



UNIVERSITY OF
CALIFORNIA
SANTA CRUZ



Master's Degree

Program in Computer

Engineering

specializing in

**NETWORK
TECHNOLOGY**

MESSAGE FROM THE DEAN

Silicon Valley is the home for many of the world's leading networking companies. These companies employ thousands of engineers and technical professionals who design, develop and support leading-edge network services and products. As a result, there continues to be an acute need in Silicon Valley for engineers with graduate education specializing in network technology.

Established in 1998, UCSC's Master's Degree in Computer Engineering Program with specialization in network technology addresses this need by providing a solid foundation in areas of computer and network architectures, protocols and related topics. Electives augment students knowledge with courses in network security, network performance, multimedia transport high-speed networks and other related areas.

The program is organized such that students learn both the theory and practice of network engineering through class exercises and laboratory projects. The courses are taught by full-time UCSC faculty, researchers on the leading edge of the networking field, and adjunct faculty, practicing engineers from local industry.

I'm pleased that UCSC is the provider of this unique graduate program to the Silicon Valley community. Additional information can be found at www.soe.ucsc.edu/msce. I invite you to request an application packet by calling (831)459-5303.

Sincerely,

Steve Kang
Dean
Baskin School of Engineering
University of California, Santa Cruz

Earn a UCSC M.S. in Computer Engineering

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Courses are presented in the Santa Clara Valley

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Courses conveniently scheduled for working professionals

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Applications accepted throughout the year

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One or more courses may be taken per quarter

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Program provides a mix of courses covering networking fundamentals and the latest networking technologies

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Like most University of California Master's programs, this program can be a stepping stone into UCSC's Ph.D. program

Master's Degree Program in Computer Engineering specializing in

NETWORK TECHNOLOGY

INTRODUCTION

The UCSC Department of Computer Engineering, now in its 20th year, has always focused its research and training on the interdisciplinary boundaries between hardware and software, including computer-aided design, computer system design, multimedia and sensor technologies, embedded and autonomous systems, and of course computer networks. In this program, you will have the opportunity to take a range of courses in these areas and new areas to come.

We began this program to make the University of California Master's of Science degree accessible and convenient to working professionals. We use a combination of synchronous distance learning and Web

storage. The synchronous distance learning will allow you to directly interact and learn from on-campus students and your Network Engineering program classmates. For those times when you cannot join our Silicon Valley classroom, or when you would like to review a class or part of the class, you will be able to access the lectures and class material from the Web.

The most important aspect of most of our courses is not the course material from textbooks and research papers, but the intensive projects integrated with each course. Indeed, many of our students complete their MS in Computer Engineering final project by extending a course project from one of their other classes. Other students apply the skills

gained in our courses to a project or problem related to their work. In all cases, our faculty are ready to assist as you embark upon this next step of graduate training.

INTENDED AUDIENCE

The UCSC MS in Computer Engineering with an emphasis on Network Engineering (MSNE) program is designed for working engineers who have earned a bachelor of science or higher degree in electrical engineering, computer science, computer engineering or an equivalent technical discipline. It is of most immediate interest to engineers who are or soon will be working in the field designing or developing network systems, components, products or services.

The UCSC MS in Computer Engineering specializing in Network Engineering

- Trains engineers for the next step in their career.
- Offers courses in a location and at times convenient to working engineers
- Teaches summer courses, depending on student need and faculty availability, allowing for accelerated progress toward the MS
- Requires three years of part-time study but enables faster and slower programs of study
- Provides a launching point for doctoral (PhD) research
- Begins with advanced undergraduate and early graduate fundamentals
- Continues with specialized study in Network Engineering
- Includes a choice of electives from areas in networking and computer systems
- Completes with an intensive 3-month project using your new skills to solve a problem.

