Introduction

The Department of Computer Science has made considerable progress during the AY 1970-71. The undergraduate and graduate programs that were restructured during the previous year, were successfully introduced this year - including an undergraduate major and a Ph.D. program. A solid research basis was established with the help of a sizable NIH Grant for a research resource on computers in biomedicine. Substantial progress was made in professional activities, departmental organization, and overall academic planning. Considerable strength was added to the faculty with the appointment of five (5) new members and three (3) adjuncts, covering a broad spectrum of activities in computer science and in computer-oriented applied mathematics. Working contacts with other departments and other units of the University have increased. In addition, the department is taking an increasingly active role in University-wide planning and technical evaluation for computer resources.

There are still many open problems and difficulties: some require more work within the department, others require more coordination within Livingston and with other relevant departments in the University (engineering and mathematics in particular), and there are certain basic problems that require policy decisions at the top level of the University (growth and coordination of computer science programs, relationships with the ECC).

It is a reasonable goal for our department to become a major center of instruction and research in computer science in the State and in the nation. The demand for computer science education and expertise is growing rapidly, and an outstanding computer science activity at Rutgers will help directly, as well as indirectly (through stimulation of other programs in the State), in satisfying this demand. With appropriate support, I think that we can come near this goal in two years.

Another important goal for the DCS is to contribute to the shaping of new academic programs in Livingston, and to participate in the development of new computer applications in significant areas of medicine, education, and planning. Our effort in the multidisciplinary research resource in computers in biomedicine is a step in the right direction.

In the following I will describe in some detail the present state of various activities in our department.
1. The Undergraduate Program

In the past year we first put into effect our restructured and expanded undergraduate program, which already included most of the offerings for a computer science major. An important objective was to integrate in an effective way courses that are oriented to three categories of students: (i) majors in computer science, (ii) students majoring in other areas who are interested in the use of computers in their work (mainly in the sciences, mathematics, engineering, and business), and (iii) students interested in a general acquaintance with computers and their uses. The following are some of the specific things that we learned from our experience with the new undergraduate program:

(a) The present form of our introductory one-semester computing course (111 or 112) is excellent. The use of interactive computing (time sharing) in this course has been extremely successful; it motivates students and it enhances learning. There is consensus in our department that all interested students (categories (i), (ii) and (iii) above) in the University should be advised to enter computing through such a course. Furthermore, it is reasonable to assume that the demand for some kind of computer education at the College level, and the search for new ways of cultivating disciplined thought, are likely to grow enormously in the coming years. The implication is that we should be prepared for a possible expansion of 111, 112 into many sections (with possible differences of emphasis among sections), and at the same time we should "spread the word" about this course to students and to faculty advisors both in Livingston and in other parts of the University.

(b) We found that a large number of the Livingston students who took the 'Introductory Computer-Oriented Mathematics' course (105-106), were not suitably prepared for the course (including some of those who had taken the College course on 'Introductory Applied Mathematics'). Other problems in this area include the amount and choice of material that can be profitably covered in two semesters, the appropriate mix of lectures with discussion and review sessions, and the best way of using computers as a motivating and exercising device. Progress was made in resolving these problems during the last year, and careful plans are being made to improve the situation next year, including a better coordination with our introductory computing course 111, 112.

