THE DEPARTMENT OF COMPUTING SCIENCE:

THE FIRST TWENTY-FIVE YEARS

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Department of Computing Science

The University of Alberta

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Preface

I was tempted to give this history the title *The Department of Computing Science 1957 - 1989: The First Twenty-five Years*. Not only would this title have been inaccurate since the Department was formed in 1964, but it would have made me open to the charge of not being able to do simple arithmetic, an indictment which very often would be true. The title would have indicated, however, that the correct date for the beginning of the use of electronic computers at the University of Alberta was 1957, rather than the date of formation of the Department of Computing Science. Furthermore, concern with numerical computations began even earlier, for example, with the use of mathematical tables and desk calculators in the Department of Mathematics.

This history, therefore, begins with some remarks on early computing at the University of Alberta, and then describes the origins of the Computing Centre with the acquisition of the first computer in 1957, its development into an academic department in 1964, and the growth of the Department of Computing Science through the next quarter-century. While I have tried to give a reasonably well-rounded account, in some places I may have dwelt too long on events or topics of particular interest to me, while in other places I may have considered too briefly items which some persons would consider of greater interest or importance. Also I may have ground an axe or two, although not too vigorously I hope. I offer no apologies for any of these idiosyncrasies. This is in no way an official history. It is simply a personal account of the development of computing in an environment where I have spent very pleasantly most of my professional life. I have enjoyed writing whatever it is that I have written. I hope others will enjoy reading it.

The Department of Computing Science:

The First Twenty-five Years

> The endless cycle of idea and action,
> Endless invention, endless experiment,
> Brings knowledge of motion, but not of stillness...
> Where is the Life we have lost in living?
> Where is the wisdom we have lost in knowledge?
> Where is the knowledge we have lost in information?
>
> T. S. Eliot, *The Rock*

Introduction

> In this day of ever greater and greater scientific advances it is very tempting to pursue a course of study which concentrates on the advancing frontier of scientific knowledge. People who take this path often find that, although they are well equipped to deal with the latest ideas and machines, they lack an understanding of how these ideas germinated and why some of the latest tools are in their current forms. They also occasionally find that they produce, after a great deal of work, a process or instrument that is already well known to more experienced workers in the field, but had never come to their attention because of their own consuming interest in the "outer limits" of the subject. This is particularly true of the very rapid development, and subsequent abandoning, of various techniques and tools of computer science.

So Michael Williams of the University of Calgary begins *A History of Computing Technology* (Prentice-Hall, 1985) which starts with the development of the first written number records of antiquity and ends with the large computing systems introduced in the 1960s.

The above remarks are equally appropriate on a smaller scale in most computer science departments which have experienced rapid growth in the last few years and where the newer faculty are caught up, and quite justifiably so, in the excitement of their own fields of research. Almost every day brings announcements of new technological achievements in hardware and software and the latest papers and books that should be read. Curriculum committees endlessly discuss and implement course changes without realizing that many of these changes are similar to those made years ago and subsequently abandoned or lost. (A recent much-touted curriculum reform at a major American university was called "old garbage in new pails" by one critic.) An appreciation of one's growth as a department may help not only put current developments into perspective but also provide lessons to be learned from past achievements and past mistakes.

It was with these thoughts in mind that this brief history of the Department of Computing Science at the University of Alberta was undertaken.

Early mathematical and statistical computing

Lest we think that computing at the University of Alberta began with the introduction of the first electronic digital computer, we might start with a very brief look at some of the methods of calculation used before the first computer was introduced and during the first few years afterwards. Some idea of mathematical and statistical computing is given by the late Professor E. S. Keeping in his *A Short History of the Mathematics Department* written in 1971. Professor Keeping joined the Department of Mathematics in 1929 and retired in 1961, having been Head for the previous seven years. He continued to lecture for the following nine years, and kept up his association with the University for many more years. He died in 1984.

The first reference to computing in Professor Keeping's history is with respect to the work of Professor J. W. Campbell who came to the University in 1920 and who was well known for his work in astronomy and classical mechanics. Professor Keeping states that Professor Campbell "prepared a useful set of mathematical tables, including some of hyperbolic functions, which he had himself calculated on a hand machine". Professor Campbell's *Numerical Tables*, described in the Preface as a "general four place table", was divided into a first part giving values for the common logarithm, square, cube and reciprocal, the circular functions, and a short table of the exponential and hyperbolic functions, and a second part giving an extensive table of the hyperbolic functions. It was printed locally and appeared first in 1929. It was reprinted in 1946. At some subsequent date *Knott's Four-Figure Mathematical Tables*, first published in 1900, were introduced into the Department and were used until the mid nineteen-sixties. These tables were loaned to students during examinations, and had the following warning, as did Professor Campbell's tables, on the front cover:

This book is the property of
THE UNIVERSITY OF ALBERTA

It must not be defaced or mutilated

Private possession may be the cause for action
by the University authorities

In addition to this warning, which was in red, the front and back covers were marked with bold red lines, presumably to aid the University authorities in their detection of private possession. Eventually, these tables were sold in the Bookstore for twenty-five cents.

Further in Professor Keeping's history we read the following:

> Equipment is another item which has increased significantly in cost in recent years. For a long time the laboratories in elementary statistics used small Monroe calculators which were cranked by hand, and there were only one or two electric desk-calculators in the whole department, of rather old-fashioned type. By 1962 many of the old calculators were almost worn out, and some newer types of hand

> calculators were purchased. [These were probably the Swedish-made Odhner calculators which weighed thirteen pounds and which accomplished multiplication and division by addition and subtraction with repeated shifting.] A little later some improved electric calculators, such as the Friden square-root type, came along and then some desk electronic models were purchased.

The only other reference that Professor Keeping makes to equipment prior to the late 1960s is the following: "In 1955 the department purchased an electric kettle to be used in preparing tea or coffee before the [mathematics] colloquium, and the staff were assessed one dollar each to pay for it." (Coffee must have been considered essential to the operation of the colloquium for in describing the new Physical Science Building which was opened in 1960 he states that the "accommodation was luxurious ... and we even had a kitchen in which coffee could be brewed prior to the colloquium meetings.)

While Professor Keeping was never involved in the use of electronic computers at the University of Alberta, he was interested in their development and use. The report of the Department of Mathematics submitted to the Board of Governors for the 1957/58 year stated that "Professor Keeping represented the department at a conference on digital computers held at Pullman, Washington."

Although the calculating aids which Professor Keeping had available throughout most of his career were primitive by today's standards, he was very much aware of the importance of proper methods of calculation in the analysis and interpretation of statistical data. He was the joint author of a very popular two-volume statistical text in which a large number of carefully worked numerical examples were a prominent feature. Finally, it is interesting to note that Professor Keeping's lectures in Engineering had an influence on the design of the pocket calculator. Two of his former students who were subsequently employed by Hewlett-Packard remembered his lectures on reverse Polish notation and incorporated this feature into the company's calculators.

Computing in the Department of Physics

The first use of an electronic computer on the campus was probably in the Department of Physics which in May 1957 established a link with the Ferranti computer at the University of Toronto. This computer was known as FERUT for Ferranti Computer at the University of Toronto. An account of this work was reported in the Summer 1957 issue of the *New Trail* in an article entitled "Electronic Brain Aids University Research". It may be of interest to quote part of this article to give an example of a description of the relatively new electronic computer which was written for the educated reader:

> Any problem that can be reduced to a numerical analysis and requires a numerical answer can now be answered in minutes on the U. of A. campus through the medium of teletype and FERUT, a high-speed digital electronic computer housed in the computation centre at the University of Toronto.
>
> A direct-line, teletype communication system with FERUT has been placed

with the University through the courtesy of the Canadian National Telegraphs, on an experimental basis. Equipment is located in the Physics Department laboratory, basement floor, Arts Building.

This new type of "correspondence course" has students and physics professors at the U. of A. preparing problems on teletype ticker tape every week. Then, on Thursdays at 5:00 p.m., a direct line with the computation centre in Toronto is cleared for University use. Transmission time is made available by the Canadian National Telegraphs and time on FERUT is paid for by the National Research Council.

The mechanics of getting a solution to any mechanical problem are comparatively simple. Previously prepared tapes of problems are fed through the teletype machine on the campus and identical tapes are punched instantaneously in the computation centre in Toronto. FERUT is fed the problem tapes which are then processed and FERUT feeds back an answer tape in typed numbers in tabular form. The answer tape is fed through a Toronto teletype which activates the keys of the machine on the campus.

There are many particular advantages of the new hook-up. Ambitious problems in the fields of physics, mathematics, engineering, statistics, etc., can now be solved on the campus in a matter of minutes, that otherwise would have taken months, perhaps years, of hard labour on a desk calculator. Problems of a numerical nature can be solved much more accurately than previously, and through the teletype medium, operators at both ends can converse.

At present, the University of Alberta has five theoretical physicists on staff, the largest number of any University in Canada. It is expected that they, and several students doing graduate work in the Physics department, will keep the new "problem-answer" system busy. ...

The article contained a photograph of George Horton, a theoretical physicist in the Department of Mathematics, seated at the teletype equipment. Looking on was Dr. E. W. R. Steacie, President of the National Research Council, who attended the official opening of the link with the FERUT computer.

It is interesting to compare the above account of the use of the FERUT with an account of its use by Don Betts, a theoretical physicist at the University of Alberta. The following is a slightly edited version of his recollections written over thirty years later:

In early 1957 there was only one progammable electronic computer in all of Canada. This was FERUT, a one-of-a-kind computer custom-built at the University of Toronto by Ferranti Electric Co. of Manchester. It was built using World War II vacuum tubes and occupied a large room in the McLennan Laboratories in the Department of Physics. Input and output was by five-hole

punched paper teletype tape. The machine had the capacity of one of today's programmable pocket calculators, but was much less reliable. A crew of eight engineers was required to maintain FERUT, but in spite of six hours of scheduled preventative maintenance each day, the computer could not be depended upon to run without failure for more than half an hour or so. Nevertheless, FERUT was a marvel of its day.

During the 1956/57 academic year [the theoretical physicists] decided to try to gain access to FERUT. Don Scott, who was then Assistant Head of the Department, was enthusiastically supportive of our goal and was instrumental in completing the necessary arrangements.

The director of FERUT, Dr. C. C. Gottlieb, agreed to let us have access to it, Canadian National Telegraphs agreed to lend us a teletype machine and to provide free use of a telegraph line from Edmonton to Toronto one evening a week, and the National Research Council provided for the cost of time on FERUT. By April 1957 all arrangements were in place, and I was sent to Toronto for two weeks to learn to write programs and prepare input tapes for the machine. I was helped by Dr. B. H. "Trixie" Worsley and Miss Dorothy Goulding of the Computation Centre in learning Transcode, a high-level language for FERUT which was written at the University of Toronto. I did not learn the much more difficult machine-language programming. On my return to Edmonton I taught Transcode to my theoretical physics colleagues and to two third-year Honors Physics students, Peter Buckley and Adele Castella, who were hired for the summer on our research grants.

The teletype machine was established in a glorified closet in the basement of the Arts Building and the teletype link was first used on May 9, 1957. The official opening of the facility, which included a ribbon cutting, was attended by the President of the National Research Council, Dr. E. W. R. Stacie, the Director of the Western Region of Canadian National Railways, the President of the University of Alberta, Dr. Andrew Stewart, representatives of the media, and by all directly involved.

Throughout the summer we and our students would prepare programs and code teletype tapes through the week for transmission on Tuesday evenings. [The article in *New Trail* gave the day as Thursday.] The two copies would then be run through a mechanical comparator at the Toronto end. Any discrepancies were fixed up by the exchange of teletype messages. The system worked tolerably well except when there was a thunderstorm anywhere between Edmonton and Toronto!

Formation of the Computing Centre

In May 1957 Dr. Andrew Stewart, President of the University of Alberta, appointed a "Committee on Electronic Equipment" to make an assessment of computing needs at the

University. The Committee's mandate was fourfold: To determine what electronic equipment the University should acquire, to determine the most efficient method of servicing this equipment, to arrange for interdepartmental cooperation in the use of the equipment, and to investigate the extent to which the University should become the provincial centre for the installation of large-scale electronic equipment. (In 1960 the Committee advised the then-president, Dr. Walter Johns, that it did not think that the University should provide technical services to the province. An exception might be made for the use of some unique facility if appropriate financing could be arranged.)

The Committee was chaired by Dr. Donald B. Scott of the Department of Physics. Other members of the Committee were Don Betts (Physics) who was the Secretary, George Ford (Mechanical Engineering), George Govier (Chemical and Petroleum Engineering), Professor Keeping, John Porteous (Electrical Engineering), and Saul Zalik (Plant Science). In July the Committee recommended unanimously that the University purchase an LGP-30 from the Royal McBee Corporation of Port Chester, New York at a price of forty thousand dollars. At the end of the same month two or three members of the Committee attended a three-day course on computers in Calgary which was sponsored by the International Business Machines Corporation. In September the Committee's recommendations were approved by the Board of Governors, the order for the computer was placed, and the computer was installed the following month. The original installation consisted of the computer with a Flexowriter console (a modified electric typewriter with a mechanical paper tape reader and punch), a photoelectric paper tape reader and a mechanical paper tape punch, and an additional Flexowriter for the preparation of program and data tapes.

The University of Alberta was the third Canadian university to acquire a computer. The first was the University of Toronto which started to design and build a computer in 1948. This computer, called UTEC for University of Toronto Experimental Computer, was a simplified version of the Institute for Advanced Study Computer at Princeton. It was operated briefly, and then replaced in 1952 or 1953 by the Ferranti computer FERUT which has already been mentioned. The second Canadian university to get a computer was the University of British Columbia which acquired its computer in March 1957. In 1966 thirty-three Canadian universities had computers.

The LGP-30 was installed in the basement of the Arts Building where the Department of Physics was then located. It was moved later to the Arts Building Annex*. At first the computing

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* *As the Arts Building Annex no longer exists and is probably unknown to many, a few remarks may be in order. Most of the following information has been taken from the minutes of meetings of the Board of Governors.

During the first two years of the Second World War the Alberta Research Council had been using the laboratories in the Department of Mining to perform all of the testing of aviation gas between Fort William and the Pacific coast. When this space was required for student use in 1941, the provincial government requested permission to build at their expense a testing facility on the campus. The Board of Governors gave immediate approval, and construction was begun

activity was under the Committee on Electronic Equipment. (Incidentally, the University, on the recommendation of the Committee, hired its first electronics technician in October 1957.) On November 1, 1960 Don Scott was appointed Director of the Computing Centre, and reported to the Vice-President, Dr. L. H. Cragg, with a mandate to offer computing services to the University. He was still Chairman of the Committee on Electronic Equipment which the previous year had been increased in size by the addition of Dr. Cragg, Alex Cairns who was the Registrar, John McNamee of the Department of Mathematics, and Bob Julius.

The Computing Centre was run on an open-shop basis with the users doing their own programming since only a few rudimentary programs were available. The operation was first supervised by Don Betts and then by George Horton. It was soon apparent that the Computing Centre would have to provide technical assistance to the users of the computer. Several students were hired to provide temporary support during the summer. One of these students was Ursula Bielenstein (later Ursula Maydell) who in 1960 became the first-time employee of the Computing Centre, resigning a year later to begin graduate work in statistics in the Department of Mathematics. In July 1958 Robert S. Julius who had an MSc in Mathematics from the University of British Columbia came to the University as a half-time Supervisor in the Computing Centre and a half-time PhD student in the Department of Physics. Other staff were soon hired, most of whom were graduate students who worked half-time during the academic year and full-time during the summer. One of those who were hired was William S. Adams who came in the summer of 1959 to complete an undergraduate degree begun at the University of Edinburgh.

Some first examples of computer use

The LGP-30 soon attracted the attention of many faculty at the University who recognized its potential usefulness in their work. A brief article describing the computer and its use appeared in the Fall 1957 issue of *New Trail*. The last three paragraphs may give some indication of the enthusiasm that greeted the installation of the computer:

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the same year on a two-story brick building approximately eighteen feet by forty feet immediately to the north and west of the Arts Building. The Board's minutes record that the cost of the building was $12 671.24 and that of the equipment was $3 987.17. The building was known informally as the "Gas Lab" and was used for testing purposes until the the Alberta Research Council laboratories were built on the campus in 1954. After this time the building became known as the Arts Building Annex, and was used for a variety of purposes. When the Computing Centre moved into the basement, the two upper floors contained offices for graduate students. A reminder of the original use of the building could still be seen in the window panes which had been scored to minimize the danger from explosions.

The Arts Building Annex was demolished during the summer of 1986 and no trace of it remains on the campus. Bill Adams and Keith Smillie each managed to rescue one or two bricks as reminders of one of the first homes of the Computing Centre.

> University officials feel that the computer is sufficiently simple in operation to be used generally by staff and students. It takes about two or three days to train an operator.
>
> An indication of the scope of research opened up by this latest University acquisition may be gained from the following illustration: An average type problem undertaken by a theoretical physicist used to take about one month to solve through the use of a desk calculator. Now, the same worker need spend about one day preparing his material to meet machine operation requirements. Actual computations will take about one hour. Many problems which formerly were considered too time consuming to attempt can now be tackled without hesitation.
>
> The new digital computer will be of vital use to personnel in chemistry, physics, engineering, plant science, social sciences, and other fields. Problems involving a number of variables can be accurately solved in short order.

The article gave a picture of the LGP-30 with the top raised and the front panel removed to show the circuitry. Shown were two members of the Department of Physics, Harry Schiff seated at the console with Lynne Trainor standing behind him looking at the printed output.

The theoretical physicists in the Department of Physics were very early users of the electronic computer, and their use of the Ferranti computer by means of a teletype link has already been discussed. They were amongst the first users of the LGP-30 as the article in the *New Trail* just mentioned would imply, and, indeed, supervised its use during the first year of operation. The Report of the Board of Governors for the 1957/58 year has the following statement: "The University of Alberta has now installed an electronic computer of the LGP 30 type, and members of the department [of Physics], particularly Dr. K. G. Horton, have made much use of it in solving their problems."

One very early example of the use of the LGP-30 may be that found in a report dated June 4, 1958 entitled "On the meaning of marks" and written by Brian Hocking, Head of the Department of Entomology. This report gives the results of an analysis of the variations in the distribution of the final marks in some selected courses at the University of Alberta, and makes recommendations for removing inequities caused by these variations. This report, written in a style evocative of a gentler age at the University, opens delightfully with the words "For my personal guidance in trying to deal justly with my own classes, I set out to determine, during a few of the less crowded hours last summer, ...". The following sentence from the Procedures section of the report shows how soon after its installation the LGP-30 was used: "The first calculations were done on a desk calculator; when a digital computer became available, this was used to complete the work." In the Acknowledgements the author thanks, in addition to the Registrar, "Miss J. C. Shore for much of the machine calculation, and Mr. S. Crause and members of the digital computing class for help in programming the calculation of averages".

The Department of Soil Science was a very early user of the computer. Although fertilizer

trials had been carried out in the Department since the early 1920s, it was not until 1956 that statistical designs such as randomized blocks and balanced lattices were used in the analysis of the data. For the first two years desk calculators were used for the calculations. One of the machines used was a Monromatic which allowed the operator to accumulate at one time the sums of squares and cross-products, and also, by means of a counter mounted on one side, the number of pairs of observations involved in these sums. However, starting in 1958 the services of the Computing Centre were used. In the report for that year we read that "The contribution of Mr. R. S. Julius, Computer-in-charge of the digital computer is acknowledged." The report for the following year states that "The contributions of Mr. R. S. Julius and Mr. G. Marliss who operated the digital computer are much appreciated." The computer program used to analyze the 1958 data which were arranged in a two-way randomized block gave the treatment totals, the error mean square and the F-ratio for treatments. Listings of the program and some of the results are still available. The following paragraph from the three pages of operating instructions for the program is of interest as it shows the method of data preparation required at the time:

> Set up the matrix of data with treatments in the rows and replications in the columns. The program allows for no decimals, i.e., the values in the matrix must be whole numbers. Where the data contain decimals multiply by 10, 100, etc. to remove the decimals. Furthermore all numbers in the matrix must contain the same number of digits. The smaller numbers (if any) must therefore be preceded by a "0" or "00", etc.

Another example of the use of the LGP-30 in Soil Science is given in a paper written by J. A. Toogood and D. L. Lynch which appeared in the *Canadian Journal of Soil Science* in August 1959. The following excerpts indicate the role played by the computer and the staff (italics added):

> ... The areas above the cumulative frequency curves were calculated by a digital computer, type LGP-30. The computer was supplied with the cumulative weights of soil retained on the sieves and the total weight for each sample. The computer program, worked out by R. S. Julius, included the following steps:
>
> 1. Conversion of cumulative weights to cumulative percentages;
> 2. Calculation of equation for best fitting curve.
> 3. Integration to find the desired area.
>
> As the computer was able to convert the raw data for a sample to a mean weight-diameter in 90 seconds, the handling of the data was very much simpler and faster than the graphical method. ... The digital computer played an important role in the study. ... *The computer program simplifies the calculation to the extent that the determination of weight-diameter could become a routine soil test.*

Another example of the use of the LGP-30 is provided by a paper given by Fenton MacHardy of the Departmental of Mechanical Engineering at Congrès International Technique du Machinisme Agricole held in Paris in 1961. One of the examples given in the paper involved finding the optimal allocation of tractor resources for preparing and planting a given area of land. Computationally the problem involved the solution of a linear programming problem with ten

variables including slack and surplus variables and four constraints and required about two minutes on the LGP-30.