“ I have been a firmware engineer in the networking industry for many years. Before my Master’s in Computer Engineering with specialization in network engineering at UC Santa Cruz, I had a task and a project specific knowledge of networking technology. The MSNE education gave an in depth understanding of the building blocks of the designs of various protocols both in wired and wireless areas. The class projects and papers are based on advanced and forward looking research areas while there is enough emphasis on existing technologies. The classes and projects in Network Engineering helped me build confidence in tackling complex problems at work as well as in my private endeavors. ”

Woldeloul Kassa

Admission criteria are identical to UCSC’s standard requirements with consideration given for related work experience. Students enrolling in this program are expected to have a bachelor of science degree or higher in computer engineering, computer science, electrical engineering or related fields with an equivocal 3.0 (B) or better grade point average. Satisfactory scores on the GRE general test are required. Also, applicants from countries where English is not the primary language must score a minimum of 570 (paper-based) or 230 (computer-based) on the TOEFL exam. Applicants whom already possess a strong command of the English language may request to waive, subject to discretion, the TOEFL exam in their statement of purpose. Application deadlines for commencing the following quarter are X, Y, and Z.

Students must be admitted prior to taking any of the program courses.* Application packets are available by calling (831)459-5303 or submitting an e-mail request to: msce@soe.ucsc.edu.

**Prospective students wishing to pursue this program before being accepted can take classes through concurrent enrollment. Upon approval from the respective instructor and payment of course fees, students will participate fully in all aspects of the course and can transfer up to 15 credits to the degree program upon acceptance. For more information on the concurrent enrollment program please submit a request for information to: msce@soe.ucsc.edu.*

Completion of a total of nine 5-unit courses are required for the award of the M.S. degree

BASE REQUIREMENTS

Students must demonstrate proficiency in fundamental base areas of computer engineering, most often by having previously taken appropriate courses at the undergraduate level

Up to two 5-unit base requirement courses may be applied to the programs elective requirements if taken through UCSC.

CE 107 Mathematical Methods for Systems Analysis

CE 110 Computer Architecture

CE 111 Introduction to Operating Systems

CE 177 Applied Graph Theory and Algorithm

CORE COURSES

(THREE REQUIRED)

CS 201 Analysis of Algorithms

CE 202 Computer Architecture

CE 252a Computer Networks

ELECTIVE COURSES

(FIVE REQUIRED SELECTION VARIES FROM YEAR TO YEAR)

Examples of the electives are:

