Purdue University

Purdue e-Pubs

Department of Computer Science Technical Reports

Department of Computer Science

1993

The 1981, 1986, and 1990 Long Term Plans of the Department of Computer Sciences

John R. Rice

Purdue University, jrr@cs.purdue.edu

Report Number:

93-036

THE 1981, 1986, AND 1990
LONG TERM PLANS OF THE
DEPARTMENT OF COMPUTER SCIENCES

John R. Rice

CSD-TR-93-036
June 1993

PURDUE UNIVERSITY

A PLAN FOR EXCELLENCE IN COMPUTER SCIENCES

Peter J. Denning

John R. Rice

Lawrence Snyder

Paul Young

July 15, 1981
Revised August 26, 1981

Objectives

This document is a plan for Computer Sciences at Purdue University for the rest of the 1980s. Most of the discussion is focussed on building a department during the next five years that will serve Purdue for many years afterward. Our principal objective is:

> *The Computer Sciences Department at Purdue should be the best among the Big Ten universities and among the top ten in the U.S.*

We believe that, in the tight markets projected for computer science during the next decade, any lesser goal would be a path to a second-rate department. We do not intend to be part of a second-rate department.

Assumptions

Our plan to achieve and maintain this goal is based on four assumptions about computer science in the U.S. and the environment at Purdue University:

1. Computer science has become and will remain a fundamental discipline. It is intellectually challenging in its own right. It supports other sciences and engineering. It will receive major support by scientific and technological universities. The current surge of interest is not a transient that will soon pass.
2. Severe manpower shortages at the PhD level will persist through the 1980s. This situation is unstable. Many departments will cease to function in research. The surviving departments will be characterized by strong, lab-oriented experimental science programs backed by strong theory groups. High-quality teaching and research environments will be essential to attract and retain high-quality faculty.

3. At Purdue, large student-faculty ratios will persist in the CS department. We are prepared to live with this as a fact of life if the support and research environment compensates. We believe that we can optimistically count on expanding faculty by only two per year; faster expansion is unlikely in the current and expected manpower markets.

4. Purdue University's many problems in computer science must be dealt with simultaneously in an organized, coherent way. Piecemeal efforts will sap our energy without producing significant progress. There must be an overall plan to take us to our goal.

The current market in the computer science field is highly competitive. It must be met aggressively. Survival will not be cheap.

In the two sections following, we summarize the current state of computer science nationally and at Purdue. We then describe our vision of the instruction and research environment that meets the objectives set forth above. We present milestones for a five-year plan that will take us to this goal. We estimate the amount of space, the capital investment, and sources of funding for the facility envisioned.

Current State of Computer Science Nationally

The severe manpower shortage in the computing field is especially acute at the PhD level. Because it has been well documented, there is no need to belabor the details here. [1,2,3,4] The Snowbird Report (footnote 2), a joint declaration of the department heads of the PhD-granting PhD departments in the U.S., gives a concise summary of the problem. The national inability to attract and retain high-quality faculty and graduate students in CS has four roots: very high teaching loads that interfere with research and proper supervision of graduate students; obsolescent experimental facilities; insufficient laboratories for instruction and research; and lagging salaries. Not only do these factors discourage new PhDs from taking university positions, they discourage new baccalaureates from entering graduate school.

The Snowbird Report describes possible capital investments in experimental computer science. A department desiring only a "low level" of commitment can get by with an investment of $10K per researcher. (A researcher is a faculty member, graduate student, or technician assigned to a research project.) A department desiring a "moderate level" of commitment -- sufficient to support some experimentation and teach students the methods of experimental science in computing -- requires about $30K investment per researcher. A department committed to the "frontier level", which enables it to perform substantive new research and set new directions for the field, requires an investment of about $60K per researcher. This last figure is compar-

---

[1] **The Feldman Report:** J. Feldman, Editor, "Rejuvenating Experimental Computer Science," *Communications of ACM*, September 1979.

[2] **The Snowbird Report:** P. J. Denning, Editor, "A Discipline in Crisis," *Communications of ACM*, June 1981, 370-374.

[3] P. J. Denning, "Eating Our Seed Corn," *Communications of ACM*, June 1981, 341-343.

[4] National Science Foundation and Department of Education Report to the President of the United States, *Science and Engineering Education in the 1980s and Beyond*, October 1980.

able to the investment expected to support a new research faculty member in other experimental sciences on this campus such as biology or chemistry.

The CS Departments at MIT, Stanford, and Carnegie-Mellon Universities exemplify the frontier level of capitalization -- at least $60K per researcher. Each of these departments has developed a critical mass of faculty and facilities that enables it to maintain a significant flow of funds from government and industry. With newly acquired funds from DARPA and NSF, the CS Departments at University of Washington, Berkeley, Cornell, Illinois, and Wisconsin will have investments surpassing $60K per researcher by 1983. These figures are funds directly controlled by the departments; they do not include general support of computing through campus computing centers. Illinois and Wisconsin are our major competitors in the Big Ten.

The VAX research facility run by the CS department at Purdue has about $350K invested in it at present; another $150K will be invested for research shortly. There are about 25 research faculty using this facility and 25 PhD graduate students, a total of 50 researchers. This investment is about $10K per researcher, putting us in the "low" category noted in the Snowbird Report. Since VAX facilities are becoming standard in CS departments around the country, the competitive edge we had about two years ago because of this facility has vanished. The capital investment to put the existing research faculty at the "frontier level" is about $3M, six times the current figure.

Owing to the manpower shortage, the national situation is presently unstable. There are presently 77 PhD-granting computer science departments in the U.S. averaging 13 faculty each. Among these departments, the total number of positions to be filled each year is estimated at around 200. The non-PhD-granting departments have an additional 400 open positions. This total demand (600 PhDs) compares with total production of about 250 PhDs nationally, of which less than 40% choose academic careers, and still fewer meet our standards. We believe that, within a few years, most of the PhD-granting departments will cease to do significant computer science research because they will be unable to attract faculty of sufficient experimental caliber. There will remain a handful of survivors, probably 10 to 15 departments nationally. We intend that Purdue be among the survivors. The plan below is not merely a plan for excellence; it is a plan for survival.

Current State of Computer Science at Purdue

In 1978 Richard Conway of Cornell University conducted a survey of the department heads of PhD-granting CS departments in the US and Canada in an attempt to learn perceptions about each other's quality and standings. The top nine were: Stanford, Carnegie-Mellon, MIT, Cornell, Berkeley, Illinois, UCLA, Toronto, and Purdue. The perception of Purdue was, however, one of decline. The decline was halted briefly in 1979-80 with the arrival of the new VAX, the selection of a new Head, and an extraordinarily successful recruiting season. Unfortunately, the available evidence suggests that 1979-80 was an exception, not the reversal of the decline. The reasons are summarized below.

Computational Facilities

Almost all second-rate departments now have a VAX or equivalent to support faculty research, and almost all are smaller departments than ours. Our own VAX is demonstrably overloaded. Response time is typically slow; most graduate students have no access at all; no instruction is supported by the machine. The arrival of a second VAX in September 1981 will, given the increased size of the faculty and graduate program, simply restore our computing power to the level of second-rate departments in the country.

New PUCC facilities such as the CRAY-1 machine and th PDP-11/70 terminal support system do not meet our needs for high quality interactive computing for majors.

Undergraduate Enrollments

Undergraduate enrollments have increased horrendously. About 550 Science freshmen have declared computer science as their major for Fall 1981. (This compares with 330 for Fall 1980.) Despite our best efforts at recruiting, we managed only to maintain our FTE strength for 1981-82 (see below). We have the same number of TAs as last fall. The workload presented to the current faculty is far higher than in any other department of the School of Science. We judge the current staffing situation to be highly unstable. Without significant relief, we expect massive defections to begin within two years. Once begun, defections will be difficult or impossible to arrest.

Quality of Graduate Program

Graduate applications are down to the danger point this year: unless we can find more qualified applicants, we will be unable to fill our open TA positions. Part of the problem is undoubtedly the general market conditions -- lucrative jobs luring the best students away from graduate school. But much of the problem arises from three internal factors.

First is, simply, money. The current TA stipend ($477 per month) is inadequate even for West Lafayette. The departments with whom we are directly competing (e.g., Wisconsin and Illinois) now offer starting stipends approaching $600 per month. Even the best schools (e.g., Carnegie-Mellon), which traditionally underpay graduate students, are also offering stipends approaching $600 for Fall 1981. We need to significantly raise stipends in order to obtain better applicants.

Second is the quality of the computing facilities for graduate students. Most incoming students, even from small colleges, perceive Purdue's facilities to be inferior to those available in their undergraduate days. Merely adding general facilities to PUCC will not solve this problem. We need specialized departmental facilities that permit faculty to supervise students in projects. Laboratories are essential.

Third is lack of office space. Fewer than half of incoming students will have offices. Accommodations near faculty advisors are essential for TAs, RAs, and fellowship students.

Money, facilities, and space combine to create a poor impression on prospective graduate students. Hence, they do not accept our offers of admission.

Secretarial Support

The department currently has one secretary for the department head, one for student affairs, two for research projects (Blue CHiP and Interpreter Generation), one technical typist for the rest of the faculty, and one clerk. The situation is intolerable. It has worsened in the last two years as the faculty has increased. Even faculty who have grant money to contribute cannot get space for secretaries. The current faculty is acutely aware that much of their valuable time is consumed by typing, editing, filing, phoning, and scheduling. As long as the department is burdened with excessive student enrollments, *superior* secretarial service is essential to relieve part of that burden. One secretary for each four faculty members is required.

Faculty Hiring

In the 1981 recruiting season we had 80 applicants, invited 17 persons for interviews, extended 3 offers, and got one acceptance. Most of those who turned down our offers did so because they perceived the small schools they selected as having more hospitable, less burdensome environments. During the same period we lost one faculty member and we notified two assistant professors that 1981-82 would be their terminal year. Barring unexpected success in recruiting in spring 1982, we face a *decline* in faculty size for 1982-83.

Given the current and expected shortages of PhDs, we cannot expect to hire many new faculty. Our only hope of attracting high quality faculty is a high quality environment. Without this, we will not only fail to attract good new people, but we will fail to keep the good people we now have.

Space

It is clear that many of the above problems arise because of a lack of space. We currently have no more offices for new faculty, insufficient room for current graduate students, no room for additional secretaries, no room for more equipment, no room for more student terminals, no room for laboratories. With the possible exception of the ground and basement floors, the Math Sciences Building was not designed for laboratories. The University needs a coherent plan for developing the space required to support computer science. Possibilities include a new wing of the building over the auditorium or new quarters in another building.

The Envisioned Facility

We envision a CS department active in experimental computer science and with state-of-the-art facilities for instruction and for research.

Lower-division instruction will be primarily based on interactive terminals. By 1985, however, we may be using personal computers. These facilities will use syntax-directed editors that know the language in which the student is programming and prevent input of syntactically invalid programs. Students will keep a limited amount of personal software and files on line; they will learn about distributed computing and network access. New grading systems will reward those who reuse existing software and penalize those who start from scratch. Electronic classrooms will permit students to watch over the instructor's shoulder through personal video workstations. More advanced applications may be part of instruction, such as symbol manipulation, graphics systems, and VLSI systems.

Upper division instruction will also use terminals for routine work but will make heavy use of advanced software tools, software parts composition systems, design projects, and lab work. In the lab, students will experiment with different connections of machines, take measurements on hardware and software, and learn how to apply the methods of experimental science in their work. They will use advanced personal scientific workstations and graphics equipment for projects.

