Computer Science Overview

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The Field

The rapid and widespread use of computers and information technology has generated a need for highly trained workers proficient in various job functions. These computer specialists include computer scientists, database administrators, and network systems and data communication analysts. Job tasks and occupational titles used to describe these workers evolve rapidly and continually, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers.

Computer scientists work as theorists, researchers, or inventors. Their jobs are distinguished by the higher level of theoretical expertise and innovation they apply to complex problems and the creation or application of new technology. The areas of computer science research range from complex theory to hardware design to programming-language design. Some researchers work on multidisciplinary projects, such as developing and advancing uses of virtual reality, extending human-computer interaction, or designing robots. They may work on design teams with electrical engineers and other specialists.

Computer science researchers employed by academic institutions have job functions that are similar in many ways to those employed by other organizations. In general, researchers in academic settings have more flexibility to focus on pure theory, while those working in other organizations usually focus on projects that have the possibility of producing patents and profits. However, some researchers in non-academic settings have considerable latitude in determining the direction of their research.

With the Internet and electronic business generating large volumes of data, there is a growing need to be able to store, manage, and extract data effectively. Database administrators work with database management systems software and determine ways to organize and store data. They identify
user needs and set up new computer databases. In many cases, database administrators must integrate data from outdated systems into a new system. They also test and coordinate modifications to the system when needed, and troubleshoot problems when they occur. An organization’s database administrator ensures the performance of the system, understands the platform on which the database runs, and adds new users to the system. Because many databases are connected to the Internet, database administrators also must plan and coordinate security measures with network administrators. With the growing volume of sensitive data and the increasing interconnectedness of computer networks, data integrity, backup systems, and database security have become increasingly important aspects of the job of database administrators.

Network systems and data communications analysts, also referred to as network architects, design, test, and evaluate systems such as local area networks (LANs), wide area networks (WANs), the Internet, intranets, and other data communications systems. Systems are configured in many ways and can range from a connection between two offices in the same building to globally distributed networks, voice mail, and e-mail systems of a multinational organization. Network systems and data communications analysts perform network modeling, analysis, and planning, often requiring both hardware and software solutions. For example, a network may involve the installation of several pieces of hardware, such as routers and hubs, wireless adaptors, and cables, while also requiring the installation and configuration of software, such as network drivers. Analysts also may research related products and make necessary hardware and software recommendations.

**Preparation**

Computer scientists should be creative, inquisitive, analytical, and detail oriented. They must have a strong grasp of mathematics, including calculus, probability, and statistics, and computer systems. Preparation in one or more of the sciences, such as, physics, chemistry, biology, is also a requirement. Abilities to work as part of a team and to communicate well also will be important as computer science jobs frequently require interaction with specialists outside of computer science or engineering. To hone these skills, recommended coursework includes English, writing, social studies, and humanities.

Entry level positions in the field typically require a four year bachelor-of-science degree in computer science, information science, or computer engineering. State-of-the-art high technology research and development positions frequently require the M.S. or Ph.D. degree in either computer science or computer engineering. Tenure track professorial positions in a university require the Ph.D. degree.
Computer Science vs. Computer Engineering vs. Information Science

Most four year degree programs in computer science and computer engineering are accredited by the Accreditation Board for Engineering and Technology (ABET). Typically these degree programs reside in the university’s College of Engineering. The computer engineering degree program resides in the Department of Computer Science and Engineering, or the Department of Electrical and Computer Engineering, or it may be a stand alone Department of Computer Engineering. In some cases, such as, MIT and University of California at Berkeley, these degrees are offered in the Department of Electrical Engineering and Computer Science.

Typically there is considerable overlap in the computer science and the computer engineering degree programs. The major difference between the two accredited degree programs is that an engineering design component is required in the accredited computer engineering degree program.

