COMPUTER SCIENCE PLAN

CONTENTS

APPENDICES

ABSTRACT

This report puts forth a preliminary ten-year plan for the newly established Department of Computer Science at Kansas State University. The plan establishes the baseline of current departmental status, proceeds to key objectives for meeting projected social requirements for computer science, and then describes milestones to achieve these objectives for faculty, physical resources, curriculum and students. The joint KU/KSU program for doctoral candidates is highlighted as a unique requirement of this plan. The method borrows from key concepts in the Planning, Programing, Budgeting System approach (PPBS), with special emphasis on cost and performance evaluation.

A basic goal is to meet the challenge of swift advances in computer science and technology culminating in public use of computer services in the 1980's in the form of mass information utilities. To meet this challenge in the KSU context, the following major milestones are anticipated.

- 1971: Initiate joint KU/KSU Ph.D. program
- 1973: Expand the effective scope of the department from computer science to computer and information science
- 1975: First Ph.D.'s receive their doctorates from the joint program
- 1977: All undergraduates receive at least one introductory course in computer science at KSU--no computer illiterates on campus
- 1979: KSU graduates and KSU faculty make a major impact on computer research and technology--KSU becomes a leading center for computer studies
- 1981: Full spectrum of computer and information science skills and related interdisciplinary skills are taught and developed at KSU for mass use and specialized social applications of computers

During this ten-year period, growth in the student body, faculty, and budget is projected as follows to meet the above planning requirements. Graduate students progress from 30 in 1971, to 50 in 1976, to 70 in 1981; undergraduate majors and minors in computer science increase from 200 in 1971, to 425 in 1976, to 600 in 1981; other students taking computer science courses grow from only about 100 in 1971, to 4000 in 1976 when all undergraduates are required to have some familiarity with computer science, to 5000 in 1981 as KSU grows in total student body. The Computer Science faculty increases from 8.5 in 1971, to 21 in 1976, to 30 in 1981 with commensurate diversification in curriculum and research. Student and faculty performance will be measured by standardized evaluative instruments. The departmental budget, including computer services which is roughly 40 percent of the total, rises from some $200,000 in 1971, to $780,000 in 1976, to slightly over one million dollars in 1981. The million-dollar goal in 1981 is believed sufficient to serve the projected requirement of 5000 students taking introductory courses, 600 majors and minors in computer science, research and teaching requirements for the equivalent of 30 full-time faculty, with necessary supporting staff and computer services. At that point we expect KSU to be a leading national center for theoretical and applied interdisciplinary work in computers and computer services to meet rapidly burgeoning social needs.

I. INTRODUCTION AND KEYNOTE

This report covers current status and preliminary plans of the newly formed Computer Science Department at KSU. Since this Department is less than one month old at this writing, long-range plans are unavoidably tentative and await further corroboration among principals within the University and between KSU and KU in regard to the recently projected joint Ph.D. program offered by both universities.

The body of the report encompasses four basic areas: objectives, faculty and resources, curriculum, and students. Each of these four sections describes current status of the Department of Computer Science to establish a baseline for projections, objectives for desired evolutionary growth, and a ten-year summary plan listing major milestones in departmental development. Supporting data and evidence are placed in the Appendix, listed in order of appearance in the text.

This introductory section is primarily devoted to an overview of computer science, a forecast of key trends, and the development of basic roles and objectives to meet university needs in the growing application of computers to social affairs. Accordingly, the introduction is cast in the form of a keynote to set the stage for more detailed planning in the body of the report.

Computers have been with us since man used his hand as a digital computer. The position of the sun in the sky was probably the first analog computer. The ancient abacus was a major computational improvement over the human hand, and sundials and clocks were significant advances over subjective estimates of the position of the sun. In a mystic revelation of things to come, Pythagoras proclaimed, 2500 years ago, that all things are numbers.

With the advent of the modern electronic digital computer, spawned only one human generation ago in World War II, Pythagoras' cryptic dictum is realized as computers weave a binary web about virtually all phases of human affairs.