It is important that the College courses oriented to remedial and enrichment in mathematics be strengthened. More and better efforts are needed in this area; also there should be a better coordination between these courses and our course 105-106.
Planning and experimenting with an innovative course such as 105-106 requires a considerable amount of effort. I believe that we should continue developing and giving this course as part of our program, especially with a view to finding new, effective, computer-assisted methods for teaching mathematics. Eventually, I think that such a course should be given by a mathematics department. There is some progress in the University along these lines. The Mathematics department in Rutgers College has started experimenting last year with computer-assisted calculus instruction, and they plan to enlarge the experiment next year with about 150 freshmen participating. Undoubtedly, this activity was partly stimulated by our program in this area. I think that we should be in close contact with the Rutgers College Mathematics department (exchanging ideas and experiences) in connection with these computer-assisted introductory courses. We have initiated such contacts this spring. Related to all this is the question of a mathematics department at Livingston. I think that such a department should be established soon; it should be closely tied to the other New Brunswick Math departments, and it should have strong working ties with our department. When a math department will be established in Livingston, I expect that it will be responsible for our 105-106 course, and in addition it will offer many other undergraduate courses in mathematics (linear algebra, algebraic structures, differential equations, graph theory, probability theory, logic and foundations, mathematical models) that would interest computer science students as well as students in several other programs in Livingston.

(c) The demand for our 200-level courses in computer problem solving methods (211 and 212) has exceeded our expectations. The students who enrolled in these courses come from all parts of the University, and there is considerable spread in their academic background and orientation. Each course is being given in several sections, and we plan to experiment with certain inter-section variations to accommodate the student variety. Next year we will divide the 212 sections in two parts, one requiring some computing background and the other without such a requirement. In planning these courses, it is extremely important for us to have a better coordination (in terms of requirements, course objectives and expected enrollments) with other relevant academic programs in the University, especially with Engineering, Mathematics and some of the Science units.

The major features of our undergraduate program for the coming year are (i) a continuation of the program introduced last year, with emphasis on "local" improvements based on last year's experience, and a sizable expansion in the number of sections; (ii) a planned change of the key course 301-302 to the strengthened version 311-312; and (iii) introduction of two important 400-level courses (401 and 402), which complete our offerings of required courses for majors. In addition, we plan to encourage the orientation of independent study activities towards computer projects of practical value (to our department, to the CCIS or to other departments). In 1972-73 we plan to complete the implementation of our undergraduate curriculum, including the balance of our planned offerings at the 300 and 400 level. One of the interesting possibilities at that time is the introduction of an "atelier-type" seminar at the senior level, with emphasis on the design and implementation of software systems.
I believe that the effectiveness and impact of our undergraduate program depends to a great extent on academic coordination and on good communications. These are areas in which the College and University administrations can help a great deal.

The student enrollment in our undergraduate courses depends on the admissions in Livingston and on the nature of arrangements that permit students outside Livingston to take courses offered by our department. The admissions profile of Livingston is much influenced by the collection of images that Livingston projects. Work in computer science, the potential of computer methods for educational innovations, the challenge and opportunity of approaching some of the complex problems of the modern world via computers, the job opportunities in the computer field--these notions are not as yet strong parts of the Livingston image. From the point of view of our department, and more generally from the point of view of Livingston, it would be beneficial to make an effort towards an image which would include a clear computer-science component. A helpful move in this direction would be to issue a brochure on undergraduate computer science at Livingston (similar to the brochure on our graduate program which we issued last year). We plan to work on such a brochure this fall.

At present our department has a sizable enrollment of undergraduates from outside Livingston. This is likely to continue. However, we have here several problems: It is still not possible for students outside Livingston to major in computer science; computer science options are planned in other Colleges without the DCS being informed (there is no elementary attempt at coordination here, even though it involves students taking some of our courses); there is poor communication and coordination with other departments (especially in Engineering) in connection with computer service courses. Following our initiative, some progress was made this spring in communications with Engineering and with the College of A & ES on the subject of introductory computing courses. However, the larger question of academic coordination remains; in addition to departmental initiative and goodwill, there is need for appropriate University-wide policy and implementation mechanisms. I hope that some progress will be made in this important area next year.

Computer Science is a new discipline, and it is still poorly understood within the University. A continuous effort to explain and clarify goals, subject matter and opportunities in this area is desirable, especially oriented to undergraduates. With this in mind, we are planning a sequence of general lectures on computer science for the fall of the coming year.