Information science degree programs are tailored to prepare students for careers in the application of computers in business. Therefore these degree programs typically reside in business colleges and are not accredited by ABET. Although there are a few ABET accredited programs offered in engineering colleges. In addition to computer science courses in programming, computer organization and operation, computer networks, databases, these degree programs require courses in business and management, and fewer courses are required in mathematics and the sciences than in computer science and engineering degree programs.

Admission Requirements
Admissions requirements for undergraduate computer science programs include a solid background in mathematics (algebra, geometry, trigonometry, and calculus) and science (biology, chemistry, and physics), and courses in English, social studies, humanities, and computer and information technology. Bachelor’s degree programs in computer science typically are designed to last 4 years.

Co-ops
Internships and Coops provide students with a great opportunity to gain real-world experience while still in school. In addition, graduates can enhance their employment opportunities by participating in internship or co-op programs offered through their school.

Courses of Study
In a typical four year 120 semester hour computer science degree program students studying computer science will complete 40 semester hours of study in computer science topics, along with at least 30 semester hours of study in mathematics (discrete mathematics, differential and integral calculus, and probability and statistics) and science topics, usually including a lab experience. Students will study topics such as algorithms, data structures, software design, concepts of programming languages, and computer organization and architecture. In addition, theoretical foundations, problem analysis, and solution design will be presented within the program of study. Students will also be exposed to a variety of programming languages and systems and should become proficient in at least one higher-level language. Good communication skills will be developed along with general studies in humanities, social sciences, and the arts.
Ongoing Study
Technological advances come so rapidly in the computer field that continuous study is necessary to keep one’s skills up to date post graduation. Employers, hardware and software vendors, colleges and universities, and private training institutions offer continuing education. Additional training may come from professional development seminars offered by professional computing societies.

Accredited Programs
Those interested in a career in Computer Science should consider reviewing programs that are accredited by the Accreditation Board for Engineering and Technology, Inc. (ABET). ABET accreditation is based on an evaluation of a program’s student achievement, program improvement, faculty, curricular content, facilities, and institutional commitment. The following is a current list of universities offering accredited degree programs in Computer Science.

- Alabama A&M University
- University of Alabama at Birmingham
- The University of Alabama in Huntsville
- The University of Alabama
- University of Alaska Fairbanks
- Appalachian State University
- Arizona State University
- University of Arkansas at Little Rock
- University of Arkansas
- Armstrong Atlantic State University
- Auburn University
- Baylor University
- Bloomsburg University of Pennsylvania
- Boise State University
- Bowie State University
- Brigham Young University
- Bucknell University
- California Polytechnic State University, San Luis Obispo
- California State Polytechnic University, Pomona
- California State University, Chico
- California State University, Dominguez Hills
- California State University, Fullerton
- California State University, Long Beach
- California State University, Los Angeles
- California State University, Northridge
- California State University, Sacramento
- California State University, San Bernardino
- California University of Pennsylvania
- University of California, Berkeley
- University of California, Davis
- University of California, Los Angeles
- University of California, Riverside
- University of California, Santa Barbara
- Calvin College
- Case Western Reserve University
- Cedarville University
- Central Connecticut State University
- University of Central Florida
- College of Charleston
- University of Cincinnati
- University of Nebraska at Omaha
- University of Nebraska-Lincoln
- University of Nevada-Las Vegas
- University of Nevada-Reno
- University of New Hampshire
- University of New Haven
- New Jersey Institute of Technology
- College of New Jersey
- University of New Mexico
- University of New Orleans
- State University of New York at Binghamton
- State University of New York at Brockport
- State University of New York at New Paltz
- City University of New York, City College
- City University of New York, College of Staten Island
- Nicholls State University
- Norfolk State University
- North Carolina Agricultural and Technical State University
- University of North Carolina at Greensboro
- North Carolina State University at Raleigh
- North Dakota State University
- University of North Dakota
- University of North Florida
- University of North Texas
- Northeastern University
- Northern Arizona University
- University of Notre Dame
- Oakland University
- The Ohio State University
- Ohio University
- The University of Oklahoma
- Oregon State University
- Pace University
- Pacific Lutheran University
- University of the Pacific
- University of Pennsylvania
- Plymouth State University
- Polytechnic University
- Portland State University