CE 230 Computer Performance Evaluation

CE 250 Multimedia Systems

CE 252b Modeling of Communication Protocols

CE 254 High Speed Computer Networks

CE 255 Advanced Computer Communication

CE 257 Wireless and Mobile Networks

CE 259 Sensor Networks

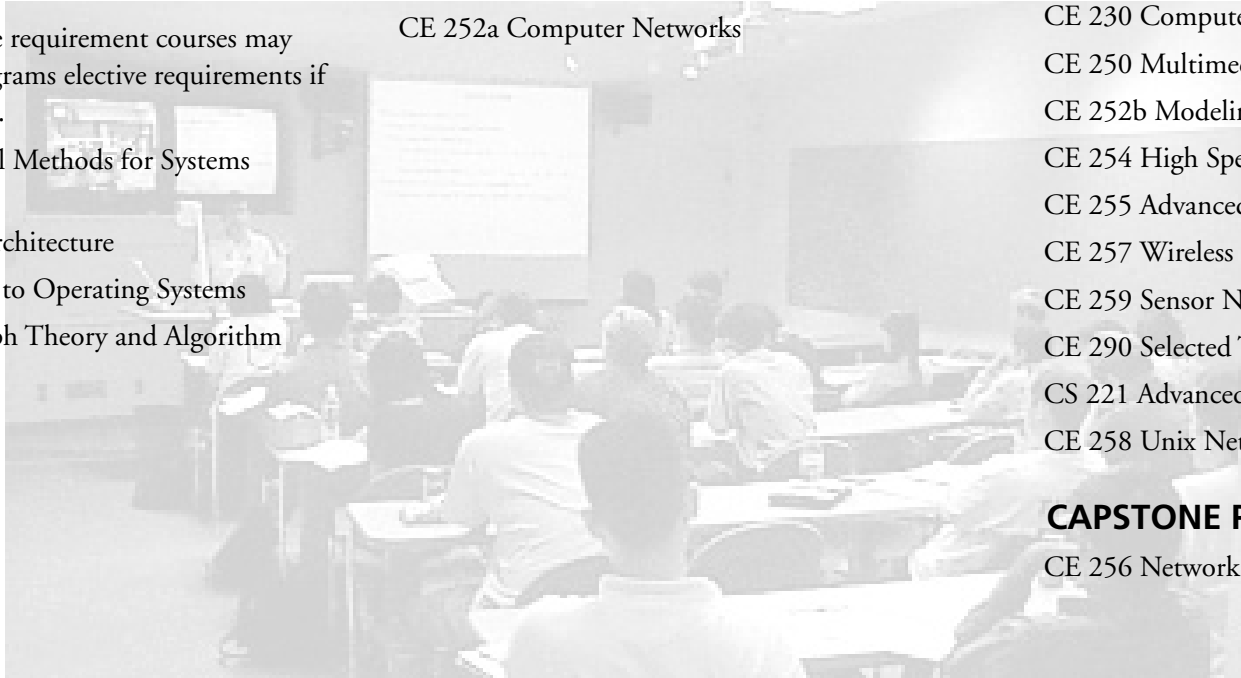
CE 290 Selected Topics

CS 221 Advanced Operating Systems

CE 258 Unix Network Internals

CAPSTONE PROJECT

CE 256 Network Design Project



Course Descriptions

CE 107 MATHEMATICAL METHODS OF SYSTEM ANALYSIS: STOCHASTIC

Introduction to fundamental tools of stochastic analysis. Probability, conditional probability, Bayes Theorem, random variables, independence, discrete-time stochastic processes and Markov chains. Instructor's choice of additional topics, most likely drawn from confidence measures, difference equations, transform methods, stability issues, applications to reliability, queues, and hidden Markov models.

CE 110 COMPUTER ARCHITECTURE

High performance computer architecture including examples of current approaches and the effect of technology and software. Instruction set design and RISC, cache and virtual memory, pipelining, SIMD (array and vector) processors, MMIO multiprocessors, interconnection schemes, and performance.

CS 111 INTRODUCTION TO OPERATING SYSTEMS

Fundamental principles of operating systems: process synchronization, deadlocks, memory management, resource allocation, scheduling, storage systems, and study of several operating systems. A major programming project will be required.

CE 177 APPLIED GRAPH AND THEORY ALGORITHMS

Basic concepts and algorithms are reviewed including trees, Eulerian and Hamiltonian graphs, and graph transversal. Algorithms are explored to solve problems in connectivity, routing, matching, and embedding of graphs. Graph theory and algorithms are developed around applications in computer engineering.

CS 201 ANALYSIS OF ALGORITHMS

Rigorous analysis of the time and space requirements of important algorithms, including worst case, average case, and amortized analysis. Techniques include order-notation, recurrence relations, information-theoretic lower bounds, adversary arguments. Analysis of the key data structures: trees, hash tables, balanced tree schemes, priority queues, Fibonacci and binomial heaps. Algorithmic paradigms such as divide and conquer, dynamic programming, union-find with path compression, augmenting paths. Selected advanced algorithms. Introduction to NP-completeness.

CE 202 COMPUTER ARCHITECTURE

Provides a thorough and fundamental treatment of the art of computer architecture. Topics include concepts of von Neumann architectures, methods of evaluating

CPU performance, instruction-set design and examples, compiler issues, instruction pipelining, superscalar processors, methods for reduction of branch penalty, memory hierarchies, I/O systems, floating-point arithmetic, and current issues in parallel processing.

CE 230 COMPUTER PERFORMANCE EVALUATION

Introduction to methods of analysis of computer performance. Predictive performance models with emphasis on queuing models. Exact and appropriate solution methods, discrete-event simulation, and numeric iterative approaches. Analytical solutions and their computation. Separable queuing networks, decomposition approaches. Examples of practical application. Performance measurement, model validation, robustness of models and operational analysis.

CE 252A COMPUTER NETWORKS

Issues resulting from organizing communication among autonomous computers. Includes network models and switching techniques; medium access control protocols and local area networks; error control and retransmission strategies; routing algorithms and protocols; congestion

control mechanisms and end-to-end protocols; application-level protocols; and application of concepts to wireless and wireline networks, with emphasis on the Internet.

