CSE@50

COMPUTING AT THE UNIVERSITY OF MICHIGAN

The Early Years through the 1960's

by Norman R. Scott

In a display case in the Lurie Engineering Center of the University of Michigan's College of Engineering, an example of advanced computing technology of the early 20th century, a cylindrical slide rule can be seen. It consists of two coaxial cylinders 18 inches long, carrying segments of a 30-foot slide rule, mounted so that they can be rotated independently and moved axially relative to each other. It is a Keuffel and Esser product, model 4012, and the instruction manual refers to it as "Thacher's Calculating Instrument, for performing a great variety of useful calculations with unexampled rapidity and accuracy, cylinder 18" in polished Mahogany Box with Directions — each $35.00."

The preface of the manual says, "— With the Thacher Calculating Instrument — the scales are 30 feet long so that they will give results correctly to four and usually five places of figures, sufficient to satisfy nearly every requirement of the professional and business man. — By the use of this instrument, the drudgery of calculation is avoided, and the relief to the mind may be compared with the most improved mechanical devices in overcoming the wear and tear of manual labor."[1]

But that was then, and if we jump 100 years to today, at the start of the 21st century, we find the University of Michigan so fully computer connected that it's hard to conceive of any further steps. Every residence hall's dorm room has computer access. Every faculty office, every laboratory, every business office, every record keeping function is computerized. Admissions records, alumni records, student course registrations are all on computers. The University Hospital uses computers in everything from records to laboratory procedures to assistance in surgery. The library catalog is online, and many more examples could be cited.

How we got here from there is the matter we shall examine in the following pages as we trace the steps, up through roughly the 1960s, that led ultimately to today's condition of "compubiquity."

Professor Emeritus Norman R. Scott joined the Department of Electrical Engineering at the University of Michigan in 1951 and retired from the Department of Electrical Engineering and Computer Science (EECS) in 1988. He was actively involved in the early days of computing at Michigan, including teaching one of the first courses on analog and digital computer technology in 1954, and completing much of the design work for the Michigan Instructional Computer (MIC) in 1955. He became a fellow of the IEEE in 1965. His paper about the early years of computing at Michigan was adapted specifically for the CSE@50 celebration in May 2008.

The Supplement was compiled by Professor Emeritus Toby J. Teorey, who joined the Department of Electrical and Computer Engineering in 1972 and retired from EECS in 2005. He specialized in computer system performance analysis and database design.

a Data Processing by Punched Cards

Until the appearance of the electronic digital computer shortly after WWII, computing technology made only a small impact on the University. As did many other large organizations, the University used punched card technology (tabulating machines) to perform record keeping and accounting functions. The University's first keypunch machines were purchased in 1919, and printed reports that were generated using this sorting and tabulating equipment were first published in 1927. By the 1930s the Registrar's Office was accumulating and printing out grade sheets and reports on a regular basis, and the University Hospital also used such equipment for gathering statistics.

At about that time (early 1930s) the University established the Tabulating Service to handle payrolls, Registrar's reports, and similar activities for several campus departments. The affiliated Tabulating Machine Laboratory taught techniques and machine operations to students from the Department of Mathematics, the School of Business Administration, and the School of Public Health. A major accomplishment of the Tabulating Service was the processing of some two million cards produced in the 1954 field tests of the poliomyelitis vaccine, which had been developed by the University's Dr. Jonas Salk.

Although the equipment of the Tabulating Service was augmented with an IBM Card Programmed Calculator (CPC) in 1952, this centralized service was ultimately replaced by facilities in the payroll office, the registrar's office, and the various departments it formerly served.

This same period, the 1930s through the post-war years, was also the heyday of that early "personal" computer, the slide rule. On college campuses everywhere, engineers could be readily identified by the orange scabbards, in which they carried their slide rules at their waists. Slide rule accuracy was sufficient for most engineering purposes, and when the pocket digital calculator became available some students didn't know how to use them effectively. I recall asking a colleague whether he had seen changes since all students had started using pocket calculators. "Yes," he answered. "Now I'm seeing wrong answers to ten decimal digit precision."

b Theoretical Studies in the 1940s

Another important "pre-computer" activity, that is, one which was not hardware dependent, was the creation of a research group under Professor Arthur W. Burks, a team which later became the Logic of Computers Group. Burks, who had received his PhD in philosophy at the University of Michigan, had participated in the design of the ENIAC at the Moore School of Electrical Engineering at the University of Pennsylvania. In that work, he had been associated with J. Presper Eckert and John Mauchly of the Moore School, Dr. Herman Goldstine of Aberdeen Proving Grounds, and Dr. John von Neumann of the Institute for Advanced Study at Princeton. It was this latter connection that led to the publication of the seminal 1946 paper by Burks, Goldstine, and von Neumann, entitled "Preliminary Discussion of the Logical Design of an Electronic Computing Instrument."[2] Burks joined the University of Michigan in 1946, and in 1949, with the aid of funding from the Burroughs Corporation, established the University's first research effort in the field of computers. One result of this early collaboration with Burroughs was the concept of a push-down store for evaluating parenthesis-free logic expressions in the so-called Polish notation, and Burroughs incorporated this idea in their B5000 computer.