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Prepared as part of the Sloan Career Cornerstone Center (www.careercornerstone.org)
Note: Some resources in this section are provided by the US Department of Labor, Bureau of Labor Statistics.
| Clemson University                        | University of Portland                      |
| Coastal Carolina University             | Prairie View A & M University                |
| University of Colorado at Colorado Springs | Radford University                        |
| University of Colorado at Denver and Health Sciences Center | Robert Morris University               |
| University of Connecticut               | Rochester Institute of Technology          |
| Drexel University                       | Rose-Hulman Institute of Technology        |
| East Tennessee State University         | Rowan University                            |
| Eastern Kentucky University             | Salem State College                        |
| Eastern Washington University           | San Diego State University                 |
| University of Evansville                | San Francisco State University             |
| Fairleigh Dickinson University (Metropolitan Campus) | San Jose State University              |
| Florida A & M University                | University of Scranton                     |
| Florida Atlantic University             | Shippensburg University                    |
| Florida Institute of Technology         | Slippery Rock University                   |
| Florida International University (University Park) | University of South Alabama               |
| Florida State University                | University of South Carolina Upstate        |
| Gannon University                       | University of South Carolina               |
| George Mason University                 | South Dakota School of Mines and Technology |
| The George Washington University        | South Dakota State University              |
| Georgia Institute of Technology         | University of South Florida                |
| Georgia Southern University             | Southeastern Louisiana University          |
| Grambling State University              | University of Southern California          |
| Hampton University                      | Southern Connecticut State University      |
| University of Houston                   | Southern Illinois University-Edwardsville  |
| University of Houston-Clear Lake        | University of Southern Maine               |
| Howard University                       | Southern Methodist University              |
| Idaho State University                  | University of Southern Mississippi         |
| University of Idaho                     | Southern Polytechnic State University      |
| University of Illinois at Chicago       | Southern University and Agricultural & Mechanical College |
| University of Illinois at Urbana-Champaign | St. Cloud State University              |
| Illinois Institute of Technology        | Stephen F. Austin State University         |
| Illinois State University               | Stevens Institute of Technology            |
| Indiana University-Purdue University Fort Wayne | Stony Brook University         |
| Iona College                            | Syracuse University                        |
| Iowa State University                   | University of Tennessee at Chattanooga    |
| Jackson State University                | Tennessee Technological University         |
| Jacksonville State University           | Texas A & M University                      |
| The Johns Hopkins University            | University of Texas at Arlington           |
| Kansas State University                 | University of Texas at Dallas              |
| The University of Kansas                | University of Texas at El Paso             |
| Kennesaw State University               | Texas Christian University                 |
| University of Kentucky                  | Texas State University-San Marcos          |
| Lafayette College                       | The University of Texas-Pan American       |
| Lamar University                        | The University of Toledo                   |
| Lehigh University                       | Towson University                          |
| University of Louisiana at Lafayette    | Tufts University                           |
| University of Louisiana at Monroe       | Tulane University                          |
| Louisiana State University, Shreveport  | The University of Tulsa                    |
| Louisiana Tech University               | United States Air Force Academy            |
| University of Louisville                | United States Military Academy             |
| Loyola College in Maryland               | United States Naval Academy                |
| University of Maine                    | Utah State University                      |
| University of Maryland Baltimore County  | Utah Valley State College                  |
| University of Massachusetts Boston       | Villanova University                       |
| University of Massachusetts Dartmouth   |                                         |
**Specialty Areas**

Most computer scientists are further classified by areas of focus. The following is a list of several major specialty areas within computer science:

- **Algorithms and Theory**
- **Artificial Intelligence**
- **Architecture, Parallel Computing and Systems**
- **Bioinformatics and Computational Biology**
- **Database and Information Systems**
- **Graphics, Visualization and the Human Computer Interface**
- **Systems and Networking**
- **Programming Languages, Formal Systems, and Software Engineering**
- **Scientific Computing**

**Algorithms and Theory**
Research in this area focuses on the design and analysis of algorithms and data structures for problems arising in several areas of computer science, including automatic software verification, computational geometry, data mining, and machine learning.

