication systems are presented with some consideration given to privacy issues.

Course Outline: Historical Overview of Cryptography, Privacy, Mathematical Overview, What did Shannon say about cryptography, Transposition and Substitution Ciphers, Rotor Machine and Poly-alphabetic Ciphers, Block Ciphers: DES, Can DES be attacked, Public Key Systems, Knapsack System, The Knapsack System Bites the Dust, RSA System, Key Management, Digital Signatures and Authentication, Stream Ciphers, Linear Shift Registers, Non-Linear Shift Register, Privacy and Cryptography.

1400512 Advanced Information Assurance

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400510

Objective: This course provides a comprehensive view of information security so as to develop a big picture perspective. It also provides exposure to some advanced concepts in information security and assurance, including some recent research results.

Course Outline: Ethics in security research, Publish/subscribe systems, Control systems/power grid, Privacy in social networks, Cloud computing Security, P2P Privacy, Wireless security, Privacy in healthcare applications, Security metrics.

1400513 Computer Forensics

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400510

Objective: Upon successful completion of this course, you will be able to demonstrate a working knowledge of basic computer forensics applications and tools; understand the fundamentals and basic principles of computer forensics and crime scene analysis; and apply the principles and procedures of computer forensics.

Course Outline: Introduction to Cyber Forensics, Criminalities, Disk Structures/Controlled Boot Environment, Bag and Tag, Search and Seizure: Legal Rules, Evidence Acquisition, Media Analysis, File systems, Data Hiding, Mac Forensics, HFS Plus, Anti-Forensics

1400514 Network security

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400510

Objective: Computer and communication security has emerged as a central field of study, with the growing indispensability of the Internet in our day-to-day life. This course provides a broad introduction to host-based and Internet-based computer security.

Course Outline: Introduction, Web security, Security standards, SSL/TLS and SET, Intruders and viruses, PGP and MIME for electronic mail security, Firewalls, Secret Key and Public/Private Key Cryptography, Cryptographic Hashes and Message Digests, Authentication Systems (Kerberos), Digital signatures and certificates, Kerberos and X.509v3 digital certificates.

1400519 Advanced Topics in Information Security

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400510

Objective: Advanced Topics in Information Security

Course Outline: TBD

1400520 Computer Networks

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Student must have taken an undergraduate course in Computer Networking or related field

Objective: To learn such principles of networking that focus on an analytical approach to network design, dimensioning and controls.

Course Outline:

- This is a graduate level course on computer networking focusing on advanced topics and is a must for anyone interested in doing research in computer networks.
- This course examines the current and emerging research topics in computer networking.
- Topics covered include network protocols, network measurement, Internet routing, and peer to peer applications, etc.

- Students are expected to carry out a research project that may include modeling, analysis, design, and implementation components.

1400521 Advanced Computer Networks

Credit Hrs. 3, Contact Hrs. 3
Prerequisite: 1400520

Objective: To acquaint students with major internet protocols, their features, details, and Functionality. Also introduce student to principles and abstractions underlying design choices, and how tradeoffs affect the overall system

Course Outline: Introduction to internetworking, Internet concept, Datagram concept and datagram format, Error messages and error handling, Routers and datagram processing, Protocol layering, Transport protocols, Reliable Stream delivery service (TCP), Distance-vector and link-state routing algorithms, Autonomous systems concept, Interior gateway protocols, Client-server model for applications, Network and internet management, Recently emerging protocols and technologies.

1400522 Wireless and Adhoc networks

Credit Hrs. 3, Contact Hrs. 3
Prerequisite: 1400520

Objective: The course provides fundamental knowledge of both ad hoc and sensor networks. It will focus on applications, hardware, and network architecture of both types of networks.

Course Outline: The course will introduce the state of the art in ad hoc networks and sensor networks, and it will focus on distributed algorithms and protocols of both ad hoc and sensor networks. The course starts with introduction on applications, hardware, and network architecture of ad hoc networks. Then it will focus on protocols and algorithm for ad hoc networks. After that the course will introduce sensor network and its protocols.

1400523 Digital Communication and Coding Theory

Credit Hrs. 3, Contact Hrs. 3
Prerequisite: 1400520

Objective: To develop fundamental design and analysis techniques necessary for understanding and working with modern digital communication systems.

Course Outline: Principles and techniques of digital modulation, demodulation. Transmission and coding, 0 Applications of modern digital communication systems.

1400529 Advanced Topics in Networking

Credit Hrs. 3, Contact Hrs. 3
Prerequisite: 1400520

Objective: Advanced Topics in Networking

Course Outline: TBD

1400530 Software Engineering

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Student must have taken an undergraduate course in Software Engineering or related field

Objective: The goal of software engineering is to control the quality of software by following engineering principles during development.