Growth of the Computing Centre

Use of the LGP-30 continued to increase in the late 1950s. An article appearing in *The Edmonton Journal* on November 22, 1960 said that the University's computer, which was referred to as a "30 computer", was being used twenty-four hours a day and seven days a week. Furthermore, it stated that "the University expects shortly to launch an extensive computer training program for students, and that arrangements are being made to obtain a faster unit for the newly established centre". In addition to the use of the computer in the departments discussed in the previous section and in the Computing Centre itself, it was being used by the departments of Animal Science, Chemical Engineering, Chemistry, Educational Psychology, Electrical Engineering, Geology, Mathematics, Physiology, Plant Science, Political Economy, and Psychology, as well as by the Alberta Research Council. An additional LGP-30 was rented for a three-month period in August 1961 to meet the demand from the Alberta Research Council.

Late in 1960 the University tried to make arrangements for the acquisition of a used IBM 704 computer from the Toronto offices of IBM for two hundred and forty thousand dollars which was one quarter of the cost of a new computer. It was intended that this computer would be used not only for research and teaching but also for work in the Registrar's and Bursar's offices. However, adequate financial support could not be obtained from the National Research Council which regarded the Computation Centre at the University of Toronto as the major Canadian academic computing centre and the only one then deserving major financial assistance. The Committee then recommended that a much smaller computer, the IBM 1620 Data Processing System, be rented at a cost of 3 126 dollars a month. The National Research Council was prepared to provide partial support for this smaller computer. The Board of Governors approved the Committee's recommendation, and the IBM 1620 arrived in May 1961. The recommendation to acquire this computer was the last official action of the Committee on Electronic Equipment which then ceased to function.

The IBM 1620 Data Processing System had 20 000 characters of core storage and a paper tape reader and punch. This machine was initially intended primarily for research while the LGP-30 was to be kept for teaching. Later in the year this system was replaced by a new 1620 with a card reader and punch and the following July three IBM 7330 magnetic tape units were added. The original 1620 system was sent to the Alberta Research Council which had been using about forty percent of the time available. The LGP-30 remained in use until the middle of 1963.

In September of 1962 Alan Heyworth was hired to assist in the operation of the Computing Centre. After the arrival of the 1620 the Centre continued to be operated on an open-shop basis with persons using the equipment to run their own programs. However, as the demand increased this form of operation was seen to be unsatisfactory and a change to a closed-shop operation with Computing Centre staff operating the equipment was begun. On April 1, 1963 a completely closed-shop operation was implemented.

The LGP-30 and IBM 1620 computers

In this section we will give some very general information on the configuration, operation times, logical design and programming of the LGP-30 and IBM 1620 computers. This information has been taken from the reference manuals provided by the manufacturers, and is intended to give a glimpse of the state of computing technology in the late 1950s and early 1960s.

The LGP-30 weighed eight hundred pounds, occupied twenty-two cubic feet and required a floor area of eight square feet. The computer contained 113 vacuum tubes and 1 350 diodes. The recommended air conditioning was 1 1/4 tons for the equipment, one full-time "maintainer-operator" and two observers. (It was not stated what the observers were supposed to be observing.) Storage consisted of a magnetic drum with a capacity of 4 096 thirty-two-bit words arranged in sixty-four tracks of sixty-four sectors each with one word in a sector. Input and output was by means of a Flexowriter, an electric typewriter with a ten-character-a-second paper tape reader and punch. The clock speed was 120 kilocycles giving addition and multiplication times, inclusive of storage access, of 8 750 and 24 000 microseconds, respectively. The internal operation was binary so that all data had to be converted from decimal to binary on input and from binary to decimal on output. Numbers were assumed to be represented in fixed-point form and be less than unity in absolute value. The order code consisted of sixteen one-address instructions.

The Programming Manual for the LGP-30 consisted of fifty-six pages of typescript in a coil binding and was written in understandable but somewhat unpolished prose. The introductory paragraph, entitled "What is programming", contained the interesting statements "Programming the Royal Precision LGP-30 is basically simple. Understanding certain problems requires certain knowledge, however programming for the LGP-30 does not." (Many persons undoubtedly disputed these statements as they read further.) A description of the structure and programming of the LGP-30 was preceded by a discussion of organizing calculations on a hypothetical desk calculator. The remainder of the manual was approximately evenly divided into sections on the structure of the computer, programming, number systems including the scaling of fixed-point binary numbers, input-output procedures, and a summary of the order code. There is a reference to a "LGP-30 Subroutine Manual" which presumably contained programs for input and input, number conversion and trigonometric functions.

A consideration of the IBM 1620 shows how not only the technology was developing but also the standards of documentation were improving, although the differences between the LGP-30 and IBM 1620 material may be partly attributed to the unfailing high standards of IBM publications. The IBM 1620 Data Processing System was described in a seventy-page *1620 Reference Manual* which was attractively produced, well-written and illustrated with photographs of the system and several logic diagrams. The Central Processing Unit had 20 000 positions of core storage expandable to 60 000 positions, a console panel and a typewriter for input and output. A paper tape reader and punch allowed input and output at rates of 150 and 15 characters per second, respectively, and a card reader and punch had speeds of 250 and 150 cards a minute, respectively. Each position of storage consisted of four bits for representing a digit in

binary coded decimal format, a flag bit and a check bit so that negative numbers and alphabetic and special characters could be represented. The word length was variable with a minimum size of two positions. There was an order code of thirty-nine twelve-digit two-address instructions. Addition, subtraction and multiplication were done by table lookup while division was by either a subroutine or an "automatic divide" feature. The times of arithmetic operations depended on the lengths of the operands, and for addition and subtraction on their signs and relative values. The addition of two ten-digit numbers took from about 1000 to 1800 microseconds and their multiplication about 17 000 microseconds.

Programming for the 1620 could be done in machine language, a Symbolic Programming System SPS, or FORTRAN. There was also an IBM library of utility routines which performed "most of the more standardized computations and routine tasks occurring in many computer problems". Since the FORTRAN language was relatively new, it was introduced in the manual as follows: "FORTRAN (FORmula TRANslation) is the term applied to another IBM programming system that translates a problem, expressed as a series of algebraic statements, into a complete machine language program, generating the step-by-step instructions necessary to solve the problem". At the end of the manual a further brief description of FORTRAN ended with the statement "The IBM FORTRAN Bulletin (Form J26-4200) describes FORTRAN language in detail."

The original FORTRAN II compiler at the University of Alberta was soon replaced by the FORGO "load-and-go" compiler and other programs available through the SHARE library. In 1963 the University of Alberta 1620 Tape System, written by Peter Csontos, Ron Davis and Barry Mailloux, was introduced. This system included the GO monitor which allowed for job-to-job transition without operator intervention. (Another programming project resulted in a program that allowed the 1620 to play a variety of musical selections including Bach through a radio.)

An Extension programming course

In January and February of 1960 Bill Adams gave a course on programming the LGP-30 for the Department of Extension. The course consisted of twelve two-hour lectures on consecutive Tuesday and Friday evenings. A brief discussion of these lectures will give us a glimpse of how an introduction to programming has changed in thirty years and at the same time how some of the principles have remained the same.

The course began with a brief description of the structure of the LGP-30 and its components. The principles of programming were then introduced and illustrated with a few problems such as the computation of the area of an annular ring, moving a contiguous block of data from one part of storage to another, polynomial evaluation, and Newton's method for finding square roots. Since arithmetic was done in fixed point with binary numbers, there was considerable discussion of number representation and scaling. Finally subroutines and subroutine linkages and input-output operations were discussed.

To give some idea of the nature of machine-language programming on the LGP-30, consider

the first example given in the course. The problem was to find the area of the ring between two circles, of radius R and r, say, one of which encloses the other. It was assumed that the radii and the value of π were already stored in binary form. In Pascal this computation could be accomplished by the statement

```
Pi * (BigR + LittleR) * (BigR - LittleR) .
```

(When the complete Pascal program for this problem was run with the test data shown for the LGP-30 program, an error in the fourth decimal place of the original calculations was found.) The order code for the LGP-30 was one-address with a one-character operation code followed by a four-digit decimal address. Arithmetic was carried out with one operand in the accumulator register and the other operand in the specified memory location. With these few comments the following LGP-30 program should be understandable:

```
Loc.    Instr.    Comments
0000    B 0010    R to Acc
0001    A 0011    Add r to Acc
0002    C 0012    Store R+r and clear Acc
0003    B 0010    R to Acc
0004    S 0011    Subtract r from Acc to give R-r
0005    M 0012    Multiply R-r by R+r
0006    M 0009    Multiply by Pi to give Area
0007    C 0012    Store Area
0008    Z 0000    Halt
0009              Pi  { Storage of       }
0010              R   {   data as        }
0011              r   {   binary numbers }
0012                  { Working storage  }
```

Of course, the above code does not represent a complete program. In the LGP-30 program the value of π and the values of the radii had to be entered and converted to binary with the appropriate scale factors and the calculated area converted from binary to decimal. However, the example does provide a brief glimpse of the nature of programming for the LGP-30.

Since the term "scale factor" has been mentioned in the above discussion, it may be worthwhile to make a few remarks about scaling since the concept may be unknown to those who program today in a conventional high-level language. The LGP-30 was a fixed length binary machine with the binary point assumed to be at the left-hand end of the number. For example, the integer 16 would be stored as the binary representation of the number obtained by multiplying 16 by some power of 2 that would give a product less than unity. A scale factor of 5 would mean that 16 be would be scaled by multiplication by 2-5 giving the decimal fraction 0.5, which would then be stored as the binary number 01000000000000000000000000000000, where the left-hand digit represents the sign and the right-hand digit which is always 0 marks the end of the thirty-two-bit number. Similarly, the integer 2 could be stored with a scale factor of 2 giving

010000... . Then the product of these two binary numbers would be calculated as 001000... with a scale factor of 7, and would represent the decimal fraction 0.25 multiplied by 27 or 32 which is the correct decimal product. In many problems the programming to keep track of the scale factors would be the most difficult part of the program. However, until floating-point subroutines became available there was simply no alternative.

The above discussion shows that the *details* of programming have changed fundamentally in the thirty years since this course was given. However, many of the *principles* have not changed, and are just as valid today as they were thirty years ago. For example, on the second page of the notes we find the following comment: "This course is intended as a practical course in programming and it is of great importance that assignments should be done; otherwise nothing will be learned." Further on we find a discussion of the steps required in the solution of a problem on a computer. These begin with the statement of the problem, and continue through to test calculations, debugging, and, finally, "specifications" which is underlined three times. This example may serve to show the importance, and the difficulty, of obtaining the correct balance between the details of a rapidly changing technology and the underlying principles of its use which is of more enduring value.

First courses and degrees

The first courses for students in computing were given by John J. McNamee of the Department of Mathematics. The 1959/60 Calendar lists Mathematics 460 "Numerical analysis" which covered topics such as vector and matrix equations and solution of eigenvalues, finite differences, interpolation, differential and integral operators, initial value and boundary value problems. The Calendar the following year listed a graduate course, Mathematics 640 "Advanced Numerical Analysis", in which topics were selected from "problems and procedures of current interest" giving eigenvalues and eigenvectors of large-order matrices, quadrature, partial differential equations, linear programming and game theory as examples.

The first course devoted to computers rather than numerical analysis was Mathematics 641 "Automatic digital computers and programming" which was also given by John McNamee and which appeared for the first time in the 1961/62 Calendar. The description of the course was as follows:

> **641. Automatic Digital Computers and Programming** (3-6;3-6)
> Scientific applications of accounting machines, and development of automatic computers. Storage systems, arithmetic units, input and output mechanisms. Arithmetic in general radix. Simple algebraic logic. Logical systems of control (one-address, three-address, etc.)
> Flow diagrams. Construction and use of library routines. Codes of principal types of machines, with detailed knowledge of one machine.
> Each student will be expected to solve several problems on a computer. Students should have a knowledge of elementary coding before entering this course.
> References: Wilkes, Wheeler and Gill, *The Preparation of Programmes for an Electronic Digital Computer*; Alt, *Automatic Digital Computers*.

Corequisite: Mathematics 640.

The 1961/62 Calendar also listed in the Faculty of Engineering an introductory programming course, Eng. Comp. 400. This was an intensive course given before the beginning of the First Term. The Calendar description indicated that it was for "9 days beginning Sept. 14, 1961".

During the 1963/64 academic year the following courses were given by the staff of the Computing Centre: Statistics 256. *Numerical Mathematics, Statistics and Probability* (First-year Mathematics); Computations 300. *Compiler Language Programming* (Third-year Engineering); Business 351. *Data Processing* (Third-year Commerce); Business 353. *Quantitative Methods for Business Decisions* (Third-year Commerce); Mathematics 458. *Numerical Analysis and Computational Methods* (Fourth-Year Engineering). In addition four non-credit courses were given in the Department of Extension as well as a non-credit course for University staff.

Since the Computing Centre was not an academic department, students working in computing were awarded MSc degrees in Numerical Analysis through the Department of Mathematics. From 1962 to 1964 the following seven degrees were awarded: William A. Murray, *The Numerical Solution of Partial Differential Equations by Closed Difference Methods*; William S. Adams, *Probabilistic and Deterministic Aspects of Digital Computers*; Arthur Kuhn, *Nonlinear Systems and Nonlinear Programming*; Barry J. Mailloux, *Numerical Solution of Differential Equations*; Gary S. Marliss, *The Numerical Solution of Functional Equations Arising in Stochastic Learning Models*; Frank Stenger, *Numerical Integration in n Dimensions*; and Gary R. Jackson, *Rational Approximations*.

Formation of the Department of Computing Science

The need for an academic rather than a service department was debated within the Faculty of Science during the 1963/64 academic year. Don Scott believed that the faculty of the proposed department should teach and do research in the areas of numerical analysis, statistics, coding and information theory, and the theory of digital computers, and in addition should provide some service to those doing research in the University. Some members of established departments wondered why computing needs could not be fulfilled by the Department of Mathematics; others asked how other institutions such as Harvard were accommodating computing. The academic members of the Computing Centre, led by Don Scott, finally convinced a sometimes doubting Faculty that a separate department was needed, and the Department of Computing Science came into existence on April 1, 1964. Don Scott was appointed Department Head, a position he held as well as that of Director of the Computing Centre. The choice of the name "computing science" instead of the more common "computer science" was deliberate in order to indicate that *computing* rather than *computers* was to be the foundation of the discipline. Another explanation attributed the name to a typographical error. Although both names appear in the correspondence regarding the formation of the Department, the second explanation is undoubtedly suspect.

Initially there were five faculty members in the Department: Don Scott, Bob Julius who was made Assistant Head, Bill Adams, Bill McMinn who had an engineering degree from the University of Toronto and who formerly worked for IBM, and Keith Smillie who had come from

the Dominion Bureau of Statistics in 1963 and who for one year had a joint appointment with the Computing Centre and the Department of Mathematics. In addition to the two courses in numerical analysis and the computing science topics course mentioned previously, there was Computing Science 300, a FORTRAN programming course for engineers. The previous year Keith Smillie had begun Statistics 256 for the Department of Mathematics; this was an elementary introduction in approximately equal proportions to probability, statistics and numerical analysis.

The first MSc degree granted by the Department was conferred at Fall Convocation in 1964 to Harry Maximchuk whose thesis was entitled *A Matrix Formulation of Initial Value Problems*.

First years - 1. People and courses

In 1965 the number of faculty members was increased to eight when Ursula Maydell, Frank Stenger, and Kellogg Wilson who had a joint appointment with the Department of Psychology joined the Department. In the following six years fourteen more persons arrived so that in 1971 the total number of full-time academic staff was seventeen since a few of the newcomers stayed for a short time only, and two of the original members of the Department, Bob Julius and Bill McMinn, had left. Some of the new staff came from other universities and organizations, e.g., Stanley and Doreen Heaps from the Nova Scotia Technical College in Halifax, John Penny from the Commonwealth Scientific and Industrial Research Organization in Canberra, Wayne Davis from the Department of Communications in Ottawa, and John Tartar from the Autonetics Division of the Rockwell Corporation in Anaheim, California. In addition, two University of Alberta graduates who had just completed doctorates returned to the Department. They were Barry Mailloux who had been studying at the Mathematisch Centrum in Amsterdam, and Wayne Jackson who had been at the University of Toronto.

The first introductory programming course for Computing Science students, Computing Science 310, was introduced in the 1965/66 Calendar with the following description:

> **310. Elements of Programming** (3-0,3-0)
> Logical structure of computers; instructions; algorithms and programs; language of computer programming; conventional computers; assemblers and compilers.
> Corequisite: Mathematics 304.

The following year the BSc degree with Honors in Computing Science appeared in the calendar along with course descriptions of eight courses. The following year fifteen courses were listed. The first undergraduate degree was awarded at the Spring Convocation in 1968 to Barbara Diane Reader. The 1970/71 Calendar listed Honors, Specialization and Concentration programs in Computing Science, and a total of forty courses, of which fourteen were undergraduate courses, six were graduate courses, and twenty were 500-level courses which could be taken by both undergraduate and graduate students. Because of the backgrounds and interests of the persons who were in the Department in the 1960s, the emphasis in the teaching and research was, in addition to programming languages, in such areas as numerical analysis, optimization, statistical analysis and algorithms, and logical design. Thus the undergraduate degree could be considered

to be a major in mathematics with a minor in programming.

Courses were numbered such that a course which was a prerequisite for another course had a lower number than that course. Introductory courses could be numbered in the 200s, 300s or 400s, depending on the students for whom they were intended. The thought never occurred to anyone that some day some one might exhaust the supply of allowable numbers (Is there not a countable infinity of them?), thus instituting a complete renumbering of all undergraduate courses in the University! An example of the logic, or lack of logic, in course numbering at the time may be of interest. In 1965 two service courses in programming were introduced independently: Computing Science 456 for students in Science and Agriculture, and Computing Science 462 for Psychology students. The first course was numbered 456 since its originator already gave Statistics 256 and presumably became attached to the last two digits. The reason for the numbering of the second course is unknown. When it was found that the two courses could be combined, the number 459 was chosen since it was the arithmetic mean of 456 and 462. (Later the number was changed to 359 to denote the introductory nature of the course, and later still to 351 for reasons now forgotten. The number has just been changed again to 251.)

During the early years of the Department there were many lively debates about the nature of computing science and the content of courses. Two or three of these might be mentioned here if only to emphasize that differences of opinion are always present, and indeed they should be in a healthy organization, and that friendships and professional relationships can survive even the most heated arguments. One problem that emerged very soon after the formation of the Department was concerned with the teaching of programming. There were those who believed strongly that one should start with a high-level language such as FORTRAN while others believed with equal fervour that a simple machine language should be the first language. Indeed, a machine-language and assembly-language simulator MENTOR/MENTORSAP had been developed in the Department for precisely this purpose. This topic was debated at departmental meetings, faculty offices and undoubtedly in the hallways for some months. Differences over this problem between two of the principal protagonists were finally settled very amicably over lunch one noon in the Faculty Club. Another argument arose one year over the shortage of space for IBM keypunches, and during one lively discussion the suggestion was made to move some equipment into Don Scott's office which was larger than any other faculty office in the Department. Fortunately, reason prevailed and Don Scott retained the use of his entire office. The following year the distribution and collection of the type elements for the IBM 2741 terminals produced another spirited discussion. These elements were expensive, costing about twenty dollars each, and were easily broken. The details of this argument and its outcome have been long forgotten.

One discussion which originated during this period concerned the APL language and its place in a computing science curriculum. Since Kenneth Iverson, the originator of APL, was raised in Alberta, it was relatively easy for the Department to have him visit and give a lecture on his work. Thus the Department became associated with the language almost from the beginning, due largely to the initial interest and work of Bill Adams. First the language was used as a mathematical notation as it was originally conceived. Brief use was made of a batch simulator which was obtained from IBM through a former student. Then in 1966 the APL system at

Yorktown Heights, New York was used through a telephone connection - at considerable expense it might be noted - and one MSc thesis was completed and some preliminary work was done on a statistical package. When the IBM 360/67 was installed in July 1967, APL was one of the first systems that was operational. Although APL was used extensively by a few members of the Department, the language was largely ignored except for some use for the teaching of statistics and digital simulation, and APL continued to be regarded as the "language with all the funny symbols". The roots of the debate over the role of APL were possibly the same as those of the MENTOR/MENTORSAP controversy since those supporting APL believed that the first language should be that one which obscured most of the details of a computation while others felt that a more primitive language in which attention to such detail was essential should be taught first. (The proponents of APL would undoubtedly agree with Oliver Heaviside, the eccentric nineteenth-century English engineer who, when criticized for not fully understanding the details of the mathematical formalisms he used, asked "Shall I refuse my dinner because I do not fully understand the process of digestion?")

First years - 2. Introduction of the PhD program

The Department, as was seen in the previous section, was very active during the 1960s in building up both the undergraduate and MSc programs. As Don Scott was most anxious to have a PhD program, the Department made a request to the Faculty of Graduate Studies in 1967 for permission to offer this degree. The report of the committee which was established by Graduate Studies is of interest as it gives a view of the Department a few years after its creation as seen by an impartial group of faculty members from other departments.