**Artificial Intelligence**
This specialty area focuses on a broad range of topics that include knowledge representation, learning, vision, reasoning, robotics, information systems, and planning. Application areas include molecular biology, manufacturing, control theory, and scheduling.
Architecture, Parallel Computing and Systems
Those focusing on the specialty area of architecture develop hardware designs, programming languages, and their compilers for next-generation computers and computing components. The specialty area of parallel computing area focuses on projects of varying size and investigates the software aspects of computation on computers composed of multiple processors.

Bioinformatics and Computational Biology
Research in this area includes developing efficient and scalable algorithms for biomolecular simulation and applying data mining, statistical machine learning, natural language processing, and information retrieval to analyze and mine all kinds of biological data, including DNA sequences, protein sequences and structures, microarray data, and biology literature, for the purpose of facilitating biology discovery.

Database and Information Systems
Individuals working in this area would conduct fundamental and cutting-edge research in databases, data mining, web mining, information retrieval, and natural language processing. Current areas of focus might include data integration, exploring and integrating the "Deep Web;" schema matching; security; mining data streams and sequential and semi-structured data; operating systems support for storage systems; text retrieval and mining; bio-informatics; database support for high performance computing; and top-k query processing.

Graphics, Visualization and the Human Computer Interface
Graphics and visualization research includes modeling and animation of natural phenomena, computational topology, graphics hardware utilization, image based rendering, implicit surfaces, mesh processing and simplification, procedural modeling and texturing, shape modeling, surface parameterization, and visibility processing. Human-Computer Interface research involves user interface tools that better support early design tasks, systems and environments that help users maintain information awareness, tools for multimedia authoring and design, interfaces that foster social interaction, and, more generally, human-computer interaction.

Systems and Networking
Networking and distributed systems group research includes a broad range of topics that include mobile systems, wireless protocols, ad-hoc networks, Quality of Service management, multimedia networking, peer-to-peer networking, routing, network simulations, active queue management, and sensor networks.

Operating system research focuses on distributed resource management, management of ubiquitous computing environments, reflective middleware, middleware "meta-operating systems," object-oriented operating system design, user interfaces that allow single users to interact with multi-computers, peer-to-peer operating system services, and context-sensitive distributed file systems, power management for data centers, file/storage systems, autonomic computing, system support for software robustness, and system support for databases. Security research includes dynamic security architectures; security for active networks; privacy, authentication, authorization, access control, and trust in ubiquitous computing environments that have mobile users; authentication in sensor networks; specification and...
validation of security access control policies; simulation of network security problems and solutions including denial of service; and next generation phone security. Real-time and embedded systems research areas include open real-time systems QoS driven real-time scheduling and communication protocols, integrated design of controllers and real-time schedulers, the integration between real-time, fault tolerant and security protocols, and robust dynamic real-time architecture for networked devices and smart spaces.

Programming Languages, Formal Systems, and Software Engineering
Those working in this specialty area study the design and implementation of computer languages, with the goal of improving both programmer productivity and program quality. The topics of study range from abstract theories of computer languages to practical questions about the use and implementation of high-level languages.

Scientific Computing
Individuals working in the specialty area of scientific computing conduct research on the development and analysis of numerical techniques for approximating mathematical models of physical systems and on algorithms for solving the resulting equations on high performance computer systems. Specific scientific and engineering applications considered include biological molecular dynamics, materials science, semiconductor simulation, astrophysics, and the design of solid propellant rockets.

Day in the Life
The rapid spread of computers and information technology has generated a need for highly trained workers to design and develop new hardware and software systems and to incorporate new technologies. Job tasks and occupational titles used to describe these workers evolve rapidly, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers.