Graduate students will work in advanced laboratories, where they will design and test large software systems, modify hardware, develop new algorithms for VLSI computation, and assist the faculty in advanced computer research. The lecture-oriented teaching loads will be low enough that faculty can devote adequate time to supervising graduate students in projects.

We envision active relations with industry through the Industrial Affiliates Program and the Cooperative Program. These programs can yield significant income in the form of contributions to the department. As a further source of income, we will seek commercial sales and licensing of software developed in the department, with part of the royalties going to the faculty and staff members who contributed.

We also envision significant research support from federal agencies for experimental projects. (Experimental computer science research is the only source of big government grants.) We will again seek a five-year large-facilities grant under NSF's Experimental Computer Science program. [5] We will cultivate our new-found ARPA and ONR contacts for further help in relation to the VLSI project and the Quanta project.

To accommodate greater lab and project orientation, computing equipment must be readily available and facilities must be at the state of the art. Otherwise, we will be unable to attract and retain high-quality faculty, attract bright students, or provide first-rate computer science education and service courses.

The Plan

In estimating our needs, we have assumed 950 majors in steady-state and approximately 4000 other students per semester enrolled in service courses. We assume the following steady-state distribution of majors among levels:

---

[5] Our 1981 proposal to NSF is entitled "A multimachine pipeline and programming environment for large-scale computation."

Freshman	Sophomore	Junior	Senior
350	250	200	150

These assumptions imply about 150 B.S. degrees will be awarded each year.

These figures also imply freshman enrollments must be *curtailed* beginning in Fall 1982. Curtailment must be based on quality of applicants, not on first-come-first-served queueing. (This is already done in the Engineering Schools at Purdue.)

In addition, there will be approximately 175 graduate students including 25-30 PhD candidates.

We believe that ultimately 40 faculty and 80 teaching assistants (i.e., 40 FTE TAs) will be needed to handle this load. (This is a smaller number than in the Biology Department, which has fewer majors than we are planning for.) Under current and projected market conditions, we feel it is unduly optimistic to assume growth of more than 2 FTE faculty per year. On the other hand, the existence of a long-range plan for computer sciences would be a strong attraction to candidates; we therefore feel this goal is realistic for the 1980s.

Figure 1 shows the administrative organization of the department. We assume 1 secretary for each 4 faculty; these secretaries must be skilled in using mathematical document preparation facilities. (They must be secretaries, not just technical typists.) The current position of Assistant Head will be expanded slightly to support two undergraduate counsellors (we presently have one). The Director of Facilities will oversee all computing equipment used for specialized instruction and research; he will oversee four systems programmers (we presently have one), one technician, and graduate assistants who run labs and assist in running the facilities; he will also oversee distribution of software developed in the department. There will be an Industrial Relations

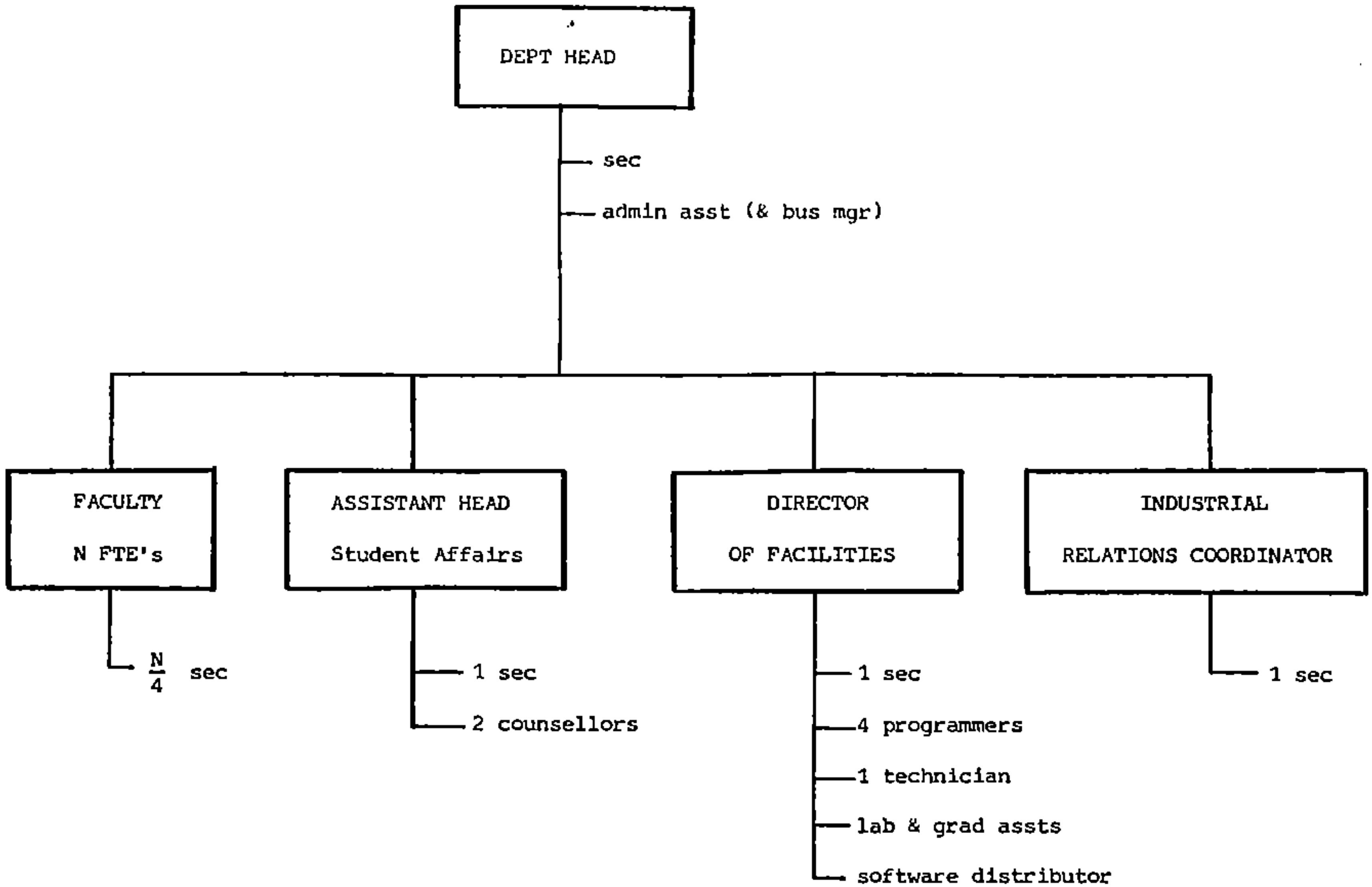

FIGURE 1: Aministrative Organization of Department

Coordinator, who manages the industrial affiliates and the cooperative programs; we expect that in due course industrial contributions will pay for this office. The Department Head requires an administrative assistant to handle business affairs, annual reports, brochures, documents, and other materials distributed outside the department.

Table 1 summarizes the staffing needs from Figure 1, showing our ultimate goals (1990) and intermediate goals (1986).

Table 2 summarizes the incremental costs for starting salaries of the additional personnel listed in Table 1. No inflation or raises have been accounted for in these estimates.

Table 3 shows offices required for the personnel in Table 2. The total, 82 offices, is approximately equivalent to three full floors in the Math Sciences Building. These estimates include space for graduate students supported by the Department. They exclude space for computer terminals.

Table 4 estimates the University's capital investment for computing equipment required to support computer science. Approximately $3M must be provided to PUCC in support of general CS undergraduate service instruction. Another $6.3M must be provided to the CS Department in support of research, laboratory instruction, and graduate instruction. Of this total, as much as $3.6M would be paid from research grants and industrial support; however, significant support from the University will be required, especially at the outset.

As shown in Table 4, the University needs computing power equivalent to six VAXes to support all lower-division instruction in the department (especially service courses). The power of four more VAXes is needed for the 600 upper-division majors. On top of this, the power of four more VAXes is needed to support all graduate instruction. These estimates are based on the VAX as a computational equivalent, not necessarily as the actual machine. We estimate that about 10% of the total capital investment must be available each year in *recurring costs* to maintain all the equipment -- this is a total of about $900K annually. In addition, about 20% of the investment must be available each year for capital replacement and upgrades.

We emphasize that much of the computing power shown in Table 4 would be provided as part of general computing support by PUCC because the service is of interest to the whole campus. We have included the figures for completeness. Systems dedicated to graduate instruction and research will be tailored for CS; this service should be provided by the CS Department under suitable maintenance agreements with PUCC. All systems noted in Table 4 should be interconnected by network.

Table 5 estimates lab requirements and space for machines. These estimates do not include space for terminals for undergraduate students. Total space listed in this table is about 1/5 of the lab space presently allocated for Biology or for Chemistry.

Our estimates for lab space are obviously rough; based on comparisons with other universities, we believe these estimates are of the right order of magnitude. On being given a definite commitment for space, we are prepared to undertake the detailed analysis to construct a precise statement of need.

Summary

Purdue's problems in computer science form a knotty complex that can be unravelled only by resolving all its components simultaneously. To properly serve the University, we must immediately stabilize our majors at 950 and service-course enrollments at 4000. By the end of five years our faculty must grow by 10, our teaching assistants by 46, and our secretarial staff by 5, our administrative staff by 2, and our technical support staff by 5. By the end of five years, PUCC must have an additional

$3M for lower-division CS instruction, the department must have an additional $3M for upper-division and graduate instruction, we must raise another $3M for research facilities. This level of capitalization is commensurate with other experimental sciences; it is at the "frontier level" noted in the Snowbird Report. To house the larger staff and facilities, the department will require space of about 50,000 square feet (excluding terminal rooms for students).

With this plan, we are virtually certain to achieve our goal of excellence.

CATEGORY	CURRENT	1986	1990
Faculty	22 FTE[1]	32 FTE[2]	40 FTE[3]
TAs	17 FTE[1]	40 FTE[2]	40 FTE[3]
Staff:			
Secretaries	5	10	15
Assist Head	1	1	1
Admin. Asst.	0	1	1
Indus. Rel. Coord.	0	1	2
Dir. Facilities	0	1	1
Programmers	1	4	5
Technician	0	1	1

Notes:

1. We have no viable plan for the current staff to handle the 1000 majors who will be on campus in Fall 1981. "Crisis staffing" will no doubt produce large lower division classes with high drop-out rates, sections of over 100 in upper division courses, and sections of over 75 in graduate courses.

2. Even with this level of staffing, there will be no faculty teaching service courses; section sizes will be about 120 in lower division courses, 100 in upper division courses, and 70 in graduate courses.

3. At this level of staffing, faculty will teach some service courses; section sizes will be about 80 in lower division courses, 75 in upper division courses, and 50 in graduate courses.

TABLE 1: Personnel Needs.

CATEGORY	CURRENT	1986	1990
Faculty	22 FTE[1]	32 FTE[2]	40 FTE[3]
TAs	17 FTE[1]	40 FTE[2]	40 FTE[3]
Staff:			
Secretaries	5	10	15
Assist Head	1	1	1
Admin. Asst.	0	1	1
Indus. Rel. Coord.	0	1	2
Dir. Facilities	0	1	1
Programmers	1	4	5
Technician	0	1	1

Notes:

1. We have no viable plan for the current staff to handle the 1000 majors who will be on campus in Fall 1981. "Crisis staffing" will no doubt produce large lower division classes with high drop-out rates, sections of over 100 in upper division courses, and sections of over 75 in graduate courses.

