Computer Software Engineers and Computer Programmers

Significant Points

- Computer software engineers are among the occupations projected to grow the fastest and add the most new jobs over the 2008–18 decade, resulting in excellent job prospects.

- Employment of computer programmers is expected to decline by 3 percent through 2018.

- Job prospects will be best for applicants with a bachelor's or higher degree and relevant experience.

Nature of the Work

Computer software engineers design and develop software. They apply the theories and principles of computer science and mathematical analysis to create, test, and evaluate the software applications and systems that make computers work. The tasks performed by these workers evolve quickly, reflecting changes in technology and new areas of specialization, as well as the changing practices of employers. (A separate section on computer hardware engineers appears in the engineers section of the *Handbook*.)

Software engineers design and develop many types of software, including computer games, business applications, operating systems, network control systems, and middleware. They must be experts in the theory of computing systems, the structure of software, and the nature and limitations of hardware to ensure that the underlying systems will work properly.

Computer software engineers begin by analyzing users' needs, and then design, test, and develop software to meet those needs. During this process they create flowcharts, diagrams, and other documentation, and may also create the detailed sets of instructions, called algorithms, that actually tell the computer what to do. They also may be responsible for converting these instructions into a computer language, a process called programming or coding, but this usually is the responsibility of *computer programmers*.

Computer software engineers can generally be divided into two categories: applications engineers and systems engineers. *Computer applications software engineers* analyze end users' needs and design, construct, deploy, and maintain general computer applications software or specialized utility programs. These workers use different programming languages, depending on the purpose of the program and the environment in which the program runs. The programming languages most often used are C, C++, Java, and Python. Some software engineers develop packaged computer applications, but most create or adapt customized applications for business and other organizations. Some of these workers also develop databases.

Computer systems software engineers coordinate the construction, maintenance, and expansion of an organization's computer systems. Working with the organization, they coordinate each department's computer needs—ordering, inventory, billing, and payroll recordkeeping, for example—and make suggestions about its technical direction. They also might set up the organization's intranets—networks that link computers within the organization and ease communication among various departments. Often, they are also responsible for the design and implementation of system security and data assurance.

Systems software engineers also work for companies that configure, implement, and install the computer systems of other organizations. These workers may be members of the marketing or sales staff, serving as the primary technical resource for sales workers, or providing logistical and technical support. Since the selling of complex computer systems often requires substantial customization to meet the needs of the purchaser, software engineers help to identify and explain needed changes. In addition, systems software engineers are responsible for ensuring security across the systems they are configuring.

Computer programmers write programs. After computer software engineers and systems analysts design software programs, the programmer converts that design into a logical series of instructions that the computer can follow (A section on computer systems analysts appears elsewhere in the *Handbook*.). The programmer codes these instructions in any of a number of programming languages, depending on the need. The most common languages are C++ and Python.

Computer programmers also update, repair, modify, and expand existing programs. Some, especially those working on

Employment of computer software engineers and computer programmers is expected to grow much faster than the average.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2008	Projected Employment, 2018	Change, 2008-2018	
				Number	Percent
Computer software engineers and computer programmers	–	1,336,300	1,619,300	283,000	21
Computer programmers	15-1021	426,700	414,400	-12,300	-3
Computer software engineers	15-1030	909,600	1,204,800	295,200	32
Computer software engineers, applications	15-1031	514,800	689,900	175,100	34
Computer software engineers, systems software	15-1032	394,800	515,000	120,200	30

(NOTE) Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook.*

large projects that involve many programmers, use computer-assisted software engineering (CASE) tools to automate much of the coding process. These tools enable a programmer to concentrate on writing the unique parts of a program. Programmers working on smaller projects often use "programmer environments," applications that increase productivity by combining compiling, code walk-through, code generation, test data generation, and debugging functions. Programmers also use libraries of basic code that can be modified or customized for a specific application. This approach yields more reliable and consistent programs and increases programmers' productivity by eliminating some routine steps.