An important area of contact for our department is with State Colleges and Community Colleges who are interested in computer science and in related subjects. During the last year, we participated in committee work sponsored by the ECC on State-wide curriculum planning and coordination in computer science. This is an area in which we are planning to become more active. One of the possibilities, which we are considering at present, is to organize a one-day symposium at Livingston,
(to be held in the fall) on computer science education in the State. Another possibility, which requires more study during the coming year, is the organization of a summer session in computer science which would be especially oriented to teacher training, mainly for faculty of State and Community Colleges, but also for selected high school teachers.

As part of our curriculum planning activities in the last year, we have prepared a set of comprehensive descriptions for our undergraduate courses with emphasis on course objectives, prerequisites, and how particular courses relate to one another. In addition, a number of specific course schedules were suggested to help both computer science majors and nonmajors to plan their overall programs of study in computer science.

I suggest a similar approach for the development of Interdepartmental programs. A variety of programs may be defined in terms of terminal sets of specifications (knowledge, skills, job descriptions). For each program, a collection of course schedules may be developed, largely on the basis of existing courses in Livingston; some of the courses will be from our department, and others may be from Biology, Economics, Urban Planning, Psychology, Sociology or Anthropology. The crucial task will be to set small working faculty groups whose function will be to formulate reasonable programs in the form of patterns of existing courses. Coordination problems are likely to appear at course interfaces. This may stimulate some changes and adjustments in existing courses (to be carried out by the departments in charge for the courses), and it may suggest new significant courses. The main idea here is that interdisciplinary studies do not necessarily need the introduction of new 'mixed' courses, or courses with multidisciplinary faculty participation. It is possible to capitalize on a few relatively traditional discipline-oriented programs by making available to students appropriate combinations of courses from these programs together with adequate advice as to how to choose among the available combinations.

In connection with academic advising, I would like to repeat a suggestion on tutorials that I made some time ago. Let us introduce a College requirement of a tutorial for the first two years of study of each student, which is to be taken for credit (1 or 2 credits per term). The goal is to discuss on a one to one basis (student-faculty member) various plans of study, academic problems and difficulties, so that students can make informed decisions about their programs, and they can get individual advice on general academic matters.

2. The Graduate Program

In 1970-71 we made considerable progress toward the implementation of our expanded and restructured graduate program. The Ph.D. program was introduced, and the M.S. program was organized around four major areas of study in computer science--hardware systems, software systems, numerical applications and non-numerical applications. New courses were introduced in each of these areas. With the planned introduction of several new courses for the next year our program will have considerable breadth, it will cover most of the major current activities in the field, and in some areas it will have a fair amount of depth (in particular in problems of language theory and design).
Our main goals in the near future are to strengthen the quality and depth of the existing courses; to achieve a better coordination among the courses in our program and with courses in other relevant graduate programs (especially with Mathematics, Industrial and Electrical Engineering, Statistics, Philosophy); and to establish a better relationship between our undergraduate and graduate programs. An integrated design of some of our 400 and 500 level courses may effectively extend the courses available to advanced undergraduates and it will enable graduate students without extensive undergraduate background in computer science to acquire material which is needed for graduate work in the field. In addition, we plan to extend our course offerings in machine design and architecture, in operating systems, in programming theory, in non-numerical algorithms, in information systems and in the organization of computer centers and networks. Clearly, this type of program extension depends strongly on the availability of appropriate new faculty.

One of the difficulties that was clearly recognized last year was the large size of introductory graduate classes. We plan to remedy this by increasing the number of sections in certain courses, and by making key required courses available both in the fall and in the spring.

In 1970-71 our graduate student population was about one hundred, of which three quarters were on a part time basis. Accordingly, all graduate classes are currently scheduled for the late afternoon or evening. There is an increasing demand by our full time students to introduce day classes. In view of the growth of our Ph.D. program (where one year of residence is required), and because we plan a shift towards a higher proportion of full time students at the M.S. level, we are planning to consider for 1972-73 a schedule which includes some day classes. This will facilitate coordination with the Princeton graduate program in computer science, which is a day program. The idea is to implement courses given by members of our department or by Princeton people so that they can be attended jointly by Rutgers and Princeton students. A day schedule will also facilitate coordination with our undergraduate program.