2. Even with this level of staffing, there will be no faculty teaching service courses; section sizes will be about 120 in lower division courses, 100 in upper division courses, and 70 in graduate courses.

3. At this level of staffing, faculty will teach some service courses; section sizes will be about 80 in lower division courses, 75 in upper division courses, and 50 in graduate courses.

TABLE 1: Personnel Needs.

PERSONNEL	SALARY ($K)
5 Secretaries @ $15K	75
1 Admin. Asst. @ $20K	20
1 Ind. Rel. Coord. @ $25K	25
1 Director Facilities @ $40K	40
3 Programmers @ $30K	90
1 Technician @ $25K	25
10 Faculty @ $30K	300
23 FTE TAs @ $12K	276
TOTAL:	$851K

TABLE 2: Incremental Personnel Costs to achieve 1986 goal.

PURPOSE	OFFICES (No.)
Faculty	32
8 Faculty Secretaries	4
Dept Head (+ sec)	3
Assistant Head (+ sec)	2
Admin. Asst.	1
Dir. Facilities (+ sec)	2
Programmers	2
Ind. Rel. Coord. (+ sec)	2
32 PhD students	8
80 TAs	20
Terminal rooms	4
Conference room	2
TOTAL:	82

TABLE 3: Office Needs (1986). The total is equivalent to about three full floors of the Math Sciences Building.

ITEM	COST ($K)
Provided by PUCC:	
6 VAX for lower-division & service (4000 per semester) @ $300K	1800
4 VAX for upper division majors (600) @ $300K	1200
TOTAL:	$3000K
Provided by the CS Department:	
Equipment for 60 active researchers @ $60K	3600
4 VAX for graduate instruction @ $300K	1200
Software systems labs, 50 mini-VAX workstations @ $30K	1500
TOTAL:	$6300K

TABLE 4: Capital Cost Estimate of Total Facilities.

PURPOSE	NEED (sq. ft.)
VLSI project	5000
Project Quanta	5000
Networks Lab	5000
Instructional Labs	15000
Machine Rooms	5000
TOTAL:	35000

TABLE 5: Space Needs for Equipment and Facilities. This is about 1/5 the lab space used by the Chemistry or Biology Departments.

A FIVE YEAR PLAN FOR EXCELLENCE

Mikhail Atallah
Douglas Comer
H. E. Dunsmore
Greg Frederickson
John Rice

CSD-TR 651
Summer 1986

Abstract

This plan, developed in the winter of 1985/86, is a follow-up to the previous plan [Denning, et.al., 1981]. The top priority goal is to increase the quality of the department measured in terms of its research and educational programs. The primary mechanism is to increase the quality of the faculty by providing a superior academic environment to attract and retain superior faculty. Modest growth in the size of the faculty is foreseen along with a substantial decrease in the number of undergraduate majors and a substantial increase in the number of Ph.D. students. Tables are given summarizing the projection for personnel, departmental finances, students and staff. An appendix summarizes the goals and achievements of the previous plan.

A FIVE YEAR PLAN FOR EXCELLENCE
DEPARTMENT OF COMPUTER SCIENCES

CONTENTS

1. EXECUTIVE SUMMARY

This plan was developed in the winter of 1985/86 by a cross section of the Computer Science faculty to provide a guide for the future of the department. It is hoped that the University administration will also approve it as a guide just as it did the previous plan [Denning et.al., 1981].

The top priority goal is to increase the quality of the department as measured by its research and educational programs. The emphasis will be on getting better, not bigger. The key components of the plan in seven areas are as follows:

Faculty. We will create a superior academic environment to attract and retain a superior faculty. Eight specific steps are proposed, the most significant are to provide superior research facilities, a much better teaching environment plus more and better Ph.D. students.

Education. We will have significantly smaller class sizes along with a moderate increase in the number of courses at the advanced undergraduate and advanced graduate levels. The experimental and laboratory components of the educational program will be increased substantially.

Research. The level of research funding will approximately triple, going from $1.2 million/year to $3.5-4.0 million/year. Seven factors are cited which contribute to this growth; the most important are (a) our young faculty will be much better supported as it matures, (b) the overall quality of the faculty will improve and (c) several large projects and/or centers will be established.

Administration/Staff. The administrative staff will be increased to reflect the recent rapid growth of the department both in numbers of people and in laboratory/experimental facilities. Key additions will be an Associate Department Head and several people on the technical staff.

Computing Facilities. Dramatic improvements in the cost/performance ratio make it plausible to plan for about 50 VAX 11/780 equivalents in the department, plus a variety of specialized equipment.

Space. The projected needs are substantially larger than existing space even though the department currently has "in reserve" about 4,000 ft^2 of lab space (being used as classrooms) and about 10 offices (being loaned to Mathematics or used for visiting scholars). The projected deficit in space at the end of the 5 year plan is about 12-15,000 ft^2 of laboratory space and 12-15 offices.

Budget. This plan can be accomplished with a steady increase above inflation of $200,000/year in the Department's operating budget. At that point the Department's resources and responsibilities will have moved into the normal range as measured by such things as student/faculty ratio, cost per credit hour, cost per major, etc. Note that the research support budget is expected to grow much faster at a rate of about $500,000/year. These funds will help indirectly to finance a number of the planned improvements.

The next five sections describe the components of this plan in more detail. Section 7 presents tabular data on plans or projections of personnel, faculty evolution, finances and budget, students, and space. The Appendix presents a summary of the goals and achievements of the 1981 Plan for Excellence. The 1985/86 goals of this plan were met rather well except for two items: there were serious shortfalls in funds for S&E (operation of computing facilities) and space for research labs.

2. THE FACULTY

The current faculty consists of about 33 full time equivalents (FTEs) and its structure is summarized in Table 2 of Section 7. The faculty is quite young which suggests there will be considerable change both in people and in their fields of interest. Growth to about 38-40 FTE faculty is planned.

The Plan's principal point is to create a superior academic environment which will attract and retain superior faculty. The following specific mechanisms are identified:

A. *Provide excellent research facilities*. High quality, state-of-the-art general computing services will be provided as well as a variety of specialized interesting facilities (e.g., parallel machines, sophisticated graphics, specialized workstations). Ample space for laboratories must be available.

B. *Attract more and better Ph.D. students*. New energy is to be put into this.

C. *Provide competitive salaries*. Current salaries are generally average for high quality schools, but not more. The lower cost of living at Purdue helps some, but is not a strong attraction for younger faculty.

D. *Provide competitive teaching environment*. The department must continue evolving from the high teaching loads traditional in mathematics to those typical of engineering and experimental science departments. More assistance (both staff and student) will be provided to support the teaching program.

E. *Emphasize special areas of excellence*. The department is already strong in some areas (theory, scientific computing, software engineering, systems) and these strengths will be the foundations of future quality enhancements. Adding an area of strength will involve a committment to 3-4 excellent people.

F. *Hire a superstar distinguished professor*. The department is very short of senior researchers and this goal has top priority. The competition is fierce, but we must try hard.

G. *Maintain a vigorous visitor/colloquium program.*

H. *Maintain a congenial/cooperative atmosphere.*

The facilities and student aspects of these mechanisms are discussed in Sections 3 and 5. Other mechanisms require mostly money (salaries, colloquium program) while the rest require a judicious combination of effort, organization, money, cooperation and perseverance.

3. THE EDUCATIONAL PROGRAM

3.1 Undergraduate

The number of undergraduate majors is expected to decline substantially, to about 750 majors from the current 1,000+. Table 4 gives a projection for the next five years. This reduction will be very beneficial for both the faculty and students. Currently, some class sizes are far too large and the variety of undergraduate offerings is too limited. The combination of 30% fewer majors and 15% more faculty provides the opportunity to raise significantly the quality of the undergraduate program. Even so, care will be needed to provide high quality within the resources expected to accrue.

Curriculum evolution is constant in Computer Science. We must be vigilant to maintain an up-to-date program while not proliferating courses unnecessarily. Thus the number of undergraduate courses will remain relatively small, but there may be major reorganizations of the undergraduate program.

More specific plans for the undergraduate program are:

A. Reorganize the degree requirements to provide a better "core" and more flexibility with a minimum number of courses.

B. Introduce new laboratory courses or laboratories for existing courses as follows:

1986/87:	Graphics (new course)
1987/88:	Artificial Intelligence (new course)
	CS 404 (Software Engineering)
later:	CS 330 (Second course for majors)
	CS 430 (Third course for majors)
	Systems Programming (new course)

The three new courses will be the only additions to the undergraduate program. The facilities implication of these courses are discussed in Section 4.

C. Introduce an honors program. We conjecture that this can be done with a modest expenditure of resources, a specific implementation plan is to be developed.

D. Increase the number of undergraduate assistants from 32 to 40. This helps the department and provides more suitable work for undergraduate majors.

3.2 Undergraduate Service Courses.

The plan is to maintain the current commitment of resources. These courses will continue to be taught primarily by visitors and instructors because the projected increases in faculty are barely sufficient for the planned improvements in the undergraduate and graduate programs.

3.3 Graduate Majors.

The number of graduate students is to increase from 125 to 180. All the increase will be in Ph.D. students. This requires a substantial enhancement in the graduate course offerings, especially for 600-level and seminar courses. These have been held down in the past because of the lack of faculty.

A vigorous program to attract high quality graduate students will be devised. Current efforts in this area are much too small.

More specific plans for the graduate program are:

A. Increase the numbers of supported positions as follows:

Fellowships:	from 4 to 10
Research Assts:	from 18 to 50
Teaching Assts:	from 60 to 70
Staff Assts:	from 6 to 12
Total Supported:	from 95 to 160

The total supported includes some supported outside the department (e.g., fellowships and assistants in other departments).

B. Increase the course offerings as follows:

500-level, regular courses:	offer 2 more per year
600-level, regular courses:	offer 4 more per year
Special 590, 690 courses:	offer 10 more per year

Note that the laboratory facilities needed for the undergraduate program will also be used in the graduate program.

4. THE RESEARCH PROGRAM

The research program will grow dramatically in the next five years. There are several factors that will contribute to this growth:

(i) The faculty will be more senior, more established, and consequently, better funded.

(ii) The quality of the faculty will improve.

(iii) Some big projects and centers will be established.

(iv) Research in Computer Science is becoming more experimental in nature and thus larger in size.

(v) The number of faculty will increase.

(vi) More academic year support will be available to support a larger research program.

(vii) More effort will be put into identifying sources of funding, both in government and industry.

The current level of research support in Computer Science is $1.7 million (this is actual expenditures from July 1, 1985 to June 30, 1986). The above factors will increase this level by about $2.5 million up to $4.0 - 4.5 million.

The increase in the research program depends on many individual efforts. The department as a whole will concentrate on establishing large scale projects or centers that have high national visibility and provide substantial support for the students, faculty, staff and facilities. Promising areas for such projects and centers are: parallel computations, software engineering, systems and networking, and interdisciplinary research. We must be alert for new opportunities that arise in this fast changing field.

The financial information summarized in Table 3 of Section 7 shows the increased level of research support and its effects on the operation and purchase of computing facilities.