Course Outline:

- Research Directions in Software Engineering
- Project management
- IEEE Standards for developing software life cycle
- CMMI process improvement framework
- Conceptual Representation of Software Systems
- Domain engineering
- Requirements Tractability
- Applications Frameworks
- Software Product Lines
- Component Models
- Component Composition
- Software Reuse
- Service Oriented Architecture
- Architectural Patterns
- Design Patterns
- UML
- Aspect Oriented Programming
- Legacy System Management and Evolution
- V&V frameworks
- Software Refactoring

1400531 Software Quality Assurance

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400530

Objective: This course introduces concepts, metrics, and models in software quality assurance. The course covers components of software quality assurance systems before, during, and after software development. It presents a framework for software quality assurance and discusses individual components in the framework such as planning, reviews, testing, configuration management, and so on. It also discusses metrics and models for software quality as a product, in process, and in maintenance. The course will include case studies and hands on experiences. Students will develop an understanding of software quality and approaches to assure software quality.

Course Outline: Describe SQA, its activities, goals, and responsibilities. Explain SQA payoffs and tradeoffs. Discuss the role of SQA at each stage of the software project life cycle and at the project management level. Identify the people who constitute the quality team and specify the options for organizing the quality team. Describe the components of an SQA Plan. Explain how to launch SQA and the problems that are encountered during the launch.

1400532 Advanced Software Engineering

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400530

Objective: This course aims to teach students a number of advanced techniques to enhance their software development capabilities in order to tackle enterprise level problems and provide efficient software solutions. Students will be exposed to techniques that are gaining increasing attention in the industrial and research communities. They will apply the software engineering techniques to homework assignments and mini-projects throughout the course. Both individual and group-oriented exercises will be assigned.

Course Outline: This course presents different techniques to overcome the challenges of building software systems, either from scratch or by incorporating ready made parts into local and distributed systems.

1400533 SW Process Management and Maintenance

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400530

Objective: This course introduces concepts, techniques, and tools to successfully manage long term, large scale software projects. A successful software project has to meet customer requirements on time and within budget. The course covers tools and techniques for project planning, scheduling and process improvement. The course also covers topics related to software evolution.

Course Outline: The course will cover Planning and Managing Large Scale long term Software Projects: topics include: Project management, risk management, planning, project tools, working in a team, Software Development Processes, Heavyweight vs. lightweight methodologies.

1400534 Software Testing

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400533

Objective: The course will attempt to prepare students to test software in structured, organized ways. This course should provide practical knowledge of a variety of ways to test software, an understanding of some of the tradeoffs between testing techniques, and a feel for the practice of software testing and the research in software testing

Course Outline: Concepts and techniques for testing software and assuring its quality. Topics cover software testing at the unit, module, subsystem, and system levels, automatic and manual techniques for generating and validating test data, the testing process, static vs. dynamic analysis, functional testing, inspections, and reliability assessment

1400539 Advanced Topics in Software Engineering

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400530

Objective: Advanced Topics in Software Engineering

Course Outline: TBD

Course Contents: TBD

1400540 Database Management

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisite: Graduate Standing

Objective : The course will expose the students to the internals of database management systems, allowing them to understand its internal functionality. This will have a direct impact on using and tuning database management systems

Course Outline: The course will cover techniques in schema designing, SQL queries, and relational algebra. Physical storage techniques. Query processing/optimization. Transaction management. Mechanisms for concurrency control and disaster recovery

Course Contents:

- The Entity-Relationship Model
- Relational Algebra and Calculus

- SQL Queries, Constraints, and Triggers
- Physical Data Storage
- Data Indexing
- Query Evaluation
- Query Optimization
- Transaction Management
- Concurrency Control
- Recovery Management

Textbooks/References

Database Management Systems, Third Edition. By Raghu Ramakrishnan, Johannes Gehrke Publisher: McGraw-Hill (2003) - Hardback - 1065 pages - ISBN 0072465638

References:

- Fundamentals of Database Systems, Sixth Edition. By Ramez Elmasri, Shamkant B. Navathe Publisher: Addison-Wesley (2010) - Hardback - 1172 pages - ISBN 0136086209
- Database systems: The Complete Book. By Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom Publisher: Pearson Prentice Hall (2009) - Hardback - 1203 pages - ISBN 0131873253

1400541 Distributed Database Systems

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisite: Database Management 1400540

Objective:

A student successfully completing this course should be able to:

- Appreciate the limitations of a centralized database.
- Understand the techniques used to implement distributed transaction processing, and query processing
- Understand how reliability and security issues extend to distributed database systems

Course Outline:

- This course will cover fundamental concepts and issues of distributed database systems.
- The course will not cover the use of a distributed database management system.
- Students are expected to have an undergraduate-level familiarity with concepts of database systems and networking.

