

# The Art Of Unit Testing: With Examples In C

## Software testing

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Software testing is the act of checking whether software satisfies expectations.

Software testing can provide objective, independent information about the quality of software and the risk of its failure to a user or sponsor.

Software testing can determine the correctness of software for specific scenarios but cannot determine correctness for all scenarios. It cannot find all bugs.

Based on the criteria for measuring correctness from an oracle, software testing employs principles and mechanisms that might recognize a problem. Examples of oracles include specifications, contracts, comparable products, past versions of the same product, inferences about intended or expected purpose, user or customer expectations, relevant standards, and applicable laws.

Software testing is often dynamic in nature; running the software to verify actual output matches expected. It can also be static in nature; reviewing code and its associated documentation.

Software testing is often used to answer the question: Does the software do what it is supposed to do and what it needs to do?

Information learned from software testing may be used to improve the process by which software is developed.

Software testing should follow a "pyramid" approach wherein most of your tests should be unit tests, followed by integration tests and finally end-to-end (e2e) tests should have the lowest proportion.

## Concolic testing

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Concolic testing (a portmanteau of concrete and symbolic, also known as dynamic symbolic execution) is a hybrid software verification technique that performs symbolic execution, a classical technique that treats program variables as symbolic variables, along a concrete execution (testing on particular inputs) path. Symbolic execution is used in conjunction with an automated theorem prover or constraint solver based on constraint logic programming to generate new concrete inputs (test cases) with the aim of maximizing code coverage. Its main focus is finding bugs in real-world software, rather than demonstrating program correctness.

A description and discussion of the concept was introduced in "DART: Directed Automated Random Testing" by Patrice Godefroid, Nils Klarlund, and Koushik Sen. The paper "CUTE: A concolic unit testing engine for C", by Koushik Sen, Darko Marinov, and Gul Agha, further extended the idea to data structures, and first coined the term concolic testing. Another tool, called EGT (renamed to EXE and later improved and renamed to KLEE), based on similar ideas was independently developed by Cristian Cadar and Dawson Engler in 2005, and published in 2005 and 2006. PathCrawler first proposed to perform symbolic execution along a concrete execution path, but unlike concolic testing PathCrawler does not simplify complex symbolic

constraints using concrete values. These tools (DART and CUTE, EXE) applied concolic testing to unit testing of C programs and concolic testing was originally conceived as a white box improvement upon established random testing methodologies. The technique was later generalized to testing multithreaded Java programs with jCUTE, and unit testing programs from their executable codes (tool OSMOSE). It was also combined with fuzz testing and extended to detect exploitable security issues in large-scale x86 binaries by Microsoft Research's SAGE.

The concolic approach is also applicable to model checking. In a concolic model checker, the model checker traverses states of the model representing the software being checked, while storing both a concrete state and a symbolic state. The symbolic state is used for checking properties on the software, while the concrete state is used to avoid reaching unreachable states. One such tool is ExpliSAT by Sharon Barner, Cindy Eisner, Ziv Glazberg, Daniel Kroening and Ishai Rabinovitz

## Game testing

*Game testing, also called quality assurance (QA) testing within the video game industry, is a software testing process for quality control of video games*

Game testing, also called quality assurance (QA) testing within the video game industry, is a software testing process for quality control of video games. The primary function of game testing is the discovery and documentation of software defects. Interactive entertainment software testing is a highly technical field requiring computing expertise, analytic competence, critical evaluation skills, and endurance. In recent years the field of game testing has come under fire for being extremely strenuous and unrewarding, both financially and emotionally.

## Nondestructive testing

*Non-Destructive Testing (NDT/ NDT testing) Techniques or Methodologies allow the investigator to carry out examinations without invading the integrity of the engineering*

Nondestructive testing (NDT) is any of a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage.

The terms nondestructive examination (NDE), nondestructive inspection (NDI), and nondestructive evaluation (NDE) are also commonly used to describe this technology.