As software design has continued to advance, and some programming functions have become automated, programmers have begun to assume some of the responsibilities that were once performed only by software engineers. As a result, some computer programmers now assist software engineers in identifying user needs and designing certain parts of computer programs, as well as other functions.

Work environment. Computer software engineers and programmers normally work in clean, comfortable offices or in laboratories in which computer equipment is located. Software engineers who work for software vendors and consulting firms frequently travel to meet with customers. Telecommuting is becoming more common as technological advances allow more work to be done from remote locations.

Most software engineers and programmers work 40 hours a week, but about 15 percent of software engineers and 11 percent of programmers worked more than 50 hours a week in 2008. Injuries in these occupations are rare. However, like other workers who spend long periods in front of a computer terminal typing at a keyboard, engineers and programmers are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Training, Other Qualifications, and Advancement

A bachelor's degree commonly is required for software engineering jobs, although a master's degree is preferred for some positions. A bachelor's degree also is required for many computer programming jobs, although a 2-year degree or certificate may be adequate in some cases. Employers favor applicants who already have relevant skills and experience. Workers who keep up to date with the latest technology usually have good opportunities for advancement.

Education and training. For software engineering positions, most employers prefer applicants who have at least a bachelor's degree and broad knowledge of, and experience with, a variety of computer systems and technologies. The usual college majors for applications software engineers are computer science, software engineering, or mathematics. Systems software engineers often study computer science or computer information systems. Graduate degrees are preferred for some of the more complex jobs.

Many programmers require a bachelor's degree, but a 2-year degree or certificate may be adequate for some positions. Some computer programmers hold a college degree in computer science, mathematics, or information systems, whereas others have taken special courses in computer programming to supplement their degree in a field such as accounting, finance, or another area of business.

Employers who use computers for scientific or engineering applications usually prefer college graduates who have a degree in computer or information science, mathematics, engineering, or the physical sciences. Employers who use computers for business applications prefer to hire people who have had college courses in management information systems and business, and who possess strong programming skills. A graduate degree in a related field is required for some jobs.

In addition to educational attainment, employers highly value relevant programming skills and experience. Students seeking software engineering or programming jobs can enhance their employment opportunities by participating in internships. Some employers, such as large computer and consulting firms, train new employees in intensive, company-based programs.

As technology advances, employers will need workers with the latest skills. To help keep up with changing technology, workers may take continuing education and professional development seminars offered by employers, software vendors, colleges and universities, private training institutions, and professional computing societies. Computer software engineers also need skills related to the industry in which they work. Engineers working for a bank, for example, should have some expertise in finance so that they understand banks' computing needs.

Certification and other qualifications. Certification is a way to demonstrate a level of competence and may provide a jobseeker with a competitive advantage. Certification programs are generally offered by product vendors or software firms, which may require professionals who work with their products to be certified. Voluntary certification also is available through various other organizations, such as professional computing societies.

Computer software engineers and programmers must have strong problem-solving and analytical skills. Ingenuity and creativity are particularly important in order to design new,

functional software programs. The ability to work with abstract concepts and to do technical analysis is especially important for systems engineers because they work with the software that controls the computer's operation. Engineers and programmers also must be able to communicate effectively with team members, other staff, and end users. Because they often deal with a number of tasks simultaneously, they must be able to concentrate and pay close attention to detail. Business skills are also important, especially for those wishing to advance to managerial positions.

Advancement. For skilled workers who keep up to date with the latest technology, prospects for advancement are good. Advancement opportunities for computer software engineers increase with experience. Eventually, they may become a project manager, manager of information systems, or chief information officer, especially if they have business skills and training. Some computer software engineers with several years of experience or expertise can find lucrative opportunities working as systems designers or independent consultants, particularly in specialized fields such as business-to-business transactions or security and data assurance.