Last year we prepared a set of comprehensive descriptions for our graduate courses. This was part of our extensive curriculum planning activities, and it was mainly intended to assist our students in the planning of their programs. As part of our effort to reach more potential students and to let them know of our new strengthened programs, we have issued (and broadly disseminated) a flier describing our programs. We expect to continue having students with a professional orientation (mainly oriented to a terminal M.S.) and also students with an academic-scientific orientation. In both of these categories, we are looking for an increase in quality (background, seriousness of purpose, intellectual alertness) of the students that we are admitting.

The written Masters examination was given for the first time last year, and it proved to be quite successful. Next year we expect to give for the first time the oral qualifying examination. The formulation and administration of these examinations is an important task to which
considerable effort is being directed; it provides essential feedback for our curriculum planning, and in general it increases the maturity of our graduate programs.

During 1970-71, a graduate student organization was formally established. A committee of nine student representatives was elected, and graduate students were appointed to (and actively participated in the work of) key departmental committees. Faculty and course evaluations by the graduate student body are planned for the next year.

The graduate program in computer science can provide an important component for several new graduate programs in the University. The Health Planning graduate program, which was recently discussed with the Livingston Urban Studies Department, is a good example of such a program. A program in Linguistics (for which there is considerable interest and competence in Rutgers and in Princeton) is another interesting possibility worth pursuing next year. Also, any extension of Livingston in directions of applied science can benefit from early coordination with the computer science program, especially in view of our interest and capabilities in advanced applications and in computer-oriented applied mathematics.

3. Research

One of the important achievements of the last year was the establishment of the NIH-sponsored research resource on computers in biomedicine. Considerable effort was directed to the organization of a group of investigators for the resource, to the formulation of a research plan, and to discussions with NIH administrative and scientific groups which led to the approval of the resource for a period of 3 years starting June 1, 1971. The research resource is a multidisciplinary collaborative activity with people from several academic units in Rutgers as well as from outside the University. The resource is mainly centered in our department, and its emphasis is on advanced uses of computers in biomedical research, especially in modeling, in the management of complex data bases, and in diagnostic problem solving. Most of the DCS faculty are involved in the research resource (with the majority receiving partial support from NIH), both in discipline-oriented projects (e.g., medicine, ecosystems) and in core computer science research. In addition, the resource involves investigators from psychology, ecosystems, bioengineering and medicine. I consider the establishment of the research resource significant in several ways: (i) it indicates that the DCS is moving to a state of competence and strength which is recognized at the national level (witness the strong recommendation of the NIH National Advisory Council, and the decision to fund us under conditions of general financial tightness in Washington); (ii) it opens the way to the creation in Rutgers of a regional center for advanced work at the interface between computer science and biomedical sciences; and (iii) it provides a reasonable organizational model for other multi-disciplinary and interinstitutional enterprises that may be launched in the University. The lines of research developed in the resource, and the support opportunities for graduate students (the resource will support 4 RA's) are also important elements in the implementation of our young Ph.D. program. For the next year we face the important
challenge of implementing the research resource—in particular, making substantial research progress in each of its areas of study.