Course Contents

- Distributed transaction processing and concurrency control
- Distributed reliability and security
- Distributed query processing
- Parallel database systems
- Advanced Topics
- For the first three areas, we will start by observing problems and investigating solutions in a centralized database.
- Then we will extend to a distributed database and address the issues of distribution.
- The focus of this course is on concepts (algorithms and protocols) used in distributed databases.
- Advanced topics will cover current issues in distributed database systems including P2P databases, web databases, sensor and stream databases.

- The theoretical work will be augmented with project work allowing students to implement some of the distributed algorithms or protocols.

Textbooks/References

- Principles of Distributed Database Systems, (Second Edition), by Tamer Ozsu and Patrick Valduriez Prentice Hall ISBN 0-13-659707-6 (1999)
- Concurrency Control and Recovery in Database Systems, by P.A. Bernstein, V. Hadzilacos and N. Goodman Addison Wesley.

1400542 Machine Learning and Data Mining

Prerequisite: Database Management, 1400540
Credit Hrs. 3, **Contact Hrs**. 3

Objective

This course introduces students to the primary approaches to machine learning and data mining from a variety of fields, including inductive inference of decision trees, neural network learning, statistical learning methods, reinforcement learning, clustering, and discovery.

Course Outline

- Introduction: What is machine learning? Concept formation
- Decision trees: test selection, pruning, MDLP, Increment versus Bach
- Instance-based learning; logically weighted regression
- Neural networks: Perceptrons and gradient descent, back propagation
- Bayesian approaches: Basics, EM, hidden Markov models
- Knowledge discovery in databases
- Empirical evaluation of learning systems
- Boosting, feature selection
- Computational learning theory
- Scientific discovery; deviation detection
- Clustering
- Reinforcement learning; Q-learning; TD-learning
- Learning from time series

Course Contents

- Data Mining has emerged at the confluence of artificial intelligence, statistics, and databases as a technique for automatically discovering summary knowledge in large datasets.
- This course introduces students to the process and main techniques in data mining, including classification, clustering, and pattern mining approaches.
- Data mining systems and applications are also covered, along with selected topics in current research.

Textbooks/References

D. Hand, H. Mannila, P. Smyth (2001). Principles of Data Mining. MIT Press

1400543 Multimedia Databases

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisite: Database Management 1400540
Objective

Prepares students for research in multimedia database systems. Students are exposed to a variety of emerging innovative techniques to store, manipulate, communicate, visualize, and reason with multimedia systems.

Course Outline

- Introduction to multimedia applications
- Multimedia Database Management: Logical Modeling
- Case Studies: Oracle Media Server
- Multimedia Database Management: Physical Management
- Distributed multimedia systems
- User Interface, tools and methodologies
- Design on Oracle Web Server

Course Contents

- This course provides a general coverage of three major areas that include
  a) multimedia data management (logical and physical modeling),
  b) broadband network architectures and
  c) protocols for distributed multimedia communication, and user interface environments.
- Various models and specification methodologies in these areas are introduced. The discussion is augmented with various case studies.

Textbooks/References : Current literature

1400544 Information Retrieval

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisite: Database Management, 1400540

Objective

This is an introductory course for graduate students covering the practices, issues, and theoretical foundations of organizing and analyzing information and information content for the purpose of providing intellectual access to textual and non-textual information resources. This course will introduce students to the principles of information storage and retrieval systems and databases. Students will learn how effective information search and retrieval is interrelated with the organization and description of information to be retrieved. Students will also learn how to use a set of tools and procedures for organizing information, will become familiar with the techniques involved in conducting effective searches of online information resources and will build a professional search engine

Course Outline

- Introduction to information retrieval
- Basic techniques, models and terms
- Basic tokenizing, indexing, and implementation of vector-space retrieval
- Experimental Evaluation of Information Retrieval: performance metrics, evaluations on benchmark text collections.
- Query operations and languages
- Text Representation: word statistics, morphology, index term selection using thesauri, metadata and markup languages (SGML, HTML, XML).
- Web Search: search engines, spidering, metacrawlers, robots, agents, and link analysis
- Text Categorization: categorization algorithms, applications to information filtering and organization
- Language-Model Based Retrieval: using Naive Bayes text classification for ad-hoc retrieval, improved smoothing for document retrieval

- Text Clustering: Clustering algorithms, applications to web search and information organization
- Information Extraction and Integration: web metadata, extracting data from text, semantic web, collecting and integrating specialized information on the web
- Recommender System: collaborative filtering and content-based recommendation of documents
- XML retrieval
- Multimedia Information Retrieval: mining information from audio, video, and text

Course Contents

This course covers basic and advanced techniques for text-based information systems. Students will explore organization, representation, and access to information; categorization, indexing, and content analysis; data structures for unstructured and semi structured data; design and maintenance of such databases, efficient text indexing, retrieval and classification schemes; use of codes, formats, and standards; analysis, construction and evaluation of search and navigation techniques; and Web search including crawling, link-based algorithms, and Web metadata; text/Web clustering, classification; and text mining. Students will be examined through a project along with a report and presentation, midterm and final exam, and exercises and class participation.