We shall return to this topic in Section (j) below.

c The Arrival of the MIDAC (1952)

MIDAC, the Michigan Digital Automatic Computer was the University's first electronic digital computer. It was built at the University's Willow Run Research Center, an off-campus center devoted to defense research projects. The Center was directed by Harry H. Goode,[3] who was well known for his work in the engineering of large-scale systems. Construction of MIDAC was under the direction of John DeTurk, a talented engineer who had never troubled to complete his undergraduate work at the University of Illinois. The machine was essentially a copy (with benefit of hindsight) of the SEAC, the Bureau of Standards Eastern Automatic Computer. It was a serial machine, operating at the blinding pulse rate of one megahertz and had a high-speed memory of 512 45-bit computer words stored as circulating pulses in mercury delay lines. There were 64 of these delay lines, each storing and then re-circulating eight groups of 48 pulses. Its main memory was 6144 words stored on a magnetic drum. Construction was started in early 1951, and the machine was in use by the next year.[4]

d Computer Use and Instruction in the Early 1950s

As a tool of the Willow Run Research Center, the MIDAC was not readily available for undergraduate use on the central campus. It was primarily used on defense work, such as study of the BOMARC ("Boeing – Michigan Air Research Center") missile, and for such purposes it was supplemented by a faster machine named MIDSAC, for Michigan Digital Special Automatic Computer. (MIDSAC used MIDAC's pulse logic circuitry and the same kind of mercury delay line storage, but was a more nearly parallel machine.)

Consequently, although undergraduate courses in numerical methods and in machine language programming were taught in 1952 by John W. Carr III of the Department of Mathematics, few students had the opportunity to run their programs. A Chemical Engineering PhD thesis was completed on the MIDAC in 1956 by Ronald Crozier, but most students had to wait until the arrival of facilities on the central campus for their first real use of a digital computer.

However, the analog computer[5] era was already in full swing at that time. A major installation of analog equipment at the University's Willow Run Research Center was begun in 1951 under the direction of Vernon Larrowe. Somewhat over $100,000 worth of equipment made by Reeves Corp., which included more than 200 operational amplifiers as well as special function equipment, was installed. This equipment was used in simulation and test of the BOMARC missile's homing system. Over the next few years this equipment was augmented by more amplifiers made in-house and by various Philbrick equipment, until the total installation comprised around 500 amplifiers, making it one of the country's largest analog computer installations. However, when Boeing's work on the BOMARC concluded around 1956, much of this equipment went back to Boeing, and the analog installation diminished in importance as digital computers took over.

Like the MIDAC, the Willow Run analog computer equipment was not readily available for student use. However, instructional analog computers came into use as early as 1949 in the Department of Aeronautical Engineering. A leader in the design and use of these machines was Professor Robert M. Howe of Aero.[6] He subsequently helped found Applied Dynamics Co., which became a leading supplier of analog machines for university and other laboratories across the country. By the mid-1950s the Chemical Engineering Department had several of the Applied Dynamics computers in its labs as did the Engineering Mechanics Department in its Dynamics Lab. The analog computer was superbly suited to the solution of systems of ordinary linear differential equations, which are of-

ten encountered by engineering students, and even though their accuracy was only about 1%, the ease of using the machine and of adjusting its parameters made it valuable as an instructional tool. Many departments of the College of Engineering had well equipped analog computer labs for undergraduate instruction by the mid-1950s.

e The Summer Computer Courses (1953-1963)

The availability of the MIDAC made possible the presentation in 1953 of a two-week summer computer course for visitors from industry, government, and other universities. This course was organized and led by Professor John W. Carr III, and introduced students to programming on the MIDAC, numerical analysis, and computer logic. Thirty-five students heard lectures by Carr and by Walter Bauer, Ralph Dames, and Norman Scott.

Similar courses were presented in succeeding summers, and their scope and popularity grew rapidly. In subsequent summers the enrollment climbed to well over 200. They were able to attract outstanding lecturers from many parts of the world, and the roster of those is a who's who of early computing. Among the lecturers were: Allen Newell, W. F. Bauer, James Cranwell, Herb Simon, Fritz L. Bauer, Klaus Samelson, Alan J. Perlis, Noam Chomsky, Paul Green, Jean Felker, Arthur W. Burks, James E. Robertson, Grace Murray Hopper, Samuel N. Alexander, Herb J. Grosch, William N. Papian, Edward J. McCluskey, W. V. Quine, Alonzo Church, Alston S. Householder, Robert L. Ashenhurst, William H. Kautz, George Mealy, Dudley A. Buck, and Jim Wilkinson.