Job Duties
Computer scientists must be able to think logically and have good communication skills. Because they often deal with a number of tasks simultaneously, the ability to concentrate and pay close attention to detail is important. Computer scientists employed in private industry may advance into managerial or project leadership positions. Those employed in academic institutions can become heads of research departments or published authorities in their field. Database administrators may advance into managerial positions, such as chief technology officer, on the basis of their experience managing data and enforcing security. Computer specialists with work experience and considerable expertise in a particular subject or a certain application may find lucrative opportunities as independent consultants or may choose to start their own computer consulting firms.

The Workplace
Computer scientists normally work in offices or laboratories in comfortable surroundings. They usually work about 40 hours a week -- the same as many other professional or office workers.
do. However, evening or weekend work may be necessary to meet deadlines or solve specific problems. Given the technology available today, telecommuting is common for computer professionals. As networks expand, more work can be done from remote locations through modems, laptops, electronic mail, and the Internet.

Like other workers who spend long periods in front of a computer terminal typing on a keyboard, computer systems analysts, database administrators, and computer scientists are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome or cumulative trauma disorder. Through the adoption of good practices and modification of the workplace environment these problems can be mitigated.

Teams and Coworkers

Although computer specialists sometimes work independently, they frequently work in teams on large projects. They must be able to communicate effectively with computer personnel, such as programmers and managers, as well as with users or other staff who may have no technical computer background.

Earnings

According to the US Department of Labor, Bureau of Labor Statistics, median annual earnings of computer and information scientists were $93,950 in the most recent data. The middle 50 percent earned between $71,930 and $118,100. The lowest 10 percent earned less than $53,590, and the highest 10 percent earned more than $144,880. Median annual earnings of computer and information scientists employed in computer systems design and related services were $95,340.

According to the National Association of Colleges and Employers, Summer 2008 Salary Survey Class computer science graduates were offered an average salary offer of $60,416.

Employment

According to the US Department of Labor, Bureau of Labor Statistics, computer scientists and database administrators hold about 542,000 jobs in the U.S., including about 58,000 who were self-employed. Employment was distributed among the detailed occupations as follows:

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Network systems and data communication analysts - 262,000
Database administrators - 119,000
Computer and information scientists, research - 25,000
Computer specialists, all other - 136,000

Although they are increasingly employed in every sector of the economy, the greatest concentration of these workers is in the computer systems design and related services industry. Firms in this industry provide services related to the commercial use of computers on a contract basis, including custom computer programming services; computer systems integration design services; computer facilities management services, including computer systems or data processing facilities support services for clients; and other computer-related services, such as disaster recovery services and software installation. Many computer scientists and database administrators are employed by Internet service providers; Web search portals; and data processing, hosting, and related services firms. Others work for government, manufacturers of computer and electronic products, insurance companies, financial institutions, and universities.

A growing number of computer specialists, such as network and data communications analysts, are employed on a temporary or contract basis; many of these individuals are self-employed, working independently as contractors or consultants. For example, a company installing a new computer system may need the services of several network systems and data communication analysts just to get the system running. Because not all of the analysts would be needed once the system is functioning, the company might contract for such employees with a temporary help agency or consulting firm, or with the network systems analysts themselves. Such jobs may last from several months to 2 years or more. This growing practice enables companies to bring in people with the exact skills they need to complete a particular project, rather than having to spend time or money training or retraining existing workers. Often, experienced consultants then train a company’s in-house staff as a project develops.

The following is a partial list of employers of Computer Scientists:

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<tr>
<th>Technology Intensive Firms</th>
<th>Other Firms</th>
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<tr>
<td>Apple Computer</td>
<td>3M Worldwide</td>
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<td>AT&amp;T</td>
<td>Abbott Laboratories</td>
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<tr>
<td>Cisco Systems</td>
<td>Best Buy Corporation</td>
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<tr>
<td>Dell</td>
<td>Bristol-Myers Squibb Company</td>
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<td>Fujitsu Siemens Computers</td>
<td>CNN</td>
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**Career Path Forecast**

According to the US Department of Labor, Bureau of Labor Statistics, computer scientists and database administrators are projected to be one of the fastest growing occupations over the next decade. Strong employment growth combined with a limited supply of qualified workers will result in excellent employment prospects for this occupation and a high demand for their skills.