In the short span of this last human generation, computers have proliferated at an almost unbelievable rate, accompanied by severe growing pains and much chaos and disorder. There are over 100,000 computers throughout the world. Computer power and computer hardware cost-effectiveness have doubled every two to three years over the 1950's and 1960's. Computational speeds have progressed from tenths of a second to trillionths of a second; size has been cut down exponentially from vacuum tube computers in large block houses, as with the AN/FSQ-7 used in SAGE air defense, to room-size transistorized computers, to head-sized spaceborne computers with advanced integrated circuits; and the storage of information has progressed from 150 words in the ENIAC to over one million words (or 8 million bytes) of high-speed memory in our largest computers today.

Computer applications started with such tasks as the computation of ballistic missile trajectories and nuclear reaction equations in World War II, with the computer playing the role of high-speed number cruncher (calculators). The advent of the real-time command and control systems in all the major armed services in the 1950's highlighted Pythagoras' dictum with brilliant clarity --computers were not merely gigantic number crunchers, they were essential for national survival, and could be applied, in principle, to virtually all human affairs. Real time systems permit positive control over events at the time of their occurrence; they represent a major evolutionary advance in social control of human affairs. Subsequent to interactive man-computer communication in real-time command and control, time-sharing appeared in the 1960's. With time-sharing, different users could share the same computer with independent tasks, entering and leaving the system at different times, as with a public utility. Online and offline computer applications in the 1960's spread rapidly through the aerospace industry, the sciences, the business world, and later through the arts. Mass information utilities--the universal extension of interactive computer services to the general public in the natural environment of the user--will appear in prototype form this decade, and will become established as a major social force in its own right in the 1980's.

The economic impact of computers is already massive. The computer industry operates at the annual rate of some 10 billion dollars per year for goods and services today, and many predict that it will be the largest single industry in the 1980's.

The 1960's also witnessed the emergence of computer science (and/or information science) as an academic discipline in its own right in major universities not only in the United States, but also throughout the world. The definition and scope of this infant science propelled by powerful economic and political forces has been the subject of hot dispute. Engineering, mathematics, and business schools, among others, have variously claimed to be lawful progenitors and rightful heirs to this new science.

The first departments of computer science were primarily concerned with justification of the field as a scientific academic discipline in its own right. Hence great emphasis was placed on academic respectability, particularly on mathematical, logical, and theoretical roots, generally in the direction of pure rather than applied science. Social problems and social requirements were not vital for survival of nascent computer science departments, and social payoff received short shrift when computer science applied for academic recognition. However, as indicated in this introduction, the manifest destiny of computers as a powerful socio-economic-political force in its own right, necessitates a redirection of academic values in computer science toward a more humanistic balance, with social benefits as the main theme.

The crux of the future of computer science is in social use. This fundamental axiom is based on the premise that everyone will soon become a significant user of computer services. In the first human generation of computer development from World War II to the present, the prime beneficiaries have been government, industry and other large institutional users. A generous estimate at this time would indicate that only one percent of the general population has significant interaction with computers in their daily affairs. However, with the new generation of college students, who will reach their prime about the year 2000, computer usage will spread from one percent to almost 100 percent, particularly with the rise and spread of cost-effective mass information utilities at home, in the office, and in schools. The computer elite, serving less than one percent of the population, will have to change its values, method, and practice to serve the information needs of all citizens in all walks of life. If not, the information rich will get richer, the information poor will get poorer, and democratic opportunity may disappear. Nothing less than a democratization of computer science is needed, not later, but now, for academic leadership in meeting the challenge of social excellence in the extension of computer services throughout society.

This democratization of computer science can assume a variety of new forms. Educationally, every college student could be exposed to basic instruction and use of computers so that there will be no computer illiterates on the campus. An individual ignorant of computers, their capabilities and limitations, will be at a crippling disadvantage in relation to his contemporaries. Thus, a basic strategic goal is the systematic extension of introductory computer science to meet the diversified needs of all college students.

