The School of Information and Computer Science

Established in 1963, the School of Information and Computer Science is rapidly improving its position as one of the better computer science departments in the country. A 1982 survey by the Conference Board of Associated Research Councils ranked the School “most improved” among the fifty-seven Ph.D.-granting computer science departments included in the study. Although the survey did not rank the departments overall, an average of the four most important rating parameters would place the School fourteenth in the nation.

The School of ICS has two missions—education and research—and strives for excellence in both.

Research
ICS faculty members perform research in areas that span the field of information and computer science. Faculty in many of these areas are nationally and internationally recognized experts. Many factors contribute to the research environment in the School of ICS. Most important is funding, which is provided largely by government agencies, although private industry, through gifts of equipment and funds, makes a notable contribution as well.

Another factor is fast communication of research results. For this purpose, the School sponsors an active colloquium series as well as specialized seminars in computer systems theory and artificial intelligence.

A key ingredient in any research program is the quality and quantity of computing power available. The School is fortunate to have a rich collection of computer systems. The School’s DEC VAX 11/780 links Georgia Tech to the CSNET national computer science network; CSNET, in turn, provides access to ARPANET. The School also has a cluster of three VAX 11/780 machines. Other major systems include three PRIME computers and three IBM System 370s. Many of the School’s computer systems are linked by the NCSU local network, which in turn connects to a campus-wide network. The latter network provides dial-up access to any machine in the School.

In addition to general-purpose systems, the School owns specialized research equipment. A Symbolics 3600 Lisp machine provides support for research in artificial intelligence. There are two major systems for research in computer graphics: an Amiga RISC/3000 graphics processor and an Evans & Sutherland PS 300 system.

In addition to supporting the educational programs of the School, the campus computing center operates a Pyramid IXX system that is used by the School for research purposes. The Pyramid allows the use of both System V UNIX and Berkeley UNIX.

Education
The School awards bachelor’s, master’s, and doctoral degrees in Information and Computer Science. The B.S. program offers students a well-rounded education in information and computer science. Students take a standard sequence of courses until their senior year, when they choose areas of specialization. The M.S. degree offers more advanced training. Fifty credit hours are required for the M.S. degree, including required courses in six subjects. The Ph.D. program is designed to prepare students for academic and research careers. There is no set number of hours required for the degree. The program emphasizes a broad understanding of information and computer science coupled with intensive study in the student’s area of specialization, culminating in a doctoral dissertation.

The educational programs of the School are supported by a wide variety of computer equipment. Introductory computer courses often use the Hewlett-Packard classroom-laboratory equipped with terminals connected to an HP 3000/44 system. Both introductory and advanced courses use the IBM Computer-Supported Instruction Laboratory, which includes two classrooms, each with thirty IBM PCs connected to an IBM 4361 through three IBM S/370 systems. Special equipment for instruction in computer graphics includes a Tektronix 4115 system, twelve Tektronix 4017 graphics terminals, and four color inkjet printers. Some ICS classrooms use the facilities of the campus computing center, which operates CDC CYBER 170/536 and 170/835 systems and an IBM 4341.

School of Information and Computer Science
Georgia Institute of Technology
Atlanta, Georgia 30332
Fall 1984

Georgia Tech is a unit of the University System of Georgia.
During the 1983-84 year, the School of Information and Computer Science continued its efforts to control enrollment and gain the resources—faculty, space, funding, and equipment—that it needs to become one of the best departments in the country.

Enrollments stabilize
In accordance with the School's plans, the number of undergraduate majors in ICS declined to about 660, while the number of master's students remained at about 170 and the number of doctoral students rose to over 10.

ICS moves to different offices
During June 1984, most ICS faculty and staff members moved to different offices. Although the School remains in the same building, the move resulted in a net gain of 12 offices; it also allows the School to occupy more contiguous space and gain visibility on campus. At the same time as the move, the School switched to a new analog modern telephone system.

New faculty join ICS
Despite a nationwide shortage of computer scientists with doctorates, the School continued to attract top-notch faculty. Two assistant professors, Oliver He and Gopalakrishnan Vlavianos, joined the School in the fall of 1983. The presence of He, who has both a doctorate from M.I.T. and an M.B.A. from Northeastern, has strengthened the School's computer networking program. Vijayan is an expert in applying the tools of graph theory and algorithms to such problems as VLSI design. As a doctoral student at Princeton, Vijayan helped design ALU, a language for describing VLSI layouts.

Partha Dasgupta joined the School in the fall of 1984 as an assistant professor upon completion of his doctoral thesis, Toward a Versatile Approach to Database Concurrency Control at the State University of New York at Stony Brook.

ICS faculty make news
School Director Raymond E. Miller was nominated for president of the Association for Computing Machinery, but lost to Adi Shamir. The election was held during the spring of 1984. Two members of the faculty assumed new titles during the 1983-84 year. Professor Richard DeMillo became assistant director for Research, and John Passloff became assistant director for Laboratories. Professor DeMillo was the subject of a profile in Atlanta's weekly magazine section of the Atlanta Journal and Constitution in January 1984. Professor Peter J. Stennes retired on July 1, 1984, having served Georgia Tech for thirty years. He was awarded the title of professor emeritus, making him the first ICS faculty member to hold that rank. He will continue to work for the School part-time.

IBM Computer-Supported Instruction Laboratory opens
In the fall of 1984, the School opened a new Computer-Supported Instruction Laboratory, funded and equipped by the IBM Corporation. Although used extensively for ICS courses, the facility also serves English, Mathematics, Physics, and Social Science and will soon extend its services to other departments. The $1 million laboratory, which is supervised by Associate Director Lucia Chiaramonte and Dean Les Karpinski, includes an IBM 4301 mainframe, three IBM 225s, and the hundred IBM Personal Computers.

New equipment arrives
During 1983-84, the School arranged to purchase a cluster of three VAX 11/750s. Although these will be used by the Graphics project for the construction of a reliable distributed operating system, the machines will also be available for general research use.