CE 252B MODELING OF COMMUNICATIONS PROTOCOLS

Theory and practice of computer communication networks. Emphasis is on verification and performance analysis of network control processes. Topics includes protocols for channel access, point-to-point and multipoint reliable transmission, routing, congestion control, network management, multicasting, and ATM networks.

CE 256 NETWORK DESIGN PROJECT

This project-based course is a capstone for the program. It helps students tie together what they have learned in the other program courses by applying these concepts to a practical problem or project.

CE 258 UNIX NETWORKING INTERNALS

In depth treatment of the implementation of network protocols in typical open-source UNIX systems. Topics include implementation of send and receive functions, buffer management, interrupt handling, locking, scheduling and timer management. Major implementation project required.

CE 259 SENSOR NETWORKS

This class will provide a comprehensive overview of sensor networks, including their unique features and constraints, fundamental design principles, as well as current state-of-the-art on sensor network algorithms and protocols.

The course will cover recent technical papers on several aspects of sensor networks. It will be heavily oriented toward a term project.

CS 221 ADVANCED OPERATING SYSTEMS

A detailed study of the issues involved in operating systems design and implementation. Readings cover current research topics and systems of historical significance. Topics include (but are not restricted to) process and memory management, protection, security, synchronization, performance evaluation, file systems, distributed systems.

CE 250 MULTIMEDIA SYSTEMS

Study of state-of-the-art technology for networked multimedia systems. Data processing and communication requirements for distributed multimedia systems. Topics include audio, image, and video delivery and compression standards, networking for multimedia, scene composition, and digital television.

CE 254 HIGH SPEED COMPUTER NETWORKS

Fiber-optic technology; fiber-optic link design; network protocol concepts; coding and error control; high-speed

local area and metropolitan-area networks; gigabit networks; error-and congestion-control; photonic networks; research topics.

CE 255 ADVANCED COMPUTER COMMUNICATIONS

Special topics on the design, verification and performance analysis of computer communication protocols. Topics include local area networks, packet radio networks, inter-networking, end-to-end services, mobile computing and communication, middleware.

CE 257 WIRELESS AND MOBILE NETWORKS

An interdisciplinary course on wireless communication and mobile computing. Covers the physical aspects of wireless communication but emphasizes higher protocol layers. Topics include cellular networks, packet radio and ad hoc networks, wireless transport protocols, security, and application-level issues.

CE 258 UNIX NETWORK INTERNALS

In-depth treatment of the implementation of network protocols in typical open-source Unix systems. Topics include implementation of send and receive functions, buffer management, interrupt handling, locking, scheduling and timer management. Major implementation project required.

Program Faculty

Faculty includes the following UCSC faculty and other members of the Computer Engineering Department.

Alexandre Brandwajn

Professor of Computer Engineering. B.A., Docteur-Ingenieur, Docteur d'Etat, University of Paris. Dr. Brandwajn was employed by the Amdahl Corporation before he joined the UC Santa Cruz faculty. His research interests lie in computer architecture, performance modeling, queuing networks models of computer systems, and operating systems.



J.J. Garcia-Luna-Aceves

Professor of Computer Engineering. B.S., electrical engineering from Universidad Iberoamericana, Mexico; M.S. and Ph.D. in electrical engineering from University of Hawaii at Manoa. Dr. Garcia-Luna-Aceves was a center director of the Network Information Systems Center at SRI International in Menlo Park, California. His current research interests center around computer communication. He has published more than 270 papers, three patents and a book, and has been Program Chair and General Chair of ACM Mobicom, ACM MOBiHoc, and ACM SIGCOMM conferences.



Richard Hughey

Professor and Chair of Computer Engineering. B.A. in mathematics and B.S. in engineering from Swarthmore College; Sc.M. and Ph.D. in computer science from Brown University. Dr. Hughey's research interests include computer architecture, parallel processing, and computer applications in biology. His research includes the SAM: Sequence Alignment and Modeling System, a software implementing linear hidden Markov models for protein and nucleotide analysis; and the UCSC Kestral Parallel Processor, a single-board SIMD supercomputer.

