

Research in the Computer Science Department
at Indiana University

1979-80

edited by

Mitchell Wand

Computer Science Department

Indiana University

Bloomington, Indiana 47405

TECHNICAL REPORT No. 98

RESEARCH IN THE COMPUTER SCIENCE DEPARTMENT

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AUGUST, 1980

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1. Introduction

Two events marked the 1979-80 year in research: Doug Hofstadter's awards and the funding of a departmental research computing facility.

Douglas Hofstadter won the 1980 Pulitzer prize for general non-fiction for his book, Godel, Escher, Bach: An Eternal Golden Braid, published in 1979. The book also won an American Book Award. In addition, Professor Hofstadter won a prestigious Guggenheim Fellowship, which he will spend in 1980-81 at Stanford University studying the esthetics of computerized typeface design.

The other highlight was the receipt from NSF of \$175,000 for a departmental research computer. This facility, which we expect to be operational in Spring 1981, will enable us to pursue a variety of experimental studies which are not feasible on our current equipment. Its improved document-production capabilities should increase our productivity in many aspects of our work.

Beyond these news items, research has continued at a brisk pace. We continue to be a major center in semantics and other theoretical aspects of programming languages. The addition of Jim Burns and John O'Donnell has strengthened our systems area. With Stan Kwasny and Robert Filman added to Doug Hofstadter, we have reached a critical mass in artificial intelligence. Our hardware development lab is progressing nicely.

Notwithstanding this laundry list, our real strength is in our people and their interaction. Our faculty brings a wide variety of views and techniques to bear on research problems. It is this interplay of ideas which elicits new insights and makes IU an exciting place to do research.

Mitchell Wand
August, 1980

2. Faculty

Cynthia Brown, Assistant Professor; Ph.D., University of Michigan. Analysis of algorithms, theory of computation. Algorithms.

John Buck, Lecturer and Assistant Chairman; Systems analysis, data base and information systems; computer science education.

James Burns, Lecturer; Ph.D. expected 1980 from Georgia Tech. Theoretical computer science, parallel and distributed systems, and distributed data bases.

George Epstein, Professor; Ph.D., University of California, Los Angeles. Systems design, multiple-valued logic, computer science education.

Robert Filman, Assistant Professor; Ph.D., Stanford University. Artificial Intelligence, programming languages, distributed computing, data base systems, logic, and man-machine interaction.

Daniel P. Friedman, Associate Professor; Ph.D., University of Texas at Austin. LISP, Program methodology, list, string, and graph processing languages, formal semantics, artificial intelligence.

Stanley Hagstrom, Professor, Computer Science and Chemistry; Ph.D., Iowa State University. Computer hardware, laboratory automation, computer networking, operating systems, compilers, analysis of algorithms in the area of ab initio quantum chemistry.

Douglas Hofstadter, Associate Professor; Ph.D., University of Oregon. Artificial intelligence, representation of knowledge, natural language understanding, logic.

Stan Kwasny, Lecturer; Ph.D. expected 1980 from Ohio State University. Natural language understanding, artificial intelligence, computer graphics, and computational linguistics.

John O'Donnell, Lecturer; Ph.D. expected 1980 from University of Iowa. Computer architecture, microprogramming, compilers, and operating systems.

Franklin Prosser, Professor; Ph.D., Pennsylvania State University. Operating systems, digital hardware, computer science education.

Paul Purdom, Associate Professor and Chairman; Ph.D., California Institute of Technology. Analysis of algorithms and compilers.

Edward L. Robertson, Associate Professor, Ph.D., University of Wisconsin. Theory of Computation, Computational Complexity, Analysis of Algorithms, Hardware and Software Systems Architecture.

Mitchell Wand, Associate Professor; Ph.D., Massachusetts Institute of Technology. Theory of programming, logic, algebra, and artificial intelligence.

2. Faculty (Continued) --

David Wise, Associate Professor; Ph.D., University of Wisconsin.
Applicative programming, data structures, and languages.

3. Facilities

The primary computing facilities for the Computer Science Department are provided by the Indiana University Computing Network. This network currently consists of a CDC 6600/CYBER 172 in Bloomington and a DEC KL10 in Indianapolis, connected via high speed transmission lines. There is limited network access to an IBM 370/158 in Bloomington, used primarily for administrative computing. A PRIME 750 in Bloomington and an IBM 4341 in Indianapolis will be added to the network by 1981. Departmental access to the network is facilitated by a Remote Job Entry station and a terminal cluster in Lindley Hall, where the department is located. Most full-time faculty have individual CRT terminals.