5. THE FACILITIES

5.1 Educational Computing and Laboratories

The departmental computing is logically divided into educational, administrative and research. Educational computing is, in turn, divided into three categories:

A. *General computing provided by PUCC.* These facilities have traditionally been grossly overloaded and this has prevented faculty on many occasions from teaching appropriate material. We strongly support a large increase in the computing power provided for general support of courses.

B. *Laboratory computing provided by PUCC.* Several laboratories have dedicated equipment with hardware support provided by PUCC and software/supervisory support provided by the Computer Sciences Department. Much better computing service is provided to the students in these labs and we plan to expand this approach.

C. *Laboratory computing provided by CS.* Some laboratories with specialized equipment and systems are operated entirely by the Computer Sciences Department.

The laboratory space is provided by the Computer Sciences Department. The current educational laboratories are:

CS110: two labs equipped with 22 IBM PC/AT's each

CS230:	one lab with 22 terminals supported by a dedicated dual processor VAX 11/780
CS503/536:	one lab equipped with a network of LSI 11's supported by a VAX 11/785

The laboratories planned for the near future are:

Graphics:	one lab equipped with workstations supporting 12-15 graphics terminals
Artificial Intelligence:	one lab equipped with workstations providing 10-12 AI stations.

In the longer term we plan on:

CS330/430:	one lab for core CS courses
Various:	one lab with powerful UNIX workstations

We anticipate that equipment cost (list price) for one laboratory is about $150,000-$300,000 (depending on the type). The PUCC maintenance and operating costs per year are probably about 10% of the equipment cost and the extra costs to the Computer Sciences Department for supervision and support is about $25,000/year per laboratory.

5.2 Research and Administrative Computing Facilities

The goal is to have one VAX 11/780 equivalent per faculty, plus adequate support for secretarial, administrative and facilities staff. This means about 50 VAX 11/780 equivalents. A resource allocations system will be installed to insure that the services provided match the priorities of the department. The bulk of the funding for this is to come from research grants and much of the increased capacity will be in the form of workstations. The installed computing capacity in the spring of 1986 is over 20 VAX 11/780 equivalents, but it is unevenly distributed. The general research and administrative computers are grossly overloaded while some machines are lightly used. Note that the special nature of some machines means that their "power" is not easily made available to the department as a whole and, indeed, some are dedicated to specific research projects.

The user community for research and administration computing will consist of about 160 people in 1991 (40 faculty, 60 Ph.D. students, 20 staff, 12 secretaries and 25 M.S. students). The general characteristics for the facilities planned are as follows:

Gross computing power: 50 VAX 11/780 equivalents.

User stations:	High quality color (20), lower quality color (20), high quality (bit mapped) (50), lower quality (70).
I/O devices:	Access to all varieties of black and white paper printers, phototypsetters, color printers, wide bed printers, video displays and copiers
Networks:	Access to all major national and international networks and all important campus facilities.

Note that the CS computing facility currently has about 100 user stations (mostly simple terminals) for about 120 users. Only graduate students involved in research projects are (and will be) given access to these facilities.

It is interesting to note that the biggest difference between this plan and the previous one is in the projected computing power needs. This is a reflection on the dynamic changes underlying the computing profession. Even the current plan only provides what will be considered "ordinary" facilities by 1991.

5.3 Space

The department's space needs are divided into three somewhat independent categories: teaching laboratories, research laboratories, and offices. We discuss these categories in this order, the order of increasing concern.

The new Computer Science Building was planned for eleven teaching laboratories. In the first year of occupancy these are used as follows:

Equipment	Course
In Use:	
Personal Computers (two):	CS110
Graphics:	CS435
Terminals:	CS230
Terminals:	General graduate student use
Terminals/Microcomputers:	CS503 and CS536
In Reserve:	
Seminars/Occasional Use	
Classrooms (four)	

The four classrooms are currently assigned to Schedules and Space with the understanding that they will be converted to laboratories as needed.

The anticipated five new laboratory courses will require two or three new laboratories depending on the course enrollments and versatility of the equipment selected.

The new Computer Science Building contains 4,700 ft^2 of research laboratory space and 2,050 ft^2 of computer room space. This is a large increase over the previous situation (1,300 and 840 ft^2, respectively), but far short of the 20,000 ft^2 projected need in the earlier plan. In the first year, 3,200 ft^2 of the research lab space and 1,200 ft^2 of the computer room space was in active use. It is expected that all the research lab space will be in active use before the end of the second year. Some more space can be obtained by "squeezing" people tighter, but it is clear that this space will be gone by the end of 1987.

There are three factors that will contribute to the need for additional research lab space: (1) computer science research is becoming increasingly experimental in nature, (2) the research faculty will increase some (perhaps 15%), and (3) the research faculty is maturing and will be involved in larger projects. Our analysis of the future suggests that the previous estimate of 20,000 ft^2 of required research lab and computer room space is still a reasonable one. This is less than 20% of the corresponding space of the Chemistry or Biological Sciences Departments at Purdue.

Office space is the major shortcoming of the new Computer Science Building. The original plan was for a faculty of 40, but it did not adequately foresee the growth in support staff for facilities, research projects, visitors, centers, and administration. The office space for graduate teaching and research assistants is adequate for the number the department had in the 1983-85 period. However, we plan on a substantial increase in research assistants in the next five years. The result is that all the office space will be gone by the end of 1986. After that a substantial squeeze for offices will begin.

The five rooms now in reserve will provide some of the research lab, educational lab and office space needed. These rooms have about 4,400 ft^2 and it is clear that they cannot come close to providing for two or three teaching labs, 18 offices and 13,000 ft^2 of research laboratories. In view of the long lead time for acquiring space, planning must begin now on how to meet these needs. Quantitative projections of space needs are given in Table 5.

6. ADMINISTRATIVE AND STAFF SUPPORT

6.1 Departmental Administration

The department has grown substantially over the years without acquiring adequate support for administrative and staff operations. Some of these duties have fallen upon the faculty and some are not being done. Tasks that need better support include industrial relations, recruiting graduate students, managing educational labs, and departmental administration. Using faculty for these tasks detracts from our plan to provide a superior departmental environment.

6.2 Facilities and Laboratory Operations

The superior environment that we desire must include an excellent support staff for the computing and experimental facilities. Furthermore, we must start providing general support for the teaching laboratories and for the laborious software preparations for many regular courses. The main burden for supporting research experimental facilities will fall upon the research projects, but there are still many general support tasks that must be provided. Our budget projections assure that the staff additions listed below to support research labs will be paid from research grants.

Thus, over the next five years, we plan that the department add the following:

* Associate Department Head (perhaps rotating for a 2-3 year period).
* Assistant Department Head (responsible for industrial relations, publicity, government relations, development).
* Three secretaries (beyond any dedicated to research projects, centers, etc.).
* Three Programmers (one for educational services, two for general research/administrative support).
* Two Technicians (one for educational services-labs, one for general support).
* Five graduate assistants (two for educational services, two for general support, one for research lab support).
* Ten undergraduate assistants (five for educational services, three for general support, two for research lab support).

These additions are included in the personnel projection of Table 1.

7. QUANTITATIVE DATA AND PLAN

7.1 Assumptions of the Plan

This plan is based on four assumptions, three of these are outside the department's control:

1. *Department Budget*. The Computer Sciences Department's budget will increase about $200,000 per year (in constant dollars) over the next five years. These increases are in addition to normal raises, inflationary increases in supplies, etc. This is the level of increase that was agreed to in 1981 when the previous plan was presented and discussed.
2. *Undergraduate Enrollments*. A substantial decrease in undergraduate enrollments will occur, dropping the number to 750 or fewer. This seems rather plausible in view of the demographics and a return to normalcy of interest in Computer Science.
3. *Research Funding*. The level of federal research will double (in constant dollars) and the level of industrial support will triple. The result will be an increase of about $2+ million/year in external research funding (from $1.7 million to $4.2 million).

The fourth assumption is, given the above developments, that the department and administration will make the commitment to the goal of increasing the quality of the department and its faculty.

7.2 Tabular Data

The plan is presented quantitatively in five tables: Personnel, Faculty Evolution, Finances and Budgets, Students, and Space. In each table, actual values are given for the 1981-82 and 1985-86 years along with planned values for the 1986-87 and 1990-91 years. Table 2, Faculty Evolution, also gives each year from 1985-86 to 1992-93.

Further historical data is given in the Appendix which presents an analysis of the status and progress of the 1981 Plan for Excellence.

Table 1: Personnel. Graduate Teaching Assistants also includes graduate assistants for computing facilities. Staff includes administrative and computing facilities. About 25% of the staff and secretaries and all of the Graduate Research Assistants are to be supported by grants and contracts. Values are full-time equivalents (FTEs).

	Actual		Planned	
	1981-82	1985-86	1986-87	1990-91
Faculty	22	32	33	37
Counselors and Instructors	2	4.5	5	5
Grad Teaching Assistants	17	34	36	39
Undergrad Teaching Assistants	0	8	8	10
Staff	3	7	8	14
Secretaries and Clerical	3	7	8	14
Graduate Research Assistants	11	9.5	11	25

Table 2: Faculty Evolution. The distribution of faculty in the three ranks is given based on average assumptions about future promotions, resignations, and new positions. Only people more than 50% in Computer Sciences are considered. All vacancies due to resignations are assumed to be filled at the same rank. During the six year period 1986-1992 it is estimated that over 20 positions will be filled in order to increase the faculty by five.

	Rank			
Year	Assistant	Associate	Full	Total
1981-82	11	8	6	25
—				
1985-86	16	10	6	32
1986-87	15	10	8	33
1987-88	15	11	8	34
1988-89	15	13	7	35
1989-90	14	13	9	36
1990-91	14	12	11	37
1991-92	12	13	13	38
1992-93	11	11	16	38

Table 3: Financial. Amounts shown are in $1000 units and are university budgets with the exception of capital. Capital obtained by grants includes ordinary grants and contracts, gifts and discounts. The facilities budget includes both maintenance and operating supplies. Constant dollars are assumed from 1985-86 on.

	Actual		Planned	
	1981-82	1985-86	1986-87	1990-91
Salary & Wages	1111	2270	2430	2950
Supplies & Expenses	26	60	65	85
Facilities	15	125	170	410
Miscellaneous	22	26	28	35
Capital items				
Research grants	58	792	800	1000
Education grants	0	40	50	200
Subtotal	58	832	850	1200
Recurring dept. budget	37	175	175	200
Non-recurring Purdue funds	250	125	100	200
Total	345	1133	1125	1600
Total budget (University funds)				
Current dollars	1211	2656	2980	4260
1985-86 dollars	1620	2656	2867	3680

Table 4: Students. Undergraduate student majors are given by semester and graduate by year. Degrees granted are averages over three years. Data is for the fall of each year.

	Actual		Projected	
	1981-82	1985-86	1986-87	1990-91
Undergraduate Majors				
Semester 1	507	320	290	240
2	27	22	22	18
3	205	199	205	155
4	35	28	30	22
5	138	154	135	115
6	30	36	32	26
7	81	155	160	115
8	50	96	100	70
Total	1073	1010	974	761
B.S. degrees	97	171	180	140
Graduate Majors				
Year 1	25	47	45	50
2	54	40	45	50
3	26	18	22	35
4+	36	19	20	45
Total	141	124	132	180
M.S. degrees	54	53	50	50
Ph.D.degrees	5	6	6	12

Table 5: Space. Department space is given in terms of assignable square feet, except for offices. Offices are broken down by type of occupant (some types have multiple occupants). These data do not include offices for counselors. The data given for 1986-87 and 1990-91 are estimates.