Textbooks/References

- Introduction to Information Retrieval by Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Cambridge University Press, 2008, ISBN: 9780521865715 (hard cover)
  http://nlp.stanford.edu/IR-book/html/htmledition/irbook.html (online available)
- 5. Information Retrieval--Implementing and Evaluating Search Engines by Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, MIT Press, 2010, ISBN: 0-262-02651-1 (hard cover)
  http://www.ir.uwaterloo.ca/book/ (online available)

References:

- Search Engines: Information Retrieval in Practice, 1/e by Croft, Metzler and Strohman, Addison-Wesley | Cloth, 2010, ISBN: 0136072240
- Modern Information Retrieval: The Concepts and Technology behind Search, 2/e by Baeza-Yates and Ribeiro-Neto, Addison-Wesley Professional, 2011, ISBN: 0321416910

1400549 Advanced Topics in Data and Information Management

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisite: Database Management, 1400540
Objective : Advanced Topic in Data Information Management
Course Outline: TBD
Course Contents: TBD
Textbooks/References: TBD

1400550 Parallel and Distributed Systems

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Graduate Standing
Objective

A student successfully completing this course should be able to:

- Understand basic parallel and distribute computing platforms
- Apply standard parallel programming APIs such as Pthreads, OpenMP, and MPI
- Understand the design principles of parallel algorithms, in particular the sources of performance loss that occur during parallelization

Course Outline

This course deals with emerging trends in the use of large scale computing platforms ranging from desktop multi-core processors, tightly coupled SMPs, to large-scale message passing platforms

Course Contents

- 1. Parallel and distributed platforms: processor and memory architectures, SMP and message passing hardware, interconnection networks, network hardware, and evaluation metrics for architectures.
- 2. Parallel Programming: Message passing using MPI, thread-based programming using POSIX threads, and directive-based programming using OpenMP
- 3. Parallel and Distributed Algorithms: design principles for parallel algorithms, studies of widely used parallel algorithms, metrics for evaluating performance
- 4. Applications: A variety of parallel applications from diverse domains such as data analysis, graphics and visualization, particle dynamics, and discrete event and direct numerical simulations will be discussed

Textbooks/References

Introduction to Parallel Computing, 2/E, Ananth Grama, George Karypis, Vipin Kumar, Anshul Gupta, ISBN-10: 0201648652, ISBN-13: 9780201648652, Addison-Wesley, 2003, 656 pages

1400551 Concurrent Programming

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisites: Parallel & Distributed Systems 1400550

Objective

A student successfully completing this course should be able to:

- Appreciate several methods and techniques used to parallelize code, and the suitability of their application
- Appreciate the challenges to parallelization of widely used data structures and algorithms.
- Apply the learned concepts to parallelize code with an appreciation of the trade-offs of their application

Course Outline

This course dives into the theoretical and practical details of implementing and using concurrency.

- Beginning with a foundation of classic synchronization and concurrency models, the course builds the student's knowledge in implementing the concurrent forms of widely-used data structures and algorithms.
- The student will appreciate their trade-offs, as well as the parameters for optimizing their performance.

Course Contents

Theory:

- Mutual exclusion: critical sections, Lamport's Bakery algorithm, filter locks, bounded timestamps, fairness
- Concurrency Models: Sequential consistency, linearizability, progress conditions

- Synchronization: atomic instructions/registers, compare-and-swap, load-link store-conditional, consensus protocols, non-blocking synchronization (lock-free, wait-free, and obstruction-free)

Practice:

- Locks and contention: spin locks, exponential backoff, queue locks, hierarchical locks
- Monitors: semaphores, reader-writer locks, reentrant locks
- Barriers: simple, sense-reversing, combining tree, and static tree barriers
- Fundamental problems: concurrent counting, and workload distribution
- Implementation and optimization considerations for concurrent data structures: concurrent linked lists, concurrent queues, and concurrent stacks
- Implementation and optimization considerations for concurrent algorithms: concurrent hashing, concurrent searching, concurrent sorting
- Advanced concurrency techniques: futures, scheduling, workload distribution
- Transactional memory: an alternative to locks for concurrency control

Textbooks/References

The Art of Multiprocessor Programming, Maurice Herlihy and Nir Shavit, ISBN-10: 0123705916, ISBN-13: 978-0123705914, Morgan Kauffman, 2008, 528 pages

1400552 Distributed Computing

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisites: Parallel & Distributed Systems 1400550

Objective

This course covers a range of technologies developed over the past 20+ years to solve the fundamental challenge of Design and implementation of distributed applications that use data networks (telecommunications networks/Internet/wireless networks) as their computing platform. The course focuses on:

- The shift in the computer and telecommunications and networking industries away from stand-alone solutions and toward integrated-application layered infrastructures.
- Distributed applications in a networked computing environment, placing interoperability and portability constraints, increasing the importance of standardization, and exposing the computer industry to government regulation.