Martine D.F. Schalg

Professor, Computer Engineering, B.A. in mathematics and M.S. and Ph.D. in computer science from University of California, Los Angeles. Dr. Schalg's interests are in theoretical computer science, computational geometry, VLSI design tools, VLSI complexity and formal specification languages. In recent years, her work has focused on field-programmable gate arrays. In 1987 she received an NSF Presidential Young Investigator Award. She has served on the editorial board of the IEEE Transactions on Computers since 1992.



Katia Obraczka

Associate Professor, Computer Engineering. B.S. in Electrical Engineering and M.S. in Computer Engineering from Federal University of Rio de Janeiro, Brazil, and M.S. and Ph.D. in Computer Science from University of Southern California. Dr. Obraczka was a research scientist and research professor at USC from 1995 to 2000. Her research interests include computer networks, wireless and mobile computing, distributed systems and Internet information systems.



Anujan Varma

Professor, Computer Engineering. M.S., Indian Institute of Science; Ph.D. in computer engineering from University of Southern California. Dr Varma was previously employed at IBM T.J. Watson Research Center from 1986 to 1991. In 2000, he took a leave of absence to found TeraOptic Networks, where he served as CTO. He directs the High-Speed Networks Laboratory at UC Santa Cruz. His current research interests include high-performance switching and routing, optical networks, and traffic management. He is currently directing a project at UCSC on architectures for optical data routers, under funding from DARPA.



Jose Renau

Assistant Professor, Computer Engineering. B.S. and M.S. in Computer Science from Ramon Llull University of Spain, and M.S. and Ph.D. in Computer Science from University of Illinois at Urbana-Champaign. Dr. Renau is also a consultant in advanced computer architecture with IBM Research. His research interests focus on computer architecture and include chip multiprocessors, energy/performance trade-offs, thread level speculation, interaction between architecture and compilers, and the Linux kernel.



Roberto Manduchi

Assistant Professor, Computer Engineering. Ph.D. in electrical engineering from the University of Padova, Italy. Dr. Manduchi worked in the Quicktime group at Apple Computer, Inc., from 1996 to 1997, and in the Machine Vision group at the Jet Propulsion Laboratory from 1998 to 2001, and was also an Adjunct Assistant Professor at the University of Southern California in 2000 and 2001. He joined the Computer Engineering Department in 2001. Dr. Manduchi's research interests include the areas of Computer Vision, Sensor Processing and Multimedia Communications with applications to robotics, sensor networks, remote sensing, and assistive tools for the blind. His research has been sponsored by NSF, NASA and DARPA.



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Videoconferencing

Courses in this program are video-conferenced and may originate from either the UCSC main campus or the Silicon Valley. This technology allows for interaction between instructor and students at both sites.

Student Comment

“ I had seven years of professional experience in the computer industry when I began the Master’s in Computer Engineering with specialization in network engineering at UC Santa Cruz. I was a network consultant and a certified trainer for a major networking company. The classes in the program brought a fresh and broad perspective to my hard-learned, industry, in-the-trenches experience. I very much enjoyed the opportunity to tackle complex research questions through in-depth projects. Unlike most industry training, the classes are detailed and rigorous. I liked the MSNE program so much I moved to Santa Cruz to enter their Ph.D. program in Computer Engineering! ”
-Marc Mosko

MSNE students come from

Altera	Adobe	Cisco
Hewlett Packard	Interwoven	Micron Tech
Nortel Networks	Sun	Oracle

and other Silicon Valley companies

MSNE WWW site: www.soe.ucsc.edu/msce • MSNE email: msce@soe.ucsc.edu



Application Requirement

All required documents must be on file in the graduate office by the deadline date to begin the following quarter

LIST DEADLINES

- \$50 application fee (non-refundable)
- Completed application
- Graduate Record Examination (GRE) general test scores, no older than 5 years (GRE subject exam not required)
- Applicants from countries where English is not the primary language must take the Test of English as a Foreign Language (TOEFL): Paper-based minimum score=570 Computer-based minimum score=230
- Statement of purpose
- Official transcripts
- Three letters of recommendation

Additional Questions?

Contact MSNE Coordinator Colt Hangen

E-mail: msce@soe.ucsc.edu

Phone: (831)459-5303

MSNE WWW site: www.soe.ucsc.edu/msce • MSNE email: msce@soe.ucsc.edu