It became the custom to conclude these two-week sessions with a banquet and an address by a distinguished guest. Among those guests were Herman Goldstine, Edward W. Teller, and Walter Reuther. (Mr. Reuther, the leader of the United Automobile Workers, was less than impressed by the IBM 704 that he was shown, and, perhaps thinking of displaced workers, asked "How many cars will it buy?")

f The Exchange with the Soviets (1958)

These summer courses led to the first exchange of Soviet and western computer people. Professor John Carr, who had a remarkable flair for languages, had begun to study Russian in 1956, and in 1957-1958 corresponded with Soviet computer people about an exchange visit. As a result, a group of four Soviet people under the leadership of academician A. Dorodnitsyn came to Ann Arbor in 1958 to lecture in our two-week session. While in this country they also visited the computer project at the University of Illinois and saw the computer activity at the Moore School of the University of Pennsylvania. Carr had carefully arranged that a condition of the Soviet visit would be a reciprocal visit by an American delegation, and accordingly in September four Americans went to the Soviet Union for two weeks. The American group consisted of Professors John Carr and Norman Scott from the University of Michigan, Professor Alan J. Perlis from Purdue University, and Professor James E. Robertson from the University of Illinois. We visited and lectured in Moscow, Kiev, and Leningrad and had a good view of non-military computers in the USSR.[7 8 9]

g Successors to the MIDAC

In 1952 the University acquired an IBM Card Programmed Calculator (CPC) a novel combination of punched card equipment for input/output and for program and of electronic circuitry for the arithmetic computation. This machine was used by the University's Tabulating Services for administrative and statistical purposes.

The MIDAC was ultimately shut down in 1958, having by then outlived its usefulness, by order of Dr. Merrill Flood, Director of Willow Run Research Center. However, computational facilities for the University's academic programs became available in 1956 when the University got its first IBM 650. This was installed in the Statistical Research Laboratory of the Horace Rackham School of Graduate Studies. As James Wilkes has pointed out,[10] "— this machine really marked the beginning of the present era, and was used by students in the offerings of the U-M's introductory computing course, Math 73, when first taught by Professor Bernard A. Galler in the winter 1956."

In 1952 the University acquired an IBM Card Programmed Calculator (CPC)

Since it may be hard for many of us, here in the 21st century, to realize what computer use was like fifty years ago, it is worthwhile to quote Wilkes's description of programming the IBM 650 to minimize waiting time on the drum memory:

"If the instruction address is an even number, the *data address* should be three word positions later (on any cylinder) and the next *instruction address* should be four word positions beyond that. Since there are 50 word positions around the cylinder, the correct drum rotation angle for the next instruction is 50.4 degrees. — if the instruction address is odd, the data address should be three word positions later and the next instruction address should be five positions beyond that, so the drum rotation angle for the next instruction is 57.6 degrees."

What a marvelous incentive for programming language developments!

h Engineers—An Important User Community

It should be no surprise that engineers were among the earliest and most enthusiastic users of the computer, since it enlarged the scope of things computable far beyond the limits of slide rules and desk calculators. Professor Donald L. Katz, chairman of the Department of Chemical and Metallurgical Engineering, was instrumental in obtaining a grant from the Ford Foundation to support a study of ways to use computers in undergraduate engineering curricula. Over a four-year period, starting in 1959, more than 200 faculty members from nine engineering disciplines and 65 engineering schools participated in the Ford Foundation Project at the University of Michigan. This body of disciples helped put computing into engineering curricula in many schools, and, not incidentally, enhanced Michigan's stature at the same time.

The associate director of the project from 1961 to 1963 was Brice Carnahan, who achieved considerable local distinction for his regular series of six 2-hour lectures each term on computer programming. Professor James O. Wilkes also participated, and their work ultimately led to the publication, in collaboration with Professor H. A. Luther of Texas A&M, of "Applied Numerical Methods." This influential book was published in 1969 and was widely used over the next twenty years.

Following the Ford Foundation Project, the National Science Foundation funded at Michigan a project "Computers in Engineering Education," under the direction of Donald L. Katz with Brice Carnahan as associate director. This project, like the Ford Foundation Project, involved participants from many engineering schools, and in the summer of 1965, 29 engineering teachers from 23 engineering schools spent nine weeks together, studying computing techniques and developing applications in their own fields.

i Computers in the Department of Electrical Engineering (1956)

Although the computational needs of the EE Dept. were served by the University's IBM 650 and its successors, the Department undertook the construction of the Michigan Instructional Computer (MIC).[11] This machine was completed in 1955 and available for student use in early 1956. It was made of 1mHz. pluggable logic packages based on MIDAC and SEAC dynamic logic circuitry and produced by Computer Control Co. Its main memory was a magnetic drum donated by the Ferranti Corp. As may be seen in the photo (Fig. 1), all logic wiring was accessible, and student exercises consisted of rewiring the machine to modify its behavior or of trouble-shooting the machine when the instructor altered the wiring in malicious ways. The MIC was supplemented soon by a bank of PDP8 computers, from Digital Equipment Corp., which were programmed by students in machine language.