Special Program in Computer Networking and Communications Systems
off to a good start
The School's new Special Program in Computer Networking and Communications Systems got underway during the 1983-84 year. The primary purpose of the program, which is directed by Professor Philip Embree, is to alleviate the acute shortage of personnel with education in both computer networking and communications. The program will expand to include research projects in the near future. The networking program received an important boost when Northern Telecom, Inc. agreed to donate $2.1 million worth of equipment, services, and cash. The centerpiece of the gift was three 32-10 packet switches, reportedly the largest single concentration of these switches in the U.S. The Northern Telecom gift joins earlier donations by Bolt Corporation, Codex Division of Motorola, Dynatech Data Systems, General Electric, and AT&T Bell Laboratories.

In another development, Bolt-Northern Research announced the opening of a research laboratory on the Georgia Tech campus. This laboratory is expected to have close ties with the ICS networking program.
Faculty

Albert N. Badre, Associate Professor, Ph.D., University of Michigan, 1973. Human factors in computer systems, software engineering.

W. Gus Baltz, Research Scientist, M.S., Georgia Institute of Technology, 1985. Applications systems, real-time software, computer-supported education.

Pho Yee Chen, Assistant Professor, Ph.D., University of Illinois at Urbana-Champaign, 1986. Computer system architecture, computer networks.

Lucio Chinni, Professor and Associate Director, Ph.D., University of Minnesota, 1986. Computer systems and computer networks.

Per Harald Daugete, Assistant Professor, Ph.D., Institute of New York at Stony Brook, 1964. Database operating systems, concurrency control, distributed systems, networking, distributed algorithms, operating systems.

Richard A. Dean, Professor and Assistant Director for Research, Ph.D., Georgia Institute of Technology, 1972. Software engineering, VLSI systems, computer security, theoretical computer science.

Philip H. Ehrlich, Jr., Professor, Ph.D., Stanford University, 1966. Distributed processing, computer networks, telecommunication systems, computer systems, data communications, operating systems.

John P. Eggen, Jr., Assistant Professor, M.S., University of Massachusetts, 1965. Computer programming, computer languages.

James A. Egan, Ph.D., Professor, Ph.D., Harvard University, 1966. Semantics of natural languages and genic grammar.

Mark D. Graham, Assistant Professor, Ph.D., University of Toronto, 1961. Databases, logic, theoretical computer science.

Nancy D. Griffith, Assistant Professor, Ph.D., University of Chicago, 1978. Database systems, distributed systems, analysis of algorithms.

Oliver C. Re, Assistant Professor, Sc.D., Massachusetts Institute of Technology, 1985. Local area networks, modeling and analysis of computer networks, computer networks.


Francis E. Kaiser, Associate Professor and Librarian, M.A., University of Minnesota, 1985. Mathematisches, reference retrieval, indexing, literature searching, documentation.

K. N. King, Assistant Professor, Ph.D., University of California at Berkeley, 1961. Theoretical computer science, programming languages.

Janet L. Klabud, Assistant Professor, Ph.D., 1964. Artificial intelligence, cognitive science.

E. Gary, Assistant Professor, Ph.D., University of Maryland, 1984. Artificial intelligence, computer science.

Jerry Spitz, Assistant Professor, Ph.D., University of California at Berkeley, 1982. Analysis of algorithms, computer science.

John P. Voss, Professor, Ph.D., University of Wisconsin at Madison, 1971. Programming languages, compilers, distributed processing.

M. S. Mccartney, Assistant Professor, Ph.D., University of Illinois at Urbana-Champaign, 1986. Operating systems, distributed systems, reliability.

Raymond F. Miller, Professor and Director, Ph.D., University of Illinois at Urbana-Champaign, 1961. Theory of computation, machine organization, parallel computation.

Bruce F. Noyce, Assistant Professor, Ph.D., University of Texas at Dallas, 1981. Computer graphics, geometric modeling, VLSI.

Adjunct Faculty

Leonard J. Vokes, Adjunct Lecturer, Defense Systems.

David R. Firth, Adjunct Lecturer, U.S. Army Institute for Research in Management Information and Computer Science.

J. A. Firth, Jr., Adjunct Lecturer, Medical Systems Development Corporation.

Ross Gahagan, Adjunct Associate Professor, Georgia Tech Research Institute.

Lawrence J. Galbraith, Adjunct Assistant Professor, Georgia Tech Research Institute.

Thomas E. Hennion, Adjunct Lecturer, Georgia Tech Management Systems.

John R. Mitchell, Adjunct Lecturer, U.S. Army Institute for Research in Management Information and Computer Science.

Michael McCracken, Adjunct Professor, Lockheed-Georgia Company.

Glenn W. Rankin, Adjunct Lecturer, U.S. Army Institute for Research in Management Information and Computer Science.

Robert M. Stogmann, Adjunct Associate Professor, Southern Bell Telephone Company.

Staff

Administrative and Secretarial

Edmund F. Rumiano, Assistant to the Director.

Robert L. Bulluck, Administrative Supervisor.

Ann H. Lewis, Administrative Secretary.

Debra B. Woods, Staff Assistant.

Technical

Ahmed M. Bassel, Senior Research Scientist.

Edmund F. Rumiano, Senior Research Scientist.

Walter C. Coleman, Operations Manager, CIS Laboratory.

Ronald F. Hutchins, Research Scientist.

Abe Isakac, Hardware Support Specialist.

Stephen W. Johnson, Software Specialist.

Jeffrey S. Lee, Software Specialist.

John H. Martin, Research Scientist.

Michael McCracken, Senior Research Engineer.

William D. Robbins, Senior Research Scientist.

Win E. Steckland, Research Scientist.

Edmund F. Rumiano
Georgia Tech

The Georgia Institute of Technology, founded in 1885, offers educational programs in science, engineering, management, and architecture. Georgia Tech is a unit of the University System of Georgia, which operates thirty-three colleges and universities. Tech currently enrolls eleven thousand students, representing every state and fifty countries. The student body is diverse, including 362 National Merit Scholars and 48 National Achievement Scholars among the forty-five percent of students who are African-American, Hispanic, and Asian. At least ninety-five percent of Tech's students are from the University's metropolitan area, which covers eighteen counties and includes over 2.1 million people, is twice the largest in the country. The city's location makes it a crossroads for all forms of transportation—airports, highways, and railroads. The city is served by three main highways: I-75/85, I-20, and the Beltline. Tech's relationship with the city is evident in the many companies located on campus and in the surrounding area. The city is a vibrant and diverse place to live and work, with a strong sense of community and a commitment to excellence in education and research.

