OPPORTUNITIES
FOR GRADUATE STUDY
IN THE COMPUTER SYSTEMS LABORATORY

OCTOBER 1978
Computer Systems Laboratory

Computer system design is the major focus of the laboratory. Its unique strength derives from the fact that it combines within a single organization a broad set of related design topics. These range from integrated circuit design to techniques for program verification. Rather than separating considerations of hardware design from software issues, all aspects of computer systems are treated in an integrated fashion. Faculty and students from both Electrical Engineering and Computer Science Departments participate in laboratory programs, and cooperative programs with the Integrated Circuits Laboratory to support VLSI activities are becoming increasingly important.

Several activities in the laboratory highlight current interests. The Emulation Laboratory is designed to support general research in the area of emulation. It includes a universal host machine, the EMMY, which has been especially designed to be an unbiased yet efficient host for a wide range of target machine and high level language-based architectures. The Center for Reliable Computing studies design and evaluation of fault-tolerant and gracefully-degrading systems, validation and verification of software, and efficient testing techniques. In addition, one of the most comprehensive automatic Program Verification systems exists in the CSL. The system currently deals with Pascal programs, and is being extended to include programs with abstract data types. Other work in this area includes verification techniques for concurrent programs, designing verifiable programs, and automated theorem-proving. The Center for Design Automation is a collaborative effort between CSL and the Integrated Circuits Laboratory. The scope of the research ranges from IC process modelling and circuit analysis to circuit layout, system level simulation and hardware description languages.

Topics of current research interest in CSL include:

- Compilation techniques
- Computer communication networks
- Database systems
- Design automation
- Directly executed languages
- Distributed computing
- Emulation
- Fault testing
- Fault-tolerant computers
- Microprocessor architectures
- Multi-processor systems
- Multiprocessors
- Multi-valued integrated circuits
- Operating systems
- Performance measurement
- Performance modelling
- Programming languages
- Program verification

Programs

Master of Science in CS or EE: Computer Engineering

The degree of Master of Science in CS or EE: Computer Engineering may be conferred upon students who wish to develop a competence in the design of substantial software HARDWARE computer systems. Programs include at least 42 quarter units and typically take one full-time year.

Detailed information regarding this program can be found in the COURSES & DEGREES BULLETIN, under the departmental listing of the Electrical Engineering Department or the Computer Science Department.
Master of Science in CS or EE

Candidates for the M.S. degree in either the Computer Science Department or the Electrical Engineering Department may specialize in Computer Systems by taking major course sequences in this area. Naturally students will also have to satisfy departmental distribution requirements. More detailed information is available in COURSES & DEGREES BULLETIN.

Doctor of Philosophy

Students with research interests in Computer Systems may pursue the Ph.D. degree through either the Electrical Engineering or the Computer Science Department. General requirements and admissions policies of the departments are found in the COURSES & DEGREES BULLETIN.

Note that in the Computer Science Department students (both post-B.S. and post-M.S.) apply directly for Ph.D. study. In the Electrical Engineering Department post-M.S. students apply directly with sponsorship of a faculty member, while pre-M.S. students are admitted to Ph.D. study after passing a qualifying examination given each January.

FINANCIAL SUPPORT

Research and teaching assistantships are available through the laboratory. These assistantships carry stipends ranging from approximately $2,925 to $4,536 for the academic year and provide tuition payments for 9 units per quarter. Additional support for the summer quarter is available. A special $1,000 fellowship, the Phong Bui-Tuong Memorial Fellowship, will be awarded to the most promising entering graduate student each year.

PHONG BUI-TUONG MEMORIAL FELLOWSHIP

A special $1,000 fellowship will be awarded to the most promising entering graduate student with an interest in computer systems. All students are automatically considered.

APPLICATIONS

Applications for admission are available from:

Graduate Admissions Office
Stanford University
Stanford, CA 94305

Applications for 1979-1980 should be filed as soon as possible, with a deadline of January 15, 1979 in both Electrical Engineering and Computer Science Departments. Please indicate your interest in the Computer Systems Laboratory on the application.
COMPUTER FACILITIES

The Computer Systems Laboratory facilities include: a terminal facility area, a DEC System 20, the Emulation Laboratory, several microcomputer development systems, several HP2100 and 21MX minicomputers, several HP300 (Amigos) computers, and the Distributed Computing Laboratory which will contain a network of 12 small computers and at least one large one.

HP 21MX minicomputers, used for the EE 181/CS 111 introductory course on computer organization and assembly language programming.

A DEC PDP-11/20, used for the EE 288 systems programming lab and for software research projects.

A Digital Logic Laboratory, containing breadboards, IC's, and test equipment for the EE 183 logic lab and research projects requiring construction or testing of logic circuits.