Figure 1: Michigan Instructional Computer, MIC (c.1956)

Another machine used in the computer lab was the IBM 797, one of three experimental machines built by IBM and used initially at Northrop Corporation (This machine was known at IBM as "the Wooden Wheel," a name said to derive from the names of its designers, Woodbury and Wheeler.) It was neither a card-programmed nor a stored program machine, but instead used wired programs, each being plugged on a program board a couple of feet square. Our able lab-technician/student Ron Brzesinski devised a language called SHAZAM to simplify the use of the machine, but the 797 was clearly not the wave of the future, and it was not used for more than a couple of years.

In 1957, a new graduate program, Communication Sciences, was established

j More about the Logic of Computers Group

At the same time that the computer user community was expanding, with more and more powerful facilities becoming available in the Statistical Research Laboratory and its successor, the Computing Center, another activity, less visible but no less significant was being conducted in the Logic of Computers Group (see section b above). This group, led by Arthur Burks of the Philosophy Department, had begun in 1949 with a small number of people, among them Jesse Wright who, although blind, lacked nothing in his insight into abstract matters. Other subsequent members were Calvin Elgot, Richard Laing, and John Holland. Their research was not concerned with uses of the computer, but rather with abstract questions concerning the nature of the computer, the behavior of nerve nets, and in Burks's words, "…the ancient atomistic question: Is the human a very complicated automaton?"

When it came time for Holland to undertake a PhD thesis, it became clear that the Department of Philosophy was not a suitable match for research interests such as this. Consequently in 1957, a new graduate degree program, Communication Sciences, was established in the College of Literature, Science and the Arts. Early faculty participants in addition to Burks were Gunnar Hok of Electrical Engineering, whose field was information theory, and Gordon Peterson of the Speech Department, whose specialty was phonetics, phonemics, and acoustics. Faculty from other departments also participated, and in 1967 the program became a full-fledged Department of Computer and Communication Sciences in the LS&A college, under the chairmanship of Burks.

Over the years of its existence as a separate unit, the Computer and Communication Sciences Department produced some 60 PhDs and a corresponding number of masters and bachelors. The Department also offered a wide range of courses on aspects of computers and communication sciences that were not presented elsewhere in the University. In 1984 the CCS Department was merged with the Department of Electrical and Computer Engineering to become the Department of Electrical Engineering and Computer Science, a merger that combined the computer strengths of two major units of the University.

k Back to the Big Picture — Computers at Michigan

The acquisition of the IBM 650 marked the start of widespread use of computers by academic departments on campus. A rough indication of this use is evidenced by the sequence of computers that were installed at the new Computing Center, which was established in 1959:

1959	IBM 650 (originally installed in the Stastistical Research Lab in 1956)
1959	IBM 704
1961	IBM 709
1962	IBM 7090
1967	IBM 360/67, IBM 360/50, Two IBM 360/67
1975	Amdahl 470V/6
1979	Amdahl 470V/7
1980	Amdahl 470V/8
1982	Amdahl 5860
1985	Amdahl 5860 and Amdahl 470V/8
1987	IBM 3090/400
1991	IBM ES9000-720

The IBM 650 executed 500 instructions per second, and the IBM ES9000-720 could carry out about 124 million instructions per second. By this crude measure alone, computing power at the University might be said to have increased by a factor of 248,000 over a thirty-five year span.

Figure 2: Bernard Galler operating the IBM 650

l Programming Languages and Operating Systems

Initially, the IBM 650 was used by the students themselves, who would sign up to reserve an hour on the machine, and then would operate it during that hour. Very soon, however, this mode of operation was succeeded by "batch mode," in which each user submitted a deck of cards for his own problem. These decks were successively run by the machine operator. Although users were denied the luxury of tinkering with their problems on-line, many more users had access to the machine. Users became much more careful in preparation of their programs.

Some of the drudgery of programming was relieved by the use of SOAP (Symbolic Optimal Assembly Program) assembler and MITILAC (M.I.T. Instrumentation Laboratory Computer), an interpretive program for systems of ordinary differential equations.

In 1960, the Michigan Algorithm Decoder (MAD) was first used on the IBM 704

"About late 1957, spurred by the general interest in the use of a symbol-oriented assembly language, GAT (Generalized Algebraic Translator) became available. Written by Robert M. Graham and Bruce W. Arden of the U-M Statistical Research Laboratory, GAT consisted of an algebraic language and its associated assembler, with symbolic names for operation codes and addresses, but still leaving the drum-angle determination for the programmer. The resultant ease of programming greatly enlarged the user population on the U-M campus and at other universities where the language was used."[12]

m The Michigan Algorithm Decoder (MAD) Language (1960)

By the mid-1950s, the FORTRAN language was already in use at many computer centers around the world, but in the late 1950s the U-M participated in an international attempt to create a standard programming language for scientific computing. The language was to be called ALGOL (ALGebraic Oriented Language). In 1958 a description of the proposed language (ALGOL58) was distributed with the recommendation that centers capable of implementing such a compiler should proceed. Bernard Galler recalled that the idea behind this new language proposal was akin to its authors saying "Please, everybody, implement this, let's find out what's wrong with it, and in two years we'll meet again to make corrections to the language."