Atlanta

Atlanta is a city with a rich history and a vibrant present. It is the capital of Georgia and the home of the Beltline, a 22-mile trail that circles the city. The Beltline is a popular destination for walking, cycling, and exploring the city's history and culture. The city is also home to the Atlanta Botanical Gardens, which feature a diverse collection of plants and flowers, as well as the Atlanta History Center, which offers a glimpse into the city's past through exhibits and programs. Atlanta is known for its delicious food, with many restaurants offering a variety of international cuisines. The city is also home to the Atlanta Ballet, which performs a diverse range of ballets throughout the year. In addition, the Atlanta Symphony Orchestra, which performs at the Cobb Energy Performing Arts Center, is one of the city's most popular cultural institutions. At an altitude of 1,066 feet above sea level, Atlanta's elevation is higher than any other major American city except Denver. Its moderate climate encourages year-round outdoor activities. The city is home to many, including the Georgia Aquarium, the Atlanta Botanical Gardens, and the Fox Theatre. The city also offers a variety of entertainment options, including the Atlanta Symphony Orchestra, the Atlanta Ballet, and the Atlanta Symphony Orchestra. The city is home to many attracts, including the Atlanta Botanical Gardens, the Atlanta History Center, and the Atlanta Symphony Orchestra.
Research

The School of Information and Computer Science maintains a vigorous program of research, made possible through corporate support and government grants. Research ranges from theoretical studies that pave the way for tomorrow's computer systems to practical efforts that shape the systems of today.

Major research efforts in the School include the Clouds project, the Software Tool and Evaluation Project (STEP), and the projects of the artificial intelligence group. The goal of the Clouds project is the construction of a reliable distributed operating system. The STEP project, funded by the U.S. Department of Defense, is developing methodologies and tools for software testing. The School's artificial intelligence group is creating two large AI systems: SHRINK, for psychiatric diagnoses; and NEGOTIATOR, for mediation of disputes.

Although these projects are just a sample of ongoing research in the School, they convey a sense of the breadth of ICS research. These and other research projects are presented in more detail on the following pages.

Computer System Architecture

In this past, computer systems have been designed to make efficient use of such systems. Having developed one such tool, a programming language that supports the design and construction of distributed programs, Professor Richard LeBlanc and his students are now building a monitor that allows programmers to examine interactively the behavior of distributed programs. Monitoring a distributed program presents significant challenges, since the "state" of the program involves information about an arbitrary number of processes running on a number of machines. This problem is far more complex than monitoring a typical program on a single machine, where all of the state information is in a single address space.

The current version of the monitor collects information about process interactions as a program runs. It then uses a bitmap display to provide a high-level replay of the program's execution, showing creation and deletion of processes and messages passing between them. A programmer can interact with the replay, controlling its speed and stepping to look at messages. Future developments will include an interface with a single-process debugger, allowing the actual messages collected during an execution to be used as input during a debugging session on one process.

Professor LeBlanc is also actively involved with the Clouds project (now "Distributed Operating Systems"). His interests in that project include the development of language features and programming methodologies appropriate for the Clouds environment. He is currently supervising the implementation of the Axiom language, which allows a programmer to define objects and actions. The features of Axiom allow access to the capabilities provided by the Clouds kernel. Programming with these features during the next year will provide experience to be used as the basis for higher-level feature design and methodology development.

Programming Languages and Environments

The increasing sophistication of distributed computing systems mandates the development of tools that allow programmers to make efficient use of such systems. Having developed one such tool, a programming language that supports the design and construction of distributed programs, Professor Richard LeBlanc and his students are now building a monitor that allows programmers to examine interactively the behavior of distributed programs. Monitoring a distributed program presents significant challenges, since the "state" of the program involves information about an arbitrary number of processes running on a number of machines. This problem is far more complex than monitoring a typical program on a single machine, where all of the state information is in a single address space.

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Software Engineering

Professor Richard DeMillo is investigating the properties of mutation analysis, a software evaluation technique. A software evaluator is a device to which one submits software and a collection of evidence purporting to show that the software performs as intended. With mutation analysis, the evidence used in the evaluation is in the form of test cases, and the evaluation that is returned in an indication of how well the software has been tested. Such an evaluation represents a level of confidence in the adequacy of the test cases. To be useful as evidence of a program's correctness, test data need only distinguish the program from a finite number of alternatives—the alternatives that correspond to the most likely errors to be introduced by the programmer.

In a series of automated mutation analysis systems, researchers have explored the concept of choosing the set of alternatives by making simple mutations. The underlying assumption for such a device has been that those mutations correspond to the errors most likely to be made producing the given program.

One measure of how good the "mutation score" metric might be is how many "complex" mutants it leaves unexplained. An experiment to investigate this effect for COBOL programs, using representative COBOL and FORTRAN programs in the 1000-line range, has led to the conclusion that the mutation score comes very close to representing a probability of correctness. Further research in program mutation will proceed along three basic lines: statistical foundations, graphics, and display, and human factors.

Professor DeMillo's work in mutation analysis led him to establish the Software Test and Evaluation Project (STEP). The goal of STEP is to develop new policies and methodologies for use by the U.S. Department of Defense in the test and evaluation of software. Virtually all major defense systems contain computers as critical components; the testing of software is a key consideration for insuring the reliability of these systems. Through the first two years of the project, Professor DeMillo's group carried out an exhaustive evaluation of software testing practice. This effort culminated in a number of recommendations for modifying policy for software testing. The next phase of STEP is to develop methodologies and tools that allow implementation of these policies. STEP is partially funded by the NSF, the new DOD Software Technology Initiative.

