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THE MASTER'S DEGREE PROGRAM IN COMPUTER SCIENCE

Computer Science is the largest program in the Continuing Professional Programs. This article describes the origin, development, and current status of the program.

PROGRAM HISTORY

The first course in computer science, Numerical Analysis and Computer Science, was introduced in the 1966–67 academic year and offered as part of the Numerical Science (now Applied Mathematics) Degree Program. A two-semester course, it covered topics in numerical analysis during the first semester and selected topics in programming techniques (mostly at the assembly language level) during the second semester. Introduction to Computer Arts and Science, a course that concentrated on higher level programming, was offered at the Johns Hopkins campus in Baltimore.

These were the only evening course offerings in computer science for the next four years. During that time, however, there was a growing recognition of the need for advanced training in this new discipline. In particular, it was acknowledged that practicing engineers required special training to learn what was not taught at the time of their undergraduate education. Consequently, plans were made to institute a master's degree program in computer science. The program was introduced in the 1971–72 academic year and offered the following mandatory courses: Operating Systems, Organization of Data and Files, Programming Languages, and Computational Models. Elective courses included Numerical Analysis, Symbolic Logic, Probability, and Statistics, as well as courses in Operations Research.

New computer science courses were introduced each year, and by the 1979–80 academic year there were 22 separate courses available. This growth has continued; in the current academic year 54 separate courses are offered, many of which have multiple sections.

Until 1983, when the programs at APL were integrated into the G.W.C. Whiting School of Engineering, the courses were offered only at the APL campus. In 1983, a few courses were offered at Aberdeen Proving Ground and at the Johns Hopkins Medical Institutions in east Baltimore. The Aberdeen site is being phased out, but a few courses are still offered at the Medical Institutions. In 1986 a campus was opened in Montgomery County. Courses were first held in rented quarters, but in the fall of 1988 we moved into Hopkins' new classroom building near Shady Grove Road.

Table 1 shows the size and impact of the program in terms of students, enrollment, and degrees awarded. The table suggests that, despite the Montgomery County Center's temporary facilities, some students found it more convenient geographically than the APL campus. Now that we are in our new building, we expect the enrollment at the Montgomery County Center to increase significantly in the coming years.

THE STUDENT BODY

When the Computer Science Program was started at APL in 1971, there were few students who obtained bachelor's degrees in computer science. The primary intention of the program was to encourage experienced

Table 1—Evolution of the Computer Science Program.[a]

Academic Year	*78–79*	*79–80*	*80–81*	*81–82*	*82–83*	*83–84*	*84–85*	*85–86*	*86–87*	*87–88*
Degree candidates										
APL campus	307	373	456	619	797	844	933	923	900	866
Montgomery County Center									58	115
Class enrollments										
APL campus	1050	1366	1624	2246	2752	2924	2920	3040	2830	2854
Montgomery County Center									432	582
Degrees awarded	266[b]	84	104	117	128	214	237	240	262	284

[a] Adapted from Ref. 1. Reproduced by permission, Springer-Verlag.
[b] Includes all computer science master's degrees before 1979.

scientists and engineers to enter a rapidly growing field in which trained professionals were sorely needed. To our surprise, we also received numerous applications from students whose undergraduate work was outside the traditional engineering and scientific curricula but who were anxious to enter this new and exciting field. Consequently, prerequisites in mathematics and computer science were established that would allow bright students from nontechnical fields to pursue graduate studies in computer science. During the first nine months of 1988, about 46% of the applicants majored in computer science as undergraduates, 38% majored in other technical areas, and 16% had nontechnical majors.

Because the program was directed initially to the cross training of working professionals, there was a need to guarantee that all students had a common background in essential computer science material. This was accomplished by introducing a set of mandatory core courses that presented the fundamentals of computer science at a graduate level. As the field matured in the 1970s, a growing proportion of the new students had already taken undergraduate courses in computer science; in fact, many had bachelor's degrees in this discipline. Thus, the program began to shift from one in which experienced professionals learned new skills to one in which computer-science-trained professionals sought additional training. This change affected both the contents of the core courses and the diversity and depth of the elective courses.

To be admitted into the program as a master's degree candidate, the applicant must have earned a grade point average of 3.0 for the last two years of undergraduate study, have had a year of calculus and an additional mathematics course beyond calculus, have proven proficiency in Pascal as exhibited by either prior course work or a test, and have had a course in data structures and in assembly language programming or computer organization.

Nongraduate courses are available to help potential students meet the necessary course requirements. Individuals who fail to meet the grade point requirement may be admitted as special students with the understanding that they will demonstrate their ability to perform graduate work by earning a grade of B or better in one or more courses. Such course work is not credited toward the master's degree requirement if the student is later admitted as a degree candidate. (Another category of special student is composed of those who desire to take only selected courses; many of the special students already have advanced degrees and are not interested in pursuing another master's degree.)

COURSES

There are more than 50 computer science courses that students can select. In addition, up to two electives can be taken from selected electrical engineering and applied mathematics courses. The computer science courses are grouped into three categories.

Core courses present the fundamental computer science concepts with which all master's degree graduates are expected to be familiar. They are also prerequisites for all other computer science courses.

Advanced undergraduate/beginning graduate courses are also open to advanced undergraduates and special students.

Graduate courses are open only to computer science degree candidates. Many of these courses have advanced undergraduate/beginning graduate courses as prerequisites.