The committee noted to begin with that at present the University of Toronto and the University of Waterloo were the only two Canadian universities that offered a PhD degree in computing. Furthermore, it remarked that "the increasing demand for trained personnel beyond the technical level, and at the PhD level, shows that there is a need for more centres in which such training can be obtained". Then the committee described the present situation in the Department of Computing Science. In the 1967/68 year there were eleven academic staff, and, according to the committee, the senior faculty were established scholars with a significant number of publications. In addition to a good Honors program there was an MSc program offering seven graduate courses to a total of twenty-five students. The Department had an excellent library which had all of the important books in computing that had been published in recent years and which was completely satisfactory for graduate study for the PhD. The computing facilities were quite adequate since the University had one of the largest computers in Canada. The committee did have the following comment about space:

> Space is at present a problem, but for the time being it is resolved to some extent by staff members doubling up in offices to liberate some of their former quarters for student use. This will be alleviated when new space becomes available.

The committee said that the Department was intending to limit specialization for the PhD to the areas of numerical analysis, programming languages and systems, and information retrieval.

The Department was trying currently to add four or five new faculty in order to increase its competence in these areas. Furthermore, it intended to extend the PhD program to other areas of specialization only when the education and experience of subsequent faculty warranted it.

In view of the considerations summarized above the committee recommended that the Department of Computing Science be authorized to introduce a PhD program. The recommendation was approved by the Faculty of Graduate Studies at its meeting of February 22, 1968.

The first two PhD degrees were awarded at the Spring Convocation in 1973 to George Neufeld whose thesis was entitled *Analysis of Class-Teacher Timetable Problems* and to Gary Sitton whose thesis was *Strategies for Microprogram Optimization*. In both cases the supervisor was John Tartar. At the Fall Convocation of the same year PhD's were awarded to Marek Fridrich for the thesis *Fault Detection in Combinational Networks* and to Nam Ng for the thesis *An Environment-Independent Graphics Facility*. The supervisors were Wayne Davis and Tony Marsland, respectively.

First years - 3. Hardware and software

In this section we shall summarize briefly the development of computing equipment and programming systems that became available in the Computing Centre since it was these facilities that were used by the Department of Computing Science. However, we should keep in mind that the Department and the Computing Centre were separate organizations, albeit with the same person in charge, and that by the end of the decade they would be independent organizations.

In order to meet the increasing demand for computing time an IBM 7040/1401 was installed during the summer of 1964 and the 1620 was phased out during a three-month period. The new system consisted of a 7106 central processing unit with 32 768 words of core memory, six 729-V magnetic tape drives (augmented by the three tape drives from the 1620 when that system was no longer used, and still later by additional 729-V drives), a 1401 central processing unit with 4 000 characters of core memory, a 1402 card reader and punch with reading and punching speeds of 800 and 250 cards per minute, respectively, and a 600-line-per-minute 1403 printer. The system was controlled by a supervisory program, MONITO, which handled the scheduling of jobs and the generating of accounting information. The 7040/1401 system was used first with one closed-shop and two open-shop shifts, but by September 1965 the entire operation was closed-shop.

Some of the software packages run on the system were MAP (Machine Assembly Program), FORTRAN II and COBOL compilers, an ALGOL compiler from the University of Grenoble, the LP III linear programming system, the BMD Biomedical Statistical Package, and the AGGIE student FORTRAN II compiler which was soon replaced by WATFOR from the University of Waterloo. Additional packages written at the University of Alberta included a number of statistical programs, the MENTOR and MENTORSAP simulators mentioned in the previous section, and the University of Alberta Auto Plotter.

It was soon apparent from the rapidly increasing use of the 7040/1401 that a larger system

would be required. Thus in the summer of 1967 an IBM 360/67 which allowed timesharing was installed. This system had 512 000 characters of core memory, a 4.09-million-byte drum memory, five 2311 disk drives, eight 2401-11 and 2402-11 tape drives, an 1100-lines-per-minute printer, and a 2540 card reader and punch with reading and punching speeds of 1000 and 300 cards per minute, respectively. In November the five 2311 disk drives were replaced by nine 2314 disk drives with a capacity of over 230 million bytes. The hardware was continually upgraded until in November 1969 the system had a total of 768 000 bytes of core storage, a drum, two 2314 disk units each with eight discs, eight tape drives, a CDC GRID display for interactive graphics, two printers, two card readers and punches, and fifty-six terminal ports.

The IBM OS operating system was used together with the Houston Automatic Spooling System HASP in which input jobs were read onto a disk, then processed according to priority, and the output stored on a disk for subsequent printing. While the OS/HASP system was continually upgraded, other operating systems such as the Basic Operating System BOS, Tape Operating System TOS, and the Disk Operating System DOS were also used at various times during the day and night. In addition to these systems the Computing Centre introduced its own student-oriented batch facilty SOBF which allowed students' programs to be processed much more efficiently and quickly than was possible before. Students were issued "SOB tickets" in courses. One ticket was valid for one run of a program when submitted with a program deck at the SOB wicket. Students who used up their allotments of tickets could purchase "SOB balls" made of transluscent plastic about three-quarters of an inch in diameter from a dispenser for a nickel each. These balls were dispensed by a gum-ball machine which had been purchased at an auction by Henry Ewasechko who was Operations Manager in the Computing Centre. (For about a two-month period while SOB tickets were being used a number of them would appear each morning on Jeff Sampson's door. The person or persons responsible and the reasons for this were never known.) The SOB Facility was originally on the second floor of the General Services Building, but was soon moved to GSB 361, a large room in the northwest corner of the third floor with sufficient space to accommodate a number of keypunches. The SOB Facility was used very heavily with up to one hundred students out of the twenty-seven hundred possible users waiting to submit program decks or pick up output at any one time.

A large number of software packages were available with the operating systems. These included compilers for FORTRAN, COBOL, Algol W, PL/1 and WATFOR, an interpreter for APL, and a variety of engineering and statistical packages. However, the conversion to the 360/67 system from the 7040/1401 was much more difficult than any previous conversion. Therefore it was decided that ease of conversion would be one of the most important considerations in any subsequent change in systems.

A few operating statistics for the Computing Centre for 1969 may be of interest. During that year 185 159.8 lines of output were printed, of which 15.3% were for Computing Science. (One might ask, parenthetically and not too seriously, how does one measure the number of lines to one decimal place?) The number of runs was 167 083, with 20.4% accounted for by Computing Science, and the number of hours of operation was 3 417.7, with 12% for Computing Science.

On January 1, 1971 the Michigan Terminal System MTS was introduced as the principal

operating system for both terminal and batch work. The use of the OS system was restricted to the early morning hours. On April 1, 1971 a charging system was introduced for all users of the MTS system.

First years - 4. Organization

Both the Department of Computing Science and the Computing Centre were located for many years in what was originally the Physical Science Building. During the summer of 1968 the facilities and staff were moved to the newly opened General Services Building with the Department of Computing Science on the sixth floor and the Computing Centre on the second and third floors.

In the late 1960s the role of computing began to change at the University. The Computing Centre had been formed to provide a service to the University while the Department of Computing Science was an academic department in the Faculty of Science and offered its own courses and degrees. Since Don Scott was both Director of one and Head of the other, this distinction was often blurred. The separation of responsibilities was made even less distinct since members of the Department often provided a consulting service to users of equipment in the Computing Centre and wrote many of the programs which they used. The problems were exacerbated by the conflicting demands for large amounts of computing time by the Departments of Chemistry and Physics and the Faculty of Engineering, for secure data processing by the Administration, and by the research interests of the Department of Computing Science.

An example of the lack of understanding of the nature of the Department of Computing Science and of the discipline of computing during this period may be found in the document "Detailed Program: Department of Computing Science" which was prepared by the Campus Development Office and dated June 1968. The following excerpts are of interest:

> ... The Department of Computing Science officially came into being on April 1st, 1964. The Computing Centre, which had existed before, was then, and is now, considered to be a part of the Department of Computing Science. ... While both the use of computing facilities across the University and the amount of money spent on these facilities will continue to increase for some years we do not think that the amount of space required for computing equipment will increase much beyond what it is now. ... The formula space for Computing Science has no special equipment and requires no special services. It is office and classroom space. The offices require only lighting, telephone outlets, the ordinary number of wall outlets, and blackboards. ...

How difficult it was to foresee needs and to make others appreciate them!

The first change was the formation in May 1966 of the Administrative Data Processing Unit with Bill McMinn as Director. Then in 1968 the Computing Centre began to function as an independent service organization with Bill Adams, who retained his academic appointment in the

Department, as Associate Director. The Computing Centre was reorganized into three groups with managers responsible to the Associate Director: Alan Heyworth, Manager of Operations; Graeme Pratt, Manager of Information Services; and Gerry Gabel, Manager of Research Systems. Graeme Pratt very shortly resigned to return to England and was replaced by Vic Yanda. In 1970 Alan Heyworth accepted a position at the University of Toronto and Gerry Gabel became Manager of Operations and Systems. This position was soon split with Henry Ewasechko becoming Manager of Operations and Gerry Gabel becoming Manager of Systems. In 1970 following recommendations made by the Computer Facilities and Policy Committee and approved by General Faculties Council and the Board of Governors the Computing Centre became a separate organization under a Director reporting to the Vice-President (Academic). The Computing Centre would be allowed to provide a service to business, industrial and professional interests outside the University as the need arose and at commercial rates as long as the outside commitment did not take precedence over any University work. In 1971 Dale H. Bent, an Associate Professor of Business Analysis who had been Acting Director for a year, was appointed Director. Dale had received a BSc and MSc in mathematical statistics from the University of Alberta and was completing a PhD in operations research from Stanford University. He was a co-author of the widely used book *Statistical Package for the Social Sciences*.

Thus the Department of Computing Science became a user of the computing facilities as was any other department in the University. The separation of the Department of Computing Science from the Computing Centre was intended to make clear to the University the distinct functions of each organization and to improve the administration of each. Whatever help the separation was administratively, the distinction was still not appreciated by many users since the two organizations had almost identical names and were in the same building. Confusion exists to this day, as any receptionist in each organization knows only too well, even though Computing Services is now officially known as University Computing Systems.

One unfortunate result of the separation of the Department of Computing Science and the Computing Centre was that all of the equipment and most of the support staff were assigned to the Computing Centre. Thus one of the most serious problems for the Department in the 1970s was to acquire computing equipment to handle the teaching and research which could not be done on the computer now administered by Computing Services.

Donald B. Scott

The name of Don Scott has appeared many times in this account as the first Director of the Computing Centre and the first Head of the Department of Computing Science. Since he may be unknown now to many persons with an interest in the Department, it seems appropriate to make some mention of his life and contributions to the University.

Don Scott graduated from the University of Toronto in Mathematics and Physics in 1937 and then went to McGill University where he received a PhD in Physics in 1940. In the same year he came to the University of Alberta as a Sessional Lecturer in Physics. On December 6, 1940 he was the subject of the first of a series of columns in *The Gateway* called "Looking around

corners", and was introduced as follows: "Our first personality to be introduced in this series is a pleasant young man who comes to Alberta from McGill to take up the duties of an instructor in Physics. Dr. Scott up to now has been a fairly steady inhabitant of Toronto, and apparently such an environment in no way proves a handicap to the inhabitants therein." He rose steadily through the academic ranks and in 1955 was appointed Professor of Physics. His work in nuclear physics involved supervision of many MSc theses, consulting activities with the University Hospital, and, for a short period, a joint appointment with the Cross Cancer Institute. From the beginning of his association with computing, he approached his work with great energy and a sense of humour, and was largely responsible for the early development of computing at the University. Throughout his career with the Computing Centre and Department he concerned himself with the administration, leaving the teaching and research to the other members of the academic staff.

Don Scott was devoted to teaching and considered it to be one of the most important and rewarding responsibilities of a university professor. His lectures were carefully prepared and clearly presented, and he soon established a reputation both as an excellent lecturer and as a person who cared for his students. His enthusiasm for lecturing in physics continued throughout his career.

In addition to his academic duties Don Scott was involved in many activities in the University. He was a long-time member of the University Athletic Board and was Chairman of the Awards Committee for fifteen years. He was also active in the Association of Academic Staff and was a Chairman of the Academic Welfare Committee and also a President of the Association. He was a founding member of the Faculty Club and one of its early Presidents.

In 1971 he stepped down as Chairman of the Department of Computing Science, and shortly afterwards was appointed University Ombudsman, a position he held for four years. He died of cancer on June 11, 1975 in his sixty-second year.

1971 to 1981 - 1. People and courses

Don Scott was succeeded by John Penny who served as Acting Chairman for one year while the Department looked for a Chairman. In the summer of 1972 Arthur Wouk, a numerical analyst from Northwestern University, became Chairman of the Department. He soon became known for his idiosyncratic mannerisms and attitude towards life, and presided over the Department with benevolent lethargy. He considered Edmonton to be beyond the frontiers of civilization, a place that could be endured only with frequent visits to the United States. Arthur served as Chairman for four years, took a year's sabbatical leave, and then returned to teaching. While he was in the Department, he served as editor of book reviews for *SIAM Reviews,* and there was a steady stream of books coming into the Department from the publishers and leaving again to reviewers. He resigned from the Department in the autumn of 1983, accepting a position with the Office of Army Research in Durham, North Carolina. He and his wife, Vita, were given a warm and affectionate farewell party at an ethnic restaurant on Whyte Avenue noted for its exotic dancing, a form of entertainment which was new to some of the more staid members of the Department.

When Arthur Wouk went on leave in 1976, John Tartar was appointed Acting Chairman for

one year. At the end of that year he was appointed Chairman for a five-year term. John filled the position with an urbane style and friendly disposition and kept an office that was always open to all members of the Department.

Very few new faculty were recruited in the 1970s. One was Graham Toope who was appointed in 1972 as the first Administrative Professional Officer. By 1976 a total of three persons had held this position for brief periods. In 1976 the position was replaced by that of Faculty Service Officer and filled by Steven Sutphen who had just received an MSc degree in the Department. Four of the new faculty who were recruited stayed for only three years. Since some of the faculty who came earlier left during the same period, there was a net decrease of one so that in the 1980/81 academic year there were only fifteen faculty consisting of five Assistant Professors, eight Associate Professors and two Professors. The number of courses increased during the same period from fifty-one in the 1971/72 academic year to seventy-one in the 1980/81 year with most of the increase being in senior undergraduate and graduate courses. However, throughout this period there was a dramatic increase in the number of students taking courses, not only undergraduate and graduate courses leading to degrees in the Department but also service courses for students from a variety of other departments and faculties. Indeed, total enrolments in all courses increased from 2 348 in the 1977/78 academic year to 4 590 in the the 1981/82 academic year.

Additional resources were obviously required to meet the increasing demand for courses and the supervision of graduate students. Unfortunately, all requests for substantial assistance were unanswered. In June 1981 John Tartar resigned with one year still remaining in his term, feeling that it was futile to remain longer as Chairman. Thus on a rainy Tuesday afternoon on the last day of the month the Department held a wine-and-cheese party for him in Room 652 which was then a lounge. As is customary on these occasions John was presented with a pair of University bookends in appreciation of his work as Chairman. John also presented Wayne Jackson, who had been appointed Acting Chairman for one year, with a carrot (a rather limp carrot by the time of the presentation) and a stick to be used to reward or encourage, as appropriate, the members of a very discouraged Department. John remained as a member of the Department, and in 1985 was appointed Associate Vice-President (Information Systems).

Little did the Department realize that it was facing not only even larger enrolments but was entering a world where the catch phrases would be "high tech", "world class" and "computer literacy". Before discussing these developments and their effect on the Department, let us consider developments in computing during the 1970s.

1971 to 1981 - 2. Hardware and software

During the 1970s the Department began to acquire its own computing equipment. However, the equipment in the Department of Computing Services continued to be used for teaching and research. We shall first give a brief summary of the developments in Computing Services and then turn to developments in the Department.

The IBM 360/67 continued to be upgraded with additional printers and tape drives. In 1974 a

PDP 11/45 with a PACX exchange that supported forty terminal ports was installed and the first Remote Job Entry stations were in operation. By the end of the same year the 360/67 was operating at full capacity. A year later it was replaced with an Amdahl 470 V6. Although this was done in December at the end of the first term, there was little disruption to regular service. In 1976 the 2741 terminals were replaced by Lektromedia display terminals and Decwriter terminals for hard copy. In 1978 the NCS 7008 Optical Mark Reader was installed. In 1979 the Amdahl 470 V6 was upgraded to an Amdahl 470 V7, and the first Xerox page printer was installed. During the 1979/80 academic year students began to use terminals rather than the Student Oriented Batch Facility to enter and run programs. In May 1980 the University signed an agreement worth 2.3 million dollars with Control Data Canada Limited for a PLATO Computer Assisted Instruction system, and eight PLATO terminals were installed in the General Services Building the same month. At the end of the year the PLATO laboratory in the Faculty of Medicine was opened. Services for users that were established during the 1970s included the Applications Programming Group, a statistical program library, and a text processing group which designed and implemented TEXTFORM, an extremely large and complicated and even ponderous package that could be used for wordprocessing and typesetting.

During the 1970s there occurred a series of computer offences at the University of Alberta which had their origins in the Department. The resulting trial and subsequent appeals caused nation-wide publicity in the daily and periodical press. In the spring of 1976 a student investigated the security of the MTS system as a project for a Computing Science course. Unfortunately, the resulting program which could reduce the charges for a computer run became available to other uses. The following year it became apparent to Computing Services staff that malicious users were tampering with the MTS system and causing malfunctions. After an extensive and lengthy investigation charges of theft and tampering were brought against a University student, a former University student and a high-school student. One person was convicted on both charges, another was convicted on the charge of theft and the third acquitted. Both of the convicted persons received suspended sentences, one of which was overturned by the Alberta Court of Appeal on the grounds that the computer could not be defined as a "telecommunication facility" and thus be covered by the Criminal Code. The Government of Alberta made an unsuccessful attempt to appeal this decision to the Supreme Court of Canada.

Now let us consider some of the most important computers acquired by the Department during the 1970s. The first computer was a used Digital Equipment Corporation PDP-9 which was purchased from American Used Computer in 1970 for 19 700 dollars. This system had 8K of 18-bit memory, an Extended Arithmetic Element to speed up multiplication, division and shifting, a teleletype console and oscilloscope display, a paper tape reader and punch, and a card reader. The cycle time was one microsecond; addition required two cycles. Two 256K fixed-head disks having an average access time of seventeen milliseconds were added shortly, and a Sykes Compucorder 100 cassette tape drive was added in 1972. The software include the DOS-9 operating system, FORTRAN IV, FOCAL which was an interpreter similar to BASIC, an assembler and an editor. The PDP-9 was used for a large number of small projects as well as for Wayne Davis's research in image processing. This research was moved to the PDP-11/60 in 1977. When the PDP-9 was purchased the Hour Meter registered 6 634 hours. When it was sold as surplus in 1980 the Hour Meter was at 15 993 hours.

In the budget for 1971/72 John Hauer, Barry Mailloux and Tony Marsland proposed that the Department purchase immediately a PDP-11/20 system at a cost of between 45 000 and 70 000 dollars. Another machine was to be purchased the following year. Experience in teaching and research with this equipment together with the PDP-9 would be invaluable in determining the requirements for a larger machine. However, only 20 000 dollars was made available as a result of this request, and this money was used to purchase the disks for the PDP-9. The following year a proposal was submitted for the newly announced PDP-11/45. This proposal was accepted, and in June 1972 an order for the 11/45 at a cost of 45 000 dollars was placed. The system, which arrived the following January, had a 16K core memory, a removable disk of 1.2M words, card reader, and a Centronics dot matrix printer. The operating system was DOS-11 which, unfortunately, did not use many of the features of the PDP-11 including the Memory Management Unit. Therefore, Tony Marsland proposed that the Department obtain a copy of the UNIX operating system from the Bell Laboratories in Murray Hill, New Jersey where he had worked before coming to the University of Alberta. One reason for obtaining UNIX was that it would enable him to match the Belle chess program developed at the Bell Laboratories on the PDP-11/45 with his own program, Wita, which ran under MTS on the IBM 360/67. The fourth edition of UNIX was shipped to the University in October 1973; it is believed to be the first version of UNIX used outside of AT&T. The PDP-11/45 was for some persons the most significant of the Department's computers, and was used in numerous research projects. It was called "Chatty Cathy" because of the work of Dan Salomon who used it for a project on voice synthesis. On January 14, 1986 at 2:53 p.m. it registered one hundred thousand hours of use, an event which was marked by an appropriate celebration, after which it was formally retired. The PDP-11/45 was kept in the Department in recognition of its important role in teaching and research.

The proposal which enabled the PDP-11/45 to be purchased also contained a proposal for the establishment of a Microcomputer Laboratory with a microprogrammable computer. Persons involved in the proposal included Bill Adams, John Hauer, Barry Mailloux, Tony Marsland, Steve Sutphen who was then the graduate student representative on the Computer Committee, and John Tartar. This proposal developed out of a review of the undergraduate curriculum by Bill Adams prompted by a concern for employment prospects in Western Canada for graduates of computer science programs. The purpose of this laboratory was to introduce students to the different computer architectures that were becoming available. The scope of material to be covered in the laboratory might best be seen from the description in the 1974/75 Calendar of Computing Science 412, the primary course that was developed for it:

> CMPUT 412. *Introduction to Minicomputers*. *3 (either term, 3-3). Minicomputer characteristics and applications; logic design using current logic components; organizational structure of representative minicomputers; problems of short word lengths and small memories; timing and control of asynchronous I/O; applications in data communication and control; laboratory investigation of specific minicomputers. Prerequisite: Computing Science 315. Note: Intended for general students and for those who do not intend to pursue graduate studies.