As mathematics is handmaiden to the sciences, so is computer science handmaiden to the larger sphere of science, technology, and the new problem-oriented interdisciplines. Computers are revolutionizing scientific method, not only in practice, but also in spirit. Increasing experience with case histories of large-scale, long-term computerization in military, educational, scientific, and commercial settings have repeatedly demonstrated that the most effective utilization of computer services occurs as users become sufficiently educated and sophisticated to take over on their own. The ignorant user is the impotent user. Thus, the goal of computer science in this area is to learn the necessary interdisciplinary skills by working on cooperative teams with the full spectrum of computer users, to help such users to help themselves so that they can become relatively independent of computer specialists.

It is not recommended that computer scientists plan for their own extinction by helping users to become self-sufficient. The state of the art in computer science is swiftly changing with new advances springing from all sides. Developments such as natural language processing--computer recognition of conversational voice input and generation of intelligible verbal output--are bound to revolutionize the method and spirit of computer science. Continuing research is needed in basic computer science on all fronts to keep up with rising demands for more diversified and more cost-effective information services.

However, the current bias in computer science toward pure science to the neglect of applied science needs to be corrected. The traditional courses in logic, hardware architecture, programing, numerical analysis, languages and compilers, simulation, heuristics, and automata theory need to be supplemented by more applied courses in system design and development, empirical test and evaluation (e.g., statistics and experimental design), and the scientific study of the human use of computers (e.g., the intersection of computers and social science). These areas represent a systematic extension of scientific method to computer theory, making computer science more scientific in the empirical sense of the term, and humanizing computer science by adapting its theory and findings to human parameters. Both the computer industry and academia have been derelict in the past in putting forth untested, shoddy hardware and software for widespread application to gullible users. Computer technology has been guided by arbitrary procrustean principles rather than scientifically verified human use. With the universalization of computer services, higher quality control standards will be required, particularly for mass information utilities.

Within the university structure, computer science will have to demonstrate a high degree of cooperation with virtually all other disciplines. Computer science departments will need to train professionals of all callings in generalized computer techniques and concepts relevant to advances in each calling. Cross-fertilization of computer science with other disciplines should be encouraged to keep up with new problems and growing demands from all fields. Such cross-fertilization could occur through a variety of mechanisms--split appointments, interdisciplinary grants, mission-oriented institutes, interdisciplinary departments and degrees, and community projects. New computer-related developments could be pioneered either by interdisciplinary teams, computer scientists alone, or the object discipline alone. Flexibility and pragmatic use of available interdisciplinary resources should be pursued. The problem and its solution should define the disciplinary mix. For example, development of mass information utilities requires close cooperation of many diverse skills such as: computer scientists, communications engineers, municipal government, CATV operators, vendors of peripheral equipment, regulatory agencies, vendors of user services, banks, management teams, information specialists, and many others.

This brief introduction is aimed at the spirit, not the letter of the new roles expected of computer science in the future. Subsequent sections spell out in greater detail alternative plans for realizing the foregoing philosophy in the KSU and the KU/KSU context. Many of the recommended changes are rather substantial, and will require much cooperative experimentation to adjust means and ends to resources. It is in this experimental spirit that our plans are offered.

BIBLIOGRAPHY

1. Atchison, William F., and John W. Hamblen, Status of Computer Sciences Curricula in Colleges and Universities, Communications of the ACM, Vol. 7, No. 4, April 1965, pp. 225-227.

2. Computing Reviews - updated from year to year.

3. Computers and Automation - updated from year to year.

4. Parsons and Williams, Forecast of 1968-2000 of Computer Developments and Applications, Copenhagen, Denmark, 1968.

II. GOALS

1. PURPOSE

Computer science is difficult to define, but its concern is with machines for computing and information handling and the ways and means by which they can be made to carry out their work. This is admittedly vague and is subject to a variety of emphases reflected by the different patterns among the schools offering programs in this field. Certainly the field is an evolving one with a need to be responsive to new directions. Unlike entomology or geography, computer science is likely to be part of the curriculum of students majoring in a wide range of disciplines. In this sense it has the universality of English or of mathematics, which are essentials to scholarship in many fields. Thus, in addition to being concerned with computer science in its own right and as a field with its own majors, we must be sensitive to the need for and applications of computer science in such fields as engineering, mathematics, statistics, the physical, biological and social sciences, the humanities, business and medicine.