Distributed Operating Systems

A current problem in distributed systems is that of combining multiple computer systems to provide a unified environment for users. The Clouds project, led by Professor Martin McKeandry, is tackling this problem by designing and building a reliable distributed operating system. The fundamental aim of the project is to provide a testbed for the evaluation of techniques for constructing distributed systems.

Clouds is a global operating system; it allocates and manages all resources (processors, files, etc.) globally. No distinction is made between local and remote resources. Instead, decisions assigning processors to particular tasks are made on the basis of heuristics. Distributed data management is a major consideration for Clouds. The kernel provides highly reliable data management, simplifying this task for the operating system and application programs. The Clouds group is currently working on a prototype kernel for a cluster of VAX 11/750 systems.

The architecture supported by Clouds will provide objects and actions. Objects, which are instances of abstract data types, provide the basis for consistency. Atomic actions are the basis for recovery. Actions help to categorize the state of system components after failure.

The Clouds project is closely integrated with Professor LeBlanc's projects. His work on the monitoring of distributed programs will facilitate the development of systems under Clouds. Clouds, in turn, will provide support for distributed programming languages.
Computer Networks

Computer networking is fast becoming a major area of research within the School. Three faculty members are performing research in the area, with the inauguration of the academic program in Computer Networking and Communications Systems. The work will involve increased research activity.

Over the past year, Professor Philip E. Borgio has conducted an investigation of the performance of an Ethernet type local area network. The objective of this project was to validate a CSUMAC simulation model by making measurements on an operational network. One of the most important findings was that currently available instrumentation equipment is not adequate to precisely determine the performance of data communications systems or computer networks. Most of the existing instrumentation and test equipment, such as data analyzers and protocol analyzers, have been developed for the primary roles of testing the functionality and execution of communication protocols. Such pieces of equipment do not contain enough timers and counters to collect sufficient performance statistics. Special equipment has been developed during this project to perform these functions, and the availability of this equipment will greatly enhance both the educational and research effectiveness of our laboratories.

Another area of research activity during the past year has been the investigation of flow control in network architectures. It is obvious that the effects of flow control are governing the performance of many, if not most, data communications and computer networking systems. Even the performance of flow control in simple point-to-point circuits is the presence of errors is not well understood. When the problem is complicated by the introduction of cascaded flow control mechanisms with data lines connected together in tandem, our lack of understanding becomes even greater. The problem does not end there. Of equal importance is the interaction of different flow control mechanisms with the various levels of a layered architecture. What are the results when flow control mechanisms are nested one inside another and then cascaded over separate links that are connected together in series?

During the past year, work in this area has concentrated on the definition and development of flow control mechanisms for wave simulation programs. A data link simulator is presented which includes the effects of errors in a layered flow control mechanism that supports the study of nested flow control mechanisms in which each layer may use a different credit mechanism. An important aspect of this work will be validation against an operational system.

In addition to studying computer networks, Professor Birol is applying such operations research tools as queuing theory and mathematical optimization to research the performance evaluation of computer systems, including the flow control problem and the problem of concurrency control in database systems.

Professor Ming-Yee Chen's research interests include communication networks, especially local area networks, as shown by his joint work with Professor Birol. He is particularly interested in the design and analysis of integrated voice and data traffic in a wide-band communication network.

Database Systems

Professor Nancy Griffiths is investigating methods of synchronizing the activity of multiple database users and recovering from system crashes. This investigation involves both theoretical and experimental methods. The significance of the study from a database point of view involves the representation of data in a new-structured network. The study showed that the percent of updates processed, restricted additions and subtractions from the total in such a database is independent of network size and faster for large networks than a centralized representation. Thus, an airline reservation system could be fully distributed among any number of cities without degrading its performance.

Professor Marc Graham's research in the theory of databases is from viewing databases as a set of elementary facts, the database itself, and a set of general rules, the user-specified constraints. In this model, which is well established in artificial intelligence, query answering is just logical inference. Professor Graham and others have recently proposed an application of this idea in which user constraints are taken from the class of data dependencies. He is now examining several questions that arise from this view. How powerful must the language be to answer these queries? Can these queries be answered efficiently, and how difficult are they in general? How might a system built on these ideas be constructed?
Computer Graphics

ICS computer graphics research, led by Professor Bruce Naylor, focuses on the synthesis of realistic 3D color images for animation and simulation applications. Substitutes include interactive design of objects and their movement in time, geometric model representation systems, rendering algorithms (e.g., visible surface determination), and architectures for real-time image synthesis.

Current projects include the design of a generic modeling system based on the explicit use of functional programming at both the language level and in the actual representation of the geometric model. This allows every aspect of the model, including geometric shape and physical attributes, to be defined by functions. Thus, for instance, making aspects of a model a function of time, is needed for animation, is straightforward.

A second effort is the design of graphics systems that support concurrent processing. ICS has focused on the organization of the frame buffer buffer. Professor Naylor has devised a new scheme for distributing the pixels among the memory chips to allow easy concurrent access to any pixel in M memory blocks, where M is the total number of memory chips.

Another project is a comparative experimental analysis of visible surface algorithms. Many such algorithms have been devised, but little is known about their relative performances. Professor Naylor’s group has implemented ten visible surface algorithms and is now constructing initial experiments. The primary goal of this work is the identification of algorithms to be used in the design of highly concurrent VLSI-based architectures.

Other issues being considered by Professor Naylor’s group include improving the computational efficiency and capability of ray tracing algorithms, as well as the illumination models, and exploring new computational techniques for producing fractal geometries based on iterative function systems.

VLSI Systems

The study of VLSI (Very Large Scale Integration) systems is one of the newest areas of research in the School. Subjects of interest to ICS researchers range from fundamental theoretical issues, such as the complexity of VLSI-related algorithms, to the application of VLSI components in computer system design. ICS faculty currently involved in VLSI research are Professors Richard DeMillo, Bruce Naylor, and Gopalakrishnan Vijayan.

One current thrust of the School’s VLSI research is the development of design tools for high-level chip design. At Princeton, Professor Vijayan was instrumental in the development of a PASCAL-like language for procedural specification of layouts. An important aspect of the language is that the user is not required to specify any metric values, but instead describes only the topology of the circuit under design. Several chips have been successfully designed and fabricated using the language. ICS researchers have extended this approach of design by including a sophisticated interface for geometric programming, requiring the user to specify little more than topology and self-organization. Tools such as these should lead to a significant reduction in the time required to design a VLSI layout.