Core courses have undergone considerable revision over the years. When the program began, undergraduate courses were few, and exposure to aspects of the new technology was considered appropriate graduate study. In time, the concepts became better understood, and they filtered down into the undergraduate curriculum. As a result, some of the core courses (such as the Pascal programming and computer organization courses) were eliminated and became prerequisites for admission to the program. Other core courses were upgraded to present more advanced materials. There are now three core courses: Foundations of Software Engineering, Computer Architecture and Advanced Assembly Language Programming, and Introduction to System Software.

To graduate, a student must have satisfied the core requirements by either taking the core courses or providing evidence that the material was covered before admission to the program. Ten courses are required for the master's degree; at least four of these must be 700-level computer science courses. The remainder may be taken from the computer science curriculum and from approved electrical engineering courses.

The computer science courses are organized into nine areas of concentration, providing a perspective for the students in setting up their program. Students are not required to declare an area of specialization, however, or to take a given number of courses from any single area. In fact, they are encouraged by their advisors to select the mix of programs that best matches their career goals. Table 2 shows the courses offered (other than the core courses), arranged by category.

THE FACULTY

The strength of any graduate program depends on the knowledge, dedication, and commitment of its faculty. Because the primary mission of APL makes it a user of computers rather than a center for research in computer science, it has been necessary to recruit faculty from outside APL to build a balanced program. We have been very fortunate in developing an outstanding and stable group of computer specialists who have demonstrated their desire to share their specialized knowledge and experience in a classroom setting.

Unique among the G.W.C. Whiting School of Engineering Continuing Professional Programs conducted at the APL center, the majority of the Computer Science Program faculty is not affiliated with APL. About 31% of the faculty members work at APL; 6% come from other Johns Hopkins divisions; 6% from other universities; 15% from R&D laboratories; 15% from the U.S. Government; 9% from IBM; 8% from

Table 2—Course offerings in the Computer Science Program.

Artificial Intelligence
- Artificial Intelligence
- Artificial Intelligence Programming
- Advanced Topics in Artificial Intelligence: Expert Systems
- Advanced Topics in Artificial Intelligence: Robotics
- Advanced Topics in Artificial Intelligence: Natural Language Processing
- Advanced Topics in Artificial Intelligence: Computer Vision
- Advanced Topics in Artificial Intelligence: Neural Networks

Computer Engineering
- Introduction to Switching Theory
- Computer Architecture: Design and Implementation
- Microprocessors: Software Viewpoint
- Signal Processing for Computer Scientists
- Geometric Databases
- Parallel Processor Design

Computer Methodologies
- Models and Simulation
- Introduction to Image Processing
- Mathematical Elements for Computer Graphics
- Procedural Elements for Applied Computer Graphics

Communications Networks
- Computer Security and Privacy
- Data Communication Networks
- Local Area Networks
- Computer Network Architecture and Protocols

Computer Systems Organization
- Comparative Computer Structures
- Small Computer Architectures and Interfacing
- Computer Performance Evaluation

Information and Database Management
- Principles and Organization of Computer Database Systems
- Organization of Data and Files
- Advanced Topics in Database Systems

Programming Languages, Compilers, and Operating Systems
- Programming Language Concepts
- Operating Systems
- Small Computer Operating Systems and Applications Software
- Software Development in the UNIX Environment
- Compiler Design
- Compiler Theory

Software Engineering
- Structured Design
- Software Engineering with Ada
- Structured Testing and Maintenance
- Projects in Software Engineering
- Program Development, Style, and Documentation
- Modeling Real-Time Systems
- Software Engineering
- Software Quality Assurance

Foundations and Theory of Computation
- Applied Combinatorics and Discrete Mathematics
- Computational Models
- Design and Analysis of Algorithms
- Logic, Languages, and Machines
- Complexity of Computations
- Queuing Theory with Applications to Computer Science
- Parallel Processing Algorithms and Architectures

Westinghouse; 8% from MITRE; and 2% are self-employed. This diversity has allowed the program to provide both comprehensive offerings during the start-up phase of the Montgomery County Center and to provide specialized courses at both centers.

Not only does the Computer Science Program rely on outside faculty for teaching its courses, but it also has been successful in integrating outside faculty members into the program's management. All academic aspects of the program are the responsibility of the program committee, which is composed of the following faculty members: Vincent G. Sigillito, APL (Chair); Robert S. Grossman, APL (Vice Chair); Bruce I. Blum, APL; James E. Coolahan, Jr., APL; Robert L. Martino, NIH; Aaron Navarro, MITRE; Richard Nierporent, MITRE; Waldo T. Renich, APL; and John Sadowsky, System and Engineering Development Corporation. The committee meets semiannually; it sets admission prerequisites and other admission requirements, helps to identify and select new faculty members, approves new course offerings, and determines which electives from other programs will be credited toward a master's degree in computer science.

In addition, each committee member acts as coordinator for one of the nine areas of concentration. They are responsible for identifying the new courses needed in their area of concentration and for ensuring that existing courses evolve with the growth of new knowledge and techniques, eliminating or combining courses as appropriate. It is this division of a large program into smaller, logically cohesive units that allows us to manage, in a timely manner, the academic needs of such a large and varied program.

CONCLUDING REMARKS

During the past decade, class enrollments in the Computer Science Program at APL have nearly tripled. Just as these enrollments began to level off, the Montgomery County Center opened. The expected growth in enrollments at the Montgomery County Center and the need to refine and add new courses in this rapidly expanding science will continue to challenge us during the next decade.

REFERENCE

[1] Sigillito, V. G., Blum, B. I., and Loy, P. H., "Software Engineering in The Johns Hopkins University Continuing Professional Programs," in *Software Engineering Education*, Springer-Verlag, Berlin, Heidelberg, p. 23 (1988).

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VINCENT G. SIGILLITO's biography can be found on p. 85.