Students in assembly-language and operating systems courses get hands-on experience using three TI 980's owned by the department. These machines will be replaced by individual microprocessor stations by Fall, 1981. Each station will include an M6809 CPU, single or dual floppy disks, and a CRT terminal. Some stations will have printers or other interfaces.

The department maintains a well-equipped hardware development laboratory, with an assortment of microprocessors and supporting equipment. A feature of this laboratory is the Logic Engine, a general-purpose controller for horizontally microprogrammed systems. This device has been used to build disk controllers and small computers; it is currently being used in the development of a FORTH machine. A second feature is a facility for the production of two-sided plated-through printed-circuit boards, such as the one used for the Logic Engine.

In Spring 1981, the department will take delivery of a Digital Equipment VAX 11/780. This system was funded by the National Science Foundation, with a University contribution, to provide a vehicle for faculty and graduate student research. The configuration will include 2Mb primary memory, approximately 500 Mb permanent and 50 Mb removable disks, a dual density tape drive, and a graphics printer. Interfacing for terminals, networking, and other purposes will be via microprocessor "peripheral processors."

4. Summaries of Research Projects

Aspects of Applicative Programming for Systems

Daniel P. Friedman
David S. Wise

Applicative programming is the implementation of algorithms entirely by functional specification; no values are assigned and hence no side effects occur. Applicative programming assists in algorithm design and verification and can ease the serialization constraints inherent in most programming languages. Recent extensions to applicative programming allow the specification of extensive objects such as job streams and of contending concurrent evaluations, with special relevance to operating systems.

Program Specification and Verification: Algebraic and
Logical Approaches

Daniel P. Friedman
Mitchell Wand

Formal techniques for verifying program modules include algebra, Parnas modules, and semantic modelling. One goal of this research is to unify the three approaches in an easily understood theory including a formal language, a proof theory, and a theory of models and implementations. A second goal is the application of these techniques to problems of programming languages and operating systems.

Empirical Studies of Hard Problems

Cynthia A. Brown
James E. Burns
Paul W. Purdom
Edward L. Robertson

Many problems of great practical significance have been shown to be "hard" using theoretical ideas such as NP-completeness. These results emphasize worst case behavior. This research concentrates on heuristics, approximations, and search strategies which work efficiently on realistic cases of these practical problems. General techniques and heuristics for specialized problems are both considered. Computing facilities are used to evaluate the quality of answers supplied by proposed techniques and to analyze their resource requirements.

Artificial Intelligence

Robert E. Filman
Douglas R. Hofstadter
Stan C. Kwasny

This research will explore fundamental mechanisms for representing knowledge and inferring patterns and will apply developed techniques from artificial intelligence to problems of the human-computer interface. The fundamental research will focus on deep understanding of problems which do not require elaborate descriptive mechanisms, such as sequences of integers, and on incorporating heuristic mechanisms in the represented knowledge base. Applying known natural language techniques to present more human interfaces, for example to time-sharing command languages, should provide valuable insights into the relationship between formal and natural languages and additionally provide great benefits to system users.

Simulation Studies of Distributed Systems

James E. Burns
John O'Donnell
Franklin Prosser
Edward L. Robertson

Distributed systems are becoming ever more significant with advancing technology, but analysis is made impossible by the complex interactions that occur. The proposed research would develop simulation tools for distributed systems and apply these tools to the study of particular aspects of these systems. The tools would allow specifying systems in detail or by stochastic parameters - for example, specifying actual message content versus average message traffic - and would facilitate clustering the behavior of subsystems as units in a larger system. Particular topics to be considered included distributed data bases, load sharing systems, and algorithms providing synchronization and security.