In large organizations, programmers may be promoted to lead programmer and be given supervisory responsibilities. Some applications programmers may move into systems programming after they gain experience and take courses in systems software. With general business experience, programmers may become programmer-analysts or systems analysts, or may be promoted to managerial positions. Programmers with specialized knowledge and experience with a language or operating system may become computer software engineers. As employers increasingly contract with outside firms to do programming jobs, more opportunities should arise for experienced programmers with expertise in a specific area to work as consultants.

Employment
Computer software engineers and computer programmers held about 1.3 million jobs in 2008. Approximately 514,800 were computer applications software engineers, about 394,800 were computer systems software engineers, and about 426,700 were computer programmers. Although computer software engineers and computer programmers can be found in a wide range of industries about 32 percent were employed in computer systems design and related services. Many also worked for software publishers, manufacturers of computers and related electronic equipment, financial institutions, and insurance providers. About 48,200 computer software engineers and computer programmers were self-employed in 2008.

Job Outlook
Overall, employment of computer software engineers and computer programmers is projected to increase much faster than the average for all occupations. Job prospects should be best for those with a bachelor's degree and relevant experience.

Employment change. Overall, employment of computer software engineers and computer programmers is projected to increase by 21 percent from 2008 to 2018, much faster than the average for all occupations. This will be the result of rapid growth among computer software engineers, as employment of computer programmers is expected to decline.

Employment of computer software engineers is expected to increase by 32 percent from 2008–2018, which is much faster than the average for all occupations. In addition, this occupation will see a large number of new jobs, with more than 295,000 created between 2008 and 2018. Demand for computer software engineers will increase as computer networking continues to grow. For example, expanding Internet technologies have spurred demand for computer software engineers who can develop Internet, intranet, and World Wide Web applications. Likewise, electronic data-processing systems in business, telecommunications, healthcare, government, and other settings continue to become more sophisticated and complex. Implementing, safeguarding, and updating computer systems and resolving problems will fuel the demand for growing numbers of systems software engineers.

New growth areas will also continue to arise from rapidly evolving technologies. The increasing uses of the Internet, the proliferation of Web sites, and mobile technology such the as wireless Internet have created a demand for a wide variety of new products. As more software is offered over the Internet, and as businesses demand customized software to meet their specific needs, applications and systems software engineers will be needed in greater numbers. In addition, the growing use of handheld computers will create demand for new mobile applications and software systems. As these devices become a larger part of the business environment, it will be necessary to integrate current computer systems with this new, more mobile technology.

In addition, information security concerns have given rise to new software needs. Concerns over "cyber security" should result in the continued investment in software that protects computer networks and electronic infrastructure. The expansion of this technology over the next 10 years will lead to an increased need for software engineers to design and develop secure applications and systems, and to integrate them into older systems.

As with other information technology jobs, offshore outsourcing may temper employment growth of computer software engineers. Firms may look to cut costs by shifting operations to foreign countries with lower prevailing wages and highly educated workers. Jobs in software engineering are less prone to being offshored than are jobs in computer programming, however, because software engineering requires innovation and intense research and development.

Employment of computer programmers is expected to decline slowly, decreasing by 3 percent from 2008 to 2018. Advances in programming languages and tools, the growing ability of users to write and implement their own programs, and the offshore outsourcing of programming jobs will contribute to this decline.

Because they can transmit their programs digitally, computer programmers can perform their job function from anywhere in the world, allowing companies to employ workers in countries that have lower prevailing wages. Computer programmers are at a much higher risk of having their jobs offshored than are workers involved in more complex and sophisticated information technology functions, such as software engineering. Much of the work of computer programmers requires little localized or specialized knowledge and can be made routine once knowledge of a particular programming language is mastered.

Nevertheless, employers will continue to need some local programmers, especially those who have strong technical skills and who understand an employer's business and its programming requirements. This means that programmers will have to keep abreast of changing programming languages and techniques. Furthermore, a recent trend of domestic sourcing may help to keep a number of programming jobs onshore. Instead of hiring workers in foreign locations, some organizations have begun to contract with programmers in low-cost areas of the United States. This allows them to reduce payroll expenses, while eliminating some of the logistical issues that arise with offshore outsourcing.