The Minicomputer Laboratory was discontinued in the early 1980s when microcomputers became available and there was much less need to study differences in computer architecture. John Tartar's association with the Microcomputer Laboratory led to his participation in the formation of the ACM Special Interest Group on Minicomputers.

Late in 1975 Bill Adams and Keith Smillie took delivery of an IBM 5100 minicomputer for use in their research and teaching which involved APL. (The BASIC language was also available on this computer by throwing a switch.) The 5100 was a small computer by the standards of the day, measuring 17.5" by 24" by 8" and weighing forty-eight pounds. The cost including a printer was 18 300 dollars. It had an attached keyboard, a small screen allowing 16 lines of 64 characters, a memory of 16K bytes expandable to 64K bytes, a tape unit for permanent storage, and a communications adapter which allowed the output to be displayed on a television monitor. The system fitted conveniently on the top shelf of an audio-visual trolley with the printer on the bottom shelf. This system was used effectively for several years both in the classroom for teaching and in the office for course preparation and research. We might note that the IBM 5100 was followed by the IBM 5150 and IBM 5160 which were better known as the IBM PC and the IBM XT.

The last major minicomputer of the 1970s to be discussed here is the Nanodata QM-1. This machine, which was acquired in 1974 at a cost of just over 250 000 dollars, was developed at the University of Buffalo and was intended as a universal microprogrammable computer. The original intention was to use the computer to emulate each of several minicomputers so that programs developed on this computer could be run on the minicomputers. However, the emulators were never developed and the QM-1 was used for research purposes. The largest programming project was a PDP-11 emulator written by John Demco for his MSc thesis. Other projects arising from an architecture working group headed by Subrata Dasgupta included QM-C which was similar to a RISC computer and the S* language for describing parallel architectures. The QM-1 was retired in 1984, never having been used to its full capabilities, and still remains in the Department.

1971 to 1981 - 3. A Christmas party

In the early days of the Computing Centre and the Department parties were held at the home of Don and Betty Scott. At first everyone could gather together in the living room, either sitting on chairs or on the floor. When the living room became too small for the number of persons present, some would go downstairs to the family room, returning upstairs frequently since the refreshments were served there. However, as the Department grew, their house soon became too small, and parties had to be held elsewhere. Two popular places were the party rooms at Jeff and Gloria Sampson's condominium and Barry and Isobel Mailloux's apartment. As the years passed, memories of these larger and larger parties faded except that everyone could remember having a good time.

One Christmas party that is certainly still remembered by the participants took place in the mid 1970s at which the graduate students presented a play giving their version of a departmental meeting. As a copy of the script for this play still survives, we might give a few edited excerpts

from it as a diversion from the more serious aspects of this history and to show that computing science wasn't considered to be all serious work. In the excerpts which follows the cast, in order of appearance, was as follows:

Narrator	Nick Cercone
Sandy Otternothavedonit (Sandy Orthner)	Janet King
Gene Willing (Jean Wilson)	Glynis Dorey
King Awful (Arthur Wouk)	Garry Helander
Willie Kellogg (Kellogg Wilson)	Mark Johnson
Apl Adams (Bill Adams)	Jim Heifitz
Kelvin Simile (Keith Smillie)	Lorne Weinkauf
Boring Mailboxx (Barry Mailloux)	John Demco
Leonardo de Schue (Len Schubert)	Alan Benbow
Anthony Tony (Tony Marsland)	Ian McMaster

Two other members of the cast were Catherine Descheneau and Peabrain Sutphen.

And now for some excerpts from the play:

> Narrator A cold, cold Edmonton summer day. It's 35 degrees below zero, but sunny!! Enter the professors, scholars and the faculty members of the Department of Computing Science. Most of the faculty arrive bright and early, approximately 11:30 a.m., several hours after the bushy-tailed secretaries make the scene. Gene Willing, the librarian, and Sandy Otternothavedoneit have been having coffee for about two hours and are now making their way back to their desks in time to greet Dr. King Awful, the Head of the Department, as he arrives.
>
> Sandy Otternothavedonit (*in a very sugary voice*) Good morning Dr. Awful
>
> King Awful (*as he unwraps himself, removing the eight scarves, ten toques and twenty-three pairs of shorts*) Mumble, mumble, mumble.
>
> ...
>
> Gene Willing Oh, Dr. Awful, there were some more thefts from the Reading Room last night. This time they got *Lady Chatterly's Lover* and *Lassie Come Home*.
>
> King Awful Those scoundrels! Those cads! My favorite books.
>
> ...
>
> King Awful Have I got a deal for you. I have here in my hand one gross of Venus HB pencils. Remember that the pencil fund has been spent. Now I can let you have them at a reasonable price. Normally these fine pencils go for fifteen

cents a piece but for you I have a special deal.

Narrator At about this point the undeclared meeting gets under way and pencils seem to be the topic of primary importance. ...

King Awful We will now commence the meeting. Now I have several points that I want your agreement on. I should like to point out that all abstensions during voting will be assumed to be yeas, and all nays will be totally ignored.

...

Willie Kellogg ... Well, as I said before previously on other occasions, afferent interaction has frequently been criticized previously, see, for example, Hilgard (1948). Such criticism has usually been directed against the inadequacy of the postulate to deal with the complexity of perception, ...

...

Apl Adams Well Boring, why not write the report in APL, it's much more concise, and what's more it works in the now not in the to come (chuckle, chuckle, iota).

Kelvin Simile (*whisking his brow furtively*) Here here APL, I do believe you've got it (*breaking into song*) Yes, I do believe you got it, you've got it, you've got it. I do believe you've got it. (*APL joins in*) and the whole world knows. Yes, we do believe we've got it ... (*fading off into a vector*)

...

Boring Mailboxx Well, let's see now - oh yes - there's the *Algol 68 Report*, *Son of Algol 68 Report*, *New Improved Algol 68 Report*, *Limited Edition Algol 68 Report*, *I was a Frustrated Teenage Algol Procedure* and the *Algol 68 Report Revisted*.

King Well, you certainly have been busy lately, but how long can you continue this torrid pace?

Boring You can fool some of the people some of the time, and that's usually good enough.

...

Leonardo de Schue I have just a few submitted papers to the *Journal of Cognitive Psychology*, *International Journal on Artificial Intelligence*, *Journal of the Association for Computing Machinery*, *Information and Control*, *Chemical*

Reviews, *Scientific American*, *Aeronautical Engineering Journal*, *Pattern Recognition Journal*, and *National Geographic*.

King Good God man! Can't you specialize?

Leonardo But they're all the same article.

...

King ... Well, what about you, Anthony?

Anthony Tony (*rubbing his hands together briskly*) Yes, I have some. There's *Paging in a Hostile Environment*, *Chess on $100 a Day*, *The Black Queen and the White Bishop*, and *Stalking the Wild Blue-eyed Swedish Volvo*.

King Well, well, enough of that. Now then, it has come to my attention lately that nothing has come to my attention.

...

The 1980s - 1. People, organization and courses

Now let us return to the Department in the summer of 1981 just after John Tartar had resigned as Chairman and Wayne Jackson had been appointed Acting Chairman. There were not enough faculty to meet the increasing course enrolments, and there were inadequate resources to accommodate either the teaching or the research in the Department. The faculty and support staff were disheartened, and found little solace in the realization that many other computer science departments in Canadian and American universities were faring similarly.

During the summer Wayne Jackson prepared a report summarizing the situation that the Department was in and the resources that would be required for the Department to meet its commitments. The newly appointed Dean of Science, W. John McDonald, then appointed an ad hoc committee to expand this report into a detailed proposal to be sent to the Planning and Priorities Committee. The committee consisted of Robert J. Crawford of the Department of Chemistry as Chairman, Wayne Davis and Wayne Jackson of the Department of Computing Science, and Donald Fenna of the Department of Applied Sciences in the Faculty of Medicine. During the following year the committee interviewed all members of the Department and many other persons in the University, examined enrolments in previous years and made projections for the following few years, and estimated the faculty, staff and equipment necessary to meet the demands resulting from the increasing numbers of undergraduate and graduate students and a rapidly expanding technology.

In December 1981 the committee had produced a report of well over one hundred pages entitled "Expansion of the Department of Computing Science". (The cover showed a graph of total weekly student hours per term per faculty member for the years from 1970 to 1981 for each

of Computing Science, the Faculty of Science and the University. As might be expected this graph showed an almost exponential increase for Computing Science over the last part of the range whereas the hours for the Faculty and the University declined over parts of the period except for a slight increase for the last year.) The main recommendation was for a substantial expansion in resources for the Department. The report may appear in retrospect to be excessively long and even rather pretentious. However, it was written in response to a crisis faced by a discouraged and overworked faculty, and it did produce immediate results. The Dean gave first priority to the Department in the Faculty of Science, and later in the 1981/82 year the Planning and Priorities Committee gave the Department first priority in the University.

Wayne Jackson left the University in June 1982 to join Athabasca University, and Wayne Davis was appointed Acting Chairman on July 1 until a new Chairman could be appointed. The situation in the Department continued to worsen, and, at the end of the 1981/82 academic year, all four faculty who had joined the Department in 1980 left. Although three new faculty were recruited the same year, only one, William W. Armstrong, was a senior full-time faculty member. (The other two were Jeffry Pelletier who had a joint appointment with the Department of Philosopy, and Daniel Boulet who was hired as an Lecturer, the only person of that rank that the Department has ever hired.) In 1982 the position of Administrative Professional Officer was established again and was filled first by Arnold Adam. Wayne Davis continued as Acting Chairman until March 1, 1983 when Lee J. White who was Chairman of Computer and Information Science at Ohio State University in Columbus, Ohio became Chairman. Therefore, at the end of February, 1983 for the third time in less than two years the faculty and staff of the Department gathered together to say goodbye to their Chairman or Acting Chairman and to welcome the new Chairman.

Lee White continued, and even intensified, the vigorous recruiting program that had begun under Wayne Jackson and Wayne Davis and which had been made possible by the support from the Faculty of Science and the University. Soon new faculty were being attracted to the Department, with four including Lee White coming in 1983, five in 1984, three in 1985, and seven in 1986. By 1989 there were sixteen Assistant Professors, seven Associate Professors and eight Professors in the Department. In addition, with the appointment of Alynn Klassen in 1986 and Catherine Descheneau in 1987 there was a total of three Faculty Service Officers.

In May 1983 a two-day retreat was held at the Westridge Park Lodge in Devon. Assisted by a "professional organizer" from Toronto, the Department was able to spend two complete days discussing past problems and planning for the future. (One memorable incident during this retreat occurred when some one, possibly a student and certainly a man disguised as a women, burst into the room, rushed over to Arthur Wouk, sat on his knee, and told him what a wonderful person he was.) Since then retreats have been held annually, usually in May after term is over. In 1984 the retreat was held at the Providence Renewal Centre, and in each of the following two years a retreat was held at the Mayfield Inn. Now they are more modest and inexpensive gatherings of one-day duration, and are held at Lister Hall. They have become a very important means of establishing goals and providing some togetherness in a rapidly expanding Department.

Lee White encouraged the establishment of research groups within the Department as one

method of promoting cooperation amongst persons with similar interests. These groups were Artificial Intelligence, Database Systems, Distributed Systems, Graphics, Programming Languages and Methodologies, Robotics, and VLSI and Graphics. The most obvious manifestations of their existence are large signs on the doors of the respective laboratories. They have been very useful in keeping together faculty and students. (We might ask, parenthetically, whether the Department should form a research group complete with sign and laboratory of all those persons who are not members of a research group, and, if it did, what logical precedence there would be for such a group.)

During the summer of 1982 the newly renovated Assiniboia Hall was opened, and a few members of the Department moved from the General Services Building to the north end of the third floor. Within a year or so the Department was occupying all of the third floor except for the south end which was occupied by Pensions and Benefits Administration. The space was taken up by over a dozen faculty and Sessional Lecturers, one secretary, and a few graduate students together with two research laboratories and one conference room. In 1984 more space was found in the southeast corner of the fourth floor of the Central Academic Building for a few members of the support staff and some graduate students. By the late 1980s, then, the Department was occupying all of the sixth floor of the General Services Building, most of the third floor of Assiniboia Hall, and a dozen or so offices on the fourth floor of the Central Academic Building. In addition, a few graduate students were accommodated in the Printing Services Building. This dispersal of staff created serious problems in communication and even some problems in morale. These problems were alleviated somewhat by the increased use of electronic mail which provided an efficient means of keeping in touch on day-to-day matters. Occasionally persons would give vent to their frustations by sending long messages to their colleagues. At times the volume of mail would be increased by the users of UNIX replying to a message with "r" which sent the reply to all of the recipients of the original message instead of with "R" which sent it only to the originator. This confusion continues to the present time.

During the 1980s enrolment in courses in the Department continued to increase. Computer science becoming increasing popular as a discipline, and the development of the personal computer in the early 1980s was making computer literacy the current educational fad. Primary and secondary schools were coming under pressure from parents, school boards, provincial governments and the students themselves to establish courses in computer literacy. Many of these courses would amount to little more than some BASIC programming taught by poorly prepared teachers only too aware of their own lack of competence in the face of modern technology. The rush to computer literacy caused a dramatic increase in the enrolments in CMPUT 261 and CMPUT 262 which in the late 1970s and early 1980s had enjoyed considerable success and modest enrolments as courses emphasizing the cultural and historical aspects of computer science for students in the Faculties of Arts and Education. In the mid 1980s these courses were converted to computer literacy courses with texts chosen from the multitude of large and glossy computer literacy texts that were flooding the market and with assignments done in the Macintosh labs which were opened in the Central Academic Building in 1984. To meet the need for instructional staff Lee White hired a large number of Sessional Lecturers who took over much of the work in the introductory courses including often their coordination and the selection of software. During the first term of the 1985/86 academic year there was a total of

thirty-two such staff. Whatever may be thought of part-time staff having so much involvement in junior courses, the Department must be grateful to these persons for their devoted service.

As the number of students in the introductory courses increased, so did the amount of work required to provide laboratory support for them. This work included the selection and training of Teaching Assistants, organization and supervision of laboratories, assistance with the preparation of assignments and laboratory materials, and assessment of future hardware and software requirements. Much of this work had been coordinated informally for many years by Bill Adams, but it was becoming apparent to some persons in the Department that a full-time staff was required. In July 1987 an Instructional Support Group was formed and Catherine Descheneau was appointed a Faculty Service Officer to be in charge of this group. Catherine had obtained all of her degrees in the Department, the last being a PhD under the supervision of Jeffrey Sampson, and had previously been a Sessional Lecturer in the Department. The Instructional Support Group has continued to provide an invaluable service and has made a significant contribution to the quality of instruction in many courses.

The undergraduate curriculum, which had changed very little during the 1970s, was considerably revised during the 1980s. Not only did the new faculty who came during this period introduce courses in their own specialties, but the Curriculum Committee was influenced by computer science programs in Canadian and American universities and the curricula developed by the Association for Computing Machinery and the Institute for Electrical and Electronics Engineers. By the end of the decade the curriculum covered the following areas: analysis of algorithms, artificial intelligence, compiler construction, computer graphics, computer organization, data base management, data structures, discrete mathematics and logic, file management, image processing, introductory programming, logical design, numerical methods, programming languages, simulation, switching theory, systems programming, and telecommunications. In addition, students graduating with the BSc degree were expected to have a good background in mathematics, statistics and physics.

Enrolment in the Honors and Specialization programs increased rapidly in the early 1980s. In the 1980/81 year about one hundred and eighty students were admitted to the program. In 1983/84 almost three hundred and fifty students were admitted. As a result in 1984 a limit was imposed of one hundred and ten students a year entering the program in the second year. Since then, about one hundred students have entered the program each year, and, beginning in the 1987/88 year, about fifty have graduated each year. As enrolments continued to increase also in the service courses given by the Department for students in other Faculties, limits had to be placed on the enrolments in these courses beginning in the 1988/89 year.

For many years the Specialization Program consisted of four main areas, referred to as streams. These were Computer Design, Business Applications, Scientific Applications, and Software Design. Students graduating in the program had the area of specialization shown on their diplomas. However, in 1987 the accreditation study of the Honors and Specialization programs by the Canadian Information Processing Society suggested that these streams imposed too great a constraint on students' programs. On the recommendation of the Curriculum Committee the Department decided to abolish the streams and relax some of the requirements

and give the students more flexibility in the selection of courses.

In order to give some stability both to the content of introductory and second-year courses and also to teaching assignments to faculty, the Curriculum Committee instituted a policy in the late 1980s that texts and laboratory assignments would remain stable over a four-year period and that each faculty member would attempt to build up a selection of five courses which he or she felt comfortable to give. The effects of this policy should be seen in the early 1990s.

As the Department began to recruit more staff, the amount of administrative work increased. To handle some of the academic aspects of this work Bill Adams was appointed Associate Chairman in July 1987. His main responsibilities were the undergraduate program and the newly formed Instructional Support Group, two duties for which he was very well-qualified because of his extensive experience in teaching introductory courses and organizing the associated laboratories.

It is a pleasure to record that Tony Marsland was the recipient of a McCalla Professorship for the 1985/86 academic year. These professorships were named in honour of Dr. A. G. McCalla, the first Dean of Graduate Studies, and came from the sale of University farm lands to the provincial government in 1980. They enable the recipients to devote a year to uninterrupted research. Tony spent the year continuing his research and writing on distributed computing.

One event in the 1980s that must be recorded is the Department's first retirement. On April 28, 1988 over two dozen persons gathered at the New Dragon Restaurant on Whyte Avenue to say goodbye to Kellogg Wilson. After a very large meal, undoubtedly a source of much pleasure to the guest of honour, Kelly's colleagues were able to reminisce - with varying degrees of accuracy - on his twenty-three years of service to the University and to wish him and his wife, Kay, their very best wishes for the future. (We might note that one of the best descriptions of Kelly had been given many years previously by a Dean of Science, who, when introducing Kelly at a meeting of the Science Dining Club, had remarked that "Kelly cut an interesting figure on the campus.")

Lee White's term as Chairman was marked by the recruitment of over a dozen new faculty, improved laboratory facilities for teaching and research, more technical support staff, and the beginning of more formal associations with local business and industry. During the 1987/88 academic year, the last year of his five-year term as Chairman, the Dean of Science set up a Selection Committee to select a new Chairman. Lee, who was one of three candidates and the only one to receive strong support from the Department, was offered a second term as Chairman. He declined, however, and, having been honoured by the Department at a wine-and-cheese party, went to Cleveland, Ohio to become Chairman of the Department of Computer Science and Engineering at Case Western Reserve University.

The Department, then, had to pick once again an Acting Chairman. Bill Adams was unavailable as he had just given up the Associate Chairmanship to take a well-deserved study leave. Others in the Department were suggested for the position but declined. The Dean, undoubtedly after much deliberation, selected Bob Crawford who had also just been appointed

Associate Dean (Research) in the Faculty of Science. Bob, although of course not a computer scientist, was no newcomer to either administration or to the Department. He was a former Chairman of the Department of Chemistry, had been on numerous University committees, and had been a member the committee established in 1981 to make recommendations for the Department of Computing Science. Thus, Bob Crawford became the third Acting Chairman in seven years. One of his first acts was to appoint Ursula Maydell as Associate Chairman.

The summer of 1988 was one of change and even some uncertainity. In addition to having a new Acting Chairman, the Department was planning to move its staff from Assiniboia Hall to the General Services Building. It had been hoped at first to obtain sufficient space to consolidate the whole Department, but unfortunately the Instructional Support Group had to remain in the Central Academic Building. At the end of the summer and as first term was beginning the move was made even though the renovations were still in progress and the new offices were only sparsely furnished. By the end of November, though, the move was complete, and the Department was occupying comfortably furnished offices on all of the sixth floor, and about one-half of the seventh floor and one-quarter of the eighth floor.

During the 1988/89 year a Selection Committee was again formed and the search for a Chairman was resumed once again. By March the Department had selected Paul G. Sorenson from the University of Saskatchewan for a five-year term as Chairman. Paul was no newcomer to the University of Alberta having received a BSc from the Department of Mathematics in 1967 and an MSc from the Department of Computing Science in 1969. After receiving a PhD from the University of Toronto, he joined the Department of Computational Science at the University of Saskatchewan. So during the long, sunny days at the end of June the Department said goodbye to Bob Crawford at a number of farewell receptions, and settled down to await the arrival of the new Chairman.

The 1980s - 2. Hardware and software

At the beginning of the 1980s the mainframe computer in the Department of Computing Services was used in many courses and for much of the research in the Department. In some of the courses this facility was used throughout the decade. For example, CMPUT 214 and CMPUT 215 used whatever version of Pascal was currently available and CMPUT 351 used FORTRAN. In addition, the Departmental computers acquired in the 1970s were used in a number of courses. Increasing use was made of electronic mail using MTS on the mainframe and UNIX on the Departmental computers. However, the most significant developments in computing style during this period were the installation and use of new computers in the computing laboratories in the Department and the use of personal computers in faculty and staff offices and in many of the courses in the Department.

In 1980 the PDP-11/45 and PDP-11/60 computers were being used an increasing amount in the Department. Their limited storage capacities and sixteen-bit word length were presenting serious problems. In December a purchase order was issued for a Digital Equipment Corporation VAX 11/780 before the necessary funds, almost half a million dollars, were available. Unfortunately, an application to NSERC for a capital equipment grant was turned down, and the

Faculty of Science capital grant was only one hundred thousand dollars. Therefore, John Tartar decided to commit the Department's portion of the funds from the capital budget of the new Computer Engineering program for this purpose. As a result the first VAX 11/780 arrived in September 1981. As might be expected this decision created some problems in the relations between Computing Science on the one hand and Electrical Engineering and the Dean of Engineering on the other. Wayne Jackson, who had just succeeded John Tartar as Acting Chairman, had to use a considerable amount of diplomacy and resolution to keep the computer in the Department.