Circuit reliability is an issue of overwhelming concern at all stages of the design process. ICS research in this area involves two approaches. The first applies the techniques of fault analysis to VLSI design testing. When a VLSI system is specified functionally, it is possible in principle to devise an automated system that will quickly and accurately assess the coverage of a given set of test cases for a circuit.

Such techniques can be effective replacements for exhaustive testing (which is usually intractable or random testing, which is frequently ineffective). The fact that the techniques can be automated makes them suitable for inclusion in many stages of the design process. The second approach is to “design for errors.” Since large area VLSI designs can present a number of engineering advantages for custom chip designs, it seems natural to try to balance the inherent unreliability of large chips with the possibility of exploiting added function. Indeed, simple computations with the exponential fault model show that it is possible to use traditional redundancy techniques to increase total reliability.

Another important aspect of the VLSI effort is the involvement of ICS faculty in the Institute-wide Microelectronics Research Center, Professors DeMillo and Naylor are members of the Technical Committee, while Professor Raymond Miller is on the Advisory Committee. The purpose of the Center is to coordinate the integrated circuit research being performed by various units on the Tech campus. The Center’s work ranges from device physics and materials to system design and computation. The Center sponsors seminars that allow microelectronic specialists on and off campus to be kept abreast of each other’s research, and in addition, operates a technical information service for rapid dissemination of research results.

Although the Center is primarily a coordinating body, it owns a DEC ALMA CHIPS 2200 electronic circuit design system, an industry standard. The system, with two interactive color graphics workstations, supports the design of custom, master cells, and gate-array based VLSI chips, as well as layout and checking for printed circuit boards. The Center also operates a Harris 8000/32-bit computer system.
Computer Security

Throughout most of the 1970s, secure computer systems were identified with secure processor multiplexing systems (e.g., Hydra, Multics, or Unix). The conventional approach to the multilevel security problem for computer systems has been the software solution, as exemplified by limited-resource operating systems, which require the user to specify security transactions through a strict and tightly constrained operating system (the security kernel).

Professor Richard DeMillo, together with Professor Richard Lipson of Princeton University, is investigating the result of negating the assumption that sharing implies multiplexing. His approach is motivated by the rapid advance of personal computers, distributed computing, and telecommunications technology. When a single processor environment is replaced by a distributed system, designers can exploit the distributed nature of the system to enhance its security characteristics. Single-processor systems, a sequent channel is a fixed, conceptual path for information flow, in a distributed system, however, it is possible to place a physical barrier between two processors merely by placing them on different processors. In the distributed system, the channel is explicit; it is a physical device that can be secured by encryption, monitored by physical means, and used to maintain various security properties by protocols.

The design of encryption-based protocols has led to theoretical questions concerning their analysis. Research is underway to provide models of cryptographic protocols in which security properties can be established. This work has already led to a number of new protocols, many of which are described in the new book, Applied Cryptography: Cryptographic Protocols and Computer Security Models, written by Professor DeMillo. In collaboration with four other experts in cryptography and security, Professor DeMillo has been able to show that this question is formally equivalent to independence problems in classical mathematics. In addition to his work in pure theoretical computer science, Professor DeMillo has also integrated the tools of theory to problems from other areas of computer science. His research in VLSI systems, computer security, and software engineering is described under those headings.

Professor K. N. King's work includes the study of automata-based complexity—the study of complexity classes defined by resource-bounded automata. His work so far has dealt primarily with restricted forms of alternating automata, particularly alternating finite automata and Turing machines. Professor King is also interested in computational models inspired by VLSI systems and other recent computer science developments.

Theoretical Computer Science

Broadly speaking, theoretical computer science is concerned with the formulation of abstract models of computational processes and the study of properties of computation through those models. Researchers at Georgia Tech are currently studying not only standard sequential and parallel models of computation, but also newer models of VLSI computer, distributed computing, and database management.

One topic under study by Professor Richard DeMillo is the question of whether P = NP, which asks whether problems that can be solved efficiently on a non-deterministic model of computation can also be solved efficiently on a deterministic model.
Human Factors in Computer Systems

The objective of Professor Albert Badre's research in the human factors of computer systems is to identify and explore empirically the human factors that affect the design and operation of computer systems and the efficiency of the software development process.

Professor Badre's latest work involves designing technology into the user-computer interface. Many software systems that claim to be "user-friendly" merely provide an interactive, menu-driven interface. While this is fine for novices, more experienced users find menus to be an obstacle to efficient use of the system. Some systems attempt to solve this problem by providing both a novice, menu-driven interface and an expert, command-driven interface. Unfortunately, the two modes of interaction are usually independent; experience gained through the use of one menu does not help the user learn the commands needed for the expert interface. This two-level interface also fails on two other counts: it does not allow a smooth transition from novice to expert, and it does not acknowledge that a person can simultaneously be an expert user of some system functions but a novice user of others.

Professor Badre believes that a user interface should be designed so that a novice user can gradually develop into an expert through experience gained by using the system. This goal can be achieved by designing the interface so that the following conditions are met:

1. The interface should provide an introduction to new vocabulary and the generation of new sentences for "chunking" actions (grouping atomic actions into larger units).
2. The interface should provide an introduction to new vocabulary and the generation of new sentences for "chunking" actions (grouping atomic actions into larger units).
3. The interface should provide an introduction to new vocabulary and the generation of new sentences for "chunking" actions (grouping atomic actions into larger units).
4. The interface should provide an introduction to new vocabulary and the generation of new sentences for "chunking" actions (grouping atomic actions into larger units).
5. The interface should provide an introduction to new vocabulary and the generation of new sentences for "chunking" actions (grouping atomic actions into larger units).

Another area of research activity, motivated by distributed processing in heterogeneous environments, is the design of user-compatible transparent front ends. Professor Badre is experimenting with different strategies of command generation and command presentation and user selection.