A Microprocessor Laboratory, containing microprocessor breadboards and development systems for use in the EE 281 microprocessor lab course and by special student projects and research projects such as microprocessor-based medical data acquisition system.

An Emulation Laboratory, based on a 32-bit user-microprogrammable high-speed processor called EMMY. This machine is used for microprogramming special projects and for research on microprogramming, emulation and directly-executable languages. Emulators have been written on EMMY for several large and small computers, including the IBM 360/370 and the Intel 8080.

The Design Automation Laboratory, containing an HP 2100S computer, dedicated to logic simulation and fault test generation using the HP-TESTAID software. In addition some computer graphics equipment is available for DA tasks. A major expansion in the area of color graphics is now underway.

The Center for Reliable Computing, using two terminals to facilitate research activities in the area of fault-tolerant computing. A terminal room houses a Diablo 1620 hard copy terminal; a Hazeltine 1510 CRT terminal is available in the general office area.

The Computer Systems Laboratory Terminal Room, housing a collection of CRT graphics and hard copy terminals. It is available 24 hours/day for general use by students, and provides access to any of the computer systems listed below:

LOTS - DEC System 20 for instructional use.
SAIL - PDP 10 for research in Artificial Intelligence.
SUMEX - PDP 10 for research in medical related areas.
SCIP - IBM 370/168 for general university-wide computing.
SLAC - two IBM 370/168 and a 360/91 for research of interest to the Linear Accelerator group.
## COURSES

Courses in Computer Systems

(Note: When courses are cross-listed in Computer Science and Electrical Engineering, both numbers are shown.)

| EE 180 | CS 107 | Systematic Programming (Aut, Win, Spr) |
| EE 181 | CS 111 | Introduction to Computer Organization, Machine and Assembly Languages (Aut, Win, Spr, Sum) |
| EE 182 | CS 112 | Digital Computer Organization (Aut, Win) |
| EE 183 | CS 193 | Digital Logic Laboratory (Aut, Spr) |
| EE 274 | - | The Computer as a Laboratory Instrument (Aut, Win, Spr, Sum) |
| EE 280A, B | - | Computer Applications Laboratory (Win, Spr) |
| EE 281 | CS 194 | Microcomputer Laboratory (Aut, Win, Spr) |
| EE 283 | - | Analog Computer Design and Application (Spr) |
| EE 284 | CS 151 | Introduction to Discrete Mathematics (Win) |
| EE 285 | CS 142 | Language Features and Their Implementation (Aut, Win) |
| EE 286 | CS 143 | Compilers (Win) |
| EE 287 | CS 145 | File and Database Systems (Win) |
| EE 288 | CS 191 | Computer Systems Laboratory (Spr) |
| EE 380 | CS 310 | Seminar on Computer Systems (Aut, Win, Spr) |
| EE 381A | CS 211A | Theory of Switching (Aut, Win,) |
| EE 381B | CS 211B | Logic Design and Digital Systems (Win, Spr) |
| EE 383 | CS 243 | Compiler Project (Spr) |
| EE 385A | CS 319A | Digital Reliability Seminar (Aut, Win, Spr, Sum) |
| EE 385B | CS 319B | Computer Systems Analysis Seminar (Aut, Spr) |
| EE 385C | CS 319C | Computer Architecture and Emulation Seminar (Aut, Win, Spr) |
| EE 385D | CS 319D | Design Automation Seminar (Aut, Win) |
| EE 385E | CS 319E | Concurrent Programming Seminar (Aut, Win, Spr) |
| EE 385F | CS 319F | Distributed Computing/Computer Communications (Aut, Win, Spr) |
| EE 386A, B | CS 246A, B | Operating System Design (Win, Spr) |
| EE 387 | - | Algebraic Coding Theory (Aut, Spr) |
| EE 388 | CS 247 | Computer Systems Evaluation (Spr 1980) |
| EE 389 | CS 242 | Programming Language Design (Aut) |
| EE 392C | | Program Verification (Win) |
Courses in Computer Systems (continued)