The computer scientists and database administrators occupation is expected to grow 37 percent from 2006 to 2016, much faster than average for all occupations. Employment of these computer specialists is expected to grow as organizations continue to adopt and integrate increasingly sophisticated technologies. Job increases will be driven by very rapid growth in computer systems design and related services, which is projected to be one of the fastest growing industries in the U.S. economy.
The demand for networking to facilitate the sharing of information, the expansion of client-server environments, and the need for computer specialists to use their knowledge and skills in a problem-solving capacity will be major factors in the rising demand for computer scientists and database administrators. Firms will continue to seek out computer specialists who are able to implement the latest technologies and are able to apply them to meet the needs of businesses as they struggle to maintain a competitive advantage.

As computers continue to become more central to business functions, more sophisticated and complex technology is being implemented across all organizations, fueling demand for computer scientists and database administrators. There is growing demand for network systems and data communication analysts to help firms maximize their efficiency with available technology. Expansion of electronic commerce -- doing business on the Internet -- and the continuing need to build and maintain databases that store critical information on customers, inventory, and projects are fueling demand for database administrators familiar with the latest technology. Because of the increasing reliance on the Internet among businesses, information security is an increasing concern.

The development of new technologies leads to demand for various kinds of workers. The expanding integration of Internet technologies into businesses, for example, has resulted in a growing need for specialists who can develop and support Internet and intranet applications. The growth of electronic commerce means that more establishments use the Internet to conduct their business online. It also means more security specialists are needed to protect their systems. The spread of such new technologies translates into a need for information technology professionals who can help organizations use technology to communicate with employees, clients, and consumers. Explosive growth in these areas also is expected to fuel demand for specialists who are knowledgeable about network, data, and communications security.

Computer scientists and database administrators should continue to enjoy excellent job prospects. As technology becomes more sophisticated and complex, however, these positions will demand a higher level of skill and expertise from their employees. Individuals with an advanced degree in computer science or computer engineering or with an MBA with a concentration in information systems should enjoy favorable employment prospects. College graduates with a bachelor’s degree in computer science, computer engineering, information science, or MIS also should enjoy favorable prospects, particularly if they have supplemented their formal education with practical experience. Because employers continue to seek computer specialists who can combine strong technical skills with good business skills, individuals with a combination of experience inside and outside the IT arena will have the best job prospects. In addition to growth, many job openings will arise from the need to replace workers who move into managerial positions or other occupations or who leave the labor force.

Professional Organizations
Professional organizations and associations provide a wide range of resources for planning and navigating a career in Computer Science. These groups can play a key role in your development and keep you abreast of what is happening in your industry. Associations promote the interests of their members and provide a network of contacts that can help you find jobs and move your career forward. They can offer a variety of services including job referral services, continuing education courses, insurance, travel benefits, periodicals, and meeting and conference opportunities. A broader list of professional associations is also available at www.careercornerstone.org.

► Association for Computing Machinery (www.acm.org)
Founded in 1947, ACM is a major force in advancing the skills of information technology professionals and students worldwide. Today, its 80,000 members and the public turn to ACM for the industry's leading Portal to Computing Literature, authoritative publications and pioneering conferences, providing leadership for the 21st century.

► Association for Women in Computing (www.awc-hq.org)
The Association for Women in Computing is a non-profit professional organization for women and men who have an interest in information and technology. The Association is dedicated to the advancement of women in the technology fields.

► IEEE Computer Society (www.computer.org)
With nearly 100,000 members, the IEEE Computer Society is the world's leading organization of computer professionals. Founded in 1946, it is the largest of the 39 societies of the IEEE (www.ieee.org).