Course Outline

- The course is designed as a hands-on course, with a heavy emphasis on developing your own distributed applications.
- The course focuses on building distributed applications from loosely coupled components that can be dynamically composed (Service Oriented Architecture).
- The course content covers: Basics of networking; socket programming; Java networking facilities; RPC and RMI; CORBA; WWW, XML, Web Services (and potentially P2P and Grid Computing) and mobile computing platforms and programming.

Course Contents

- Network Computing Introduction
- Intro to Network Architectures, client-server architectures, network-centric computing
- Basic Programming Models: Messaging vs. Distributed Shared Memory
- Socket Programming/ Remote Procedure Calls/ Remote Method Invocation
- Introduction to Software Architectures
- Introduction to Software Design Patterns

- Service-Oriented Architecture, Service- Standards
- Java Enterprise Edition, P2P, Grid Computing
- Mobile Computing platforms & programming

Textbooks/References

- Distributed Systems: Principles and Paradigms, by Andrew S. Tanenbaum and Maarten van Steen, Prentice Hall== Latest Edition.
- Building Web Services with Java, 2nd edition, by Steve Graham et al., Sams Publishing Latest Edition.

1400553 Parallelizing Compiler and Code Optimization

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Parallel & Distributed Systems 1400550
Objective

A student successfully completing this course should be able to:

- Appreciate the parallelism available in all stages of the compilation process.
- Apply advanced techniques to improve the result of code optimization.
- Understand the trade-offs of the learned techniques.

Course Outline

- This course presents the concepts needed to design and implement advanced optimizing preprocessors and code generators.
- Specific emphasis will be put on techniques for exploiting parallelism in multiprocessors.
- Each student will conduct a compiler implementation project.

Course Contents

- Dataflow analysis (more advanced analyses, such as partial redundancy elimination)
- Static Single Assignment form (how to construct it, how to use it)
- Loop transformations (cache models, automatic transformation frameworks)
- Pointer analysis (efficient flow insensitive analyses, interprocedural analysis)
- Shape analysis
- Autotuning
- Parallelization

Textbooks/References

- Michale Wolfe, High Performance Compilers for Parallel Computing, Addison-Wesley, ISBN 0805327304.
- Utpal Banerjee, Dependence Analysis, Kluwer, ISBN 0792398092.
- Ken Kennedy and John R. Allen, Optimizing Compilers for Modern Architectures: A Dependence-based Approach, Morgan Kaufmann, ISBN 1558602860.
- Cooper and Torczon, Engineering a Compiler, Morgan Kaufmann, ISBN 155860698X.

1400554 Parallel Computer Architecture

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Parallel & Distributed Systems 1400550
Objective

A student successfully completing this course should be able to:

- Understand the structure of shared memory multiprocessing

- Understand bus-based and directory-based cache coherence protocols
- Understand hardware support for synchronization support
- Be aware of the latest developments and future directions of processor architectures

Course Outline

- This course provides an in-depth study of the design, engineering, and evaluation of modern parallel computers.
- Scalable multiprocessors are investigated thoroughly, including directory-based cache coherence, interconnection network design, software-based virtual shared memory, and latency tolerance through multithreading and other means.

Course Contents

- Shared memory multiprocessors and multi-cores
- Bus-based coherency protocols
- Hardware support for synchronization
- Interconnection networks
- Scalable shared memory
- Directory-based coherency protocols
- Advanced topics: e.g. GPGPU architecture, hybrid architectures, network processors

Textbooks/References

Parallel Computer Architecture: A Hardware/Software Approach. David Culler, J.P. Singh and Anoop Gupta , ISBN: 978-1-55860-343-1

1400559 Advanced Topics in Parallel and Distributed Systems

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Parallel & Distributed Systems 1400550
Objective: Advanced Topics in Parrallel and Distibuted Systems
Course Outline: TBD
Course Contents: TBD
Textbooks/References: TBD

1400560 Advanced Computer Architecture

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Graduate Standing

Objective

This course introduces students to the field of advanced computer architecture. It introduces the students to the principles of superscalar processor design and multiprocessors

Course Outline

This course will cover the design of advanced microprocessors and computing systems with emphasis on performance. Topics will include pipeline processor design, superscalar processor design, out-of-order execution, simultaneous multithreading, memory subsystem design, I/O and multiprocessor system design