OFFICES

	Faculty	Secretary	Staff	Grad. Students	Total
1981-82	30	4	1	21	56
1985-86	39	7	8	35	89
1986-87	40	7	8	36	91
1990-91	45	8	11	45	109

OTHER SPACE

	Labs	Machine Rooms	Conferences Rooms	Terminal Rooms
1981-82	300	280	158	474
1985-86	4715	2059	824	1100
1986-87	4715	2059	824	1100
1990-91	16000	4000	824	700

APPENDIX ONE

PLAN FOR EXCELLENCE
DEPARTMENT OF COMPUTER SCIENCES
PURDUE UNIVERSITY

Analysis of Status and Progress
John Rice, November 1983
(Updated August 1986 for 1986-87 year)

Peter Denning, John Rice, Larry Snyder, and Paul Young prepared the department's *Plan for Excellence* in the summer of 1981. This Plan and its goals were agreed to in principle (but not as to specific details) by the Dean and Provost that summer. This analysis is to determine the progress that has been made so far and to assess the current status of this Plan.

The method used here is completely quantitative. There are many specific quantitative goals stated in the Plan for the years 1986-87 and 1989-90. Corresponding values have been obtained for 1981-82 and then linear interpolation used to produce year by year milestones. In some instances (e.g., supplies and equipment maintenance), we have derived numbers from the Plan which were not explicitly given there. The financial goals of the Plan were expressly given in constant dollar terms, these (except for capital items) have been adjusted for inflation as follows:

1981 to 1982	8%
1982 to 1983	6%
1983 to 1984	5%
1984 to 1985	4%
thereafter	0%

Thus these numbers are in constant 1985 dollars after 1985.

The analysis is reduced to simple tables of the following variables:

PERSONNEL

Faculty FTE	Grad. Teaching Asst. FTE
Secretarial	Other professional staff

FINANCIAL

Salary and Wages Budget
Capital Budget
Misc Budget
Supplies and Expenses Budget
Capital Equipment Installed

OFFICES

Faculty GTA
Secretarial Staff

SPACE (excluding offices)

Labs Machine rooms
Conference rooms Terminals

Numbers from the Plan and the original 1981-82 situation are starred, the other Plan numbers are obtained by linear interpolation. Actual values for years 1981-1987 are also given following the slash after Plan numbers.

Table 1: PERSONNEL
Entries are "Plan"/"Actual".
Counselors and instructors are not included

	FACULTY FTE	GTA FTE	SEC'Y	STAFF
1981-82	22*	17*	3*	3*
82-83	24/22.4	22/24	5/6	5/3
83-84	26/24	26/23	7/5.5	6/4
84-85	28/28	31/32.5	8/6	7/4
85-86	30/27	35/34	9/7	9/7
86-87	32*	40*	10*	11*
87-88	35	40	12	11
88-89	37	40	13	12
89-90	40*	40*	15*	12*

Table 2: FINANCIAL (amounts are $1000)
Amounts are those budgeted at the beginning of the year except for capital which are year end figures.

	Salary&Wages Budget(Note 1)	Supplies&Expenses Budget(Note 2)	Capital Equip. Installed(Note 3)	Capital (Note 4)	Misc. Budget
1981-82	1,111*	100*/51	654	345*=37+250+58	22*
1982-83	1,393/1,238	148/155	1,071/1,035	401/381 (98+0+283)	26/25
1983-84	1,668/1,454	212/135	1,490/1,449	457/414 (10+210+154)	31/25
1984-85	1,967/1,898	288/185	1,908/1,963	513/514 (50+112+352)	35/25
1985-86	2,270/2,057	338/195	2,326/2,477	569/996 (125+72+799)	40/25
1986-87	2,495*/2300	384*/225	2,744/3,494	625/	43/25
1987-88	2,682	429	3,162	681	45
1988-89	2,807	474	3580	737	47
1989-90	2,994*	529*	4000*	800*	49

Note 1. Amounts include transfers from School of Sciences funds for 1984-85.

Note 2. Supplies and expenses Plan consists of consumables which are adjusted for inflation and faculty growth, plus equipment maintenance which is 10% of equipment installed. Starting in 1985-86, the actual S&E of the department is reduced by the maintenance costs of items used exclusively for teaching (these items are also excluded from the capital equipment installed).

Note 3. Installed capital equipment does not recognize depreciation or obsolesence. Actual values are perhaps one third to one half less than the amounts shown.

Note 4. Capital expenditures consists of three parts (separated by +'s) and do not include items used exclusively for teaching:

recurring department budget
+ non-recurring university purchases
+ gifts and purchases from grants

Table 3: OFFICES

These data do not include offices for counselors.

	FACULTY	SEC'Y	STAFF	GRAD STUDENTS
1981-82	30*	4*	1*	21*
82-83	31/29	5/4	3/4	23/34
83-84	32/28	7/4	4/7	25/22
84-85	33/31	8/5	6/4	26/20
85-86	34/39	9/7	8/8	27/35
86-87	35*/40	10*/7	9*/8	28*/36
87-88	38	12	10	29
88-89	41	13	11	30
89-90	43*	15*	12*	30*

Note 1. The numbers for 1985-86 include the new CS building plus part of the 4th floor of the Math Science. The graduate student offices beginning in 1985-86 are measured in units of 120-150 sq.ft. offices holding 3 students each.

Table 4: SPACE-EXCLUDING OFFICES (in square feet)

	LABS	MACHINE ROOMS	CONFERENCE ROOMS	TERMINALS
1981-82	300*	280*	158*	474*
82-83	3900/600	1224/576	206/158	500/474
83-84	7500/816	2168/838	254/158	525/616
84-85	11,100/1300	3112/838	302/158	550/616
85-86	14,700/4715	4056/2059	350/824	575/1100
86-87	18,000*/4,715	5,000*/2,059	400*/824	600*/1,100
87-88	19,000	6,000	430	630
88-89	21,000	7,000	470	670
89-90	22,500*	8,000*	500*	700*

Note 1. The machine room space includes PUCC space in 1981-85.

Note 2. The numbers for 1985-86 include the new building for CS plus the following from the 4th floor of Math Science: Machine: 158, Terminals: 316.

COMPUTER SCIENCES FIVE YEAR PLAN

John R. Rice

December 14, 1990

Abstract

This plan is a minor modification of the 1988 and 1989 five year plans developed by Mike Atallah, Doug Comer, Buster Dunsmore, Greg Frederickson and John Rice. It is divided into three parts: (1) Undergraduate education, (2) Graduate education and research, and (3) New building for Computer Sciences, Mathematics and Statistics. Highlights of the plan are: (1) Upgrade undergraduate education by restructuring the curriculum, establishing more laboratories, and using only permanent faculty for teaching. (2) Establish two large research centers or groups and increase research funding by 50%. (3) Establish graduate degree programs in Software Engineering and in interdisciplinary Computational Science. (4) Improve the department support staff substantially. (5) Obtain 14,000 – 16,000 square feet of new space.

CS) UNDERGRADUATE EDUCATION - DEPARTMENT OF COMPUTER SCIENCES

A. GENERAL

The number of undergraduate majors is expected to stabilize at about 500. Table 1 gives a projection for the next five years. Currently, some service course class sizes are too large and the variety of undergraduate offerings is limited. The combination of 10% fewer majors and 10% more faculty provides the opportunity to raise the quality of the undergraduate program for majors. Even so, care will be needed to provide high quality teaching with the expected resources.

Table 1. Undergraduate majors are given by semester. Degrees granted are averages over three years. Data are for the fall of each year.

		Actual				Projected
		1981-82	1985-86	1988-89	1989-90	1991-92
Undergraduate Majors						
Semester	1	507	320	172	146	130
	2	27	22	16	16	15
	3	205	199	99	111	100
	4	35	28	15	22	20
	5	138	154	92	77	68
	6	30	36	15	20	16
	7	81	155	98	92	80
	8	50	96	91	82	75
Total		1073	1010	598	566	504
B.S. Degrees		82	172	115	133	90

Curriculum evolution is constant in Computer Science. This year we are examining the whole undergraduate program with an eye towards the requirements in the CSAB accreditation guidelines and the new ACM/IEEE-CS curriculum guidelines. There will be a comprehensive recommendation by the departmental Undergraduate Committee by early 1991 concerning course modifications. The Committee will then oversee the course redevelopment involved. We must be vigilant to maintain an up-to-date program while not proliferating courses unnecessarily.

Basic Plan

B. New Programs

We are making more of our courses into laboratory courses - taking note of the fact that Computer Science is rapidly becoming a lab science. Ultimately many of our core courses as well as elective courses will contain a lab section in which students become proficient in good software development principles and practices under the watchful attention of skilled undergraduate assistants, graduate assistants, and even faculty. Such lab components will be in addition to the already commonplace out-of-class assignments involving the use of workstations and lab equipment.

We are currently creating a new Software Engineering minor. This will include a lower division course introducing students to the concepts of this very important new area of Computer Science and will also include at least two lab-based upper division courses in which undergraduate students will get hands-on experience in software development with state-of-the-art software engineering concepts.

We also plan to introduce an honors program that will include adding some new courses and creating honors sections of some existing courses. Furthermore, we are going to broaden the co-op experience for Computer Science students. We are going to a more flexible plan that will permit such situations as summer work experience and experience with more than one company.

Proposal for the new undergraduate curriculum

The following is the first draft of a proposal to restructure the undergraduate curriculum in computer sciences at Purdue which will be debated extensively in the months to come.

Highlights of the new program

* Change required core courses
* Change math requirements
* Alter GPA requirements
* Alter science requirements slightly
* Alter requirements on CS electives

Things not changed

* A.S. degree requirements
* Communications (English, etc) requirements
* Free electives
* Co-op programs

Degree requirements

To receive a Bachelor of Science degree, computer sciences majors must:

1) Complete eight computer sciences sources called the "core courses" (listed below), and four additional courses beyond the core. The latter must include a two-course sequence in a specialization area (described below). The remaining two courses can be chosen for further depth or specialization, as the student wishes.
2) Maintain at least a 4.5 GPA in the major to graduate. They must pass every course in the core with a grade of "C" or better.
3) Complete courses in mathematics, other sciences, and the humanities to develop their analytic, experimental, and communication skills. The following requirements for the B.S. with a major in computer sciences is intended to fulfill the School of Science requirements. A total of 124 credits is required. Mathematics

courses below MA 161 and computer sciences courses below CS 180 cannot be used to satisfy any of these requirements. The proposed computer science major requirements are 40 hours as follows:

Core requirements (total of 28 hours):

CS 182	Intro to Computer Science I
CS 183	Intro to Computer Science II
EE 266/CS 240	Digital Logic
CS 250	Computer Organization and Architecture
CS 260	Analysis and Design of Algorithms
CS 300	The Computing Professional (1 hr. Pass/Fail)
CS 352	Programming Languages & Translators
CS 360	Software Methodology
CS 413	Operating Systems & Networks

One of the following sequences:

Systems and Software (CS 404, 440)
Scientific Computing (CS 414, 415)
Information Processing (CS 440, 442)
Theory of Computation and Algorithms (CS 481, 483)
Artificial Intelligence (CS 572)
Computer Graphics (CS 435)

Two other courses in CS at the 400/500 level, with no more than six hours total of credit from CS 490 and CS 590 courses.