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<tr>
<th>EE 481</th>
<th>CS 341</th>
<th>Computer-Aided Design of Digital Systems (Spr)</th>
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<tr>
<td>EE 482</td>
<td>CS 311</td>
<td>Advanced Computer Organization (Aut,Spr)</td>
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<td>EE 483</td>
<td>CS 341</td>
<td>Topics in Concurrent Programming (Spr)</td>
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<td>EE 484</td>
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<td>Computer Communications Networks (Spr)</td>
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<td>EE 485</td>
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<td>Advanced Computer Systems (Aut,Win,Spr,Sum)</td>
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<td>CS 144A,B</td>
<td>Data Structures (Win,Aut)</td>
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<td>CS 150</td>
<td>Introduction to Combinatorial Theory (Win)</td>
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<td>CS 154</td>
<td>Formal Languages (Spr)</td>
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<td>CS 155</td>
<td>Concrete Mathematics (Aut)</td>
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<td>CS 156</td>
<td>Introduction to the Mathematical Theory of Computation (Aut)</td>
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<td>CS 190</td>
<td>Assembly Language Programming (Aut)</td>
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<td>CS 206</td>
<td>Computing with Symbolic Expressions (Aut,Spr)</td>
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<td>CS 246</td>
<td>Operating Systems (Aut)</td>
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<td>CS 247</td>
<td>Computer System Evaluation (Spr alternate years, 1980)</td>
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<td>CS 293</td>
<td>Computer Laboratory (Aut,Win,Spr,Sum)</td>
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<td>CS 300</td>
<td>Computer Science Colloquium (Aut,Win,Spr)</td>
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Some 3-Course Sequences in Computer Systems
(Select a sequence of 3 courses across a single line.)

EE 381A, 381B, 388, 481, 482, 484
EE 285, 286, 287, 386A, 388, 484
FACULTY

Research Opportunities in the Computer Systems Laboratory

Listed below are thumbnail sketches of the Computer Systems faculty. While their major research activities have been cited, every attempt will also be made to accommodate students with research interests not covered by one of these activities. For more information contact the faculty members listed.

Forest Baskett, Associate Professor of Computer Science and Electrical Engineering, Ph.D. (CS), University of Texas at Austin, 1970, is interested in the design and analysis of computing systems and computing system components. While on leave for the past two years at Los Alamos Scientific Laboratory, he worked on designing and implementing the DEMOS operating system for the CRAY-1 computer and plans to pursue the potential of that system as the basis for a distributed operating system in a network environment. In addition, Professor Baskett has been involved in the development of some Markov models of the DEMOS' sophisticated file system to predict and analyze the performance of the buffering scheme used by the file system. He is interested in designing and developing display oriented personal computing systems in a scientific networking environment, including a multiprocessor computing engine. He also expects to continue his work in the measurement and analysis of computer system components, including CPU structures.

Michael J. Flynn, Professor of Electrical Engineering, Ph.D. (EE) Purdue University, 1961, is interested in computer organization, particularly the design and architecture of computer systems using parallel processors, and multiprocessors. Professor Flynn has developed the Emulation Laboratory and conducts studies in the areas of microprogramming, interpretive languages, and the coordination of asynchronous processes.

John L. Hennessy, Assistant Professor of Electrical Engineering, Ph.D. (CS), State University of New York at Stony Brook, 1977, has been interested in programming language design and programming methodology, particularly with the aim of increasing software reliability. He is also interested in distributed computing systems, operating systems, and microprocessors.

Balasubramanian Kumar, Assistant Professor of Electrical Engineering, Ph.D. (CS), University of Illinois, 1978, has been interested in computer system architecture and performance and modelling. He is also interested in the analysis and synthesis of hardware and software structures for distributed systems, especially for high-speed computation.
David C. Luckham, Adjunct Professor of Electrical Engineering, Ph.D. (Mathematical Logic), Massachusetts Institute of Technology, 1963, is known for his work on the theory of program schemes and on automated theorem proving. Professor Luckham is currently working on the design of program specification languages, the design and implementation of concurrent programming languages, and on automated aids to programming. He leads a research group which is implementing program verifiers and investigating their application to various aspects of software production including debugging, documentation, and automatic programming.

Edward J. McCluskey, Professor of Computer Science and Electrical Engineering, Sc.D. (EE), Massachusetts Institute of Technology, 1956, is widely known for his contributions to switching theory, and is the author of a standard text on the subject. His current research efforts are directed toward the area of fault-tolerant computing. His major investigations are centered around the evaluation of various redundancy techniques for ultra-reliable computers and around design and testing problems for highly available and maintainable systems, including multiprocessors.

Robert M. Metcalfe, Consulting Associate Professor of Electrical Engineering, Ph.D. in Applied Mathematics, specializing in Computer Science, Harvard University, 1973, is currently working on computer communication. His other research interests include packet switching, computer communication protocols, distributed operating systems, and the application of distributed computing and computer communication techniques to the problems of building very large scale integration systems.

Susan S. Owicki, Assistant Professor of Electrical Engineering, Ph.D. (CS), Cornell University, 1975, has been investigating proofs of correctness for parallel programs. Her main research interests lie in the area of parallel systems and program verification, and she is also involved in investigating design methodologies for program systems, programming language semantics, operating systems, structured programming, and distributed computing.