Job prospects. As a result of rapid employment growth over the 2008 to 2018 decade, job prospects for computer software engineers should be excellent. Those with practical experience and at least a bachelor's degree in a computer-related field should have the best opportunities. Employers will continue to seek computer professionals with strong programming, systems analysis, interpersonal, and business skills. In addition to jobs created through employment growth, many job openings will result from the need to replace workers who move into managerial positions, transfer to other occupations, or leave the labor force. Consulting opportunities for computer software engineers also should continue to grow as businesses seek help to manage, upgrade, and customize their increasingly complicated computer systems.

Although employment of computer programmers is projected to decline, numerous job openings will result from the need to replace workers who leave the labor force or transfer to other occupations. Prospects for these openings should be best for applicants with a bachelor's degree and experience with a variety of programming languages and tools. As technology evolves, however, and newer, more sophisticated tools emerge, programmers will need to update their skills in order to remain competitive. Obtaining vendor-specific or language-specific certification also can provide a competitive edge.

Earnings

In May 2008, median annual wages of wage-and-salary computer applications software engineers were $85,430. The middle 50 percent earned between $67,790 and $104,870. The lowest 10 percent earned less than $53,720, and the highest 10 percent earned more than $128,870. Median annual wages in the industries employing the largest numbers of computer applications software engineers in May 2008 were as follows:

Professional and commercial equipment
   and supplies merchant wholesalers 93,740
Software publishers...87,710
Management of companies and enterprises 85,990
Computer systems design and related services 84,610
Insurance carriers 80,370

In May 2008, median annual wages of wage-and-salary computer systems software engineers were $92,430. The middle 50 percent earned between $73,200 and $113,960. The lowest 10 percent earned less than $57,810, and the highest 10 percent earned more than $135,780. Median annual wages in the industries employing the largest numbers of computer systems software engineers in May 2008 were as follows:

Scientific research and development services $102,090
Computer and peripheral equipment manufacturing..101,270
Software publishers...93,590
Navigational measuring electromedical
   and control instruments manufacturing....................91,720
Computer systems design and related services 91,610

Median annual wages of wage-and-salary computer programmers were $69,620 in May 2008. The middle 50 percent earned between $52,640 and $89,720 a year. The lowest 10 percent earned less than $40,080, and the highest 10 percent earned more than $111,450. Median annual wages in the industries employing the largest numbers of computer programmers in May 2008 are shown below:

Software publishers...81,780
Management of companies and enterprises 71,040
Computer systems design and related services 70,270
Employment services 70,070
Insurance carriers 69,790

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer science averaged $61,407 in July 2009.

Related Occupations

Other professional workers who deal extensively with computer technology or data include:

Actuaries
Computer network, systems, and database administrators
Computer scientists
Computer support specialists
Computer systems analysts
Engineers
Mathematicians
Operations research analysts
Statisticians

Sources of Additional Information

State employment service offices can provide information about job openings for computer programmers. Municipal chambers of commerce are an additional source of information on an area's largest employers.

Further information about computer careers is available from:
➤ Association for Computing Machinery, 2 Penn Plaza, Suite 701, New York, NY 10121-0701. Internet: **http://computingcareers.acm.org**

➤ Institute of Electrical and Electronics Engineers Computer Society, Headquarters Office, 2001 L St. NW., Suite 700 Washington, DC 20036-4910. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

➤ University of Washington Computer Science and Engineering Department, AC101 Paul G. Allen Center, Box 352350, 185 Stevens Way, Seattle, WA 98195-2350. Internet: **http://www.cs.washington.edu/WhyCSE**

➤ National Center for Women and Information Technology, University of Colorado, Campus Box 322 UCB, Boulder, CO 80309-0322. Internet: **http://www.ncwit.org**

The Occupational Information Network (O*NET) provides information on a wide range of occupational characteristics. Links to O*NET appear at the end of the Internet version of this occupational statement, accessible at **http://www.bls.gov/ooh/ocos303.htm**