Because NDT does not permanently alter the article being inspected, it is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research. The six most frequently used NDT methods are eddy-current, magnetic-particle, liquid penetrant, radiographic, ultrasonic, and visual testing. NDT is commonly used in forensic engineering, mechanical engineering, petroleum engineering, electrical engineering, civil engineering, systems engineering, aeronautical engineering, medicine, and art. Innovations in the field of nondestructive testing have had a profound impact on medical imaging, including on echocardiography, medical ultrasonography, and digital radiography.

Non-Destructive Testing (NDT/ NDT testing) Techniques or Methodologies allow the investigator to carry out examinations without invading the integrity of the engineering specimen under observation while providing an elaborate view of the surface and structural discontinuities and obstructions. The personnel carrying out these methodologies require specialized NDT Training as they involve handling delicate equipment and subjective interpretation of the NDT inspection/NDT testing results.

NDT methods rely upon use of electromagnetic radiation, sound and other signal conversions to examine a wide variety of articles (metallic and non-metallic, food-product, artifacts and antiquities, infrastructure) for integrity, composition, or condition with no alteration of the article undergoing examination. Visual inspection (VT), the most commonly applied NDT method, is quite often enhanced by the use of

magnification, borescopes, cameras, or other optical arrangements for direct or remote viewing. The internal structure of a sample can be examined for a volumetric inspection with penetrating radiation (RT), such as X-rays, neutrons or gamma radiation. Sound waves are utilized in the case of ultrasonic testing (UT), another volumetric NDT method – the mechanical signal (sound) being reflected by conditions in the test article and evaluated for amplitude and distance from the search unit (transducer). Another commonly used NDT method used on ferrous materials involves the application of fine iron particles (either suspended in liquid or dry powder – fluorescent or colored) that are applied to a part while it is magnetized, either continually or residually. The particles will be attracted to leakage fields of magnetism on or in the test object, and form indications (particle collection) on the object's surface, which are evaluated visually. Contrast and probability of detection for a visual examination by the unaided eye is often enhanced by using liquids to penetrate the test article surface, allowing for visualization of flaws or other surface conditions. This method (liquid penetrant testing) (PT) involves using dyes, fluorescent or colored (typically red), suspended in fluids and is used for non-magnetic materials, usually metals.

Analyzing and documenting a nondestructive failure mode can also be accomplished using a high-speed camera recording continuously (movie-loop) until the failure is detected. Detecting the failure can be accomplished using a sound detector or stress gauge which produces a signal to trigger the high-speed camera. These high-speed cameras have advanced recording modes to capture some non-destructive failures. After the failure the high-speed camera will stop recording. The captured images can be played back in slow motion showing precisely what happened before, during and after the nondestructive event, image by image. Nondestructive testing is also critical in the amusement industry, where it is used to ensure the structural integrity and ongoing safety of rides such as roller coasters and other fairground attractions. Companies like Kraken NDT, based in the United Kingdom, specialize in applying NDT techniques within this sector, helping to meet stringent safety standards without dismantling or damaging ride components

## Code coverage

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In software engineering, code coverage, also called test coverage, is a percentage measure of the degree to which the source code of a program is executed when a particular test suite is run. A program with high code coverage has more of its source code executed during testing, which suggests it has a lower chance of containing undetected software bugs compared to a program with low code coverage. Many different metrics can be used to calculate test coverage. Some of the most basic are the percentage of program subroutines and the percentage of program statements called during execution of the test suite.

Code coverage was among the first methods invented for systematic software testing. The first published reference was by Miller and Maloney in Communications of the ACM, in 1963.

## Point-of-care testing

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Point-of-care testing (POCT), also called near-patient testing or bedside testing, is defined as medical diagnostic testing at or near the point of care—that is, at the time and place of patient care. This contrasts with the historical pattern in which testing was wholly or mostly confined to the medical laboratory, which entailed sending off specimens away from the point of care and then waiting hours or days to learn the results, during which time care must continue without the desired information.

## Exam

*instances, the developer of the test may not be directly responsible for its administration. For example, in the United States, Educational Testing Service*

An examination (exam or evaluation) or test is an educational assessment intended to measure a test-taker's knowledge, skill, aptitude, physical fitness, or classification in many other topics (e.g., beliefs). A test may be administered verbally, on paper, on a computer, or in a predetermined area that requires a test taker to demonstrate or perform a set of skills.