The algorithms for GAT were the kernel for U-M's implementation. The 2000 words of IBM 650 storage were entirely used, leaving no space for the tables needed to use arbitrary variable names. However, the recent arrival of the IBM 704 with its attached high speed drum made the inclusion of arbitrary variable names possible. Galler added that capability to the existing compiling algorithms.

As Wilkes reports,[13] "the Computing Center started to try to implement 1958 ALGOL, to see what difficulties it introduced into language development. --(They) found that there were several features specified in 1958 ALGOL that were either too hard to implement, impossible to implement, or too inefficient when done. Bruce Arden, Bob Graham, and Bernard Galler changed the language in each of these areas, so as to get something working, and by the time they were finished, they believed that it was too far from 1958 ALGOL to be called by that name, so they thought up their own name--MAD (Michigan Algorithm Decoder), MAD

Figure 3: Bruce Arden and Bernard Galler at the IBM 704

first began working correctly in about February 1960, and was first used on the IBM 704." By the time a simpler to implement version of ALGOL (ALGOL60) had been proposed, U-M among other centers preferred to stay with their successful efforts rather than starting over.

The MAD compiler for the IBM 704 was written in three parts: a front end written by Graham that included the parser, the back end written by Arden which created the machine language and the middle section by Galler which tied it all together. MAD became universally used throughout the University for many years and also found acceptance at other places, such as M.I.T., the University of Maryland, and the Ford Motor Company. It was used in the famous air traffic control system SAGE.

n Creation of the Computing Center (1959)

By 1959, the usefulness of the IBM 650 for a wide variety of courses and projects across the entire campus had become so evident that a decision was made to transfer computing operations from the Statistical Research Laboratory to a new organization, the Computing Center, set up under the Rackham School of Graduate Studies to serve the entire University community.[14] Its funding would derive from charges to sponsored research and contract accounts using the equipment. The first director of the Computing Center was Professor Robert C. F. Bartels of the Department of Mathematics, who continued in this role until his retirement in 1978.

In August of 1959, the IBM 650 was replaced by an IBM 704,[15] the first of a long succession of upgrades over the following years. A space was made available in the North University Building for the machine and for the Computing Center staff, and the location became known as "NUBS," for North University Building Station. Two years later, in August 1961, this machine was in turn replaced by an IBM 709 that had been used by the Willow Run Research Center until their sponsored research ("Project Michigan") ran out. A year later it in turn was succeeded, by an IBM 7090.

***It was in the period of 650-704-709-7090 machines that some of the most valuable contributions of the Computing Center staff were made, namely, the MAD language (1960) and the foundations for the Michigan Terminal System (MTS) operating system (1966).

Figure 4: Brice Carnahan and Robert Bartels (c.2000)

o The Michigan Terminal System (MTS)

As the number of computer users increased, the limitations of batch mode processing became evident. Methods were needed to share the use of the computer among many users while giving each the impression that there were no other users. The development of MTS, the Michigan Terminal System, was both the solution to this problem and at the same time, the most significant influence in spreading "computism" to the entire University community.

The development of MTS was spurred by M.I.T.'s experience with time sharing. Robert Graham, of the Computing Center staff, had spent the summer of 1966 at M.I.T. and brought back reports of their experience which were useful to the Computing Center Staff, who drew up the ideas for MTS under the direction of Bruce Arden. At the same time, the University had been in negotiation with three vendors to supply a new machine with facilities to allow for a time-sharing terminal system, particularly means to allow "virtual storage."[16] Ultimately, IBM's Model 360/67 was installed at NUBS in January of 1967. Close cooperation between IBM people and the Computing Center staff produced modifications of this design, which became then the IBM 360/67M, the "M" standing for "Michigan." The two Computing Center people who were the primary developers of all the details of MTS were Mike Alexander and Don Boettner. One measure of their success is the fact that within a year of the installation of this first IBM360/67M, IBM had orders for forty more.

Another indicator of the success of MTS was its adoption by many other computer centers. The University of British Columbia was the first of these, followed in February 1969 by Newcastle University. Within the next ten years MTS was also adopted by the University of Alberta, Wayne State University, and the National Laboratory for Scientific Computing in Rio de Janeiro.