The VAX 11/780 had a speed of about one million instructions per second (MIPS), and had about ten megabytes of main storage and one gigabyte of disk storage. A total of four VAX 11/780 computers were acquired. Each was given a name relating to some place in northern Alberta. The first one discussed in the previous paragraph was named Pembina. The remaining three VAX 11/780 computers were acquired in a simpler and less controversial manner than was the first one. Cadomin was acquired in 1982 from a Faculty of Science grant that was intended for equipment to relieve the load placed on the PDP-11/60 by a graphics course. Cavell and Jasper, as well as a VAX 11/730 which was named Miette, were obtained through a rather complex scheme involving a donation from Digital Equipment Corporation, a matching grant from the Alberta Endowment Fund for the Eighties, and departmental funds.

In 1982 Tony Marsland obtained a small amount of money to investigate the use of workstations that were just becoming available. In May a purchase order was issued to Sun Microsystems, a company that had just been formed a few months previously, for two Sun-1 workstations. They arrived in August and had the serial numbers 65 and 66. These were the second and third workstations in Canada, the first being at Athabasca University. Also in 1982 the first part of the Ethernet network was installed. A Sun-1 was used to develop a terminal server, called Ethertip, for the network.

In 1987 a lab of twenty Sun 3/50 workstations was installed by University Computing Systems. In addition a MIPS M/1000 was installed as a CPU server in the Department. This computer had a speed of about ten million instructions per second, thirty-two megabytes of main storage and one gigabyte of disk storage. In 1989 the Sun 3/50s were replaced by Sun 3/80s.

The printing of high-quality output has always been important in the Department. For some years many persons used the FMT and TEXTFORM wordprocessors on the mainframe computer in the Department of Computing Services and some continued to do so during the 1980s, but these systems, especially the latter, proved to be expensive and cumbersome to use, and lacked many of the symbols required for mathematical work. In order to improve the printing facilities within the Department an Imagen laser printer, one of the first in Canada, was obtained in 1982. Coincidentally, the purchase of this printer resulted in the purchase of the first Sun workstation since the Sun-1 CPU card was used in the printer. Shortly after the Imagen printer and the first Sun workstations arrived, Steve Sutphen wrote a preview package which allowed the Imagen output to be previewed on the Sun. When some of the Department moved to Assiniboia Hall, an AppleTalk network with an Apple LaserWriter was set up to accommodate the printing needs there.

IBM announced their IBM Personal Computer in 1981. The first microcomputer laboratory was installed by the Department of Computing Services in October 1982 in General Services Building 564. The equipment consisted of twelve IBM PCs with monochrome monitors and six printers, one for each two machines. In 1984 another laboratory with twenty-eight PCs with monochrome monitors and printers was opened in the Chemical-Mineral Engineering Building. The Macintosh was announced in 1984, and in the same year four Macintosh labs were opened, three in the Central Academic Building and one in the Business Building. These installations were made possible through a consortium arrangement with Apple Computer Limited and the cooperation of the Department of Computing Science. The three labs in the Central Academic Building each had twenty-four 128K Macintoshes with twelve ImageWriter printers, and the lab in Business had twenty-eight 128K Macintoshes with external drives and twelve ImageWriters. By the end of 1989 there were microcomputer labs in the University located in Business, Central Academic, Chemical-Mineral Engineering, Civil-Electrical Engineering, Clinical Sciences, Education, Faculté St-Jean, Fine Arts, General Services, Health Sciences, Law, and Mechanical Engineering.

The Department has made use of the Macintosh labs in the Central Academic Building for CMPUT 261 and 262 using QuickBASIC, Microsoft Works and MacDraw, CMPUT 325 using MacMeth which is a Modula-2 package, and CMPUT 380 and 385 using Logic Simulator which had been developed in the Department. In addition CMPUT 357 uses the Macintosh laboratory in the Business Building using LightSpeed Pascal, MacWrite, MacPaint and Excel.

The Department soon became involved in the use of microcomputers for all aspects of teaching and research. Almost every member of the academic staff acquired a Macintosh or a workstation, or both. (One of the few holdouts was Keith Smillie who steadfastly refused to have a Macintosh, maintaining that some of his work could only be done on an IBM PC or a compatible and that all of his colleagues outside of the Department used PCs.) The mainframe computers, both the Amdahl in University Computing Systems and the departmental computers, may be accessed using either MacTie with the Macintosh or PCTie with the IBM PC. Members of the support staff began to use Macintoshes for their work, although some of the Departmental records were kept on an IBM PC. Two AppleTalk networks were established for the Macintoshes, one in General Services Buiding and the other in Assiniboia Hall which were connected by a fibre optic link. Thus each Macintosh user could have access to laser printers as well as a personal ImageWriter. The use of microcomputers in the Department has made radical changes in the work of all of its members. Most faculty produce their own course material, papers and technical reports, and correspondence, and also keep their own records using microcomputers. With the use of laser printers manuscripts of camera-ready quality may be prepared. As the quality of the software keeps improving and the speed and capacity of the hardware keeps increasing, there seems to be no limit to the tasks that may be accomplished.

The 1980s - 3. Cooperative programs

During the 1980s the Department collaborated with other departments and faculties to set up joint programs. It also entered into agreements with research organizations in the People's

Republic of China and in the Soviet Union. We shall discuss briefly these cooperative ventures in this section.

In 1980 a Computer Engineering program intended as a joint program between the Department of Computing Science and the Department of Electrical Engineering was established. Support was obtained from the provincial government for five academic and four supporting positions as well as for capital and operating costs. The purpose of the program was to provide students with a good background in software topics such as programming languages, data structures and file management and also hardware topics such as electronics, digital logic and microprocessors. Initially the joint administration of the program by Computing Science and Engineering was not successful, and the program was administered by an ad hoc Computer Engineering Committee. In about 1985 the administration was shared by a formal arrangement between the two departments. Since its inception, the program has been very successful and has attracted a large number of students. It was accredited by the Canadian Council of Professional Engineers in 1983.

A Specialization program in Geo-Information Processing and Mapping to be conducted jointly with the Department of Geography was set up in 1985. The purpose was to give students an expertise in the application of computer science to cartography together with the necessary background in mathematics, statistics and geography. The brochure describing the program, entitled "from SUMER ... to SOFTWARE", listed, in addition to the courses required and academic standards and administrative details, the following academic staff: Bill Armstrong, Wayne Davis and Mark Green from Computing Science, and Jean-Claude Muller and Lillian Wonders from Geography. Two new faculty members, one an Associate Professor and the other an Assistant Professor, were recruited by Geography to work in this program. Unfortunately, the number of students enrolling in the program was small. Neither department had adequate resources to provide the necessary computing facilities. There was disagreement between the two departments on the core courses that should be required with Geography maintaining that some of the computing courses were inappropriate. Finally, Jean-Claude Muller who was the senior person in Geography actively involved in the program left the University. Therefore, during the 1988/89 academic year the program was terminated by mutual agreement of the two departments.

In the early 1980s Wayne Davis together with Terry Caelli of the Department of Psychology organized a series of monthly seminars in the areas of image processing and computer vision. After these seminars had been held for about two years, they decided that a more formal arrangement would bring this work to the attention of a larger audience. Therefore, a draft proposal was submitted to the Dean of Science and the Vice-President (Research) who encouraged them to expand the scope of their proposal. While there were persons with similar interests in the Faculty of Engineering, the most encouraging response came from the Department of Computing Science. Eventually a revised proposal was submitted to the University which resulted in the creation in April 1986 of the Alberta Centre for Machine Intelligence and Robotics (ACMIR) with Terry Caelli as Director. Its purpose was to promote research and development in the areas of computer vision, intelligent systems, robotics and control, and integrated manufacturing. A number of technical reports were prepared and

seminars given by university and industry representatives. A proposal for funding was prepared for the provincial government which unfortunately rejected it. Shortly after this Terry Caelli went to Queen's University, Wayne Davis was appointed Acting Director effective January 1988, and all the Centre's files were transferred from Psychology to Computing Science. Then Len Schubert left the Department for the University of Rochester. In September 1988 Computing Science withdrew its secretarial support and a part-time secretary was hired. Finally in December 1989 Wayne Davis resigned as Acting Director, and the Centre became inactive. Now about the only visible reminder of ACMIR are two elegant metallic plaques, one on Wayne Davis's door and the other on the door of the former secretary's office, with the following inscription:

alberta centre
for
machine intelligence and robotics

There has been considerable planning between the Department of Computing Science and the Faculty of Business to establish a program in Management Information Systems. In 1985 a joint proposal was prepared to substantially upgrade the very limited work in this area in the Department and in the Faculty. This proposal would have strengthened the undergraduate programs in Business and in Computing Science, the graduate MBA/MPM program, and the graduate program in Computing Science. This program was approved by the Board of Governors, subject to appropriate funding, in December 1986. Unfortunately, adequate funding has not been readily available and the programs have not been implemented. Another proposal was prepared in 1989 that called for funding from both the federal government and private industry for the establishment of Industrial Research Chairs in Management and Technology and in Information Systems. Work towards the establishment of these proposals continue in both the Department of Computing Science and the Faculty of Business.

The University of Alberta has had for several years a cooperative program, known as the Black Dragon River Consortium, with Heilongjiang Province in the People's Republic of China. In addition the Department has worked with the Department of Computer and Information Science of the Harbin Shipbuilding Engineering Institute. One of the main participants in this program has been Wayne Davis who has made several visits to Harbin, the first being in 1981. Near the end of 1987 a formal agreement was signed between this department and the Department of Computing Science. The purpose was to provide for a better cooperation and exchange of information between the two departments, to allow Chinese students to study at the University of Alberta, and to encourage reciprocal visits of faculty. Mark Green, Ursula Maydell, Steve Sutphen, John Tartar and Lee White have also visited Harbin.

In 1988 an agreement was reached between the University of Alberta and the All-Union Research Institute for Systems Studies of the USSR Academy of Sciences for a four-year cooperative program in artificial intelligence and data bases. The main areas of research are heuristic methods of search, hierarchical data bases, and knowledge representation. Bill Armstrong, Tony Marsland, Tamer Özsu and Johnathan Schaeffer have already visited Moscow as part of this agreement. One of the Russian visitors to the Department has been G. M. Adel'son-Vel'skii, one of two persons for whom AVL trees were named.

Supporting staff

This history has been concerned almost exclusively with academic staff, students, computer hardware and software, and departmental organization. Only rarely has the presence of others - secretaries, technicians, programmers, and analysts - even been mentioned. It is time, then, to acknowledge the very great contributions made by these people and the services they provide.

When the Computing Centre was formed, support was provided by a number of students working part-time during the academic year and full-time during the summer. Two of these persons, Bill Adams and Ursula Maydell, are still members of the Department, and Bill is a former Associate Chairman and Ursula is currently Associate Chairman. Don Scott, the first Director of the Computing Centre, of course had his own secretary. In September 1962 Alan Heyworth was hired to supervise the closed-shop operation of the Centre. As the computing facilities increased, the size of the supporting staff increased. However, when the Computing Centre separated from the Department in 1969, most of the support staff, and all of the computing equipment, went to the new Department of Computing Services. Thus the Department of Computing Science had to build up an almost entirely new staff to support its teaching and research.

One activity that was not affected by the formation of Computing Services was the Computing Science Reading Room which was established in 1968. (It is interesting to note the following remarks in the minutes of the meeting of the Library Committee when authorization for the Reading Room was given: "It must be clear that this arrangement is only temporary. When the Department of Computing Science moves back to the Physical Sciences Complex, the collection will again become part of the Physical Sciences library.") Its original purpose was to provide a laboratory for teaching and research in automated methods of information storage and retrieval for Doreen Heaps and her students. The Reading Room staff came under the departmental budget and supervision. After Doreen and her husband left the Department in 1973, the Reading Room served as a conventional library. In 1977 the Reading Room was expanded and the card catalogue for the collection was transferred from the Physical Sciences Library to the Reading Room. In January 1984 the administration of the Reading Room was returned to the University Libraries and it became part of the Science and Technology Library. The Reading Room has always played an important role in the teaching and research of the Department, and the support provided by its staff has been greatly appreciated.

There have been many changes in the organization of the supporting staff caused by the growth of the Department and the desire to provide an efficient service in a congenial atmosphere. Steve Sutphen was appointed the first Faculty Service Officer in 1976. There are now three FSOs. For some years the departmental secretary with a staff of two or three clerk-typists handled most of the office duties. The Administrative Professional Officer and the Administrative Assistant, positions now held by Brian Pinchbeck and Ollie Frost, respectively, are essential to the efficient functioning of the Department. The office staff now consists of an Executive Secretary, Administrative Professional Officer, Receptionist, Bookkeeper, and an Undergraduate Secretary and a Graduate Secretary with a Receptionist.

One important development in the Department was the establishment in 1987 of the Instructional Support Staff headed by Catherine Descheneau. This group of about a dozen persons, most of whom are graduates of the Department, supplemented during the academic year by a large number of Teaching Assistants and Markers, have provided a service of immeasurable value in support of courses and the associated laboratories in the Department.

All of the persons and groups referred to above provide a large number of services without which the Department could not exist. Moreover, their presence contributes very much to the cheerful atmosphere which makes working in the Department such a pleasure.

Canadian Information Processing Society

The Department has always taken an active part in the Canadian Information Processing Society. In the late 1960s Keith Smillie was on the Editorial Board of the *Quarterly Bulletin of the Computer Society of Canada*, as the Society and its publication were then called. (It might be noted in passing that the Editor-in-Chief at the time was Beatrix Worsley, then at Queen's University, who had received the world's first PhD in computer science at Cambridge. She has been mentioned earlier in this history in connection with the FERUT computer at the University of Toronto.) Other members of the Department who contributed to the Society in the late 1960s and early 1970s were Barry Mailloux, Ursula Maydell, and Don Scott who was one of the initiators of the 1973 National Conference which was held in Edmonton. Both Tony Marsland and Lee White served on the Executive of the Edmonton Chapter. Presently Paul Sorenson is a member of the Accreditation Council. For many years the local chapter of the Society has held its meetings at the Faculty Club.

The one person in the Department who has contributed most to the Society has been Wayne Davis. He was on the local Executive for three years in the early 1970s and was then on the National Board becoming First Vice-President in 1977 and President in 1978. He has been on the organizing committees of several local and national conferences and was also at one time Chairman of the Accreditation Council. He is now a member of the Certification Council.

Several conferences of the Society have been held in Edmonton. The 1978 National Conference was held in Edmonton; Dale Bent, Director of the Department of Computing Services, was Chairman, and Wayne Davis was Program Chairman. Many members of the Department contributed to the 1984 National Conference in Calgary, and Wayne Davis was again Program Chairman. Local conferences were held in Edmonton in 1986, 1987 and 1988, with Wayne Davis, Tamer Özsu and Ursula Maydell as the respective Program Chairmen. The 1989 National Conference was held in Edmonton with Wayne Davis as Program Co-chairman. The World Computer Chess Championship which was sponsered by CIPS and Alberta Government Telephones was organized by Jonathan Schaeffer and Tony Marsland. Jonathan's program, Phoenix, was in the top ten programs competing.

The Canadian Information Processing Society has given several awards to students in the Department. These are the Donald B. Scott Memorial Prize which has been awarded since 1976,

and the Computing Science Award and the CIPS Scholarship which have been given since 1988. Profits from local conferences have helped support these awards since 1986.

In 1988 both the Honors and Specialization programs in the Department were accredited by the Society.

In memorium

It is with regret that we record the deaths of three faculty while they were members of the Department: I-Ngo Chen on September 17, 1981, Barry Mailloux on May 26, 1982, and Jeffrey Sampson on May 26, 1985. I-Ngo Chen was known for his research in probabalistic automata, computer architecture and parallel processing, for his many papers and technical reports, and as a prominent member of the Chinese community in Edmonton. Barry Mailloux was a leading proponent of ALGOL 68, a language he worked on as a graduate student at the Mathematisch Centrum in Amsterdam, and published many papers and technical reports in this area. Jeffrey Sampson was very active in teaching, research and administration in the Department, published many papers in a variety of areas, and was the author of two texts on adaptive systems. I-Ngo, Barry and Jeff all made significant contributions to the teaching, research and life of the Department, and they are missed as colleagues and friends.

We already noted the death of Don Scott in 1975 after he had left the Department. Bill McMinn who left the Department in 1966 and the University in 1972 died in Toronto in 1983. K.-V. Leung died in Montreal a few years after he left the Department in 1973.

Retrospect and prospect

The twenty-five years during which the Department of Computing Science has been in existence have been ones of great change. The Department began in 1964 with an academic staff of five. In 1989 there were thirty academic staff and approximately the same number of supporting staff. Computing technology has changed beyond all recognition. The IBM 7040 which was installed during the summer of 1964 at a cost of about two hundred and forty thousand dollars had a cycle time of eight milliseconds and a speed of about sixteen thousand instructions per second. Twenty-five years later the Macintosh II costs about eight thousand dollars, has a cycle time of forty nanoseconds and a speed of about five million instructions per second. Comparisons with the LGP-30 which was produced six or seven years prior to the IBM 7040 are even more impressive. It cost forty thousand dollars, had a cycle time of 4.7 milliseconds and a speed of two hundred instructions per second. A single LGP-30 could have been accommodated in a faculty office with sufficient room left for a desk and chair and a few bookshelves. Now every faculty member has at least one microcomputer or workstation on his or her desk.

In 1964 the University of Alberta had just over 9 000 full-time students and 637 faculty. In 1989 there were approximately 25 000 full-time students and 1 500 faculty. The administration of the University has changed too during the same period. In 1964 there were the President, Walter H. Johns, and a Vice-President. Now there are the President, five Vice-Presidents and

several Associate Vice-Presidents. There have also been fundamental changes in the nature of the University of Alberta in the past twenty-five years. The University has changed from what might have been termed a "liberal arts college with professional schools" to one of the nation's largest universities in which research is pre-eminent. Teaching, at the junior levels at least, is often of secondary importance in spite of public pronouncements to the contrary and the concern of many faculty. However, discussions of the relative importance of teaching and research are scarcely new at this University. We might note, as one example, Dr. Johns's remarks at the opening of Red Deer Junior College in 1964, coincidentally the year the Department of Computing Science was formed:

> The universities today are havens for free inquiry - and so they should remain - but they should also be centres of teaching as well as of learning. There is a way of academic life epitomized in the phrase "publish or perish" for the academic world which requires that each person in the modern college must perforce add his own share of the contributions to the mountains of information that already reach the height of Mount Everest and are growing larger every minute. Is there to be no place for the scholar or the scientist who might wish to study this vast pile of ore to find the precious metal in it? Is there to be no place for the person who considers it is his task to pass on to the students in his classroom the results of this enormous activity for their use and comfort?

Another change during the last twenty-five years is the perceived role of education in society. Education, especially in science and technology, is now considered a means of making Canada competitive in the world's markets. Seldom do we read that the sciences (even computer science) are disciplines that might be studied for their own sake, and that there might be a purpose to education other than economic well-being.

What will become of the Department of Computing Science during its second twenty-five years? Certainly the very real excitement of working at the "outer limits", to use the phrase appearing in the quotation from Michael Williams's work at the beginning of this history, of a rapidly expanding technology will continue. Computers will continue to become smaller and faster, and their efficiency as judged by some measure such as cost per thousands of instructions per second will increase. Software will become more sophisticated and simpler to use, and some of the manuals accompanying the software might even be readable. We shall continue to embrace the latest technology, occasionally, if our experience with microcomputers and computer literacy in the last decade is typical, with more enthusiasm than understanding. We may even have the satisfaction of seeing our discipline mature and become a science in fact as well as in name.

As we go about our daily work, we might keep in mind that the Department of Computing Science is only a very small part of a very large university. As we continue to work with, and contribute to, the latest developments in the science and technology of computing, we should never forget that the chief aim of a university is, to quote Dr. Johns again, "to enoble the individual man and woman and to improve society".

Acknowledgements

One very valuable record of the development of computing at the University of Alberta has been compiled by Henry Ewasechko who joined the Computing Centre in 1966, became Manager of Operations in 1970 and was appointed Associate Director of the Networking and Computing Center Operations Division in 1988. During his career at the University Henry assembled eight large albums of photographs, clippings and other documents relating to all aspects of computing as he watched it develop, and, indeed, contributed to its development. Four of the albums are entitled *History* and deal with the period from 1957 to 1982, three entitled *Data Communications Group* continue the account to the end of 1987, and the other is entitled *Plato System History*. In addition to these eight albums there is a binder of approximately one hundred and eighty 35-millimetre slides. This material gives a remarkably complete account of the development of the central computing facilities at the University of Alberta and deserves to be preserved in the University Archives. The first album contains a copy of a twelve-page *Computing Centre History* written by John Stasiuk who joined the Computing Centre in 1963.