Tests vary in style, rigor and requirements. There is no general consensus or invariable standard for test formats and difficulty. Often, the format and difficulty of the test is dependent upon the educational philosophy of the instructor, subject matter, class size, policy of the educational institution, and requirements of accreditation or governing bodies.

A test may be administered formally or informally. An example of an informal test is a reading test administered by a parent to a child. A formal test might be a final examination administered by a teacher in a classroom or an IQ test administered by a psychologist in a clinic. Formal testing often results in a grade or a test score. A test score may be interpreted with regard to a norm or criterion, or occasionally both. The norm may be established independently, or by statistical analysis of a large number of participants.

A test may be developed and administered by an instructor, a clinician, a governing body, or a test provider. In some instances, the developer of the test may not be directly responsible for its administration. For example, in the United States, Educational Testing Service (ETS), a nonprofit educational testing and assessment organization, develops standardized tests such as the SAT but may not directly be involved in the administration or proctoring of these tests.

## Genetic testing

*Genetic testing, also known as DNA testing, is used to identify changes in DNA sequence or chromosome structure. Genetic testing can also include measuring*

Genetic testing, also known as DNA testing, is used to identify changes in DNA sequence or chromosome structure. Genetic testing can also include measuring the results of genetic changes, such as RNA analysis as an output of gene expression, or through biochemical analysis to measure specific protein output. In a medical setting, genetic testing can be used to diagnose or rule out suspected genetic disorders, predict risks for specific conditions, or gain information that can be used to customize medical treatments based on an individual's genetic makeup. Genetic testing can also be used to determine biological relatives, such as a child's biological parentage (genetic mother and father) through DNA paternity testing, or be used to broadly predict an individual's ancestry. Genetic testing of plants and animals can be used for similar reasons as in humans (e.g. to assess relatedness/ancestry or predict/diagnose genetic disorders), to gain information used for selective breeding, or for efforts to boost genetic diversity in endangered populations.

The variety of genetic tests has expanded throughout the years. Early forms of genetic testing which began in the 1950s involved counting the number of chromosomes per cell. Deviations from the expected number of chromosomes (46 in humans) could lead to a diagnosis of certain genetic conditions such as trisomy 21 (Down syndrome) or monosomy X (Turner syndrome). In the 1970s, a method to stain specific regions of chromosomes, called chromosome banding, was developed that allowed more detailed analysis of chromosome structure and diagnosis of genetic disorders that involved large structural rearrangements. In addition to analyzing whole chromosomes (cytogenetics), genetic testing has expanded to include the fields of molecular genetics and genomics which can identify changes at the level of individual genes, parts of genes, or even single nucleotide "letters" of DNA sequence. According to the National Institutes of Health, there are tests available for more than 2,000 genetic conditions, and one study estimated that as of 2018 there were more than 68,000 genetic tests on the market.

## Student's t-test

*use in significance testing, the distribution of the test statistic is approximated as an ordinary Student's t-distribution with the degrees of freedom*

Student's t-test is a statistical test used to test whether the difference between the response of two groups is statistically significant or not. It is any statistical hypothesis test in which the test statistic follows a Student's t-distribution under the null hypothesis. It is most commonly applied when the test statistic would follow a normal distribution if the value of a scaling term in the test statistic were known (typically, the scaling term is unknown and is therefore a nuisance parameter). When the scaling term is estimated based on the data, the test statistic—under certain conditions—follows a Student's t distribution. The t-test's most common application is to test whether the means of two populations are significantly different. In many cases, a Z-test will yield very similar results to a t-test because the latter converges to the former as the size of the dataset increases.

## Statistical hypothesis test

*testing could be useful for scientists. Hypothesis testing provides a means of finding test statistics used in significance testing. The concept of power*

A statistical hypothesis test is a method of statistical inference used to decide whether the data provide sufficient evidence to reject a particular hypothesis. A statistical hypothesis test typically involves a calculation of a test statistic. Then a decision is made, either by comparing the test statistic to a critical value or equivalently by evaluating a p-value computed from the test statistic. Roughly 100 specialized statistical tests are in use and noteworthy.

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