A consequence of the availability of MTS was the disappearance of punched cards and card punch machines from all over campus. Rooms full of key punches had been set up in many locations, and these soon became rooms full of terminals connected to the central computer. The facilities at NUBS rapidly became overcrowded, and the University constructed a new Computing Center building on the North Campus (at a cost of $1.5 million). This building had three stories so that computer components could be installed above one another, as well as false floors, to allow minimum wiring distance between units. It housed not only the central computer but also the administrative offices of the Computing Center and terminal space for users. With the move of the computer to the new building in 1971, the space in NUBS became a remote terminal area for users. Other remote terminals were scattered in departments all over the campus, and in 1982 another large terminal area was set up in the basement of the Michigan Union. Today large computing facilities exist in many buildings across central and north campus, with the largest being in Angell Hall and the Duderstadt Center.

p In Readiness for a New Era

Here we leave the story of the early years of computing at the University of Michigan. Everything is in place for the next great burst of computer activity. There is a broad user community, there are facilities for computing, there are degree programs and courses, there are useful languages and time-sharing means, and there are computers available in many places. The next major steps over the subsequent years involved networking and the gradual disappearance of centralized computing, to be replaced by individual computers and powerful networks to interconnect them. These years will, it is hoped, be the subject of subsequent papers by other writers.

Acknowledgments

I am grateful to the many people who have chatted with me about their knowledge of these matters, and I apologize to the many whom I may have neglected to consult. I am especially saddened that I undertook this project too late to talk with some who have now passed away.

Finally, I must note that it has been a privilege for me to have been associated over the years with the many talented people whose work has put the University of Michigan "on the map" of the computer world.

Although this paper includes many of my own recollections from the early 1950s, I am happy to acknowledge my great indebtedness to several other sources, especially the following references.

References

1. *U-M DRDA Research News,* "A Faster Cratchit: The History of Computing at Michigan," Vol. 27, No.1, January 1976.
2. *IEEE Annals of the History of Computing,* "A Career Interview with Bernie Galler," January-March, 2001, pp. 22-33.
3. Arthur W. Burks, an oral history as told to Enid Galler, May 22, 2003.
4. James O. Wilkes, "Computers and Computing," *A Century of Chemical Engineering at the University of Michigan,* March 2003.
5. Thomas Madden, term paper entitled "Computing at Michigan," submitted April 12, 1999, for History 265, under the direction of Professor Nicholas Steneck. Accessible on the web at: www.umich.edu/~hist265/links/projects/projects.html
6. Michael Dautermann, unpublished notes on his 1980s conversations with many U-M faculty and staff involved in computing.
7. Susan Topol, "A History of MTS--30 Years of Computing Service," published in the *University of Michigan Information Technology Digest,* May 13, 1996 Vol. 5, No. 5).
8. Additional contributions by Bruce Arden, Bert Herzog, John Holland, John Meyer, and Jim Wilkes.

Footnotes

1. Slide rule buffs will also be aware of the contemporaneous Fuller cylindrical device, which had a 500 inch helical scale.
2. Published by Institute for Advanced Study, Princeton, N.J.
3. Goode was subsequently honored by the Institute of Electrical and Electronics Engineers with the establishment of the H. H. Goode Award, a $2000 prize and a bronze medal awarded by the Computer Society on the basis of achievement in the information processing field.
4. A canard from those days would have it that the initials MIDAC really stood for "machine is down almost continuously."
5. The "analog computer" referred to here is the electronic differential analyzer using high-gain amplifiers with feedback connected so as to perform integration, summation, and multiplication by a constant. Voltage was the analog of the dependent variable and time the analog of the independent variable. These systems were enormously helpful to engineers, scientists, teachers and students.
6. A significant contribution to the literature was the paper "Investigation of the Utility of an Electronic Analog Computer in Engineering Problems" by D. W. Hagelbarger, C.E. Howe, and R.M. Howe, Aeronautical Research Center, University of Michigan, April 1, 1949.
7. Carr had spurned offers of government support for this visit, preferring to maintain the delegation's academic objectivity.
8. I'd like to think that the Soviet folks regarded Ann Arbor, Champaign-Urbana, and Philadelphia as places equivalent in stature to Moscow, Kiev, and Leningrad.
9. Reciprocity of visits was carefully maintained in an exchange two years later between ten western computer people and ten Soviet computer people. The story is told that on day 7 of the Soviets' visit, boots and rain garments were provided when the visitors were conducted from one IBM plant to another in a deluge, and that on day 7 of the American's visit to the Soviet Union, boots and rain garments were also provided—on a brilliantly sunshine day.
10. J.O. Wilkes, Chapter 6, "Computers and Computing," in *History of the Department of Chemical Engineering at the University of Michigan.*
11. "Analog and Digital Computer Technology," Norman R. Scott, McGraw-Hill, 1960, pp. 366-385. Much credit for the design of this machine goes to Mr. Reuben Wasserman, and much credit for its careful verification and checkout to Mr. Noriyuki Nakagawa.
12. J. O. Wilkes, op.cit.
13. J. O. Wilkes, op.cit.
14. The decision to create a computing center was not made without some vigorous arguments as to whether it might not be better to do all computing at the University's Willow Run Research Center, which could benefit from a fiscal shot-in-the-arm.
15. An IBM 701 was originally slated to be installed, but IBM had to divert that unit to the Pentagon, and after some delay, the 704 became available.
16. "Program and addressing structure in a time-sharing environment," Bruce W. Arden, Bernard A. Galler, Frank H. Westervelt, and Tom O'Brian, J1. ACM, Vol. 13, No. 1, Jan. 1966.