It is a pleasure to acknowledge also the assistance of the following persons: Bill Adams, Sharon Barrett, Bev Bayda, Wayne Davis, Edith Drummond, Ollie Frost, Ursula Maydell, Steve Sutphen and Amanda Wadsworth of the Department of Computing Science; George Ball of the Department of Entomology; Jim Robertson of the Department of Soil Science; Fenton MacHardy, Professor Emeritus of Agricultural Engineering; Olga Kolar of University Computing Systems; Trude McLaren of University Archives and Collections; and Don Betts of the Department of Physics, Dalhousie University. Most of the data on the use of microcomputers have been taken from *Dispatch*, vol. 2, no, 4, March/April 1990 published by University Computing Systems. Data on faculty appointments and numbers of courses were taken from University Calendars which were consulted in the Office of the Faculty of Agriculture. Some of the information on deceased faculty came from past issues of *Folio* provided by the Office of Public Affairs. The quotations from Dr. Johns in the previous section have been taken from *Those Tumultuous Years. The Goals of the President of the University of Alberta during the Decade of the 1960s* by Duncan D. Campbell (The University of Alberta, 1977).

> "So there it is", said Pooh, when he had sung this to himself three times "It's come different from what I thought it would, but it's come. Now I must go and sing it to Piglet."
>
> A. A. Milne, *The House at Pooh Corner*

Appendix 1

Full-time academic staff

1962-1971	Donald B. Scott
1962-1967	Robert S. Julius
1962	William S. Adams
1962-1966	William B. McMinn
1963	Keith W. Smillie
1965	Ursula M. Maydell
1965-1988	Kellogg V. Wilson
1965-1966	Frank Stenger
1966-1970	Srisakdi Charmonman
1967-1973	Doreen M. Heaps
1967-1973	H. Stanley Heaps
1967-1972	John P. Penny
1967-1970	Gordon H. Syms
1968-1981	I-Ngo Chen
1968-1977	John F. Hauer
1968-1982	Barry J. Mailloux
1968-1970	William J. Meyers
1968-1969	Richard Peddicord
1968-1985	Jeffrey R. Sampson
1969	Wayne A. Davis
1969-1983	L. Wayne Jackson
1969	John Tartar
1970-1973	Kon-Vinh Leung
1970	T. Anthony Marsland
1970-1972	Eric N. West
1971	Stanley Cabay
1972-1983	Arthur Wouk
1973-1989	Lenhart K. Schubert
1973-1980	Clement T. Yu
1976-1985	Francis Y. Chin
1980-1982	Subrata Dasgupta
1980-1982	Richard W. Heuft
1980-1982	Mary McLeish
1980-1982	Pavel J. Voda
1982	F. Jeffry Pelletier
1982	William W. Armstrong
1982-1985	Daniel A. Boulet
1983-1985	Clifford A. Addison
1983	Duane A. Szafron
1983-1988	Lee J. White
1983-1984	Karl Winklmann
1984-1987	Edward P. F. Chan
1984	Mark W. Green
1984	M. Tamer Özsu
1984-1989	Robert A. Reckhow
1984	Jonathan Schaeffer
1985	Renée E. Elio
1985	Joseph C. Culberson
1985	Wlodzimierz Dobosiewicz
1986	Pawel Gburzynski
1986	Barry Joe
1986	Ahmed E. Kamal
1986	Xiaobo Li
1986	Piotr Rudnicki
1986	Lorna K. Stewart
1986	Jia-Huai You
1987	Randolph G. Goebel
1987	H. James Hoover
1988	Ehab S. Elmallah
1988	Li-Yan Yuan
1988	Hong Zhang
1988-1989	Robert J. Crawford
1989	Paul G. Sorenson

Faculty Service Officers

1976	Steven F. Sutphen
1983-1983	Daniel C. Wilson
1986	Alynn B. Klassen
1987	Catherine Descheneau

Administrative Professional Officers

1972-1973	Graham Toope
1973-1975	Gary Albright
1975-1976	Thomas McGovern
1982-1984	Arnold Adam
1984-1987	Ivan E. Bering
1987	Brian R. Pinchbeck

Appendix 2

BSc degrees

1968
Barbara Diane Reader

1969
William John Berry
Linda Susan Easton
Eleanor Ruth English
Michael James Grohn
Robert Wallace Garve Jakes
Andrew Lap-Sang Wong

1970
Wilfrid Fred Appleyard
Ronald Stanley Askin
David John Bass
Bonnie Jean Dougall
Lorna Catherine Edey
Edward Geoffrey Ewing
David William Honey
Mark Ryan Johnson
James Lester Kestner
Yuk Ming Lee
Linda Ruth Pallister
Peter John Palmer
Victor Shapiro
Fahmi George Shlah
Ronald Charles Sohnle
Alan Hiromu Tamura
Keith Edward Toogood
Dennis Haydn Walker
Samuel John Wilmott

1971
James Wilburn Baker
Constance Faith Barnes
Lloyd David Benbow
Rose Marie Bilski
Wayne Kenneth Chelak
Ronald Norman Chilibeck
Robert Gordon Donaldson
Brian Donald Gaudette
Lorna Patricia Gibson
Donald William Haldane
Donald Joseph Harbison
Steven Malcolm Hoskin
Ervin Philip Krawchuk
Koo Adrian Lo
Echo Leona McCarley
Eleanor Carol Metrunec
Stephen Ames Miller
Alan Leslie Poon
Wayne Edward Powell
Thomas Daniel Reilly
Donald Jospeh Seidle
Harold Allan Smith
Paul Russell Sulkers
Glen Alexander Sustrik
Brian John Wesley
Robert Alexander Melnyk
Glen Frederick Mitchell
Harold Grant Zavitz

1972
Arnold Adam
John Robert Anthony Atwood
Dennis Roy Brox
Frederick James Calvert
Maria Teresa Agnes Colistro
Bruce Edgar Edwardes
Daniel Bernard James Feniak
Richard Paul Fiala
Edward James Gylander
Garry Allan Helander
Paul Scott Hinman
Yoshihiko Komatsu
Edwin Langner
Leslie Mervin Ledene
Sung Hyon Lee

Regena Hedwig Lerke
Harry Lewis
Henning Toustrup Lind
Ronald Kenneth Low
Wing-Yee Ma
James Edward Mann
Ian Gerald McCrum
Dennis Ray McMillen
Roderick Neil McPherson
Robert Ernest Mercer
Walter John Neilson
Alan Einar Ohberg
Roslind Donna Perkins
Stanley Andrew Poplawski
Freidhelm Poppe
Verna Faye Redden
John Henry Rudd
Ravindra Solanki
William Allen Sorenson
Ronald Dale Ternoway
William James Thun
Pamela Yuet Ping To
Kenneth Donald Turnbull
Stephen Moses chor-Kin Wan
Llyod Richard White
Kirk Allen Williams

1973

John Charles Anderson
Irene Ann Bailey
Kirsteen Jean Bass
Rex MacDonald Beaton
Leo Ostop Boychuk
Brenda Gay Bulmer
Michael Lok-On Chu
John Charles Demco
Stanley Lawrence DoHen
David James Evans
Betty-Lou Farrugia
Leslie Gurn Wah Gee
Christopher Gray
Nastor Washyl Gryba
Stanley Irwin Guttman
Raymond Archer Herbert
Norman Charles Keil
Eugene Peter Kindrachuk
Lettice Hung Lam
Siu-Mee Teresa Lam
Carol Joan Lane
Thomas William Lobb
Douglas George Loree
Larry Donald McCumsey
Anne Lorraine Mix
Bruce John Nattaras
Horst Neher
Johan Graundal Nielsen
Christopher John Ondrus
Elmer William Ozipko
Leonard Alexander Podgorny
Marlene Hazel Richardson
Joel Grant Riemer
Bogumil Ferdynand Romanko
Mohammad Saleem Siddiqui
Richard James Snyder
Norman Yam-Huen Tsang
Lorne John Weinkauf
Chung Wai Wong
Jaw-Ping Wong
Joseph Honyee Wong
Frank Shek-cheung Yau
Gordon Arthur Young
Leslie Andrew Zaharichuk
Huntley Wing Hung Zia

1974

Roy Martin Anderson
Veronico Ang
Daivd Bruce Butler
Larry Ross John Case
Johnny Lap Yee Chang
Dominic Man-Kam Cheng
Stanley George Dennis
Charles Arthur Eisbrenner
Dennis Earl Emmerling
Brenda Jean Fowler
Janice Irene Glasgow
Allan Curties Hart
Terrence Fitzgerald Hopkinson
Dennis Randle Jensen
Cheuk Cheung Paul Kam

Yuen Wah Kan
Doris Siu-Mui Kwan
Raymond George Lacousta
Suhkoo Lee
Melvin Neil Marler
Joseph Gerald McCormack
William Sydney McMullen
David William Miller
Eric Roy Olsen
Lakhbir Singh Parmar
Walter Terrance Prince
Donald Anthony Raypold
Samuel Thomas Michael Radke
Randy Sinoski
Geoffrey Ross Tate
Siaw Joen Tjen
Edward Yee-Wo Tong
William Chi-Hung Tung
Wayne Delbert Uniat
Ronald Douglas Wladyka
Douglas Alex Woodward
Hoi Shan Wong

1975
Linda Karen Adomat
Ronald Arthur Aldrich
Safar Ali
Kathleen Ka-Sum Cheung
Percy Sill Tung Cheung
Gerard Maurice Chevalier
Stephen Pak-Kwan Chung
Reginald Grant Crawford
Douglas Gregg Davey
Glynis Leigh Dorey
Peter Thomas Gamble
Barbara Catherine Gander
William Paul Gifford
Chi Hung Stephen Hau
Raymond Warren Wing-chi Ho
Diana Hung-Yin Ho
Ian Ceiriog Jones
Stephen Hing-sing Kam
Florence Ruth King
Thomas Pui-Lun Lam
Neil Allan Lang
Wing Ming Wilson Lau
Yiu-Wai Joseph Lau
Shek Hee James Leung
Selina Mon-Hau Mah
John Marion Matwichok
Edna Marion McKay
Lare Alexander Mearns
Diane Marie Moore
Douglas James Pachal
Leonard Brian Ponich
Ian David Richmond
Stanley Arnold Ross
Jeffrey Stephen Scales
Betty Anne Schiller
Thomas Chi-Yin Siu
Gerhard Hans Steinke
Michael Edward Stevens
Vera Sylvia Syrotiuk
Robert Lawrie Thomlinson
Karen Kar-Lung Tung
Gerald George Tychon
Douglas Roy Webster
Benedict Metody Weleschuk
Raymond Poi Heng Yee
Willis Chuen Wing Yeung
Robert Kun-To Yeung
Ronald Wiliam Zingel

1976
Larry Donald Ayers
Donald Robert Baker
Terrance George Bentley
Joseph Dennis Boisevert
Michael Wai Leung Chan
Raymond Cheuk Lun Chu
Daryld Patrick England
Frederick Edward Eves
Steven Paul Farkas
Neal Joseph Finn
William Hayes Fleury
John Brett Hammerlindl
Kenneth Robert Lang
Raymond Ka-Chun Lee
Vincent Wing Keung Lee
Francis Chiu-Ping Lua

Kam-Leung Frederick Mo
Kwok-Ho Sammy Ng
Michael Garth Peterson
Dennis Joseph Schuller
Randall Conrad Stebner
Saudin Pang Fai So
David Frederick Thompson
David Charles Upright
Lawrence Gordon Webb
Richard Alan Welykochy
Branded Branden Hon Keung Wong
Margaret Lai Ha Wong

1977
David John Bacon
Anthony Robert Bampfield
Silvana Bobowik
Earl Alexander Culham
Brian Thomas Davies
Yuen-Lung Rex Ding
James Douglas Finstad
Peter Gary Giokas
Joanne Fay-Kit Gunn
Susan An Hawe
Roger Kwok Wah Hui
Nashir Sadruoin Kara
Daniel Eitaro Kinoshita
Stanley Michael Klapauszak
Thomas Hing-Tsang Kong
William Korendyk
Harry Raymond Krawchuk
Anton Marius Kritzinger
Ronald Joseph Patrick Krywolt
Christopher Chung-On Lee
Harmen Leusink
Paul Gearoid McCourt
David Barry McVicar
Joanne Elizabeth Royer
Randy Daryl Ruwson
Vaughn Herbert Seward
Bruce Donald Sinclair
Thomas Anthony Speakman
Bikwan Margaret Tsui
Norman John Tymo
Antoine Philippe Verheijen
John Stephen Victor
Wayne William Wachell
Roger Lorne Walker
Lonnie Gordon Wong
Sai Ying Joseph Wong
David Woo
Ann-Marie Wynnyk
Kenneth Allan Yerex
Margaret Yin-Fun-Lung

1978
Vilnis Juris Caks
Schun Him Chan
Harold Yuen Pui Chan
Tsun Mau John Chan
Michael John Charchuk
Kwok-ching Ivan Cheng
Wai-Pang Cheung
Paul But Yeung Chiu
Jean Joseph Dumouchel
Ihor George Gowda
Marlowe Lawrence Greif
Gary Wing-King Gunn
Robert Fraser Heath
Theresa Susan Hiebert
Siu Hung Allan Ho
Howard James Hoover
Donald Charles Howell
Ronald Stanley Kostuik
Trudy Yuk Fun Kwok
Danny Kwok Hung Kwong
Eric Kwok-Ying Kwong
Kam-On Kwong
Patrick Fook-Cheung Lai
George Shui-Hong Leong
Kim Ming Leung
Judy Liu
Man Hay Mau
Arnold Frank Mentz
Shu Wan Mok
Nora Susan O'Neill
David George Rogers
Cathryn Ann Rogers
Kam-Sun Patrick Tong
Sally Claire Trofanenko

Henry Chen-Piu Tsan
Brenda Betty Tsui
Gary Steven Uniat
Barbara Van Noord
James Ronald Voysey
Yuk Kin Julia Wong
Ford Yuen Wong
Kum Yuen David Wu
Dwayne Nicholas Zon

1979
Fahien Ivor Bacchus
Doulgas Kim Boettcher
Daniel Alexander Boulet
Joanne Burek
Murray Scott Campbell
Medy Yin-Chun Chan
Charn Hing Clinton Choi
Steve Kwok Kwan Choi
Vincent Davis
Paul Nelson Featherstone
Leo Bert Hartman
Shenaz Jeraj
Peter Yee-Ping Lai
Robert Murray Lake
Tze Chung Michael Lau
Rose Nadine Leenders
Clayton William Lohm
Shirley Jean Lowe
Stephen John McKinnon
Richard Murray Reid
Wilfred Fu-Wah Wong
Terry Ching Yuan Wu

1980
Denise Catherine Baillargeon
Raymond Pierre Barylo
Edsin John Bickley
Brian Douglas Bray
Wendy Lou Buck
Catalina Lo Pin Chan
Ming Chan
Siew-Ching Chua
Richard Cyrynowski
Jeffrey Davis
Anne-Lise Marie Dupuis
Deborah Anne Gallon
Juergen Heinz Gedamke
Dina Gri
David Wing-Keung Gunn
Yuk-Lan Rosanna Ho
Trevor Dale Howard
Kelvin Kwok-Fai Hui
Jackson Chun-Shu Hui
Bob John Isaak
Munira Sadrudin Ishahi
Freddie Jagessar
Donald Kadonaga
Margaret Elaine Kerr
Douglas Perry Krawec
Mei-Mei Katy Kwok
Sau Wah Susan Kwok
Chung-Kam Kwong
Ambrose Sing Chi Lam
Ping Shu Lam
Mei Ngor Lau
Mo Yuen Susie Lau
Patrick Wai-Chung Law
Gary John Lewington
Chi Keung Aldolphus Li
Francis Sik Wo Lu
Arthur Gray Mackie
Clint Jerome Malone
Dale Patricia Marchuk
Yasmin Merali
Michael Martin Nielsen
David Glenn Orvis
Kevin David Rymer
Fiaz Juma Sarangi
David Elmer Schmidt
Henry Shen
Yui Man Tam
Richard James Taylor
Denise Marie Thornton
Kwong Hang Samuel Tsang
Ernie Michael Uniat
Daniel Charles Wilson
David Wong
Margaret Mi Chi Wong
Vincent Wing Sing Wong

Teng Fan Wong
Chi-Wai Maurice Yiu
Man Ip Alfred Yuen

1981
Catherine Alison Adams
Walter Gordon Aiello
Norman Sigurd Beyer
Irene Mary Braun
Douglas John Carlson
Wesley Sang Fai Chan
Kit-Ling Chan
Yuk-Ling Eliza Antonia Chan
Shoon Tin Chong
Ewe Lee Choot
Steven George Cumming
Stephen Paul Dolha
Bart Courtney Domzy
Harold Klaus Eggert
Byron Kim Glass
Wai Kong Spencer Ho
Margaret Hudson
Roderick Donald Johnson
Amin Kassam
Wayne Wai Ming Lam
Ka Keung Dennis Law
Wai Ho Leung
Ying Kit Li
Kenneth Yui-Kam Li
El Mouldi Manfoudi
Ella Mar
Valerian Nestor Markevych
Mark Wilhelm Meier
Sarah Elizabeth Anne Mercon
Yaacoub Nicholas Mitri
Chiu Ming Ng
Kay Kay Ng
Yung Lok Freddy Ng
Yim Ming Mison Ngan
Nashila Noor-Ali
Socorro Enriquez Pena
Yiu Chung Vincent Poon
Naomi Jan Rankin
Douglas Robert Reid
Patrick Chi Kong Siu
Joe Kin Chi Tam
Pelias Tat Fung Tam
Luca Romano Vanzella
Jeffrey Richard Wilkins
Diana York Wong
Patricia Shuet Ping Wong
Cranfond Sek-Hong Yu
Mick Mingtak Yuen

1982
Michael David Besney
Tanchor Boon
Rani Bulchand
Nyok Lin Chai
Kok Wai Chan
Adrian Poon Yau Chan
Priscilla P. H. Chan
Ji-Ui Chang
Ringo Cheuk-Choi Chau
King Wai Lawrence Cheung
Ying Huei Chin
Kam Yiu Lawrence Ching
Danny Yih Luen Ch'ng
Ip Wai Choi
Diana Man Wah Choy
Sean David Cormack
Timothy Richard Dean
Gordon Raymond Denotter
Brent Allen Figol
Judy Arlene Forest
Frederick Lman Keung Fung
Danielle Constance Gaba
Lynda Hammond
Christopher Harold Helmers
Holger Ralph Eric Henschel
Mark Daniel Holland
Suzanne Jennings
David Robert Jones
David Allan Koshka
James Peter Kusyk
Yuk-Fong Kwok
Kwok Leung Elvis Lam
Ivy Chak-Yau Lam
Kam-Yung Anita Lau
Chungchi Leung

Douglas Mah
Stephanie Andrea Miller
Keith Orval Mills
Susan Lorraine Neuman
Nashila Noorali
Shelagh J. O'hara
Sik-Yin Poon
Yiukwong Poon
Fred Paul Popowich
Ken Bruce Sawyer
Bartley Simpson
Patrick Sung-Chan Szeto
Richard Tang
Chun-Yin Tsang
Betty Yuk Tung
Robert James Van Thournout
Elaine Mei Wah Wong
Eric Cham-Sing Wong
Henry Hon-Wing Wong
Khai Chee Wong
Suan Bee Yeoh
Cynthia Yeung

1983
John Paul Adria
Syed Shamsher Ali
Alison Jean Bailes
Douglas Bilinski
Kenneth Andrew Bobey
Danny Chun-Min Cheng
Chun Hing Cheung
Andrei G. Chichak
Kelvin Ka Wing Chiu
Nadia Anne El-Deiry
Stuart Sik-Chiu Fung
Samson Chi-Hung Fung
David Irvin Hohm
Lily Gil-Sim Hoy
Wayne T. Karpoff
Gordon James Kendall
Siang Hwa Low
Stephen Hongzhang Ma
Ernest Mah
Bill Mah
Bruce B. McCartney
Barbara Jean Minard
Clement Wai Lun Ng
Cathy Anne Oler
William K. Olsen
Greg Paton
Gregory D. Pelton
Bradley E. Ratsoy
Allison Frances Reid
Sam James Scaber
Peternela B. Scharf
Violet R. Syrotiuk
Yuk Hing P. Tai
Angelee Joyce Wahl
Shiu Fun Grace Wong
Stanley Shui Yee
Henry Dicker Yee

1984
Randall D. Anderson
Gilles Chartrand
Yau Kuen Kris Chau
Yiu Kwong Cheng
Susan Louise Chomyn
Michael Chong
Soon-Kok Chong
Kai Kheong Choong
Kwok Wing Choy
Ching-Yee Irene Chu
Bobby Kwok-Yuen Chum
Douglas John Evans
Andrew B. Folkins
David Raymond Fudger
Garth R. Grainger
Kristin A. Gullekson
Patrick Albert Heath
Chi Iok Hobo Hoi
Joan Olive Hube
Sandie Mei May Hui
Lindsay N. Humeniuk
David Michael Kraft
Raymond Y. K. Kwan
Stuart John Lomas
Leo Roman D. Masciuch
Kathryn Jo Montegary
Man Wai Rudy Mui

Gerald Bernard Salm
Manbir Nayyar Singh
Douglas P. Stratton
William Sung-Yuen So
Raphael Su
Siew Seng Tay
Stuart M. Thompson
Chi Wah Wally Tung
Zainul M. Velji
Kin Hing D. Wong
Wai Raymond Yae