The biomedical resource could be used as a model for another significant project: computers in education. There is considerable interest in this area at Rutgers, and several specific projects are underway. At the research end, Professor M. Kochen (University of Michigan) and I started work on computer models of instructional dialogues; a proposal was prepared in this area, and it was submitted to the OE for possible support. Also Kochen and I have been active in organizational and social aspects of computer-based education; in connection with this we are organizing a session on computers in educational systems of developing nations, which is to be held in mid-August at the Jerusalem Conference on Information technology. At the development end of CAI, there has been considerable activity in our department (mainly by Professors Paull, Cox and Beaucage), in collaboration with CCIS. The main objective has been to identify existing CAI packages and to experiment with them. CAI and other related computer-based approaches hold tremendous promise for innovative education, especially in situations where there is a great variety of student backgrounds and styles of learning. It is most appropriate for us to take the lead in this area, to develop specific computer-aided courses in computer science, to work with others in the development of computer-aided courses in their academic areas, and to do research in advanced CAI systems. To advance work in this area it would be useful to create an appropriate organizational framework in the University whose function, among other things, would be to raise funds from agencies such as OE and NSF on a University-wide basis.

Our research in the area of machine problem solving continued under AFSOR support until February '71. Progress was made in representations and modeling, in program formation, in design and processing of data structures, in program equivalence, and in language descriptions. We have submitted another proposal to the AFSOR which is based on our previous work and where the emphasis is on changes in problem representations. Following recent contacts with NSF, we plan to submit a similar proposal to them. In general, it is important for us to develop a broader base of NSF support for research projects in computer science. Specific projects in computer design, in programming theory, in languages, in the theory of computation, in numerical mathematics and in graphics are appropriate candidates for NSF support. We plan to explore these possibilities next year.

One of the major sponsors of computer science R & D in the country is ARPA. They are also responsible for the development of the ARPA network, a linked system of computers which permits users to share an extensive collection of hardware and software resources. We have started to explore the possibility of ARPA support for our department, and we plan to pursue this in the coming year.

4. Colloquia, publications

In the last year we had a most interesting sequence of computer science
colloquia, with a frequency approaching one a week. The colloquia covered a great variety of current work in computer science. We plan to continue this highly successful program next year. In addition, as part of the NIH-Sponsored research resource, we plan to initiate a sequence of seminars on computers in biomedicine.

Our technical reports program is getting underway. At present 9 technical reports have been issued.

In the last year we have started issuing the 'Proceedings of the DCS', a departmental newsletter which is edited by Professor Falk. This is a very useful publication, which we plan to continue.

Members of the DCS have published several papers, presented talks and participated in various professional committee activities during the past year. The amount of publishing and the overall level of professional activities is still relatively low. The tremendous load of academic planning and instruction in a growing program with limited resources is clearly one of the reasons for this. I hope that we will reach a more balanced situation as the academic programs become more stable, research becomes a normal part of the picture, and the level of resources which is available to us will improve.

5. Faculty

This year we have made important progress in strengthening our faculty. Eight new people are joining us--five on a regular basis and three on an adjunct basis. Unfortunately, we are losing Professor S. Droege who has been a member of the DCS since its formation (she is moving to another part of the country). Our new colleagues include several senior people, as well as several recent graduates of computer science and mathematics programs. They are:

- Dr. R. Vichnevetsky, Professor (computer-oriented applied mathematics, numerical analysis, optimization, simulation, hybrid computations)

- Dr. I. Polonsky, Adjunct Professor (programming languages, symbol manipulation processes, operating systems)

- Dr. S. Levy, Associate Professor (theory of computation, machine organization, switching theory)

- Dr. M. Grigoriadis, Adjunct Associate Professor (computer-oriented applied mathematics, mathematical programming, modeling and simulation)

- Dr. B. Bruce, Assistant Professor (language processing, artificial intelligence, logic)

- Dr. E. Wilkens, Assistant Professor (switching theory, machine organization, real-time computations)
Dr. C. Beaucage, Adjunct Instructor (topology, mathematics instruction)

Mr. T. Ostrand, Instructor (automata theory, software design)

In view of the projections for our undergraduate and graduate programs, I expect that our faculty will grow roughly at the same rate next year. We are now at a point where we should start considering, in addition, visiting appointments for periods of one or two semesters. This type of appointment will improve communication with other computer science centers, and it will increase the level of intellectual stimulation in the department.