5. Publications

Publications Appearing in 1979-80

- J. Burns (with M. J. Fischer, N. A. Lynch, and A. Borodin), "Resource Allocation with Immunity to Limited Process Failure," 20th Ann. Symp. on Foundations of Computer Science (1979), 234-254.
- G. Epstein, "Selecting Don't-Care Sets for Symmetric Functions: A Pictorial Approach Using Matrices," Proc. 10th Int'l. Symp. on Multiple-Valued Logic (1980), pp. 219-225.
- R. Filman, "The Interaction of Observation and Inference in a Formal Representation System," Proc. 6th Int'l. Joint Conf. on Artificial Intelligence (1979).
- D. P. Friedman and D. S. Wise, "An approach to fair applicative multiprogramming," Semantics of Concurrent Computation, Lecture Notes in Computer Science 70, Berlin, Springer (1979) 203-225.
- D. P. Friedman and D. S. Wise, "An indeterminate constructor for applicative multiprogramming," Conf. Record 7th ACM Symp. on Principles of Programming Languages (1980), 245-250.
- E. L. Robertson, "Code generation and storage allocation for machines with span-dependent Instructions," ACM Trans. Prog. Lang. and Systems, 1, 1 (July 1979) 71-78.
- E. L. Robertson (with Ian Munro), "Parallel algorithms and serial data structures," Proc. Seventeenth Ann. Allerton Conference on Communication, Control, and Computing (1979).
- E. L. Robertson (with L. H. Landweber and R. Lipton), "On The Density and Structure of Sets in NP and Other Complexity Classes," Proc. 17th Ann. Allerton Conference (1979).
- E. L. Robertson (with I. Munro), "Continual Pattern Application," Proc. 17th Ann. Allerton Conference (1979).
- M. Wand, "Final Algebras and Data Type Extensions," J. Computer & Systems Sciences 19 (1979), 27-44.
- M. Wand, "Continuation-Based Program Transformation Strategies," J. Assoc. Comp. Mach. 27 (1980), 164-180.
- D. S. Wise, "Morris' garbage compaction algorithm restores reference counts," ACM Trans. Programming Languages and Systems 1, 1 (July, 1979), 115-120.

Articles to Appear

C. A. Brown and P. W. Purdom, "An Average Time Analysis of Backtracking," to appear, SIAM J. Computing.

G. Epstein, "Computers," World Book Encyclopedia, to appear.

G. Epstein, "A Synthesis Procedure for N-Valued Symmetric and Partially Symmetric Functions," to appear, IEEE Trans. on Computers.

D. P. Friedman (with R. Salter and T. Brennan) "CONCUR: a Language for Modelling Continuous and Concurrent Processes," to appear, J. of Computer Languages.

P. W. Purdom and C. A. Brown, "Semantic Routines and LR(k) Parsers," to appear, Acta Informatica.

P. W. Purdom and C. A. Brown, "Exact Formulas for the Buddy System," to appear, Information Sciences.

P. W. Purdom and C. A. Brown, "Parsing Extended LR(k) Grammars," to appear, Acta Informatica.

P. W. Purdom, C. A. Brown, and E. L. Robertson, "Backtracking with Multilevel Search Rearrangement," to appear, Acta Informatica.

E. L. Robertson (with I. Munro), "On the Density and Structure of NP-Complete Sets," to appear, Theoretical Comp. Sci.

M. Wand, "Continuation-Based Multiprogramming," to appear, Proc. 1980 LISP Conference.

M. Wand, "First-Order Identities as a Defining Language," to appear, Acta Informatica.

M. Wand, "Specifications, Models, and Implementations of Data Abstractions," to appear, Theoretical Comp. Sci.

Books in Print

Friedman, D. P., The Little LISPer, Science Research Associates, Palo Alto, 1974.

Hofstadter, D. R., Godel, Escher, Bach: An Eternal Golden Braid, Basic Books, New York, 1979.

Kreitzberg, C. B., and Shneiderman, B., Fortran Programming: A Spiral Approach, Harcourt Brace Jovanovich, New York, 1975.

Shapiro, S. C., Techniques of Artificial Intelligence, Van Nostrand, New York, 1979.

Wand, M., Induction, Recursion, and Programming, Elsevier North Holland, New York, 1980.

Winkel, D., and Prosser, F., The Art of Digital Design: An Introduction to Top-Down Design, Prentice-Hall, Englewood Cliffs, N. J., 1980.

Other Technical Reports

McCourt, S. "A Computer System for the Analysis of Data Generated by Molecular Studies of DNA," Technical Report No. 85 (May, 1979).

Brown, C. A. and Purdom, P. W. "An Analysis of Backtracking With Search Rearrangement," Technical Report No. 89 (April, 1980).