Course Contents

- Performance and cost
- Instruction set design and measurements of use
- Basic processor implementation techniques
- Advanced pipeline design techniques
- Memory-hierarchy design

- Multiprocessor design
- Input-output subsystems
- Future directions

Textbooks/References

- Computer Architecture: A Quantitative Approach by John L. Hennessy and David A. Patterson. 4th Edition. Morgan-Kaufmann. 2006. ISBN: 0123704901
- References:
- Modern Processor Design: Fundamentals of Superscalar Processors (McGraw-Series in Electrical and Computer Engineering) by John Shen and Mikko Lipasti

1400561 Embedded Systems

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Advanced Computer Architecture 1400560
Objective : This course introduces students to the field of embedded system design
Course Outline: Introduction to embedded systems; hardware design issues and techniques; embedded software design issues and techniques; hardware/software co-design; real world examples of embedded systems

Course Contents

- Embedded System Design (ESD) Process
- Modeling using UML
- Modern CPUs used in ESD
- Hardware design and interfacing
- Program design and analysis
- Processes and operating systems
- Networks for ESD

Textbooks/References

- Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Second Edition, 2008, Morgan Kaufmann Publishers, ISBN 978-0-12-374397-8

References:

- Frank Vahid and Tony Givargis, Embedded System Design, Prentice Hall, 2002, ISBN: 0-471-38678-2

1400562 Fault-Tolerant Digital System Design

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Advanced Computer Architecture 1400560
Objective : To get the applicant acquainted with modern design principles and techniques to achieve high reliability for computing systems
Course Outline: Basic concepts and techniques to design and implement highly reliable, available, safe and easily maintainable compute systems

Course Contents

- Goals and applications (reliability,…etc).
- Fault modeling.
- F.T. Design techniques based on hardware redundancy (TMR, hybrid, SIFT,…etc).
- F.T. Design techniques based on information redundancy (Parity, Hamming EDC Codes,…etc).
- Time redundancy, software redundancy
- Reliability evaluation (Failure Rate, MTBF, MTTR, … etc).

- Safety, Maintainability, Availability
- Self Checking Circuits
- Design For Testability
- Case Studies for F.T. Computing Systems

Textbooks/References

- "Shooman, Martin" "Reliability Of Computer Systems: Fault Tolerance…" Wiley, 2112.
- "I. Koren and C.M. Krishna" "Fault-Tolerant Systems", 2007.
- "R. Isermann" "Fault-Diagnosis Systems: An Introduction form Fault Detection to Fault
- Tolerance", 2005.
- "Michel Bantre and P.A. lee" "Hardware and Software Architectures for Fault Tolerance:
- Experiences and Perspectives", 1994.
- "Bruce M. McMillan" "Fault Tolerance for Microcomputers…", 1996.
- "Parag K. LaLa" "Fault Tolerant and Fault Testable Hardware Design" Prentice Hall,
- 1985.
- "Kanad Chakraborty and Pinaki Mazumder", "Fault Tolerance and Reliability Techniques
- for High-Density Random-Access Memories", 2002.

1400563 Reconfigurable Computing

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisites: Advanced Computer Architecture 1400560

Objective: This course introduces students to the field of reconfigurable computing. It also introduces modern CAD tools and design techniques of reconfigurable computing systems.

Course Outline

History and evolution of reconfigurable computing (RC) systems; FPGA-based system design using modern hardware description languages, HDL compilers, simulators and FPGA synthesis tools; multi-FPGA systems; CAD mapping tools – front end and back end tools; run-time reconfiguration; study of recent RC systems from academia and industry targeting a wide range of applications; CAD tools for mapping high level design descriptions to commercially available FPGAs. Literature review and research paper on specific topics is also required. The course may change slightly from year to year and may require a mix of projects and assignments. The assignments will involve digital system modeling and simulation using VHDL or Verilog. Commercially available synthesis tools targeting FPGAs will also be used. The instructor will provide unique insights into key issues in the area of reconfigurable computing based on his research and development experience in academia and industry

Course Contents

- Reconfigurable architecture
- Introduction to FPGA
- Verilog/VHDL
- FPGA architecture and design cycle
- Coarse-grained reconfigurable devices
- Applications

Textbooks/References

There is no required text book. Most of the course material will be obtained from easily available survey papers and research papers (download and print using links to IEEE and ACM web sites, provided by the University Library).

References:

- Reconfigurable Computing by Scott Hauck and Andre Dehon, Morgan Kaufmann, 2008, ISBN: 978-0-12-370522-8.