Professor Badre is also collaborating on a project to develop methods for assessing the usability of system-specific applications in both the laboratory and real-world environments. He is currently investigating an available usability evaluation system in order to complement it with an alternative user-oriented mesudi von prototyping system now under development. The long-term objective is to create a system that can evaluate the usability of an interface based on user feedback.

Artificial Intelligence

Organization and representation of the knowledge needed for doing intelligent tasks is perhaps one of the hardest problems facing researchers in artificial intelligence. Professor Janet Kolodner's research group is concerned with the manipulation of knowledge and the acquisition and use of knowledge in artificial intelligence systems. The group's second task domain is problem solving and reasoning. The goal of the research is to produce a computer system capable of not just expert reasoning, but reasoning in a way that the user can understand and improve over time.

As a first step, Professor Kolodner designed CYRUS, a computer system that stores events in the lives of former Secretaries of State and presidents, and uses this information to predict future events. This system provides the user with a historical perspective on events and allows the user to explore different scenarios. The system is being used to study the role of experience in clinical problem solving. Professor Kolodner and Dr. Robert Koontz of the Atlanta VA Medical Center study how experience changes the knowledge used in diagnosis and how experience is used during diagnosis. Failure to diagnose correctly, for example, can be avoided if a clinician is reminded of a previous similar case. The diagnosis made in that case serves as a hypothesis in the current case. The long process that might have been necessary to track down a correct diagnosis the first time will be shortened considerably the second time. The group has designed an algorithm for diagnosis that includes experience and reasoning with it through SHRINK, a computer program that diagnoses psychiatric disorders and through interviews with novices and experienced psychiatrists.
Professor William Underwood is attacking the problem of how common-sense knowledge of physical mechanisms can be represented and used in computer programs that teach people how mechanisms work and that aid people in diagnosing mechanism failures. Progress to date includes the construction of a causal network for the primary coolant system of a nuclear power plant and the creation of a computer program that uses the network to infer the causes of problems that arise during the operation of the plant. Professor Underwood is also investigating how real-world knowledge of companies of business can be incorporated in computer-based decision support systems for management. He has designed an organization description language that includes constructs for describing an organization's task environment, goals and plans, structure, operations and procedures, memories, management processes, and computer-based systems. He is building a knowledge-based management system that conveys this knowledge to users to collect organizational knowledge and then uses this knowledge to interpret managers' questions about the organization and its databases. The system has been used to build knowledge bases for a software development project organization and a portion of an academic organization.

Other work in artificial intelligence includes Professor Phanish Srinivasan's research in the field of pattern recognition, where he is currently studying adaptive methods of feature extraction. Present methods for automatic extraction and selection of features from data for pattern recognition and classification are operationally limited to data types that systems are of interest in real-life applications. One of the reasons for the limited success of present methods is their insensitivity to changes in the characteristics of patterns (i.e., input data). To overcome this limitation, Professor Srinivasan is examining adaptive systems of feature analysis and extraction, with emphasis on binary patterns and application of error-correcting coding techniques.

Cognitive Science

Cognitive science is a nearly emerging discipline that combines techniques and approaches from the fields of artificial intelligence, linguistics, psychology, anthropology, and philosophy to pursue the problem of cognition (knowledge use and acquisition). IOS researchers approach cognitive science from the perspectives of artificial intelligence, human information processing, language processing, and the philosophy of language. Professor Janet Kolodner is involved in cognitive science research as part of her work in artificial intelligence. Like that work, her cognitive science efforts explore the role of experience in expert and common-sense reasoning. In addition to the work described in the previous section, she and Professor Larry Barsalou, a psychologist at Emory University, are testing some of the predictions arising from the CYRUS model of human memory. Their work involves both psychological experiments and experiments using the computer model CYRUS. Along with Dr. Robert Kolodner, a psychiatrist, she is proposing to do in-depth interviews with novices and expert psychiatrists to learn in more detail what role experience plays in clinical problem solving.

Professor Albert Badia has conducted research in the area of problem-solving strategies, with the goal of achieving a better understanding of the processes underlying the skilled solving of ill-defined problems. Those processes include both problem-solving strategies and strategies for acquiring and organizing the knowledge necessary for solving problems. The effective diagnosis of such processes would lead to the development of computer programs that model expert solving of ill-defined problems, and on the other hand, to the computer extension of human information-handling and problem-solving capabilities. Professor Badia has been successful in introducing new techniques to delineate the representational structures in problem-solving protocols.

The third faculty member involved in cognitive science research is Professor James Gough, who studies the foundations of language and grammaticality. Professor Gough is carrying out a study of the essential nature of language as reflected in the phenomenological semiotic being of Dasein empy. His semiotic approach is Percepan and his phenomenological program stems from Husserl, Heidegger, Merleau Ponty, and Whitehead. The present stage of his study is concerned with the development of generative grammaticality and of the phenomenological semiotic analytic of Dasein.
**Systems**

**Theory**

Professor Franca Zunde is conducting a study of system structures and decompositions, in which global characteristics of various properties of linear dynamical systems are described. Linear automata, such as controllability, reachability, observability, and reconstructability, are developed using an algebraic approach (lattices). He has been able to relate properties of state space lattices to characteristics of these systems' parameter matrices and develop a method for selection of a system model with desirable structural properties. He is extending his results to state feedback control systems, characterization of state space, structure of bilinear systems, and system decomposition problems.

**Information Science**

Professor Franca Zunde's work in information science focuses on information retrieval and the modeling and design of interactive computer systems. He is investigating the feasibility of operational definitions of word's "least effort" principle and its application as an optimality criterion in information systems design.

In one project, Professor Zunde is examining certain quantitative aspects of semantic coding in an attempt to determine the relationship between diversity of meaning and syntactic properties of words and morphemes in informative texts. He will test entropy maximization theory as well as other relevant theories for their capability to account for, explain, and predict empirical findings of the study.

Finally, Professor Zunde will determine the feasibility of developing a comprehensive theory of semantic coding along the lines of Shannon's information theory, using the empirical results of the earlier investigation as test data. The study may have applications in such areas as information retrieval and the modeling and design of interactive computer systems.