Taking these applications into account, we are able to distinguish four different purposes to which computer science should address itself. We will list these briefly here, and then expand upon each in turn in this section, before giving a more detailed justification, in Section 2, of each purpose.

The KSU Computer Science Department should provide:

a. An introductory course in computer science which gives every KSU student some insight into the nature of computer programming, the scope of computer science, and the impact of computers on technology and society.

b. A variety of programs for students in other (non-computer science) fields which give them the ability to apply computer science to their own fields.

c. Training for computer science majors, at both the undergraduate and graduate levels, in the core courses of computer science, so that each student can play a role in developing a more sophisticated, humane, and useful computer technology to meet the pressing needs of a computer-serviced society.

d. A unique joint Ph.D. program for graduate students, allowing them to utilize the resources of both Kansas State University and the University of Kansas, while developing cooperative computer networks aimed at large-scale regional use.

These goals imply expansion of the scope of the department to place computer science in a more flexible posture allowing free adaptation to interdisciplinary studies and mission-oriented social problems as they arise.

In an era in which computers are assuming an ever increasing burden of the routine work of our society, an understanding of the capabilities and limitations of computers is becoming an increasingly important element in the equipment of an educated person. In earlier days, the "three R's" were considered sufficient education for a man making a place in society. By the 21st century, however, computers will be used so much in our society that some knowledge of them will be as essential as knowledge of the three R's was at an earlier time.

Even people who do not work with computers will require some understanding of them in order to avoid the bewilderment that is the lot of the illiterate today. The Computer Science Department should help to fill the educational needs of the non-technical non-specialist just as the more established sciences fill the need of non-science students. By so doing, computer science will serve both society and the computing science profession by increasing public knowledge about, and support for, computer technologies.

In order to fill these needs, our department has offered an introductory course to teach computer programming and basic computer science. This course has been divided into three sections i.e., business, scientific, and general, to make it meaningful to all university students. (See Student Achievement Section.)

Because computers have modified the professional activity of individuals in so many areas, and because the potential for effective application of computing technology to many disciplines is still being explored, large numbers of people trained in an interdisciplinary region between an applications area and computer science should be educated. The department has been alert to this need, and we have responded with a series of possible programs (see Curriculum Section) which majors in other departments might wish to combine with a computer science minor (see b.), or which majors in computer science might wish to combine with minors in other disciplines. An example is a computer science major with a minor in business.

The third principal goal of the Computer Science Department is to provide training for computer science majors, and to support research effort by the faculty and the graduate students. This training will transmit the knowledge at the heart of computer science to students, and this research will extend the knowledge which is at the heart of the discipline. The corps of students trained in computer science will become increasingly necessary for the development and maintenance of computer systems which support data handling and problem solution by workers untrained in computer science. This role for specialists in computer science is the provision of a man-machine interface for users whose primary interest is outside of computer science. For example, specialists in computer languages might design languages which help people to use the computer if they are competent in their own field of learning, but do not want to develop the computer language they need. Specialists in data organization and management might design and implement large systems to aid potential users of data processing machines to handle large, unwieldy data bases. Specialists in hardware might use new integrated circuitry to develop more powerful computers and new types of computers. Specialists in computer systems might coordinate advances in languages, data organization, data management, and machine capability into organic units which might be employed profitably by users of the systems.

Our undergraduate majors receive the core of courses recommended by the Association for Computing Machinery (see Curriculum Section), and we will update this core as the field of computer science evolves in response to research advances and to the needs of society (see Computer Science Milestones, P. II-14).

A fourth principal goal of the Computer Science Department at KSU is successful operation of a joint Ph.D. Program with KU. Such an accomplishment will provide the computer science profession, ourselves, and our students with an opportunity and environment in which to extend the body of knowledge of the profession. But less obviously, it will also serve as a model for cooperative programs in other disciplines, which may be increasingly attractive, in these times of difficult financial circumstances, for institutions of higher education.

Since the joint Ph.D. program is unique, it seems appropriate to quote some passages from the proposal which led to its existence in order to impart some of its spirit.