- Zainalabedin Navabi, “Embedded Core Design with FPGAs,” Copyright 2007, McGraw-Hill, ISBN 978-0-07-148470-1

140056 Advanced Topics in Computer Architecture and Digital Systems

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Advanced Computer Architecture 1400560
Objective: Advanced Topics in Computer Architecture and Digital Systems
Course Outline: TBD
Course Contents: TBD
Textbooks/References : TBD

1400570 VLSI Design

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: Graduate Standing
Objective: The course aims to provide digital system design methodologies, modeling and simulation.

Course Outline

- Hardware Description Language (HDL), MOS devices and technology,
- The MOS modeling, the inverter, Transistor sizing, circuit layout, static versus dynamic logic, combinational and sequential cell design.

Course Contents

- Digital system design methodologies
- Hardware description language (HDL)
- The MOS devices and technology
- The MOS modeling
- The inverter
- Transistor sizing, circuit layout
- Static versus dynamic logic
- Combinational and sequential cell design

Textbooks/References

- Essentials of VLSI circuits and Systems, Kamran Eshraghian, Douglas A. Pucknell and Sholeh Eshraghian, Prentice-Hall of India, INC., 2005.
- Basics of CMOS Cell Design, Etienne Sicard & Sonia D. Bendhia, McGraw Hill, 2007.

1400571 Computer Aided Design of Digital System

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: VLSI Design 1400570
Objective: The main objective of the course is to provide deep submicron device models and scaling

Course Outline

- Nanometer device models,
- Clocking strategies,
- Dynamic characteristics of MOS circuits,
- Dynamic logic circuits,
- Design considerations of regular structures,

- CMOS memories

Course Contents

- Nanometer device models and scaling, interconnect models.
- Clocking strategies
- Dynamic characteristics of MOS circuits.
- Dynamic logic circuits.
- Design considerations of regular structures.
- CMOS memories.
- The course is project-oriented stressing on the use of CAD tools throughout the class project.

Textbooks/References

- Basics of CMOS Cell Design, Etienne Sicard& Sonia D. Bendhia, McGraw Hill, 2007.
- Advanced CMOS Cell Design, Etienne Sicard& Sonia D. Bendhia, McGraw Hill, 2007.
- Essentials of VLSI circuits and Systems, Kamran Eshraghian, Douglas A. Pucknell and Sholeh Eshraghian, Prentice-Hall of India, INC., 2005
- Verilog Designer's Library, Prentice-Hall, Inc., 1999

1400572 CMOS Design

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: VLSI Design 1400570
Objective: The main objective of the course is to provide the technology scale-down for the sake of deep submicron device models

Course Outline

- Nanometer device models,
- Embedded memories,
- FPGA's, radio-frequency circuits,
- Converters and sensors,
- Input/output interfacing.

Course Contents

- Nanometer device models and scaling, interconnect models
- Embedded memories: RAM, dynamic RAM, EEPROM, Flash memories, Ferroelectric RAM memories, memory interface.
- FPGA's
- Radio-frequency circuits.
- Converters and sensors.
- Input/output interfacing.
- The course is project-oriented stressing on the use of CAD tools through out the class project

Textbooks/References

- Advanced CMOS Cell Design, Etienne Sicard& Sonia D. Bendhia, McGraw Hill, 2007.
- Essentials of VLSI circuits and Systems, Kamran Eshraghian, Douglas A. Pucknell and Sholeh Eshraghian, Prentice-Hall of India, INC., 2005.
- Designing with FPGA's& CPLD's, Bob Zeidman, CMP Books, 2112.

1400573 Testing of Digital Circuits

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: VLSI Design 1400570

Objective: To become familiar with Automated and Manual Techniques for generating tests for faults in digital circuits and techniques for evaluating those tests. Also, how to make testing possible and economical.

Course Outline

- Manual and Automated testing techniques and how to evaluate.
- Design for testability.
- Techniques for building in-test capability in a circuit to make it Self-Testing.

Course Contents

- Introduction, Fault Modeling.
- Test Generation Methods:
  - Combinational circuits (Boolean-Difference, D-Algorithm, others).
  - Sequential Circuits (Hamming Sequence, Hennie's Procedure, others).
- Functional Testing, Random Testing.
- Delay Test, IDDQ Test.
- Built-In Self-Test (BIST).
- Design for testability, ATE.
- Self-Checking, PLA Testing.
- Microprocessor Testing.

Textbooks/References

- "A. Miczo" "Digital Logic Testing and Simulation", 2003.
- "Bushnell and Agrawal" "Essentials Of Electonic testing for Digital Memory and Mixed-Signal Circuits", Academic Press, 2000.
- "David, Rene" "Random Testing Of Digital Circuits" Theory and Application, 1998.
- "Parag K. LaLa" "Digital Circuit Testing and Testability", 1997.
- "N. k. Jha, S. Gupta" "Testingj Of Digital Systems" Library Of Congress, 2003.
- "R.D. Adams" "High-Performance Memory Testing" Academic Publishers, 2002.
- "S. Chakravarty & Paul J." "Introduction to IDDQ Testing", 1997.