C. OTHER INITIATIVES

Undergraduate Service Courses

Our plan is to maintain the current commitment of resources. These courses will continue to be taught primarily by visitors and lecturers because the projected increases in faculty are barely sufficient for the planned improvements in the undergraduate and graduate programs. A permanent, non-faculty staff position will be added to provide continuity and administrative support for these courses. We expect that this will cost little, substantially improve the courses and make it much easier to move regular faculty into these courses.

Initiative: Upgrade Undergraduate Teaching

The initiative is to upgrade the *educational program* by a) having all lecture courses taught by regular, permanent faculty (only recitations in large service courses would be taught by graduate students), and b) providing up-to-date computing facilities for students majoring in Computer Science. This would require five new faculty positions plus converting four existing visiting or lecturer positions to regular faculty positions. The facilities improvements would come primarily from the general upgrade of educational computing which we expect the university to adopt in the near future.

A large part of the undergraduate program is carried by visiting faculty, some with Ph.D.'s, some without. While many of these people are very competent classroom teachers, they do not provide the maturity to keep courses up to date or the knowledge that students at Purdue should expect from their professors. We propose that three steps be taken:

1. *Courses for Majors.* All courses for undergraduate majors will be taught by permanent faculty in normal lecture classes or laboratories.
2. *Service Courses.* All service courses will have a permanent faculty member in charge and teaching at least one section. All large "lecture - recitation" courses will have permanent faculty presenting the lectures.
3. *Facilities.* Students majoring in Computer Science will have normal access to up-to-date computing facilities. This means modern equipment in labs as well as some publically available equipment. The power and sophistication of the equipment will be appropriate for the students, i.e., there will be different equipment for lower division majors, upper division majors and graduate students.

This teaching upgrade will require (assuming constant enrollments) nine FTE new permanent teaching faculty in Computer Science. The job market is now such that nine highly qualified faculty could be hired in a 2 or 3 year period. Funding for four of these positions is available by converting existing visiting positions to regular tenure track positions. This initiative plus the Basic Plan would increase the faculty to 45 FTE from the current 36. The estimated total cost of the undergraduate teaching upgrade is about $250,000/year.

The educational facilities upgrade is partly "general educational computing" which should be funded by the anticipated new general funding in this area. Part of the upgrade is towards better quality equipment for advanced undergraduates and graduate students. We estimate the cost of this to be about $150,000 initially and then recurring costs of $50,000/year ($20,000 operational and $30,000 equipment modernization). We propose that some part of the initial cost be paid by the CS department from its own funding.

D. EQUIPMENT AND SPACE

As suggested above, we are moving Computer Science in the direction of a laboratory science. This will lead to significant needs both for laboratory equipment as well as space for these labs and equipment. In terms of equipment, we would like to have about 250 state-of-the-art workstations available for our undergraduates situated in a combination of class labs (about 150) and open labs (about 100). This will require that we upgrade from the 3 labs we currently have to 12-15 labs. We anticipate that such equipment and labs will receive heavy use nearly all day every day

As far as the equipment available, we will want a combination of state-of-the-art workstations from a variety of companies. This will allow us to introduce our students to the myriad of both hardware and software that they will encounter after leaving Purdue. We must recognize that there will be substantial costs in main-frame hardware, disk space, system programmers, and maintenance and replacement to make such a facility a success. We foresee that this will require cooperation between the Department of Computer Science and the Purdue University Computing Center.

Educational Computing and Laboratories

Departmental computing is logically divided into three categories: educational, administrative and research. Educational computing is, in turn, divided into three categories:

A. *General computing provided by PUCC.* These facilities have traditionally been grossly overloaded and on many occasions this has prevented faculty from teaching appropriate material. We **strongly support** a large increase in the computing power provided for general support of courses.

B. *Laboratory computing provided by PUCC.* Several laboratories have dedicated equipment with hardware support provided by PUCC and software/supervisory support provided by the Computer Sciences Department. Much better computing service is provided to the students in these labs and we plan to expand this approach.

C. *Laboratory computing provided by CS.* Some laboratories with specialized equipment and systems are operated entirely by the Computer Sciences Department.

The laboratory space is provided by the Computer Sciences Department. The current educational laboratories are (the course numbers referred here are those of the current program):

CS110:	two labs equipped with 22 IBM PC/AT's each
CS180:	one lab with 22 X-terminals supported by a dedicated Sequent machine
CS435:	one lab with 15 high quality color graphics workstations
CS404/490A/536:	one lab with 10 SUN workstations and 12 HP color X-terminals
CS503/603/636:	one lab equipped with a network of SUN workstations

The laboratories planned for the near future will include:

CS180:	upgrade to support workstations with object-oriented high level environments and multimedia capabilities
CS181/251/414:	one lab equipped with basic workstations providing UNIX service and high level tools

In the longer term we plan on:

CS250/352/403/413: two more labs for core CS courses

We anticipate that equipment cost for one laboratory is about $75,000–$150,000 (depending on the type). The PUCC maintenance and operating costs per year are probably about 10% of the equipment cost and the extra costs to the Computer Sciences Department for supervision and support is about $25,000/year per laboratory.

Space

The department's space needs are divided into three somewhat independent categories: teaching laboratories, research laboratories, and offices. The teaching laboratories is of most concern and discussed here.

The Computer Science Building currently has five teaching laboratories:

Room (Equipment)	Courses
G40 (Personal Computers)	CS 110
G50 (Personal Computers)	CS 110
G18 (SUN/HP workstations and HP X-window terminals)	CS 536/542/572/690B/public
115 (X-display terminals)	CS 180
175 (Graphics workstations)	CS 435/490A/590D/590K
257 (Sun workstations- specialized)	CS503/603/636
B21 Math Science Building (HP workstations and X-terminals)	General lab

There is one classroom (111) on loan to Schedules and Space with the understanding that they will be converted to laboratories as needed. Only G66 is intended to be kept as a classroom permanently. Note that a few very small classes are held in departmental conference rooms, providing the equivalent of a "half" classroom. The anticipated new laboratories courses will require four new laboratories depending on the course enrollments and versatility of the equipment selected.

D. CONCISE SUMMARY

The three major steps of the plan are: 1) to restructure and revise the undergraduate program, 2) to have ALL undergraduate courses taught by permanent faculty and, 3) to continue introducing laboratories into the curriculum. In step 2 we are not considering recitation sections or lab sessions, but regular course lectures. It will require 5 new positions plus the conversion of 4 existing temporary positions to regular positions in order to accomplish this step. Four new laboratories and updating the equipment in the existing laboratories are required to accomplish the third step.

CS) GRADUATE EDUCATION AND RESEARCH - DEPARTMENT OF COMPUTER SCIENCES

A. GENERAL

Basic Plan

The top priority goal is to increase the quality of the department as measured by its research and educational programs. The emphasis will be in strengthening our core research groups, and create some critical mass in the areas of artificial intelligence and programming languages. The highest priority is given to the increasing the quality of the graduate students. The key components of the Basic Plan are as follows:

Faculty. We will create a superior academic environment to attract and retain a superior faculty. Seven specific steps are proposed, the most significant are to provide superior research facilities, provide an excellent teaching environment, and attract more and better Ph.D. students.

Graduate Students. We will provide more attractive stipends, more fellowships, better computing facilities, and take other steps to increase the quality of the graduate student body substantially. Most graduate students will be pursuing the Ph.D. degree.

Education. We will have comfortable class sizes while keeping the curriculum in pace with the rapid development of computer sciences. The experimental and laboratory components of the educational program will be increased substantially.

Research. The level of research funding will increase significantly, going from $4 million/year to $6 million/year. Seven factors are cited which contribute to this growth; the most important are (a) our young faculty will be much better supported as it matures, (b) the overall quality of the faculty will improve and (c) additional large projects and/or centers will be established.

Administration/Staff. The administrative staff will be increased to reflect the recent rapid growth of the department both in numbers of people and in laboratory/experimental facilities.

Computing Facilities. Dramatic improvements in the cost/performance ratio of computers make it feasible to plan for all researchers in the department within 5 years to have the equivalent of at least a 50 MIPS, 20 MFLOP's workstation with window oriented, color graphics displays. Many will have better workstations and a wide variety of specialized equipment will be available.

This Basic Plan can be accomplished with a steady increase above inflation of $100,000/year in the Department's operating budget. Note that the research support budget is expected to grow much faster at a rate of about $400,000/year. These funds will help indirectly to finance a number of the planned improvements.

Two Initiatives

In addition to the Basic Plan, we propose two initiatives that will provide major improvements in the department and its programs.

The first initiative is to establish one or more new, *major research centers*. These are expected to have 8–12 faculty collaborators in 2–4 departments and to achieve stable support from government and industry of $600,000–$1,000,000 per year. Areas being considered are *Advanced Parallel Distributed Computation, Electronic Prototyping for Physical Design* and *Computer Education Center*. An investment in start-up funds of perhaps $200,000 would be required for each center.

The second initiative is the *addition to the Mathematics and Computer Science buildings*, which is part of the School of Science plan.

The third initiative is the addition of two new graduate academic programs. We plan to create a *Masters Program on Software engineering* and a *Ph.D program in Computational Sciences.* Both new programs are in the planning stage. Their realization depends very much on the availablity of new faculty positions in our department. The MS degree will be supported by the CS department while the Ph.D degree will be supported by all School of Sciences departments. Already there is an informal agreement among the heads to implement this program. We believe that both programs will bring great visibility and prestige to Purdue.

These three initiatives are interrelated with the undergraduate teaching initiative. Neither the undergraduate education upgrade nor the new research centers initiatives are thinkable without the building addition. Even our basic plan requires more space than presently available.

The Faculty

The current faculty consists of about 32 full time equivalents (FTEs). The faculty is rather young, which suggests there will be considerable change both in people and in their fields of interest. The Basic Plan is to grow to about 36 FTE faculty.

This Plan's principal point is to create a superior academic environment which will attract and retain superior faculty. The following specific mechanisms are identified:

A. *Attract more and better Ph.D. students.* This is the highest priority item. A quantum jump in the number of outstanding Ph.D. students is to be made.

B. *Provide excellent research facilities.* High quality, state-of-the-art general computing services will be provided as well as a variety of specialized facilities (e.g., parallel machines, sophisticated graphics, specialized workstations). Ample space for laboratories must be available.

C. *Provide competitive salaries.* Current salaries are generally average for high quality schools, but not more. The lower cost of living at Purdue helps some, but is not a strong attraction for younger faculty.

D. *Provide competitive teaching environment.* The department must maintain an attractive teaching environment. More assistance (both staff and student) will be provided to support the teaching program.

E. *Emphasize special areas of excellence.* The department is already strong in some areas (*theory, scientific computing, software engineering, systems*) and these strengths will be the foundations of future quality enhancements. Adding an area of strength will involve a commitment to 3–4 excellent people.

F. *Maintain a vigorous visitor/colloquium program.*

G. *Maintain a congenial/cooperative atmosphere.*

The facilities and student aspects of these mechanisms are discussed later. Other mechanisms require mostly money (salaries, colloquium program) while the rest require a judicious combination of effort, organization, money, cooperation and perseverance.

Departmental Administration

The department has grown substantially over the years without acquiring adequate support for administrative and staff operations. Some of these duties have fallen upon the faculty and some are not being done. Tasks that need better support include recruiting graduate students, managing educational labs, and departmental administration. Using faculty for these administrative tasks detracts from our plan to provide a superior departmental environment. The recent addition of the position of Associate Department Head has helped this situation considerably, but there is still inadequate support.