**Information Systems**

Professor Vladimir Siamecka directs a five-year, $3.3 million effort to design and implement a national network of scientific and technical information services for the Arab Republic of Egypt. The major product of the first, completed phase of the program was the structured design of this sectorally oriented information network. The next phase includes the development and implementation of these services involving, among others, the development of a distributed network of Egyptian databases, interactive searching of foreign databases, a document delivery system, a nationwide manpower training program, and in the establishment of the legal and organizational superstructure to coordinate and govern this evolving national network.

Professor Siamecka's program addresses a number of R&D issues, including national portability of executive software, bilingual end-user software, uniform database design for both text and bibliographic data, and a standard bilingual command language interface for databases of diverse content. The program is receiving international attention as a case study demonstrating novel information technology development countries. Professor Siamecka's work on the program was cited by the American Association for the Advancement of Science when it presented him a Fellow in 1983.
Computer-Supported Instruction

The School's research in computer-supported instruction received a boost in 1984 with the opening of the new IBM Computer-Supported Instruction Laboratory. The goals of the Laboratory, which is one of four national demonstration sites for IBM's Academic Information Systems Division, are to demonstrate the use of IBM systems for instruction, evaluate them, and develop courseware. The Laboratory includes two classrooms, each with thirty IBM PC student workstations and one instructor station, and a demonstration room containing eight PCs. All of the PCs are networked to an IBM 3661 Model 5 via three IBM "Series 1" systems.

The CSCI Laboratory is operated by the School of CSCI and used by both CSCI and other departments, including Mathematics, Physics, Engineering, and Social Sciences, for purposes that range from document preparation to sophisticated artificial intelligence projects. Lucio Chiaraviglio, associate director of the School, and Les Nielson, dean of the College of Sciences and Liberal Studies, are co-directors of the Laboratory. During spring quarter 1984, roughly 660 students used the Laboratory, its usage is expected to triple within a few quarters.

The School operates a second computer-supported instruction facility, the Hewlett-Packard Classroom-Laboratory. The HP Classroom-Laboratory, which includes thirty student workstations and one instructor station, is connected to an HP 3000A computer system, made possible by a grant of equipment from the Hewlett-Packard Company Foundation. During its first two years in operation, the Classroom Laboratory provided 1,000 students with about 72,000 hours of instructional computing. Instructional systems and courseware for the HP system are under continuous development by faculty members Gus Bailard, Lucio Chiaraviglio, John Gods, and John Passafiume and their graduate assistants.

John Gods

John Passafiume

Gus Bailard
Colloquia

Winter 1984

Nad Goodman, Boston University "How to Understand Concurrency Control Algorithms for Distributed Database Systems"

Mary E. Lynch, Massachusetts Institute of Technology "Sleeping a Leader in a Z-Distributed Ring"

Gerald S. Tilles, Coxe Cable Communications "Integrated Switching/Metropolitan Networks: Fiber Optics vs. Coastal Cable"

Faukham Raman, University of Illinois "On-Line Package Line Scheduling"

Arnold Rosenberg, Duke University "Embedding Graphs in Books: A Layout Problem with Applications to VLSI Design" B. Chandrasekaran, Ohio State University "Expert Systems: Matching Techniques to Tasks"

Vijay K. Yorkvist, Georgia State University "Weighted AVL Trees"

Martin McKindry, Georgia Institute of Technology "Ctools: Objectives and Achievements"

S. Rutenber, University of California, Santa Barbara "First and Second Order Problem Abstractions"


Staatwuyi Suzuki, Columbia University "A Machine Architecture and Performances of a Tree Network with Collision Avoidance Switches"

Spring 1984

Michael Mikes, Harvard University "Comprehensive Approach to the Design of Relational Database Schemes"

Joseph Wilson, University of Virginia "Assembling a Digital Image Processor"

Walter W. Buehler, Ohio State University "Performance Analysis of Local Area Computer Networks"

Ravindra, Tbilisi University "Qualitative Causal Reasoning for Diagnosis of Medical Diagnosis Programs"

Richard C. Cullinane, University of Connecticut "Managing a Knowledge Base for a Controversialist"

Gerald Deucon, University of Illinois "Problem Solving in Artificial Intelligence"

Erik Bach, University of California at Berkeley "Managing a Knowledge Base for a Controversialist"

Wassan Hazolaks, Harvard University "Reynolds Agreement Under Restricted Types of Functions"

The following is a list of ICFP publications for the period between July 1, 1983 and June 30, 1984. This list includes refereed publications and conference papers. Technical reports issued by the School of Information and Computer Science are not listed separately.


Courses

Undergraduate

IC100: Information and Society
IC199: Computing Facilities
IC140: Introduction to Algorithms and Computing
IC149: Computer Programming and Problem Solving
IC179: Digital Computer Organization and Programming
IC219: Programming and Problem Solving Using Pascal
IC215: Introduction to Discrete Structures
IC220: Data Structures
IC229: Technical Information Resources
IC300: File Processing
IC389: Computer Organization and Programming
IC280: Computer Organization and Programming II
IC313: Databases
IC314: Introduction to Discrete Systems
IC315: Introduction to Mathematical Logic
IC316: Introduction to Theory of Computing
IC330: Introduction to Software Engineering
IC334: Introduction to Computational Linguistics
IC336: Introduction to Artificial Intelligence
IC340: Automatic Data Processing
IC342: Survey of Programming Languages
IC360: Information Systems
IC361: Operating System Oriented Numerical Methods
IC362: Computer Organization and Programming III
IC319: Topics in Linguistics
IC417: Introduction to Mathematical Linguistics
IC418: Introduction to Information Processes II

Graduate

IC419: Problem Solving
IC419: Computing Languages
IC411: Introduction to Theory of Computing
IC420: Project Communication and Management
IC428: Literature of Science and Engineering
IC430: Science Information Systems
IC434: Natural Language Processing
IC436: Biomedical Methodology
IC439: Information Storage and Retrieval
IC430: Data Communications
IC439: Computer Graphics
IC440: Introduction to Operating Systems
IC460: Introduction to Data Base Design
IC490: Elements of Information Theory
IC491: Computer Systems Laboratory I
IC492: Computer Systems Laboratory II
IC495: Microprogramming
IC496: Design Project I
IC497: Design Project II
IC498: Design Project III
IC470: Modes of Human Information Processing
IC479: Human Factors Software Development
IC490: 2-3: Special Topics
IC491: 2-3: Special Topics
IC492: 2-3: Special Topics