1985
Kjell V. Aasland
Steven C. Ball
Robert Michael Banks
Arthur W. Boykiw
Robert F. Boyko
Kwok Hung Chan
Patrick C. Chan
Eric Lit Chan
Avtar Singh Chatha
Kwok-Fai Cheng
William King N. Chiu
Becky Yuk-Fong Choi
Li-Tin Chong
John Brant Coghlan
Carole Jean Dhillon
Angela Mary Dobbe
Roman Fedoriw
Mark Allan Fewkes
Judith A. Gartaganis
Claude Rene Gibeau
Serge R. Gilbert
Karla J. Gilbertson
Robert M. Gregorish
Claude D. Guerette
James Edward Guloien
Kwok-Kuen Jeff Ho
Eddie Ping Chan Ho
Jon Nathan Holmes
Terence D. Holowach
Simon Chi-Yung Hong
Frankie Pak-In Ip
Mark Abraham Israel
Carol Janz
Shiraz Kassam
Paul Young Kim
Ronald Frank Kotchon
Amy Kar Wai Kwan
Brian Hubert Lake
Michael S. K. Lam
Patrick W. K. Lee
Wing Kwong Leung
Cheung-Fung P. Li
Chik-Chuen Li
Lee-Lee Lim
Corrina A. L. Lim
Mei-Lin Vivian Lim
Lisa Naomi Lister
Laura Anne Lowe
Kin Man Lui
Rocky Kwok-Keung Lui
Eugene Margulis
Claire A. McCartney
Linda Anne Mirtle
Eng Seng Ng
Kazuko Okuda
Andre J. O. Paradis
Wilhelmine Peers
Kenneth M. Revak
Myron Douglas Selby
Richard Lee Serna
Eugene M. Sheerin
Vivien Wei Man Sim
Mervyn Sookdeo
Wegman Yu Chau Tam
Herbert Wing Fai Tam
Linda Marie Tauscher
David Andrew Tetreau
Chi-Man Tou
Cary Kwok Chuen Tse
Kelly John White
Michael J. Williams
Siu Keung Wong
Jessie Yuk Lan Wong
Wing Hung Wong
David R. Wyrstiuk
Si-King Yee
Betty Y. L. Yeung

Fu Keung Tommy Yuen

1986

Shafiq Amlani
Mervyn Ui-Tiong Ang
Terry Lynn Aplin
Man Kuen Au
Fred W. Auschrat
Murray J. Ballas
Beverly Anne Bayda
Eleonora Bernhauser
Emanuel Bertolin
Thomas Brouwer
Steven Donald Buie
Sydney Louise Bull
Jeffery Peter J. Cena
Chet Checkwah Chan
Kin Hong Chan
Sin Thye Cheah
Kwok Fai Cheng
Shek Wah Chow
Allan J. Christie
Wing Kiong Chu
Sai Ming Chung
Penelope R. Crocker
Charles R. Daniel
Abid Dungarwalla
Arnold A. Ferri
Siu-Lung Gordon Fong
Wai-Fan Fung
Linda Lorraine Glass
Kevin C. Graboski
Ronald Dale Hagglund
David W. Hermanson
Jason Kam On Ho
Ka Chung Ho
Neil Thomas Holland
Yan-Yan Joy Hon
Elizabeth Pearl Hood
Annette De Jong
Gary D. Juszkiewicz
Jeffrey Vance Kelley
Colleen Kent
Gregory George Kern
Norbert L. Klingbeil
Yim Heng Kong
Paul Krewski
Forrest L. Kvemshagen
Kun-Yip Kwok
Ka Fee Irene Lam
Christina Lau
Vickitt Lau
Tin-Kit Lau
Siu-Chu Lee
Ket On Lee
Eva Kwansheung Leung
Yung-Kan Leung
Andrew T. Leung
Chi-Kwong Gordon Liu
Cedric Hou-Meng Lo
Sinny Miu-Sin Lo
Hing Chuen Lo
Shiu Kong Man
Bruce Matichuk
Suk Yee Moy
Barbara I. Neid
James Man Pong Ng
Ching Yee Ng
Kris Kim Ho Ng
Daniel Y. H. Ng
Margo Lynn Nielsen
Quin Nikel
Ronald A. Oudenaarden
Evan Peers
Cho Man Poon
Bently R. Rolf
Alain Dale Ross
Constance Rozema
Dale Eric Schuurmans
Bernie Semenjuk
Bradley Jay Senetza
Timothy John Senger
Maung Toe Set
Marc Shandro
Leslie Anne Sharpe
Parmjit Singh
Kam Shing Harry Siu
Karl Spiwek
Colleen Springer
Stephen A. Tanner

Soo Chin Teo
Kevin Mark Ushko
Christophe Warowicki
Thomas T. Welz
Michael J. Whitney
Wing Hang Brian Wong
Yui Hong Wong
Dennis W. S. Wong
Dickson Wong
Cheong Man Yeung
Dennis Po-Kwong Yip
Donna Marie Yurko
Kenneth S. Yurkovich
Darryl W. J. Zuk

1987
Theodore James Allen
Erik Martin Altmann
Sing Wah Au
Johnnie R. Baxter
Stephen Robert Byrne
David Ian Campbell
Thomas Fan-Tak Chan
Ka-Fai Chan
William Cheng
Edward Cheng
Wei Ling Chia
Kin Fan Choy
Albert S. B. Chui
Cameron Clarke
John D. Climenhaga
Kelly Davies
Chris Allan Dextrase
Hang Khanh Du
Ian James Eagles
Duane Russell Eitzen
Robert Peter Enns
Edward A. L. Eschak
Harold R. Finkbeiner
Brent Clifford Gorda
Michael Gruninger
Emily Goo Hao
Lisa Machiko Hiruki
Yuk Ling Maureen Ho
Werner O. Hoerger
Junaid Anwer Hossain
Tanis Marie Howarth
Royce W. Howland
Derek Olaf Iverson
Graeme Neal Jones
P. Winslowe Lacesso
Foon Kin Lau
Janet M. LaValley
Tony Lee
David Leung
Andy Chee-Yan Lo
Regina B. Ludwig
Peter G. Lui-Hing
Wayne Hong Mah
Kam Wah Mak
Kent Andrew McPhee
Scott William McPhee
Jeanne Meunier
Gail Cecile Miklos
Ganesh M. Murdeshwar
Karum Murtty
Ewen Robert Nelson
Robert Yick Koon Ng
Melissa Nguy
Raymond D. Radulski
Jan Marie Riess
George Rudelich
Michael Sannino
Richard James Simon
Yin-Leng Ella Siu
John W. Swekla
Claire N. Teubert
Raymond C. C. Tong
Stanley Norman Udey
Derek G. Warmington
Barry Westlund
Ramona F. Whyte
Nancy Nam Si Woo
Shun Hong Wu
Doi Chu Rochelle Yee
Trevor S. L. Yuen
Peter L. Zaborski

1988
Darren W. J. Bianchini

Kelly David Brooks
Donald J. Campbell
David Henry Carrigan
Louis Che-Kit Cheng
Robert T. Dejong
Donald O. Duncan
Harold John Evenson
David Yee-Man Fan
David Gizowski
Claude David Green
Wendy Miriam Hahn
Shiu Hei Ho
Kenneth M. Hodge
Leny Januar
Wayne S. Johnston
Gregory W. Kervin
Craig R. Kindleman
John Douglas Kneller
Marcel A. Laforce
Ivan T. J. Lamoureux
William J. Landers
Stella Wan Wah Lee
Derek Yui Wa Lee
Kam Yio Lee
Michael J. Lewchuk
Mei Fong Sabrina Li
Radana Losert
Dale Allen Lutz
Glen Shung Mah
Rolf Manderscheid
Ricky Leung Yuen Mar
Karin Helen Moerth
Yu Ho Eric Mok
Christopher Morrow
David John Paish
Janice Lou Parsons
Harold W. Peske
Timothy D. Phillips
Lev Plotkin
Daryl Edward Powley
Andre C. Prefontaine
D'arcy Owen Rainey
Elang Setiawan
Peter Sham
Sukhminderjit Singh
Stewart E. St. Dennis
Nicholas P. Steffes
Colette M. Swallow
Dean Allan Tiegs
Patrick Tonizzo
David Scott Webster
J. Leigh Willard
Heather Dawn Winitoy
Margaret S. L. Wong
Miu Yip Dora Wong
Annette Woodruff
Barany Yan
Ryan B. Zabel

1989

Micheal M. Anderson
Mario J. Antunes
Fred Eugene Boyko
John Lawrence Boyko
Alan Kenneth Bunyan
Nigel Philip Cairns
Steven Joseph Carter
Barton G. Cassady
Luc Joseph Cayer
Danny Sui Leung Chan
Carmen Kam Ming Chan
Enoch Chan
Ken Hung-K. Cheung
Shirley Sze Y. Cheung
Philip Nigel Clarke
Jeffrey David Clough
Trevor Edwin C. Cook
Robi Indra Das
Patrick John Gainer
Winnie V. Gallardo
Russell J. Giebelhaus
David A. Glass
Robert J. Guidos
Byron S. Henry
David John Hiebert
Andrew R. Hillson
Robert Stephen Hole
Deborah E. Howorko
Keith Allan Iwaniuk
Trent James Jakubec

Shaheer Juma
Michael H. Kalantar
William Kelly
Tim Howard Kennedy
Glenn T. Klettke
Paul A. Kruszewski
Debra Marilyn Kubina
Tak Wah Kwan
Jimmy Kwok K Kwong
John Bartlett Lees
Kin Man Stephen Li
Kurt Joseph Lichtner
Kenneth James Light
Gregory L. Lobe
Garry Don Mah
Karim J. Makhani
Silvia M. Marchesin
Donald James Mccrady
Stephen Mcdiarmid
John Malcolm Meikle
Barbara L. Morris
Todd Murray Olsen
Brian David Podl
Eva Rosa Poon
Randall B. C. Posynick
Aminmohamed N. Rawji
Bradley R. Reeves
Ana Dos Remedios
Curtis Scott Rempel
Ted Robert Rowe
Catherine L. Short
Ravi Inder Singh
Steven Barry Wart
James Andrew White
Douglas William Wood

Appendix 3

MSc degrees

1962

William A. Murray *The Numerical Solution of Partial Differential Equations by Closed Difference Methods*[*]

1963

William S. Adams *Probabilistic and Deterministic Aspects of Digital Computers**

Arthur Kuhn *Nonlinear Systems and Nonlinear Programming**

Barry J. Mailloux *Numerical Solution of Differential Equations**

Gary S. Marliss *The Numerical Solution of Functional Equations Arising in Stochastic Learning Models**

Frank Stenger *Numerical Integration in n Dimensions**

1964

Gary R. Jackson. *Rational Approximations**

Harry Maximchuk *A Matrix Formulation of Initial Value Problems*

1965

Cordell Rolfson *A Compiling Technique for the Iverson Language*

1966

John Alan George *An Algorithm for Finding Natural Clusters*

Rose Marie Margaret Wilinski *Solutions of a Moving Boundary Problem*

1967

Roger F. Halpin *An On-Line Information Retrieval System with an Application to Western Canadian History*

David A. Scott *The Generation of Pseudo-Random Numbers*

---

[*] * "Master of Science in Numerical Analysis" awarded through the Department of Mathematics.

Wayne A. Walker *A Variation of the Tchebycheff Quadrature Problem on the Infinite Interval*

1968

Vinod Kumar Arora *Error Analysis for Certain Matrix Equations*

David Gerard Barry *On Runge-Kutta-Nystrom Methods for Second Order Equations*

Stanley Cabay *Direct Methods for Laplace's Equation*

Gordon Francis Deecker *Interactive Graphics and a Planning Problem*

Robert Harold Huculak *Discrete Change Simulation - Two New Programming Systems*

Melvin Leslie Louie-Byne *A Numerical Algorithm for Determining Graph Isomorphism*

Thomas Perry McIntosh *Syntax Directed Analysis*

Wilma Jane Weber McKinney *A Pattern Recognition Program for Simple Line Configurations with Application to Arabic Numerals and Printed Capital Letters*

Clifford George Morgan *A Linear Boundary Collocation Method for Solving the Dirichlet Problem for Laplace's Equation*

Douglas Dale Olesky *Error Analysis of Two Elimination Methods of Computing Generalized Inverses*

Lubomir Wojtiw *Continuous Piecewise Integration*

1969

Othniel Stewart Bishop *A Queuing Analysis of the CP/67 Time-Sharing System*

Conrad Glen Edward Ferris *An Urban Traffic Simulator*

Wing Hing Huen *A Graphical Display Subroutine Package*

Brian Victor Johnson *Computer Graphics in Logic Circuit Design*

Richard David Peacocke *Computer Problem-Solving*

Paul Gordon Sorenson *Pattern Recognition with Optical Transforms and Surface Fitting*

John David Thomson *Input and Output Languages*

1970

Arun Kantilal Gatha *Statistical Evaluation of CP/67, a Time Sharing System*

Jiri Jelinek *Interactive Graphics in the Reduction of Data Obtained From a Gamma-Ray Camera*

Wilfred C. C. Ko *Some Optimum Criteria for Information Retrieval*

Graham Links *Stochastic Linear Programs*

Gordon Irvine McCalla *MUSE: A Model to Understand Simple English*

Brian John Stanger *A Simulation Study of the CP/67 Time Sharing System*

Richard L. Treleaven *Abbreviation of English Words to Standard Length for Computer Processing*

1971

Marvin Lionel Braude *An Autopsy Data Storage and Retrieval System*

James John Dimsdale *Application of On-Line Computer Systems to Library Automation*

J. Barry Dutton *System Studies Using a Simulated Computer*

Linda Easton *Describing Line Drawings to a Machine*

Ronald W. Erickson *A Methodology for Evaluating Man-Computer Systems*

Annabelle Yasgul Paloian *An Interrogative Authoring System*

Shiv Nath Verma *A Queueing Analysis of Time-Sharing Computer Systems*

1972

Shigeko Akiyama *Automatic Document Classification Systems*

Fredrick M. Alber *On-Line Thesaurus Design for an Integrated Information System*

Ronald Curtis Enerson *A Data Structure Approach to Interactive Graphics Software*

Kweku Ewusi-Mensah *A Monte Carlo Study of the Properties of Selected Tests based on Sample Spacings*

William C. Jackson *General Principles of Software Design in a Graphical Subroutine Package*

Dennis A. James *An APL Compiler-Interpreter*

Surendar Kumar *The Numerical Solution of Stiff Differential Equations*

Adrian K. Lo *An Automatic Optimum Iterative Feedback Document Retrieval System*

Marcel Albert Mercier *Study of UDC and other Indexing Languages through Computer Manipulation of Machine Readable Data Bases*

Charles Grady Morgan *Inductive Resolution*

Paul Rushton *A Critique of Programming Techniques for Playing Chess*

Victor Shapiro *Combining Independently-Compiled Algol 68 Programs*

Ronald Charles Sohnle *An Interactive Cellular Space Simulation Package*

Lloyd Keith Thomas *Algol 68 - Considerations for a One-Pass Implementation*

Dennis H. Walker *LISP/APL: A Lisp-Like List Processor Written in APL*

Peter Woo *An O.R. Approach to Optimize Computer File Systems*

1973

Fernando A. Amuchastegui *Quadratic-Separability of Boolean Functions*

Fred Appleyard *Improvements to the Language and Implementation of APL*

Francis K. Chan *Document Classification and Indexing through use of Fuzzy Relations and Determination of Significant Features*

Wayne K. Chelak *Program Reorganization for Performance Improvement in Paging Systems*

Robert Gordon Donaldson *Implications of Microprogramming*

Ronald Adolph Fischer *Properties of Boolean Functions and Hamming Distance*

Lorne Dale Fredlund *A Computer-Aided Music Facility*

Raghuptai Sahai Hitkari *Software Considerations for a Computer Graphics Terminal*

Wayne D. Ingram *Computer Recognition of Patterns in Scientific and Technical Writing*

John Kufuor-Boakye *Development and Validation of a Traffic Circle Simulator*

Som Nath Kukreja *Cellular Logic Arrays*

Donald Paul Laffin *Design and Implementation of Decision-Table Languages*

Ebenezer Amole Owolabi *Time Series Models of Urban Air Pollution*

Mushtaq Ahmad Qureshi *Computer Analysis of the Templin-Darley Test of Articulation*

S. J. Ransom *A Universal Cross-assembler* [Project]

Hartmut W. Roseke *Nordsieck's Method*

Lorna Patricia Shapiro *Sorting: A Survey, an Analysis and Some Improvements*

Melvin Wesley Smith *On the Detection of Edges in Pictures*

Samuel John Wilmott *On the Ordering of Modes in Algol 68*

Andrew Lap-Sang Wong *Automatic Telephone Directory Assistance*

Margaret L. C. Woo *A Simulation Study of the Distribution of Correlation Between Two Linear Stationary Markov Processes*

Donald E. Zarsky *Design and Implementation of a Computer-Based Teacher-Authored Instruction Manager (TAIM)*

1974

John Allen Benbow *Design of an On-Line UDC Library Automation System*

Lloyd David Benbow *On the Structure and Use of Hybrid Sequential Machines*

Subrata Dasgupta *A High-Level Microprogramming Language*

Jonathan Charles Descheneau *Mathematical Programming for Parameter Optimization*

Catherine Descheneau *Numerical Methods for a Pair of Nonlinear Partial Differential Equations*

Garry Helander *Resource Sharing in Computer Networks*

Mary Margaret Higginson *Exact Methods for Systems of Polynomial Equations*

Gaysawn Jakes *Actual Size of the Welch-Aspin Test for the Behrens-Fisher Problem*

Robert Jakes *A New Concept of Digitized Uniform Pseudorandom Number Generation*

Carmen Lorraine King *A Simulation Study of the Empirical Distribution of the Non-Zero Roots of some Sample Covariance Matrices*

Dolores Sin Kim Lam *A Study of the Behrens-Fisher Test for the Behrens-Fisher Problem*

P. R. Sulkers *A Survey of Integrated Medical Information Systems and an Application in Resource Allocation* [Project]

Brian J. Wesley *Adaptive Page Fault Control: Use of the Working Set Parameter*

1975

Vladimir F. Berka *Fault Detection in Sequential Circuits*

Andrew M. Brown *Simulation Methodology for Computer System Models*

John C. Demco *Principles of Multiple Concurrent Computer Emulation*

John Domaschenko *An Implementation Study on Microprogram Optimization*

Ian McMaster *A Proposal for Computer Acquisition of Natural Language*

Kenneth Henry Newman *Effects of Memory Architecture in Multiprocessor Design*

Margaret M. Sharon *Scheduling in Load Sharing Computer Networks*

A. R. Stanley-Jones *An Inquiry Service Oriented Supervisor*

1976

Christopher Gray *ALAI: A Language for Artificial Intelligence*

James A. Heifetz *A Machine Oriented Language for the IBM 370's*

Charles W. Huneycutt *An Interactive Biochemical Simulation System*

Teh-Chieh Kao *Computations in Matrix Rings*

Janet Elaine King *Verbs in Computer Language Acquisition*

Daniel J. Salomon *A Sequential Nanoprogramming Language*

Steven Sutphen *Virtual Memory Experiments on the UNIX System*

Christopher Mark Thomson *An Algol 68 Run-Time System*

1977

Randy Goebel *Organizing Knowledge in a Semantic Network*

Rakesh K. Jain *Computer Matching of Stereo Pictures*

D. T. Johnson *Decision Theory and Automatic Planning*

Robert E. Mercer *Adaptive Search Using a Reproductive Meta-Plan*

1978

Y. N. Arunkumar *Additional Support for Video Terminals* [Project]

D. Bruce Butler *Computerized Manpower Scheduling*

E. Cheng *A Simulated Associative Processor* [Project]

J. E. H. Clark *The Colour Display System* [Project]

Mireille Dubreuil *A Simulation System for the Study of Ecology*

S. Fok *Sorting on Magnetic Bubble Theory* [Project]

Paul C. C. Kam *Retrieval in Clustered Files*

Long-Lieh Tsai *On J-Maximal and J-Minimal Flow Shop Schedule*

Chen-Tung Ou *Distribution of Query-Document Correlations*

1979

Daniel Kam-Kui Chow *On the Construction of Feedback Queries*

D. G. Davey *A Computational Model of Language Acquisition*

S. R. Dembo *Polyprocessors: A Design Proposal* [Project]

John C. S. Lam *Optimal Parallel Graph Algorithms*

Chaluve L. Narasimhan *Digital Simulation and Optimization Techniques*

R. J. Orthner *A File Transfer Facility between Unix and MTS*

Grace Lai-Lin Ting *On Schedules with Different Release Times and Deadlines*

Gerald G. Tychon *Texture Boundaries in Digital Images*

Kathryn Ward *Characterization of an MTS Workload*

1980

P. Cheung *UNIX Performance Models Using Short Interval Data* [Project]

A. R. Covington *Organization and Representation of Knowledge*

J. A. Lamont *Fuzzy Language Learning*

B. M. Mazur *Printer Subsystem Capacity Management* [Project]

A. Olekshy *The Artful Encoding of Redundancy*

V. S. Townsend *Performance Measurement of Computer Networks*

1981

P. A. Barrow *Design of a Microprocessor Controlled Data-logger* [Project]

Murray Campbell *Algorithms for Parallel Search of Game Trees*

Lynn Klassen *An Experimental Evaluation of S**

Marius Olafsson *The QM-C: A Co-Oriented Instruction Set*

Douglas J. Rideout *Microcode Compaction on the Nanodata QM-1*

Mohammed Abdul Waheed *On the Design of Directly Executable Representations*

1982

Richard William Gillespie *The Maple Virtual Machine*

Atul Gupta *Partitioning and Assignment of Programs for Distributed Systems*

Priscilla Lisa Higham *The Complexity of a Delivery Problem*

Sundaravarathan Rajagopalan Iyengar *Interconnecting Processors with Shared I/O*

F. Lahdiri *Study and Evaluation of the VERSAbus* [Project]

Darrell Makarenko *Simulating Computer Architectures Using S*A*

M. S. Nortey *Point-In-Polygon Algorithms for Geographic Information Systems*

Mary Angela Papalaskaris *Special Purpose Inference Methods*

E. Sacharuk *Secure Personal Communications*

Carol J. Smith *Determining Minimal Planar Partitions for Graphs*

1983

P. Biswas *A Capability Architecture for ADA*

E. L. Choot *Self-Organizing Linear Search Heuristics for a Dynamic Fixed-Size List*

B. C. Domzy *Linear Systems of Polynomial Equations*

E. Fraga *Porting the UNIX Kernel to an MC68000 Based Microcomputer* [Project]

D. J. Fremont *A Methodology for the Evaluation of Dataflow Computer Architectures*

D. Jagannathan *Synchronization and Recovery in Distributed Databases*

R. C. McArthur *Pascal Programming: A Computer Assisted Learning (CAL) Project on the PLATO System* [Project]

C. M. Ng *A Word Processing Facility for the University of Alberta Hospital Data Processing System* [Project]

F. Jeffry Pelletier *Automatic Theorem Proving*

J. E. Taugher *A Representation for Time Information*

K. S. Teow *Porting UNIX V7 to a Motorola VERSAmodule* [Project]

A. Verheijen *Evaluation of Diagonal Padé Algorithms*

A. S. Wagner *Verification of S*(QM-1) Microprograms*

C. A. Wang *Intersection and Minimum Distance Problems for Planar Polygons*

1984

T. C. Bentley *A Method for Priority Switch on Ethernet*

D.-L. Lee *Fast Algorithms for Associative Memories*

A. S. Mohamed *Architecture for a Mixed-Flow Machine*

S. K. Semwal *Data Structures for Spatial Information*

D. B. Ward *AHF - A Graphics Language for VSLI Design* [Project]

X.-H. Zhou *An Automated Reasoning System* [Project]