Supplement to "Computing at the University of Michigan: The Early Years, through the 1960's"

I. EECS/CSE Departmental & Program History

1895 Electrical Engineering Department established

1957 Communication Sciences graduate program formed in LS&A, associated with two research groups:

1. Logic of Computers Group, Dept. of Philosophy (founded by Art Burks, 1949)
2. Phonetics Laboratory, Dept. of Speech (founded by Gordon Peterson)

1959 John Henry Holland, first PhD in computer science field at the University of Michigan

1964 Communication Sciences Department established in LS&A

1965 Computer Engineering undergraduate degree established in the EE Department

1967 Computer & Communication Sciences (CCS) Department established in LS&A, renamed from Communication Sciences; CCS undergraduate degree established

1969 Computer, Information and Control Engineering (CICE) graduate program formed, jointly managed among ECE, IOE, AERO

1971 Electrical and Computer Engineering (ECE) Department established, renamed from Electrical Engineering.

1984 Electrical Engineering & Computer Science Department (EECS) established, formal merger of ECE and CCS

1984 Computer Science (CS) undergraduate degree established in LS&A, administered by the EECS Department

1986 EECS Building completed on North Campus, moved from East Engineering (now East Hall)

2001 Computer Science – Engineering (CS-Eng or CSE) undergraduate degree established within the EECS Department

2003 ABET accreditation of CS-Eng and CS-LS&A degrees

2006 Computer Science and Engineering (CSE) Building completed

II. Early Courses in Computing at Michigan (1952-1979)

1952 Machine language programming (John W. Carr III, Mathematics)

1953 Engineering Summer Conferences in computing (organized by John W. Carr III): programming on the MIDAC, numerical analysis, and computer logic - Norman Scott, John Carr, Walter Bauer, Ralph Dames, and others; 1954-1956 instructors included Allen Newell, Herb Simon, Alan Perlis, Noam Chomsky, Arthur Burks, Grace Murray Hopper, Herb Grosch, Edward McCluskey, Willard Quine, Alonzo Church, and others; 1959-1963 Programming Concepts Automata, and Adaptive Systems – instructors Newell, Simon, Perlis, Chomsky, Burks, Galler, Myhill, McCarthy, Minsky, Holland, etc..

1954 EE 232 Analog and Digital Computer Technology (Norman Scott)

1956 Math 73 (Bernard Galler), programming concepts

1957 Information Theory (Gunner Hok, Anatol Rapaport)
EE 235 Digital Computer Design Principles
EE 238 Digital Computer Applications

1961	Math 73 (Bruce Arden), recitation instructor (Larry Flanigan), student in class (Scott Gerstenberger); computer programming, compilers, operating systems
1961-67	Introduction to Communication Sciences (John Holland, William Wang)
1964-66	Background work for Engineering 101, NSF project and workshops at UM "Computers in Engineering Design Education" (Don Katz, Brice Carnahan, James O. Wilkes)
1967	Math 473 (Bernie Galler), student in class (Mike Alexander), systems programming, compilers (now EECS 483), operating systems (now EECS 482)
1967	Foundations of Analog and Digital Systems (John Meyer, Bernie Ziegler)
1972	CCS 471 Software Architecture/Software Engr (Bill Riddle), now EECS 481 CCS 522, 622 Theory of Automata (Joyce Friedman, John Meyer)
1976	ECE/CCS 367 Discrete Mathematics (John Meyer), now EECS 203
1979	CCS/CICE 577 Database Management Systems (Toby Teorey), now EECS 484

III. UM Computing Center (UMCC) & Computing Timeline

1952	MIDAC, Michigan Digital Automatic Computer (John DeTurk), first (experimental) electronic computer at Univ. of Michigan
1955-56	Michigan Instructional Computer (MIC) developed for classroom use (Norman Scott, Reuben Wasserman, and Noriyuki Nakagawa)
1956	IBM 650 purchased by UM, first general use computer
1959	UMCC established (Robert C. F. Bartels, Director, 1959-1978)
1959	UMCC first computer, IBM 704 (then 709, 7090 in 1961)
1959-60	University of Michigan Executive System (UMES)
1960	Michigan Algorithmic Decoder (MAD), variant of Algol58, developed by Bruce Arden, Bernie Galler, and Bob Graham
1965	IBM 360/67 on campus (time sharing era started)
1966	Michigan Terminal System (MTS) developed, takes control of IBM 360/67 (November): B. Arden, B. Galler, M. Alexander, F. Westerfelt
1972	MERIT network goes on-line (project conceived in 1965)
1975	Amdahl 470V/6 replaces IBM 370/168 which earlier that year replaced two 360/67 computers
1983	Computer Aided Engineering Network (CAEN), Dan Atkins and Randy Frank, first broad use of distributed computing on campus, moving away from the MTS era
1985	NCUBE purchased, starting large-scale parallel computing on campus
1986	Center for Information Technology Integration (CITI) established by Dan Atkins and Dick Phillips, a new R&D organization focused on distributed computing (and more recently, security), with the UM as an additional beneficiary for all products developed
1987	NSFNet established at UM, IBM 3090/400
1990	Software Patent Institute established by Bernie Galler
1996	Internet2 organized (U.S. advanced networking consortium, over 200 U.S. universitites, over 50 international partners)