Current Doctoral Students

Laure B. Hedges
Computer graphics, human factors
Rose L. Hsu
Artic. T. Karla
Data communications
Advisor: N. H. King
Gail W. Bonson
Henry G. Bibb, Jr.
Distributed systems, programming languages
Advisor: R. A. DeMillo
David E. Brown
INP Fellowship, 1984-86
Computer applications in analytical chemistry
Advisor: J. N. B. Wood
James M. Brennan
Xian Cheng
Computer networks
Suk Y. Choo
Michael G. Christel
Jack H. Carey
President's Fellowship, 1979-79
Topic: Medical records database management system
Advisor: W. M. van der Hooft
David A. Clark
Programming languages, natural language processing, algorithms
Advisor: C. E. Shannon
Charles A. Darragh
Natural language processing, pattern recognition
Advisor: J. B. Blatt
Pipat Easawangkoon
Distributed operating systems, language design
Advisor: W. D. L. Wood
J. Davis Erick
Artificial intelligence
Advisor: R. L. K. Robinson
John C. Fasutti
Programming languages, theoretical computer science
David R. Fortunato
Computer systems
W. Glenn Sizer
Operating systems, computer architecture, artificial intelligence

Each Ph.D. student's research interests are listed below. A thesis topic and adviser agree on for each student currently working on a thesis.

Gerald R. Owens
Computer science, human factors
Advisor: H. L. Hsu
John F. Passaline
Software engineering, computer architecture
David V. Pitts
Distributed systems, programming languages, operating systems
Advisor: R. W. Pakula
Artificial intelligence
Balkrishna Ramesh
Computer networking
Thad Ranganathan
Linguistic properties of the genetic code, computational linguistics, speech understanding, heuristics
Carl F. Russell
Human factors
Advisor: J. N. B. Wood
Scott A. Vomvorakis
Antonio C. Sorensen
Programming language semantics, compilers, database languages
Advisor: R. L. Shackleford
Human factors and computer systems
Daniel T. Sheehan
Human factors and operating systems, computer architecture
Advisor: J. N. B. Wood
Hong S. Srinivasan
Computer science, human factors
Advisor: J. N. B. Wood
Robert L. Simpson, Jr.
Computer science, artificial intelligence
Advisor: C. E. Shannon
David V. Strother
Large computer systems
Advisor: E. R. Strother
Eugene H. Spafford
INP Fellowship, 1983-86
Advisor: J. L. Kolodner
Large computer systems
Advisor: J. W. Smith
David M. Storer
Computational linguistics
Advisor: J. N. B. Wood
Eugene F. Sproul
President's Fellowship, 1982-84
Advisor: J. N. B. Wood

Recent Graduates

James E. Alcina
Current position: Director of Network Services and Communications, Baran Systems, Inc.
Advisor: A. E. Benoit

David L. McKendry
Advisor: J. W. Smith

John A. Davis
Advisor: M. S. McKendry

Current position: Deputy Director, U.S. Army Institute for Research in Management Information and Computer Science

Advisor: J. W. Smith

Advisor: M. S. McKendry

Advisor: J. W. Smith

Advisor: J. W. Smith
Financial Aid for Graduate Students

The forms of financial aid available to graduate students in the School of Information and Computer Science are listed below. Other forms of financial assistance are offered by Georgia Tech, e.g., Veterans Administration Program, Work-Study, State Loans, National Direct Student Loans, and short-term loans. Information on these is available from the Office of Financial Aid, Georgia Institute of Technology, Atlanta, Georgia 30332.

President's Fellowships
Stipend of $10,000 for twelve months plus waiver of tuition and fees for one year. The award can be extended for two additional years, based on the student's academic performance and research potential. Second- and third-year awards provide a stipend of $5,000, a waiver of tuition and fees, and a supplemental research or teaching assistantship to provide the student with a total income comparable to the first-year award. Awarded to first-year M.S. and exceptional Ph.D. students by the Dean of Graduate Studies upon recommendation of the School. Highly competitive.

Graduate Research Assistantships
Part-time employment (usually on a half-time basis at a corresponding fraction of the full-time rate) between $20,000 and $25,000 for twelve months, plus waiver of all tuition and fees. Selection based on the applicant's ability to contribute to research projects of the School. Normally open to Ph.D. students.

Graduate Teaching Assistantships
Part-time employment (usually on a half-time basis at a corresponding fraction of the full-time rate) between $20,000 and $25,000 for twelve months, plus waiver of all tuition and fees. Duties consist of classroom and laboratory assistance, including instruction under supervision of faculty members.

Regents' Opportunity Scholarships
Stipend of $5,000 for twelve months. Awards are made to economically disadvantaged residents of Georgia.

Out-of-State Tuition Waivers
Awarded by the Dean of Graduate Studies upon recommendation by the School. Selection is based on economic need and academic performance.

Federal Fellowships and Traineeships
Subject to the availability of funds, a limited number of fellowships and traineeships may be awarded through participation in programs sponsored by agencies of the federal government. Prospective graduate students should also apply for competitive national fellowships such as those offered by the National Science Foundation.

For More Information

The following publications provide more information on the educational programs of the School of Information and Computer Science:

Doctoral Program in Information and Computer Science: Programs and Courses, School of Information and Computer Science, Georgia Institute of Technology, Atlanta, Georgia 30332.

For more information about the special program in Computer Networking and Communications, write to Professor Philip M. Erisova, Jr., School of Information and Computer Science, Georgia Institute of Technology, Atlanta, Georgia 30332.

The School publishes many technical reports each year. For an up-to-date list of available reports, write to Mrs. Debra V. Woods, Staff Assistant, School of Information and Computer Science, Georgia Institute of Technology, Atlanta, Georgia 30332.

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