Initiative: New Research Centers

There are several groups within the Computer Science Department with the potential to establish a major research center such as SERC (Software Engineering Research Center). Such centers have enormous positive impact on the research program of the department and contribute greatly to the prestige and educational opportunities at Purdue. We propose the university invest in the future by providing some start-up support for one or more of these groups. Three such groups are identified below, but we propose that the faculty's creativity be prodded by having an open competition for ideas. The criteria for selection will be

a) A critical mass of 8–12 collaborators including several senior researchers with well established national reputations.

b) An area that is of interest to other parts of science and/or engineering and which can attract substantial industrial support.

c) Realistic prospects for $600,000–$1,000,000 of stable external support.

The start-up support required is of two kinds:

i) Administrative costs and matching funds over a four year period of, say, $50,000, $75,000, $50,000 and $25,000 per year, respectively. This serves to get things started and demonstrates commitment to the center on the part of the University.

ii) Space and furnishings, perhaps 2,000 ft^2, plus 12 offices or so. This space can be furnished at a cost of perhaps $50,000 for furniture, plus $80,000 for specialized facilities.

The total start-up cost of a center is thus about $300,000. To illustrate the potential and nature of such centers, we roughly describe four feasible candidates:

1) *High Performance Computing*. Focus on the theoretical and practical problems of applying massive parallelism to important problems of science. Potential components include:

Source/Area	Number of People	Candidates
CS Theory	2–3	Apostolico, Atallah, Frederickson, Guerra, Hambrusch
Performance Evaluation	1–2	Spankowski, Marinescu, Rego
Scientific Computing	2–3	Dyksen, Houstis, Rice
Systems and Languages	1–2	Korb, Spafford
Electrical Engineering	2–4	Dietz, Jamieson, Siegel
Mathematics	1–2	Douglass, Lucier
Applications	2–4	Molecular Biology, Aerodynamics, Psychology, Control (Robots, Vehicles)

Potential leaders for this center include Atallah, Frederickson, Houstis and Rice.

2) *Distributed Computing Systems.* Focus on the creation and management of very large applications with multiple software systems running on a network of heterogeneous computers. Potential components include:

Source/Area	Number of People	Candidates
Systems	3–4	Comer, Dewan, Hannaford, Korb, Spafford
Databases	2–3	Bhargava, Elmagarmid
Scientific Computing	1–2	Dyksen, Houstis, Rice
CS Theory	1–2	Atallah, Frederickson
Performance Evaluation	1–2	Marinescu, Rego, Szpankowski
Electrical Engineering	2–3	Delp, Siegel
PUCC	1–2	Abell, Steele
ECN	1–2	Goebel
Application	2–4	Educational Systems, Manufacturing Facilities, Global Data Systems (geography, weather, ...), Pharmaceutical production

Potential leaders for the center include Bhargava and Comer.

3) *Elecronic Prototyping of Physical Design.* Focus on the design, analysis and simulation of realistic, complex physical objects and systems. Potential components include:

Source/Area	Number of People	Candidates
Geometric Modeling	2–3	Bajaj, Hoffmann
Scientific Computing	2–3	Dyksen, Houstis, Rice
Systems	1–2	Dewan, Korb
Applied Math	2–3	Douglass, Lucier, Milner, Phillips
Applications	3–5	Mechanical design, Aerodynamic Structures, Harsh environment tools (heat, space, deep sea) Surgical tools, Body replacement parts Electronic Prototyping of Mechanical designs

Potential leaders for the center include Hoffmann, Houstis and Rice.

3) *Computer Education Center* Focus on the design and implementation of computer sciences courses and labs, develop computer aided instruction tools, and establish a link between the department , Indiana Colleges and high schools. The transfer of computer technology to high schools and the development of a prototype undergraduate program for the 2000 will be the focus of this program. Potential components include:

Source/Area	Number of People	Candidates
Graphics	2–3	Bajaj, Dyksen, Hoffmann
Multimedia technologies	2–3	Korb, Houstis
Scientific Computing	2–3	Dyksen, Houstis, Rice
Systems	1–2	Dewan, Korb
Software engineering	2–3	Conte, DeMillo, Marthur, Spafford, Dunsmore
Artificial Intelligence	1/(mi2	Guerra, Lee

Potential leaders for the center include Dunsmore and Dyksen

The Research Program

The research program will grow significantly in the next five years. There are several factors that will contribute to this growth:

(i) The faculty will be more senior, more established, and consequently better funded.

(ii) The quality of the faculty will improve.

(iii) Some big projects and centers will be established.

(iv) Research in Computer Science is becoming more experimental in nature and thus larger in size.

(v) The number of faculty will increase some.

(vi) More academic year support will be available to support a larger research program.

(vii) More effort will be put into identifying sources of funding, both in government and industry.

The current level of research support in Computer Science is $3.1 million (this is the estimated actual expenditures from July 1, 1989 to June 30, 1990). The above factors will increase this level up to $5.5 – 6.0 million.

The increase in the research program depends on many individual efforts. The department as a whole will concentrate on establishing new large scale projects or centers that have high national visibility and provide substantial support for the students, faculty, staff and facilities. We must be alert for new opportunities that arise in this fast changing field.

B. GRADUATE NUMBERS

The number of graduate students is to increase from 150 to 180. All the increase will be in Ph.D. students. This requires some enhancement in the graduate course offerings and seminar courses.

A vigorous program to attract high quality graduate students will be devised. Current efforts in this area are much too limited.

More specific plans for the graduate program are:

A. Increase the numbers of supported positions as follows:

Fellowships:	from 4 to 12
Research Assts:	from 30 to 70
Teaching Assts:	from 55 to 60
Staff Assts:	from 6 to 10
Total:	from 100 to 150

The total includes some supported outside the department (e.g., assistants in other departments).

B.

Note that some laboratory facilities needed for the undergraduate program might also be used in the graduate program.

Table 1 shows the past, present, and expected number of graduate majors.

Table 1. Graduate majors for selected years from 1981 through 1993. Data are for the fall of each year except degrees which are three year averages.

	Actual				Projected
	1981-82	1985-86	1988-89	1989-90	1993-94
Graduate Majors					
Year 1	25	47	53	49	50
2	54	40	32	38	50
3	26	18	18	23	35
4+	36	19	28	41	45
Total	141	124	131	151	180
M.S. degrees	54	53	47	33	40
Ph.D. degrees	5	6	7	7	18

Addition to the Mathematics and Computer Sciences Building

This addition is described separately in the School of Science plan. The growth of the department's research program is now severely limited by the lack of space. As Computer Science becomes more experimental in nature, it is essential that it have more laboratory space and offices for the associated staff. The planned improvements in the educational program cannot take place without more teaching laboratories.

The Computer Science Building originally contained 4,700 ft^2 of research laboratory space and 2,050 ft^2 of computer room space. This is a large increase over the 1984/85 situation (1,300 and 840 ft^2, respectively), but far short of the 20,000 ft^2 projected needs in the earlier plans. Now, even though 1000 ft^2 has been converted from student office space to research lab space, all the research lab space is in active use. Considerable space has been obtained by "squeezing" people tighter, many research assistants are now assigned to labs and do not have offices.

There are three factors that will contribute to the need for additional research lab space: (1) computer science research is becoming increasingly experimental in nature, (2) the research faculty will increase some, and (3) the research faculty is maturing and will be involved in larger projects. Our analysis of the future suggests that the previous estimate of 20,000 ft^2 of required research lab and computer room space is conservative, but still a reasonable one.

Office space is the major shortcoming of the Computer Science Building. The original plan was for a faculty of 40, but it did not adequately foresee the growth in support staff for facilities, research projects, visitors, centers, and administration. The office space for graduate teaching and research assistants was adequate for the number the department had in the 1983-85 period. However, we have had a substantial increase in staff and research assistants and plan for another substantial increase in the next five years. The result is that additional office space must be obtained.

The two rooms now in reserve will provide some of the research lab, educational lab and office space needed. These rooms have about 1600 ft^2 and it is clear that they cannot come close to providing for one or two teaching labs, 15–25 offices and 13,000 ft^2 of research laboratories. In view of the long lead time for acquiring space, planning must begin now on how to meet these needs. The most important initiative proposed is to acquire additional space as this is the limiting factor for much of the quality improvement in the department.

D. EQUIPMENT

See COMPUTING.

E. COMPUTING

Research and Administrative Computing Facilities

The goal is to maintain powerful workstations (or equivalents) for all faculty and graduate researchers, plus adequate support for secretarial, administrative, and facilities staff. The following table shows the expected values for the computing resources to be in use by various classes of users in computer science.

Table 2. Typical Computing Characteristics for CS in 1995

Item	Units	Faculty	Grad Researcher	Undergrad Major
Integer performance	MIPS*	100	50	20
Floating point performance	MFLOPS*	100	20	10
Auxiliary storage	MB*	2000	1000	500
Main memory	MB*	64	32	16
Color	bit planes	24	24	8

*MIPS = Million Instructions Per Second
MFLOPS = Million Floating Point Operations Per Second
MB = Megabytes (million characters)

While these resources appear lavish now, workstations providing much more will be commonly available by 1995. Some in CS will have the latest, more powerful equipment available then. The bulk of the funding for this is to come from research grants and much of the increased capacity will be in the form of workstations. The installed computing capacity in the spring of 1986 was over 20 VAX 11/780 equivalents, but it was unevenly distributed. The general research and administrative computers were grossly overloaded while some machines were lightly used. The installed capacity in the fall of 1988 was over 350 VAX 11/780 equivalents. Note that the special nature of some machines means that their ''power'' is not easily made available to the department as a whole and, indeed, some are dedicated to specific research projects.

The Basic Plan implies that the user community for research and administrative computing will consist of about 190 people in 1995 (40 faculty, 90 Ph.D. students, 20 staff, 12 secretaries, and 25 M.S. students). The general characteristics for the facilities planned are as follows:

Gross computing power:	10000 VAX 11/780 equivalents in CS Department, 5000 VAX 11/780 equivalents in PUCC for majors.
User stations: (excluding labs)	High quality color (50), medium quality color (60), lower quality color (80).

I/O devices:	Access to all varieties of black and white paper printers, phototypesetters, color printers, wide bed printers, text scanners, massive storage, video displays, and copiers.
Networks:	Access to all major national and international networks, and to all important campus facilities.

Note that the CS computing facility currently has about 200 user stations (80 X terminals and 120 workstations) for about 250 users. All graduate students in CS are now given access to these facilities.

It is interesting to note that the biggest difference between this plan and the previous ones is in the projected computing power needs. This is a reflection on the dynamic changes underlying the computing profession. Even the current plan only provides what will be considered "ordinary" facilities by 1995.

The superior environment that we desire must include an excellent support staff for the computing and experimental facilities. Furthermore, we must start providing general support for the teaching laboratories and for the laborious software preparations for many regular courses. The main burden for supporting research experimental facilities will fall upon the research projects, but there are still many general support tasks that must be provided. Our Basic Plan assumes that half of the staff additions listed below will be paid from research grants.

Thus, over the next five years, we plan that the department add the following:

* One secretary (beyond any dedicated to research projects, centers, etc.).
* Three Programmers (one for educational services, two for general research/administrative support).
* Two Technicians (one for educational services-labs, one for general support).
* Five graduate assistants (two for educational services, two for general support, one for research lab support).
* Ten undergraduate assistants (five for educational services, three for general support, two for research lab support).