IV. Chairs/Associate Chairs in Computing at UM

Chair, Communication Sciences Graduate Program (1957-1967)

Gordon Peterson, 1957-1965, Professor of Linguistics

Chair, Computer and Communication Sciences Dept. (1967-1984)

Arthur Burks, 1967-1968
John Holland, 1968-1969 (Acting)
Joyce Friedman, 1969-1971 (est.)
Bruce Arden, 1971-1974
Bernard Galler, 1974-1977
Larry Flanigan, 1978-1981
Gideon Frieder, 1981-1984

Associate Chair, Computer Science and Engineering Division, EECS (1984-present)

Gideon Frieder, 1984-1986
Keki Irani, 1986-1990
Yuri Gurevich, 1990-1991
Kang Shin, 1991-1994
Toby Teorey, 1994-1997
Ed Davidson, 1997-2000
John Laird, 2000-2004
Martha Pollack, 2004-2007

Chair, Computer Science and Engineering Division

Farnam Jahanian, 2007 (Interim Chair)

V. CSE Laboratory Founding Dates & Founders

Advanced Computer Architecture Laboratory, ACAL (1985)
Chaitan Baru, John Hayes (Director), Bill Martin, Trevor Mudge, Ridgway Scott, Kang Shin, Quentin Stout

Artificial Intelligence Laboratory (1987)
Ramesh Jain (Diretor), Lynn Conway, John Holland, Keki Irani, John Laird, Steve Lytinen, Brian Schunck, Terry Weymouth

Computing Research Laboratory (1984-1989)
John Hayes, John Meyer (Director), Kang Shin

Interactive Systems Group (2006)
Mark Ackerman, David Kieras, Elliot Soloway, Greg Wakefield

Real-Time Computing Laboratory (1985)
Kang Shin (Director), 58 PhDs

Software Systems Laboratory, SSL (1989)
Chaitan Baru, Bernard Galler (Director), Cordelia Hall, Todd Knoblock, Y.C. Lee, Atul Prakash, Chinya (Ravi) Ravishankar, Stuart Sechrest, Elliot Soloway, Toby Teorey, Spencer Thomas.

Theory Group (1996)
Kevin Compton, Yuri Gurevich, Bill Rounds, Quentin Stout

VI. Major National Awards in Computing

AAAI Fellows
John Laird (1995)
Martha Pollack (1996)
Mike Wellman (2001)
Ed Durfee (2001)

ACM Fellows
Bernard Galler (1994)
Aaron Finerman (1994), UMCC
Robert Graham (1996), UMCC
John Hayes (2001)
Kang Shin (2001)
H.V. Jagadish (2004)
Karem Sakallah (2004)
Mike Wellman (2005)
John Laird (2007)
Gary Olson (2008), SI

IEEE Fellows
Norman Scott (1965)
Ed Davidson (1984)
John Hayes (1985)
Lynn Conway (1985)
John Meyer (1985)
Kang Shin (1992)
Trevor Mudge (1995)
Karem Sakallah (1998)
Pinaki Mazumder (1999)
Ed Durfee (2004)
Pete Chen (2008)

National Academy of Engineering
Lynn Conway (1989)

MacArthur Fellows
Jim Blinn (1991)
John Holland (1992)

Harry H. Goode Memorial Award, IEEE Computer Society
Ed Davidson (1992)

Eckert-Mauchly Award, ACM & IEEE Computer Society
Ed Davidson (2000)

Maurice Wilkes Award, International Symposium on Computer Architecture (ISCA)
Todd Austin (2007)

Russell Lecturer, University of Michigan (Highest Honor of UM)
Arthur W. Burks
John H. Holland

Pender Award (Moore School)
John H. Holland

VII. Startups by Current CSE Faculty

Arbor Networks
Farnam Jahanian

Cyclos Semiconductor
Marios Papaefthymiou

goknow
Elliot Soloway

SimpleScalar LLC
Todd Austin

Soar Technology
John Laird

Zattoo
Sugih Jamin


50th Anniversary Celebration
CSE@50
Computer
Science and
Engineering
University of Michigan