1400579 Advanced Topics in VLSI and CAD

Credit Hrs. 3, **Contact Hrs**. 3
Prerequisites: VLSI Design 1400570
Objective: Advanced Topics in VLSI and CAD
Course Outline: TBD
Course Contents: TBD
Textbooks/References: TBD

1400580 Image Processing

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: Student must have taken an undergraduate course in Computer vision and Graphics or related field

Objective: To cover the basic analytical methods which are widely used in image processing; to cover issues and technologies which are specific to images and image processing systems; to develop experience with using computers to process images.

Course Outline: Digital Image Fundamentals, Transformations and Spatial Filtering, Frequency domain filtering, Image Restoration and Reconstruction, Color Image Processing, Wavelets and Multi-Resolution Processing, Image Compression, Image Segmentation and Morphological Processing.

1400581 Computer Graphics

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400580

Objective: This course is designed to provide a comprehensive introduction to computer graphics leading to the ability to understand contemporary terminology, progress, issues, and trends. A thorough introduction to computer graphics techniques, focusing on 3D modeling, image synthesis, and rendering. The interdisciplinary nature of computer graphics is emphasized in the wide variety of examples and applications. Course material is structured to meet the needs of both designers and users of interactive computer graphics systems

Course Outline: Introduction to graphics, Curves, Transformations, Coordinate free geometry, 3D objects, Camera models, Visibility, Basic lighting and reflection, Shading, Texture mapping, Basic ray tracing, Radiometry and reflection, Distribution ray tracing, Interpolation, Parametric curves and surfaces, Animation

1400582 Computer Vision

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400580

Objective: The Objective: of this course is to understand the basic issues in computer vision and major approaches that address them. After completing the course, the students may expect to have the knowledge needed to read and understand the more advanced topics and current research literature, and the ability to start working in industry or in academic research.

Course Outline: Vision Psychophysics A. Vision as an inverse problems B. Assumptions in human visual perception Connectivity and Distance Functions, Image Representation and Data Structure Border Following and Thinning, Component Labeling, Edge Detection Hough Transformation A. Extraction of straight lines B. Extraction of circles Region-based Segmentation A. Split-and-merge algorithm B. Samet's neighbor finding algorithm Camera Modeling A. The pin-hole model B. The two-plane model Stereo Vision A. Epipolar geometry B. Constraints C. Rectification Pose Calculation A. Pose estimation from point correspondences B. Pose estimation using quaternions Object Recognition A. Sub-graph isomorphism B. Range Data - segmentation of range maps Optic Flows and Analysis of Time-varying Imagery Visual Tracking, Color Vision

1400583 Computational Geometry

Credit Hrs. 3, Contact Hrs. 3

Prerequisite: 1400580

Objective: The Objective: of this course is to teach graduate students: Basic data structures used to represent geometric objects. Varieties of algorithms used for geometric computations. Design computational solutions to geometric problems. Write efficient programs for doing geometric computations

Course Outline: Computational geometry is the study of the design and analysis of computer algorithms for geometric problems. In this course fundamental algorithms in computational geometry will be covered such as. convex hull of point sets, triangulation, polygon triangulation, intersection of line segments, Voronoi diagrams, line arrangements and geometric duality, point set triangulation, point location problems, linear programming, Randomized algorithms

1400589 Advanced Topics in Computer Vision and Graphics

Credit Hrs. 3, **Contact Hrs**. 3

Prerequisite: 1400580

Objective: Advanced Topics in Computer Vision and Graphics.
Course Outline: TBD
Course Contents: TBD

1400584 Visualization

Credit Hrs. 3, Contact Hrs. 3
Prerequisite: 1400580
Objective: The principal Objective: of this course is to introduce you to some of the basic concepts, algorithms, and problems in the field of 3-D computer graphics.
Course Outline: Overview of Computer Graphic Fundamentals, Specifying Changes in View (Camera Motion) A. Position Specification and Interpolation B. Rotational Interpolation (Quaternions), Equations of Motion A. Linear B. Nonlinear, Kinematic Simulations A. Singularities B. III-conditioning, Numerical Integration A. Runge-Kutta B. BuIirsch Stoer, Dynamic Simulations A. Numerical Stability B. Best Approximate Solutions, Visualizing System Evolution A. Phase Portraits B. Poincarre Maps, Chaotic Systems A. Fractals B. Strange Attractors, Visualizing Multi-Dimensional Results A. Projections B. Parallel Coordinates C. Principal Component Analysis, Aliasing A. Temporal B. Time-varying Spatial.