F. CONCISE SUMMARY

The three principal points of the plan are: 1) the establishment of two major research centers, 2) to increase the quality of the graduate students and the number of Ph.D. degrees, and 3) building new space. The center of point 1, plus other growth, will increase research funding from $3+ million to $5+ million (constant dollars). The primary action for point 2 is to create additional fellowships. The space provided by the new construction is essential to all aspects of the department's plan.

NEW BUILDING FOR
COMPUTER SCIENCES, MATHEMATICS, AND STATISTICS

Additional space is needed to serve the needs of the three departments (Computer Sciences, Mathematics, and Statistics) and the Mathematical Sciences Library. Each of these units is currently tightly squeezed for space and each anticipates a substantial increase in its space needs in the next few years. The University has a general plan to build between the Computer Sciences and Mathematical Sciences buildings, so it is assumed that the space would be in this new building. No attempt is made to plan the building itself.

The requirements are presented in five parts, the independent needs of the three departments, the needs for common ''general'' space, and the needs of the Mathematics Research Center (a proposed center involving all three departments). These five parts are presented independently.

COMMON AREAS

There is space to be shared by all three departments in a general, equitable way.

1. Well Appointed Lecture Room

During the school year the three departments average 15 to 20 formal lectures a week, plus a few other presentations of various kinds. The formal lectures are by visitors or faculty on current research topics and are attended by other faculty and advanced graduate students. Examples of other presentations are (1) proposals to the faculty for some action (form a research team, organize a committee, modify the curriculum, buy a computer), (2) departmental meetings, (3) visits by funding agency review teams. These ''other presentations'' run from two hours to two days and frequently involve people outside Purdue.

Mathematics and Statistics have no room for this purpose and usually have to go to another building. This is an inconvenience for all and sometimes a true embarrassment when visitors end up in distant, substandard rooms. Computer Science has a nice room for this purpose, but it is too small. More than half the time it cannot be used because the expected audience might be too large (over 18–20 people).

These departments need a lecture room where they can be proud to take visitors, one with a pleasant decor, excellent facilities, and comfortable seats. The room should accommodate up to 40 people.

2. Mathematical Sciences Library Expansion

This library has been in the same space for 24 years. The faculty and student bodies served have grown substantially, the computer science discipline has matured from one very small to one with a full array of books and journals. All this is on top of the natural growth of the collection. All the extra space has long ago been filled up and the designed expansion (into the second floor) has not been possible because that space is being used for equally important purposes. Thus, every new item that comes in must be matched by an item going into storage.

An expansion of about 4000 ft^2 would allow the library to restore some of its study areas, to bring some items out of storage, to provide space for new information technology, and to survive another decade or two of growth.

3. Lounge

A university faculty needs a place to meet colleagues informally to exchange views, news, and ideas. A lounge is a place to greet visitors and interact with graduate students. The Mathematical Sciences building has a large pleasant lounge area, but it is part of the library so it can be utilized only in a limited way. The location constraints are such that their space is underutilized. The Computer Science building has a well appointed lounge with, for example, a refrigerator and microwave to encourage lunches. However, it is so small (220 ft^2) that not even half the faculty can enter the room at one time. Coffee and cookies for visiting speakers always ends up with an overflow of 5 or 10 people in the hall and the rest go back to their offices.

A lounge is needed with the size of the one in mathematics and the facilities and ambiance of the one in computer sciences.

4. Graduate Student Commons

A room is needed which the graduate students can call their own, where they can meet (night or day) for study, gossip, tea, and a break. Lockers need to be provided for the many graduate students who do not have offices. Computer Science provided a small room for this purpose for two years, but it had to be taken back and used for its intended purpose as a receiving room when space became tighter. The students were very unhappy about this as the room provided the main focal point for interaction.

5. Summary – Common Areas

Lecture Room	800 ft^2
Library Expansion	4000 ft^2
Lounge	600 ft^2
Grad Student Commons	600 ft^2
TOTAL	6000 ft^2

COMPUTER SCIENCES

The Computer Sciences Department has had several long term plans for its future, the most notable are: (1) *Plan for Excellence*, Summer 1981 by Denning, Rice, Snyder and Young, (2) *A Five Year Plan for Excellence*, CSD-TR 651, Summer 1986 by Atallah, Comer, Dunsmore, Frederickson and Rice, and (3) *A Five Year Plan for Excellence in Computer Science*, December 1988 by Bajaj, Dunsmore, Houstis, Rice and Spafford. This latter plan was reorganized in December 1989 and a summary analysis of the 5 year and 10 year plan objectives was made.

The space needs presented here are derived from the above plans. The reasoning is not repeated here in detail, but we note the several trends that will require additional space: (1) Undergraduate instruction will be improved in various ways, including having **all** lecture courses taught by regular faculty. (2) The maturing of the faculty will result in an overall increase in the size of research programs. (3) Some initiatives to establish additional large research centers will be successful. (4) The number of graduate students will increase (beyond the effect of the previous trends). (5) The support staff will increase to accommodate the growth in departmental activities.

We list the sources of new space needs as follows:

1. *Maturing of current faculty's research programs*:
   3 small labs, 1 medium lab and 1 large lab.
2. *Undergraduate Instruction*:
   A. Nine new faculty: +9 offices
   B. Their lab needs: 3 small labs, 1 medium lab and 1 large lab
   C. Less three instructors: −3 offices
   D. Teaching support staff: +4 offices
   Coordinator of Instruction (2), Outreach Persons (2)
3. *New Centers*:
   A. Small center: 3 offices, 1 medium lab
   B. Large center: 11 offices, 1 small lab, 1 medium lab, 1 large lab
4. *Graduate Students*:
   A. For new activities listed above: 25
   B. General growth in program: 15
5. *Support Staff and Equipment*:
   A. Included above: 2 secretaries, 1 clerk, 5 Admin/Tech staff
   B. General growth: 2 secretaries, 1 fiscal clerk
   C. Office machines and Computer Room: 2 small, 1 large
   D. Storage: 2 small

These data are reorganized by types in the following list.

36 Offices

6: larger size (~ 180 ft^2 each)
18: moderate size (~ 150 ft^2 each)
8: small size (~ 120 ft^2 each)
4: secretarial

14 Laboratories

7: small (~ 300 ft^2 each)
4: medium (~ 600 ft^2 each)
3: large (~ 800 ft^2 each)

Five Other Rooms

1: Computer room with super AC (~ 800 ft^2)

2: Machine rooms (~ 200 ft^2 each)
2: Storage rooms (~ 400 ft^2 each)

The assignable space here is estimated to be about 14–15,000 square feet.

MATHEMATICS

The Mathematics Department needs additional space in order to provide undergraduate students with a better educational experience, and to provide faculty and graduate students a superior environment to enhance our productivity and recruiting competitiveness. Some details follow.

The Mathematics Department is engaged in a long-term program whose goal is to replace all large Calculus lectures for freshmen and sophomores with small classes of 40 students. In the past four years, eight new positions have been granted for this purpose. For reaching an intermediate stage, where freshman classes are small but sophomore classes are around 180, four more positions are needed. To find offices for these faculty under present conditions will require restrictions on accommodating emeriti (5 new ones during 1986-91) and visitors. Reducing the sophomore classes to 40 students, while keeping teaching loads competitive, will require an additional 11 faculty plus 10 more advanced TA's. There is no space available now for housing these additional personnel.

The small class format will ultimately require 5 additional classrooms, full time. A "study and help room," modelled after the successful Chemistry operation, is a possibility under consideration.

In line with University goals, and especially because of the increase in the number of our faculty, the Department aims to expand its graduate student population from the present level of around 175 up to around 190. The additional 10 TA's mentioned above would bring the number to 200. Because of lack of office space, no expansion is possible now.

An essential part of our research program, especially in the Applied Math. Center, involves the hosting of short term visitors who interact and share their expertise with faculty and graduate students. In order to enhance the benefits to Purdue of such visits, in terms of our general image and of improved communications with the global research community, we need to offer a positive and productive experience. For this purpose faculty offices for visitors to work in are highly desirable. Present space for this purpose is borderline adequate, and will certainly become less so if the four new positions mentioned above are realized.

Rapidly expanding computing activities in the Department, and in the Applied Math Center, calls for additional state-of-the-art equipment, and space to house it. Integration of computers into Mathematics teaching, being widely tested throughout the country and actively pursued at Purdue, will create further space demands. Our present computing facilities for graduate students, shared with faculty, have quickly become overcrowded. A separate laboratory for exclusive graduate student use, with enough terminals to serve up to 200 students (not all at once), will soon be necessary.

The space requirements are listed by room types as follows:

28 Offices

3: larger size (~ 180 ft^2 each)
17: small size (~ 120 ft^2 each)
8: moderate size (~ 160 ft^2 each)

Three Other Rooms

1: Computer room with super AC (~ 250 ft^2)
2: Computer labs (~ 600 ft^2 each)

The assignable space here is estimated to be about 5–6,000 square feet.

STATISTICS

The Department of Statistics is hard-pressed for space. In the next three years, we need additional space due to expansion in the activities of the Center for Statistical Decision Sciences, extra space for TA's and RA's (currently we cannot house them), the increase in the faculty and visitors, increase in the computer laboratory facilities, and increase in the space for the Statistical Consulting Laboratory.

The space requirements are listed by room types as follows:

25 Offices

4: larger size (~ 220 ft^2 each)
16: moderate size (~ 150 ft^2 each)
5: moderate (graduate students) (~ 150 ft^2 each)

Five Other Rooms

1: computer lab (~ 600 ft^2)
1: computer facility (~ 300 ft^2)
1: consulting room and lab (~ 400 ft^2)
1: seminar and reprint room (~ 400 ft^2)
1: secretarial mail room (~ 400 ft^2)

The assignable space here is estimated to be about 6–7,000 square feet.

MATHEMATICS RESEARCH CENTER (Proposed)

This Center is the subject of a current proposal to the U.S. Army for a semi-permanent center to be located in the Mathematical Sciences building. The space requirements are as follows:

Administration:	4 offices plus secretarial/reception area
Faculty:	4 offices
Post Docs:	6 offices
Fellows:	3 offices (2 per office)
Res. Assts.:	6 offices (3 per office)
Visitors:	4 offices
Lounge:	1
Seminar room:	1
Miscellaneous:	Storage, Computer, office supplies & machines

The Seminar room could be the Lecture room in the common area, the Center cannot operate without this room. If the common area lounge is available, then the Center's lounge can be of modest size. The faculty offices and two of the administrative offices are for people otherwise with offices, so this is a move in location, not a need for new offices. The space requirements are listed below based on the assumption that the common area space is available. These space requirements are listed by room types.

21 Offices:

2: large (~ 180 ft^2 each)
8: moderate (~ 150 ft^2 each)
11: small (~ 120 ft^2 each)

Other Rooms:

1: Computer (~ 250 ft^2)
1: Supplies and office machines (~ 400 ft^2)
1: Storage (~ 200 ft^2)
1: Lounge (~ 200 ft^2)

The assignable space here is estimated to be about 4,000 square feet. If the common areas are not available, then the space needs for the Center are increased by about 1,000 ft^2 .

BUILDING SUMMARY

Area	Offices	Other Rooms	Total Size
Common	0	4	6,000
Computer Science	36	19	14,000
Mathematics	28	3	6,000
Statistics	25	5	6,000
Math Center	21	4	4,000
TOTALS	110	35	36,000 ft^2