"The determining principle for such a joint undertaking is that there is to be a single program operating on and making use of the resources of both campuses. The marshalling of talent under the plan will afford the student a much wider range of educational opportunity than either school would be able to provide separately. Moreover, the plan has great future significance in view of increasing emphasis on coordination of and cooperation between programs among the several Regents' institutions."

"In combining the resources of the University of Kansas and Kansas State University at the doctoral level, an important consideration is the division of labor within the field of computer science so that expected development may proceed without overt and wasteful duplication. A blueprint for such a division, arrived at by the faculties from the two campuses, serves as the point of departure for the doctoral program. Every effort has been made to achieve a rational differentiation of research specialties. The division of the field is neither unique nor exhaustive, however, but it illustrates agreement upon separate areas of emphasis and takes into account current faculty research activity. It is understood that, in any intellectual effort, it is difficult to identify one subspecialization as being totally independent of another and that it is undesirable, if not impossible, to prohibit mental excursion into related areas. Therefore, in maintaining differentiation it is important to emphasize the current spirit of faculty determination to shape the growth of the program on each campus in distinct ways, allowing for readjustment as the program evolves. Certainly in a new field such as computer science allowance must be made for the dynamic and evolutionary character of individual interests and of the field itself. Perhaps more significant than formal agreements or legalism is the consideration of evidence of good faith and of demonstrable differentiation to be adduced from the experience of the coming years. <u>To this purpose it is essential that there be a mechanism for review, evaluation, and redirection as provided for under the Steering Committee. This committee shall have the basic responsibility to provide for differentiation and to assess the uniformity of practices and the degree of reciprocal action between the campuses, always being guided by the principle that a single program exists to best serve the student.</u>"

GENERAL PRINCIPLES

"A plan for a common doctoral program offered by the University of Kansas and Kansas State University can be based on the following principles."

"1) The computer science resources of each school should be uniformly available to doctoral students and faculty with full reciprocity.

2) There should be a single program in computer science with common academic policies and standards for the fulfillment of degree requirements.

3) Although parallel offerings will be necessary to serve students from other programs, each school will maintain complementary and differentiated research emphases in computer science so as to provide a broad choice of specializations to the doctoral student and to identify the unique areas of competence to be developed on each campus, both in current faculty effort and in future recruitment.

4) As a relatively novel undertaking which might pave the way for future joint institutional effort in certain other areas, care should be used in identifying and developing effective ways of communication between and within the student and faculty populations. That computers themselves might be an important part of such communication lends unusual potential to the present plan."

(See Curriculum for Current Classification of Doctoral Research Specialties in Computer Science.)

"Faculty Meetings. There will be a meeting of the faculty at least once each semester, alternating between the campuses. Each person may cast one vote, with voting and other parliamentary procedures to be determined by the faculty. The authority for setting degree requirements and for similar academic policies belongs to the faculty. As suggested by experience and convenience the faculty may rely on the Steering Committee to identify and develop recommendations for such matters, and, indeed, to decide them in the absence of subsequent revocation by the faculty."

2. STATEMENT OF ROLE IN THE COMMUNITY

The role of the Computer Science Department has been defined in the foregoing discussion. The widespread impact of the technology on society forces computer science to pay particular attention to educating the University's students of the possibilities, both realized and potential, which computers have engendered. If one regards the purposes as a four-tiered hierarchy, then the broadest but shallowest tier, the non-computer scientists, is the one which concerns us first. A current discussion of the profound implications of computer science to society, most of which consists of non-computer-scientists, is available in the introduction.

At the second tier (joint majors) and third tier (computer science undergraduates) of the heirarchy, narrower populations are given increasing in-depth educations in computer science and technology. The role played by the department in these levels corresponds in every regard to the roles assumed by each academic department in training students in its respective discipline, and requires no special comment. It may be re-emphasized that the very widespread applicability of the computer technology to other, sometimes quite distant, disciplines places a special requirement on computer scientists that they be particularly alert to the opportunities to encourage interdisciplinary activity by being open to educational innovations involving cooperation with experts in other fields.