Burns, J. E. "A Formal Model for Message Passing Systems," Technical Report No. 91 (May, 1980).

Ginder, J. R. "Multiprocessing CODA: Applying PLITS Formalism to a Quasi-Parallel Model of SCHEME," Technical Report No. 92 (May, 1980).

Wand, M. "SCHEME 3.1 REFERENCE MANUAL," Technical Report No. 93 (June, 1980).

Wand, M. "Deriving Target Code as a Representation of Continuation Semantics," Technical Report No. 94 (June, 1980).

Hofstadter, D. R., Clossman, G. A., and Meredith, M. J., "Shakespeare's Plays Weren't Written by Him, But by Someone Else of the Same Name," Technical Report No. 96 (July, 1980).

Colloquium Series

Douglas R. Hofstadter
Indiana University
Godel, Escher, Bach
September 10, 1979

Cynthia A. Brown
Indiana University
The Analysis of Backtracking Algorithms
September 17, 1979

Chris Morgan
BYTE Magazine
Computers and the Future
September 28, 1979

George Alexander
Systems Coordinator, Indiana Daily Student
Computerized Typesetting
October 3, 1979

David Wise
Indiana University
CONS the Magnificent (1979 edition)
October 8, 1979

Greg Chaitin
IBM Research Division
Information Theory, Metamathematics, and Biology
October 15, 1979

Nuel Belnap
Philosophy Department,
Indiana University
Multiple-Value Logic for Data Bases
October 22, 1979

Edward L. Robertson
Indiana University
Parallel Algorithms and Serial Data Structures
November 5, 1979

Mitchell Wand
Indiana University
Dynamic Logic and Abstract Data Types
November 19, 1979

John McCarthy
Artificial Intelligence Laboratory,
Stanford University
Recursive Programs as Functions In a First Order Theory
November 13, 1979

George Cohn
Wrubel Computing Center
BES2 - Applied Multiprogramming
November 26, 1979

Roy Campbell
Department of Computer Science
University of Illinois at Urbana-Champaign
Path Pascal
December 4, 1979

Robert L. Smith
Rutgers University
The Acquisition of Problem-Solving Skills by Being Taught
December 10, 1979

Dorothy E. Denning
Purdue University
Compromising CS Faculties
January 14, 1980

James E. Burns
Indiana University
Bounds on Mutual Exclusion
January 24, 1980

Don Byrd
Indiana University
Music Notation by Computer
January 31, 1980

Larry Mongin
Wrubel Computing Center
FORTH: A Stand-Alone Microcomputer Programming System
February 7, 1980

Marshal Arnett
IUPUI Computing Services
Introduction to the DEC-10 System: Tops-10, Macro-10, etc.
February 19, 21, 26, & 28, 1980

M. C. Yovits
Purdue University School of Science, IUPUI (Indianapolis)
Information Flow and Analysis: Theory, Simulation and Experiments
March 3, 1980

Uwe F. Pleban
University of Kansas
A Denotational Semantics Approach to Pre-Execution Analysis in
Lisp-Like Languages
March 6, 1980

Mark A. Ardis
University of Maryland
Data Abstraction Transformations -- A Tool for Software Maintenance
March 12, 1980

Paul F. Reynolds, Jr.
University of Texas at Austin
Parallel Processing: Languages, Schedules and Performance Results
March 13, 1980

Raymond Smullyan
City College of the City University of New York
Philosophical Fantasies
March 20, 1980

Raymond Smullyan
City College of the City University of New York
Godel's Second Incompleteness Theorem and the Paradox of the
Surprise Examination
March 21, 1980

David S. Wise
Indiana University
Impressions on Distributed Processing
April 10, 1980

Franklin Prosser
Indiana University
Excitement over Cryptology
April 17, 1980

Francine Berman
Purdue University
Is Program Verification Realistic?
April 18, 1980

James H. Morris
Xerox, Palo Alto Research Center
Experience with an Applicative String Processing Language
April 24, 1980

Douglas B. Moran
University of Massachusetts
A Computational Approach to Model-theoretic Semantics
April 25, 1980

Douglas R. Hofstadter
Indiana University
SEEK-WHENCE: A Project in Pattern Understanding
May 1, 1980

Sudhir K. Arora
McMaster University
Well Connected Relations in Data Bases
May 2, 1980