6. Organization, Clerical support

The list of our departmental committees has grown in the past year. Through these committees, the entire faculty (and in several cases graduate students) is participating in departmental affairs and in decision making. The list of committees includes Departmental Advising, Undergraduate Examinations and Scholastic Standing, Undergraduate Curriculum, Undergraduate Mathematics in Computer Science, Undergraduate Instruction for Non-Majors, Graduate Admissions, Graduate Curriculum, Graduate Examinations & Scholastic Standing, Graduate Assistantships & Fellowships, Scheduling, Computing Resources, Computer Terminal Room, Departmental Space, Colloquia & Technical Publications, Library, Newsletters & Brochures.

In most cases the committees had to address themselves to a variety of urgent special cases, without having had enough time for the development of effective procedures. One of the important organizational tasks next year will be the development of such procedures.

One of the persistent problems in our departmental office has been the insufficiency of clerical support. During the last year, the volume of activity and the urgency of demands was such that our two secretaries (supported by a part-time secretary) had to face almost continuously crisis situations. We now plan to engage a secretary under the NIH grant to assist mainly in the research activities. Additional secretarial support is one of the urgent needs for the next year.

7. Planning

In the Fall of 1970 we devoted considerable effort to long range planning for our department: expected undergraduate and graduate demand in computer science for the next 10 years (in New Jersey, and in Rutgers), the nature of departmental growth that the demand projections imply, and specific recommendations for graduate admissions. By the end of the decade, we expect our Masters program to double, and we see our Ph.D. program reaching a point where over 10 students graduate each year. The undergraduate demand in New Jersey is likely to grow extremely rapidly. The nature of this growth at the University depends among other things on the overall growth plan for undergraduate colleges and on the methods of academic coordination that will be instituted.
In the Spring of 1971, Professor Kulikowski and I participated in some aspects of long range planning for Kilmer 2, and in planning for an expanded Livingston. An orientation towards more applied science, and towards understanding and shaping relationships between science engineering and society is most appropriate for an expanded Livingston. The DCS can play an important role in such an expansion.

8. Resources; space, computing

On the basis of the long range planning data for our department, space needs for the next several years were formulated. This led to a review of space allocation plans for the DCS in the new building at University Heights. The new allocation is sufficient for our space needs in the next two years. The present plan is to move to the University Heights building in January, 1972. Interim arrangements for the Fall semester of the coming academic year are to be based on space available in the Kilmer area.

During the past year, the amount of interactive computing - in instruction, software development and research- grew rapidly at the DCS. In the Spring it was clear that the available resources for interactive computing were operating at saturation level. It was realized for some time that more careful planning of computer resources at the University was necessary, so that a more rational basis could be provided for a difficult decision-making process - where the relative roles of the University and the ECC have been ill-defined for some time. Several University committees were formed in the Spring, and they have been working hard since then to determine projections for computing demand in the University, the academic basis for these projections, and technical evaluations of possible computer configurations for the next year. Members of the DCS devoted a large amount of time and energy to the work of these committees--notably Prof. Orgass (in the Technical Committee) and myself (in the Planning Committee for Academic Computing). Considerable progress was made in the areas of planning and technical evaluation of system alternatives. Despite this, the computer situation for the next year is still uncertain at the time of this writing. Some of the major difficulties derive from the lack of senior technical manpower at CCIS (for planning, technical evaluations, and design of extended operations), and from the vagueness in the relationship between Rutgers and the ECC on matters of decision-making in the computer area. The availability of appropriate computing resources is extremely important for many academic programs in Rutgers, and it is essential for our department.

Thus, it is crucial for the DCS that efforts be made - as soon as possible - to streamline the decision-making process in the computer service area, and to bring appropriate manpower to the CCIS for strengthening the planning and technical operations. In addition, it is important for us to explore alternative (non-CCIS based) sources of computer resources.