In addition to training workers who can serve their community, nation, and world, our Department of Computer Science will offer educational institutions a model for an unusual Ph.D. program in the fourth tier of our hierarchy. The role of the Computer Science Department at Kansas State University as a partner with the Computer Science Department at the University of Kansas in offering a joint Ph.D. is a unique one on our campus. In addition to offering training to students, the program offers a model for other inter-university degree programs to be implemented in the future. In any event, the experience we will gain from this two-campus program will be valuable to others in our state system in planning similar future programs.

As this report is being written, the joint Ph.D. program is only two months old; the Steering Committee has met only once; much of the detail which will evolve to support the cooperative effort has not yet been conceived. Accordingly, very little can be said about the viability of the arrangements which have been sketched. Intense and determined effort will be required for the next several years to ensure that the potential of the program be fully realized, and a major portion of faculty effort in the departments on the two campuses will necessarily be directed toward making the joint effort succeed.

3. PRIORITIES TO GUIDE GROWTH

We have two priorities, 1) to build an excellent Ph.D. program and 2) to maintain a sound undergraduate program. The highest priority is to build the graduate faculty. This does not imply that the graduate program is intrinsically of more importance than the undergraduate program, but rather that our relative strengths are most in need of improvement at the graduate level. The areas of Data Organization, Business Applications, Programming Systems, Realtime Systems, Computer Networks, Man-Computer Communication, Computer-Aided Planning, and Large-Scale System Development have been identified as areas which would be appropriate ones for early graduate faculty additions.

We should at the same time guard the excellence of our undergraduate program in computer science, and make sure that it serves students outside of computer science, students with joint majors which include computer science, and computer science majors. This will necessitate continual surveillance of the excellence of our undergraduate curriculum, as well as of its relevance both to computer science and to society.

Although the faculty are concentrating their efforts in various areas, they are all unified in supporting our purposes as outlined previously. Their diverse interests support these goals in the aggregate, even though each individual faculty member's inclinations may favor one aspect of the total picture more than other aspects. Since the department of computer science is so new, many organizational details are still in the process of being worked through, and the department cannot be said to have established a routine in which faculty have settled into individual roles which are integrated into an overall effort.

4. SUPPORT OF PURPOSES FROM FACULTY

H. Sackman, the new Head of the Department of Computer Science, runs the department as a participatory democracy, a plan of operation derived from his professional work in studying the effectiveness of various planning techniques. Although it requires a dedication which some faculty members find onerous, it is an effective way of ensuring faculty participation in establishment and achievement of departmental goals. This participation should surpass other planning and management approaches in producing in the faculty a high degree of agreement, and of coherent effort.

This approach, so important to our departmental development, is explained in the following quotes from Dr. Sackman's paper.*

"Participatory planning refers to mutual expectations in social creation of a plan--the attitudes, beliefs, values, goals, priorities, judgments and supporting rationalizations that enter into social consensus for defining and initiating an authorized plan...."

"First, the emphasis is not evenly distributed over the entire planning process from the gleam in someone's eye to the completed final plan. The focus is primarily on the early normative stage of planning--the creation of a concurred and accepted mandate for planning in the specified planning community (the computer science faculty). Thus, the planning techniques for the earliest stages of planning (normative planning) and the earliest stages of system development (system goals), are the starting point for participatory..... planning....."

"In principle, participatory.....planning can be applied wherever human evaluation is invoked, and wherever there is a difference of opinion on explicit issues, which can occur at any point throughout the entire planning cycle."

This integration is facilitated by our participatory planning approach which allows participation by our faculty in establishment of departmental goals.

5. PROVISIONAL PLANS FOR THE DEPARTMENT

The current state of planning for the new Computer Science Department can best be illustrated by quoting extensively from a report to the Vice President for Academic Affairs by a planning committee prior to formation of the department.

These preliminary plans are subject to continuing modification and reinterpretation as gaps are filled and as new agreements are reached among the principals at KU and KSU.

"It is clear that there are many faculty members and students who may make extensive use of computers at a highly sophisticated level and who are not

*SP-3480, H. Sackman, System Development Corporation, April 6, 1970.