Allen M. Peterson, Professor of Electrical Engineering, Ph.D. (EE), Stanford University, 1952, is Co-Director of the Stanford Center for Radar Astronomy and Senior Scientific Advisor in the Electronics and Radio Sciences Division of SRI. He is best known for his discovery of the backscatter phenomenon in radio communication. Professor Peterson's computer research investigations lie in the areas of digital systems design and hardware implementation, digital signal processing, speech processing and picture compression. He also conducts radiosciences research investigations into the remote sensing of atmospheres and oceans, and the study of space systems.
Fouad A. Tobagi, Assistant Professor of Electrical Engineering, Ph.D. (CS), University of California - Los Angeles, 1974, has been interested in the mathematical modeling, analysis, and optimization of computer systems, data communication systems, and computer networks. For the past five years, he was heavily involved in the design, analysis and measurements of the Packet Radio Network, an ARPA sponsored system based on the concept of packet broadcasting. Professor Tobagi's current research focuses on the packet switching technique and its use in satellite and ground radio environments. His research interests extend also to the use of computer networks for the transmission of data under real time constraints. This includes the design, analysis and performance evaluation of real time transmission protocols in networks of various types, and the analysis of their behavior in internetwork environments encompassing several networks of different types.

Willem M. vanCleemput, Assistant Professor of Electrical Engineering, Ph.D. (CS), University of Waterloo, 1975, has been conducting research studies in design automation of digital systems, including the layout of printed and integrated circuits, digital design languages, VLSI systems design, and applications of graph theory to computer design.

Gio C. M. Wiederhold, Assistant Professor of Computer Science, Ph.D. (Medical Information Science), University of California - San Francisco, 1976, has been developing methods for the design of file and database systems and their application to planning and medicine. His extensive consulting and industrial experience have led to a standard textbook on database design. Earlier work included the development of programming and operating systems, as well as the architecture of high performance data-processing systems. His current interests include the application of artificial intelligence (knowledge based systems) methods to large databases and the development of systems to support and use multi-computer networks, and the refinement of structured and quantitative approaches to system design.
COMPUTER SYSTEMS LABORATORY LECTURERS

D. R. Allison  Lecturer in Electrical Engineering  Private Consultant  
J. R. Jacobs  Lecturer in Computer Science  Hewlett-Packard Company  
S. H. P. Lee  Lecturer in Electrical Engineering  Amdahl Corporation  
F. W. Terman  Lecturer in Electrical Engineering  Private Consultant  
J. F. Wakerly  Lecturer in Electrical Engineering  Bell Northern Research, Inc.  

RESEARCH ASSOCIATES

Dr. Danielle Beaudry, Ph.D. Department of Electrical Engineering  Stanford University, 1978  
design and evaluation of ultra-reliable computers and performance-based  
reliability measures for computer systems.  
Dr. Derek C. Oppen, Ph.D. Department of Computer Science  University of Toronto, 1975  
implementation of automated program-analysis systems and the design of  
efficient algorithms for automatic deduction.  

VISITORS  
(Recent and Current)  
Ms. Frances E. Allen - Consulting Professor  
Manager, Experimental Compiling Systems  
IBM Thomas J. Watson Research Center  
Yorktown Heights, New York  
Professor Martin Freeman - Visiting Associate Professor  
Associate Professor  
Department of Mathematics, Statistics and Computer Science  
American University  
Washington, D.C.  

VISITORS
(continued)

Professor John P. Hayes - Visiting Associate Professor
Associate Professor
Department of Electrical Engineering
University of Southern California
Los Angeles, California

Professor Valerii V. Kiryukhin - Visiting Associate Professor
Associate Professor
Department of Computer Science
Sebastopol Institute of Instrument Engineering
Sebastopol, U.S.S.R.

Professor Hans Martin Lipp - Visiting Professor
Professor
Department of Electrical Engineering
University of Karlsruhe
West Germany

Professor Bruce C. Lutz - Visiting Professor
Professor
Department of Electrical Engineering
University of Delaware
Newark, Delaware

Patrick E. Mantey - Consulting Professor
Manager, Advanced Applications Department
Computer Science
IBM Research Laboratory
San Jose, California

Professor Elliot Organick - Visiting Professor
Professor
Computer Science Department
University of Utah
Salt Lake City, Utah

Professor Reijo Sulonen - Visiting Assistant Professor
Assistant Professor
Laboratory of Information Processing Science
Helsinki University of Technology
Espoo, Finland

Professor Ursula M. von Maydell - Visiting Associate Professor
Associate Professor
Department of Computer Science
University of Alberta
Edmonton, Canada