1985

H. C. Chan *Children's Interactive Library Display System* [Project]

K. W. Chan *Image Expansion Using Interpolation and Noise-Cleaning Methods*

B. Chandramouli *An Object Oriented Database Management System for CAD Applications*

M.-S. Chia *An Event Based Dialogue Specification*

G. P. Gangadaraiah *Data Structures for Spatial Data Processing*

P. Gill *A Simulation of an Ethernet-Based PACS*

C. H. Hwang *File Organization Schemes for Geometric Data*

P. Mazumder *Networks and Embedding Aspects of Cellular Structures for On-Chip Parallel Processing in VLSI*

Maylene McMillan *Datatalk: A Data Management Facility for NIAL*

M. Palat *Data Base Management for Geo-Data*

I. A. Perera *Selecting Test Data for the Domain Testing Strategy*

P. N. Sahay *Heuristics for Selecting Best Paths for Testing Computer Programs*

G. Singh *Presentation Component for the U. of A. UIMS*

N. Srimani *New Algorithm (PS*) for Searching Game Trees*

S. R. Venkatramanan *Enhancement of Echocardiograms*

A. Vashistha *Analysis of Overheads in a System*

X.-N. Wang *Some New Approaches for Linear Quadtrees*

B. Wilkerson *Small Talk 80: Another View*

1986

A. Bailes *Response Generation*

Prakash Bettadapur *Experiments in Chess Capture Search*

J. de Haan *Inference in a Semantic Net*

J. Brett Hammerlindl *Information-Preserving Transformations of Database Schemas*

K. W. Hruday *A Multiprocessor Architecture for Real-Time Image Generation*

T. M. Koon *Performance of Update Synchronization Mechanisms*

George Labahn *Matrix Padé Approximants*

Sai Choi Lau *The Use of Recursive Transition Networks for Dialogue Design in User Interfaces*

S. Pun *A Chinese Character Software System*

A. Singh *Access Methods for a Semilattice DBMS*

R. Scott Stacey *Algorithmic Generation of Synthetic Speech*

H. K. Yim *Requirements for a Courseware Preparation System and Implementation of an Editor/Formatter*

1987

Gordon Harold Atwood *Linear Systems with Integral Domain Polynomial Coefficients*

Kenneth Bobey *Coding Schemes for the Semilattice Data Model*

James G. Borynec *First Order Logic Robot Planning System*

Nicola Joy Ferrier *Invariance Coding in Image Processing*

Vladimir Gertsberg *Partitioning a Logical Model of Data*

C. S. Law *An Execution Model for Some Parallel Logic Programming Languages*

Raymond Kim Ho *CHILDS: A Library Environment for Children*

Sven Hurum *Quantifier Scoping in Initial Logical Translations of English Sentences*

Firat Uludamar *A Study of Isolated Word Recognition Using the General Instrument SP 1000 Chip*

Larry Masato Watanabe *Guiding Constructive Induction for Incremental Concept Learning from Examples*

1988

Robert Andrew Chai *LCS: A Learning Classifier System*

Keith Fenske *An Interactive Classifier Programming Language*

Kwok-on Terence Lai *An Automatic Test Path Generator for Path Oriented Testing Strategies*

Shuh-Mei Lai *A Technique for Automated Detection of Breast Tumors in Mammograms*

Daniel Andrew Lanovaz *Godel: A Prototype Programming Environment*

Christina Lau *Object Management, Protection and Scheduling in FLEX*

Vickitt Lau *Parallelism in Nonmonotonic Multiple Inheritance Systems*

Stephen H. Ma *Blindness-Based Testing for Domain Errors*

David J. Meechan *A Heuristic Approach to Query Optimization*

Stephanie A. Miller *Time Revisited*

Randy W. G. Ng *LexAGen - A Lexical-Analyzer Generator*

Peternela Barbara Scharf *A Computer Model of Knowledge Organization and Strategy Shifts in Novice Expert Problem Solving*

Dale Eric Schuurmans *Representation and Selection Techniques for Genetic Learning Systems*

Christopher David Shaw *The Image Composition Architecture: A Highly Parallel Graphics System*

Luca Vanzella *Classification of Data Structures for Thematic Data*

Kok-Lung Wong *Distributed Simulation of Performance Petri Nets*

Xiao You Zhou *A Hybrid Structure for the Representation of Spatial Data*

1989

John P. Adria *Verifying Communication Protocols in MIZAR-2*

Hang K. Du *Intersection of Curves and Surfaces Using Elimination Theory*

George M. Ferguson *Identity and Skolem Functions in Resolution-Based Hypothetical Reasoning*

Siu-Lung Gordon Fong *Implementation of Consistency Techniques in WUP*

Michael William George *MACH: A Master Advisor for Chess*

Yuzhang Hong *Integration of Chinese in Computer Systems*

Norbert L. Klingbeil *Search Strategies for Conspiracy Numbers*

Eva Kwan-Sheung Leung *Parallel Algorithms for Relaxations Labelings*

Peter Kin Wing Leung *Abstracting and Using Domain Relations to Expedite Concept Learning*

Kris Ng *Functional Logic Programming*

William Petroske *Monte Carlo Comparison of ANOVA and Loglinear Analysis Using Bernoulli Data*

Yiu-Wing Tam *Three Dimensional Display of Medical Images*

Meei Fen Teo *Experiments in Database Buffer Management Strategies in a Virtual Memory Environment*

Charles Van Duren *A Cost Model for Computing*

Aji H. Wigena *Comparison of Thinning Algorithms*

Brian W. H. Wong *Intelligent Backtracking in Prolog*

Appendix 4

PhD degrees

1973
Marek Fridrich *Fault Detection in Combinational Networks*

George A. Neufeld *Analysis of Class-Teacher Timetable Problems*

Nam Ng *An Environment-Independent Graphics Facility*

W. Gary Sitton *Strategies for Microprogram Optimization*

1974
John T. Cumberbatch *Methods for Automatic Diagnosis of Disease*

Gordon Francis Deecker *Interactive Graphics and a Planning Problem*

Ernst J. Schuegraf *The Use of Equifrequent Fragments in Retrospective Retrieval Systems*

Robert D. Skeel *Convergence of Multivalue Methods for Solving Ordinary Differential Equations*

1975
Nicholas Joseph Cercone *Representing Natural Language*

David Lam *Fast Matrix Inversion and Application to Optics*

1976
Subrata Dasgupta *Parallelism in Microprogramming Systems*

Robert K. Lee *Optimal Parallel Computations for SIMD Computers*

Wo-Shun Luk *Analytic Evaluation of Information Retrieval Processes*

1977
Surender Kumar Kenue *On the Detection of Changes in Digital Images*

Kenneth J. McDonell *A Unified Approach to Secondary Storage I/O*

1978
Vijay V. Raghavan *Evaluation of Classification Strategies*

1979

Sreekaanth S. Isloor *Consistency Aspects of Distributed Databases*

Robert G. Willoner *On the Design of a Parallel Arithmetic Unit*

1980
J. O. Achugbue *The Complexity of Deterministic Scheduling Problems*

A. Brindle *Genetic Algorithms for Function Optimization*

G. Özsoyo_lu *Secure Statistical Database Design*

Z. M. Özsoyo_lu *Query Processing in Distributed Databases*

1981
Catherine Descheneau *Modelling and Simulation in Developmental Genetics*

1983
Y. H. Tsin *Portable Efficient Graph Theoretic Algorithms*

1984
D. K. Choi *Algebraic Computations of Scaled Padé Fractions*

K. V. S. Ramarao. *Resilient Distributed Database Systems*

1985
M. W. Dubetz *Ray Tracing Algorithms for Computer Graphics*

1986
A. A. Farrag *Concurrency and Consistency in Database Systems*

P. Kossowski *Modular Padé Forms for Bivariate Power Series*

Darrell Makarenko *The PLA Folding Problem*

R. Nozohoor-Farshi *LRRL(K) Grammars*

1987
H. J. Hernandez-Lopez *On the Boundedness of Relational Database Schemes with Respect to Functional Dependencies*

De-lei Lee *A Multi-Processor Architecture for Image Processing*

1988
Faheim Bacchus *Representing and Reasoning with Probabilistic Information*

George Labann *Matrix Padé Forms and Inverses of Block Hankel Matrices*

Cao An Wang *A New Generalized Voronai Diagram in the Plane*

1989

Liwu Li *Probabilistic Analysis of Search*

Ahmed Mohamed *A Hybrid Numerical/Knowledge Based System for Locomotion Control of a Multi-Legged Articulated Robot*

Gurminder Singh *Automating the Lexical and Syntactic Design of Graphical User Interfaces*

N. Prasad Srirangapatna *Design and Formal Specification of a Data Model and Language for a Database System for CAD Applications*

Appendix 5

Undergraduate awards

The Lieutenant-Governor's Gold Medal

1974 Geoffrey Ross Tate

The Gold Medal in Science

1982 Stephanie Andrea Miller
1984 Kin Hing Daniel Wong

The Dean's Gold Medal in Science

1988 Heather Winitoy

The Dean's Silver Medal in Science

1987 Howard James Hoover
1980 Margaret Elaine Kerr
1981 Ewe Lee Choot
1987 Erik Martin Altmann
Robert Peter Enns
1988 Dale Allen Lutz
Annette Woodruff
1989 Michael Kalantar
Deborah Howorko

The Canadian Information Processing Donald B. Scott Memorial Prize in Computing Science

1976 J. Brett Hammerlindl
1977 Joanne Fay-Kit Gun
1978 Howard Hoover
1979 Terry Ching-Yuan Wu
1980 Margaret Elaine Kerr
1981 Fred Paul Popowich
1982 Kenneth Andrew Bobey
1983 Douglas John Evans
1984 Judith Ann McGillis
1985 Linda Tischler
1986 Claire Harrison
1987 Wendy Hahn
1988 Gregory Lobe
1989 Mark Andrew Blake

The Digital Equipment of Canada Award of Merit

1982 Steven Henderson

1983 David Chun Yi Cheung
1984 Jason Kam On Ho
1985 Robert Peter Ens
1986 Siu Hang Chan
1987 Heather Winitoy
1988 Brendan Mumey

The I. P. Sharp Associates Limited Scholarship

1982 Douglas John Evans
1985 Graeme Neal Jones
1986 Heather Winitoy
1987 Michael Kalantar
1988 Dale Golding

The Barry J. Mailloux Prize in Computing Science

1983 James Edward Guloien
1984 Kris Kim Ho Ng
1985 Karen Dawn Peterson
1986 Dale Lutz
1987 Michael Kalantar
1988 Wai-Hoo Ho
1989 Jordan D. Pratt

The C A C I Scholarships in Computing Science

1984 Carol Janz
James Edward Guloien
1985 Kent McPhee
Norbert Klingbeil
1986 Winslowe Lacesso
Gail Miklos
1987 Annette Woodruff
Heather Winitoy
1988 Michael Kalantar
Paul Kruszewski

The MacDonald Dettwiler and Associates Scholarships in Electrical Engineering and Computing Science

1984 Karla Jean Gilbertson
1985 Michael J. Whitney
1986 Robert P. Enns
1987 Dale Allen Lutz

The Philip Kalmanovitch Memorial Award

1984 Robert Peter Enns

The Department of Computing Science Academic Achievement Award 1984-85

Karla Jean Gilbertson
Carol Anne Janz
Judith Ann McGillis
Linda Anne Mirtle
Eng Seng Ng

The Alberta Energy Company Limited Scolarship

1986 Eric Altmann

The Jeffrey R. Sampson Graduate Memorial Prize

1986 Judith McGillis
Ajit Singh
1987 Dale Schuurmans
1988 George Ferguson
Michael MacGregor
1989 Marcel Berard

The Amdahl Academic Achievement Scholarships in Computing Science

1987 Greg Kervin
Dean Teigs
1988 Deborah Howorko
Bradley Reeves
1989 Ingrid Bruns
Dale Golding
Wai-Hoo Ho
Beverly Ledig
Nandita Murdeshwar

The Canadian Information Processing Society Science Award

1988 Ingrid Bruns
1989 Collin Heggerud

The Canadian Information Processing Scholarship

1988 Ingrid Bruns
1989 Paul Chien-Ping Lu
Collin Heggerud

The Association for Computing Machinery Mountain Region Student Programming Contest

1987 Robert Austin
Donald Campbell
Dale Lutz
Duane Snider
1988 Patricia Evans

	Wade Holtz
	Brendan Mumey
	Russell Schultz
1989	Christopher Dutchyn *
	Michael Michels *
	Brendan Mumey *
	Russell Schultz *

* Second place

University of Alberta Computing Society Computer Programming Contest

1984/85	Allan Christie
	Dale Hagglund
1985/86	Brian Bray
	Luca Vanzella
1986/87	Donald Campbell
	Dale Lutz
1987/88	Donald Campbell
	Dale Lutz
1988/89	Michael Michels
	Brendan Mumey

Appendix 6

Some statistics

Year *	Faculty **				Degrees			Courses **					
	Ast	Asc	Pr		BSc	MSc	PhD	200	300	400	500	600	
1962					0	1	0	-	-	-	-	-	-
1963 -	-	-	-		0	5	0 -	-	-	-	-	-	
1964	2	2	1	5	0	2	0	0	0	1	0	2	3
1965	3	3	1	7	0	1	0	1	1	1	0	2	5
1966	4	3	1	8	0	2	0	1	1	3	1	2	8
1967	3	3	3	9	0	3	0	1	2	6	4	2	15
1968	7	4	3	14	1	11	0	1	5	6	6	2	20
1969	9	3	3	15	6	7	0	1	4	6	9	4	24
1970	8	6	3	17	19	7	0	1	5	8	20	6	40
1971	8	6	3	17	28	7	0	2	7	12	20	10	51
1972	4	12	2	18	41	16	0	2	8	18	23	14	65
1973	2	10	2	14	45	22	4	4	9	19	22	14	68
1974	2	10	3	15	37	13	4	4	9	20	23	14	70
1975	2	11	3	16	48	8	2	4	9	20	23	14	70
1976	2	11	3	16	28	8	3	4	10	17	24	14	69
1977	4	11	2	17	40	4	2	4	10	18	25	14	71
1978	4	10	2	16	43	9	1	4	10	18	31	14	77
1979	5	9	2	16	22	9	2	4	11	15	27	14	71
1980	5	8	2	15	58	6	4	4	11	15	27	14	71
1981	3	9	6	18	48	6	1	4	11	15	28	14	72
1982	2	8	6	16	57	10	0	4	10	15	28	14	71
1983	0	7	9	16	37	14	2	4	9	15	28	14	70
1984	3	7	8	18	38	6	2	6	9	15	28	14	72
1985	6	5	9	20	78	18	1	6	9	25	25	14	79
1986	8	5	8	21	101	12	4	6	9	25	25	14	79
1987	16	5	8	29	71	10	2	6	9	25	28	17	85
1988	16	7	8	31	59	17	3	7	8	25	28	17	85
1989	16	6	8	30	65	16	4	7	8	27	24	17	83

* Calendar year

** Data for 1964, for example, from 1964/65 Calendar

Appendix 7

Computing performance comparisons *

Computer	Year	Speed	Cycle Time	Cost ($K)	$/ KIPS	Bench-mark
LGP-30	1957	0.2 KIPS	5 ms	40	200	1
IBM 1620	1961	1.0 KIPS	20 µs	120	120	10
IBM 7040	1964	15.6 KIPS	8 µs	240	15.4	250
IBM 360/67	1967	511 KIPS	200 ns	1678	3.3	8750
Amdahl 470V6	1975	3.8 MIPS	33 ns	4050	1.1	70000
Amdahl 470V7	1979	4.8 MIPS	29 ns	3370	0.7	98000
Amdahl 470V8	1981	6.3 MIPS	26 ns	200	0.6	127400
Amdahl 580-5860	1982	13 MIPS	23 ns	5385	0.4	229320
Amdahl 580-5870	1986	21 MIPS	23 ns	1400	0.3	412776
Mac II	1987	2 MIPS	63 ns	8	0.004	
Mac IIci	1989	5 MIPS	40 ns	8	0.002	

ms = millisecond = 10-3 seconds
µs = microsecond = 10-6 seconds
ns = nanosecond = 10-9 seconds

The costs for the Amdahl 470V8 and 580-5870 are for an upgrade only.

* Data from University Computing Systems

Appendix 8

Departmental computers

1970-1980	DEC PDP-9	$19700	*
1972-1980	EAI 380 (analog)	12500	
1972-1980	Interdata 3	2000	
1972-1980	Interdata 4	4000	
1972-1981	Microdata 1600	8000	
1972-1985	DEC PDP-8	3000	
1972-1985	DEC PDP-8/L	4500	
1973-1986	PDP-11/45	45600	
1973-1980	Data General Nova 2/4	4450	
1974-1984	Nanodata QM-1	251450	
1975-1985	DEC PDP-11/04	8884	
1975-1984	IBM 5100	18300	
1977-1985	DEC PDP-8/L	775	
1977-1984	DEC PDP-11/60	88900	
1978-1985	TI 990/4	12280	
1978-1983	Norpak VDP-1	31485	
1979-1985	DEC PDP-11/05	3900	
1981-	DEC VAX 11/780 (Pembina)	467427	
1982-	Sun-1/100	10980	
1982-	DEC VAX 11/780 (Cadomin)	410159	
1983-	DEC VAX 11/780 (Cavell)	509956	
1983-	DEC VAX 11/780 (Jasper)	445504	
1985-	XEROX 1186 Lisp	58640	
1987-	MIPS M/1000	66022	
1989-	MIPS M/120	55000	

* Purchase price

Appendix 9

Undergraduate courses in 1989/90

General interest courses

CMPUT 214 Introduction to Computing Science
CMPUT 215 Programming and Data Structures
CMPUT 261 Introduction to Computation
CMPUT 262 Introduction to Computers
CMPUT 269 Structured Programming and Data Structures
CMPUT 272 Formal Systems and Logic in Computing Science
CMPUT 351 Introduction to Programming for Scientific Applications
CMPUT 352 Elements of Scientific Computing
CMPUT 357 Introduction to Computing for Business Applications
CMPUT 458 Numerical Analysis

Specialization and Honors courses

ENCMP 100 Computer Programming for Engineers
CMPUT 305 Algorithms I
CMPUT 326 Programming Languages I
CMPUT 380 Computer Organization and Architecture I
CMPUT 385 Computer Organization and Architecture II
CMPUT 392 Introduction to File Management
CMPUT 401 Software Engineering
CMPUT 405 Algorithms II
CMPUT 406 Introduction to Image Processing
CMPUT 411 Introduction to Computer Graphics
CMPUT 413 Telecommunications and Computers
CMPUT 415 Compiler Design
CMPUT 418 Numerical Analysis I
CMPUT 419 Numerical Analysis II
CMPUT 421 Simulation
CMPUT 422 Analysis of Computer Systems I
CMPUT 426 Programming Languages II
CMPUT 430 Computer Design and VLSI Implementation
CMPUT 435 Computer Systems and Architecture
CMPUT 440 Introduction to Numerical Methods
CMPUT 441 Numerical Software
CMPUT 451 Introduction to Artificial Intelligence
CMPUT 474 Formal Languages, Automata and Computability
CMPUT 480 Operating System Concepts
CMPUT 482 Computing Organization and Architecture
CMPUT 485 Systems Programming
CMPUT 492 Database Management Systems

CMPUT 496 Topics in Computing Science
CMPUT 497 Topics in Computing Science
CMPUT 498 Topics in Computing Science
CMPUT 499 Topics in Computing Science