

# Design Patterns in C++

## Unit Testing

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## Testing

- Testing can never be exhaustive
  - you can never discover all the program bugs by running tests, simply because (except in trivial cases), the number of tests to be executed is badly exponential
  - nevertheless, testing is useful because you can catch **some** bugs, the most evident and probably the most important bugs in a program
  - also, tests give some evidence that the program is conforming with the specification, and this is useful for the customer
  - therefore, even if testing does not prove correctness, it proves something, and something is better than nothing!
  - Every programmer acknowledges that testing is an important activity in coding
- There are many types of testing:
  - Unit testing, functional testing, integration testing, etc.
- Here we discuss Unit Tests, a tool for the programmer

# Unit testing

- Unit testing is a method by which individual units of source code are tested to determine if they are fit for use
- A **unit** is the smallest testable part of an application, typically a class or a function
- Unit tests are written by programmers as part of their coding work
  - The idea is to test an unit (a small piece of code) in isolation
- The goal is to:
  - 1 Find bugs in code
  - 2 Be able to refactor (i.e. change the code) later, and check that the unit continues to work
  - 3 Check that modifications to other units (on which the unit under test depends upon) will not break the assumption and invalidate the behaviour of the unit
- item 2 and 3 are also called *regression testing*, and are fundamental to check properties (as the Liskov Substitution Principle, for example)

## The problem with test

- Writing tests is a boring activity
  - It works against human nature
  - it is a lot of additional code to write (set up the environment and all the necessary objects, write the testing code, run the test, check the result, etc.)
  - the test code needs to be maintained and kept constantly in sync with the tested code
  - most of this work is not very funny, whereas a programmer wants to write useful application code (a more inventive and rewarding activity)

# Testing is boring

- As a consequence, most programmer simply do not test
  - Testing is time consuming
  - There is never enough time, so the programmer concentrates on *important* things, like producing application code
  - Tests are code, and we may introduce bugs in testing code, producing “false positives”
  - and many other excuses
- Forcing programmers to write tests is not the right approach
  - It is against human nature, so after a while, he will stop anyway
  - ... unless ...

# Making testing more attractive

- The first rule is to make the make the testing activity automatic
- The programmer should not spend time in *checking* the output of the test to see if everything is ok
  - Let the PC automatically check the outcome
  - the only thing the programmer wants to see is: **OK**, or **FAIL**, and not endless screens of text output to be checked
- Then, make it easy to run suites of tests
  - All tests should be grouped in test suites, and it should be possible to compile and execute them with one single command
  - as soon as a new test is written, it is added to the test suite and executed along with the other tests

- Tests should be written by the programmer *before* coding the unit
  - In other words, first write the test, then write the functionality
  - Run the test after compiling
- “Run tests often” means “Run tests every time you compile”
  - The habit of running tests should be automatically embedded in the development tool
  - in addition to “I should make my program compile”, the objective is now also “I should make all the tests run smoothly”

## Advantages

- Substitute “debugging” with “testing”
  - Testing is done while coding, while debugging is done later,
  - Testing **is** a special kind of coding, while debugging means slowly going through existing code in a painful way and under pressure
  - Tests are there to stay, and can be run automatically at any time, while debugging does not stay, it is wasted time
- Certainly, you will be convinced that testing may be more funny than debugging
- Maybe you will also become convinced that testing may be very productive
  - If you can drastically reduce the amount of time spent in debugging, more that the time you spend in testing, then you productivity increases

## Testing to addressing change

- Testing is a fundamental tool to address the “need for change”
- If you need to change existing code (or add additional code/functionality), you want to make sure that existing tests do not break
- if they do break,
  - Maybe you introduced a bug in the code that breaks existing code
  - Maybe you violated an assumption made by existing code (see LSP)
  - Maybe you need to change the test because the specification has changed and the test is not valid any more
- In any case, since you test every time you compile, you can immediately spot the error
  - As opposed to discovering the bug during integration testing, when you will need to trace back the problem and debug you code to find where the problem is
- which alternative is more time-consuming?

## Testing coverage

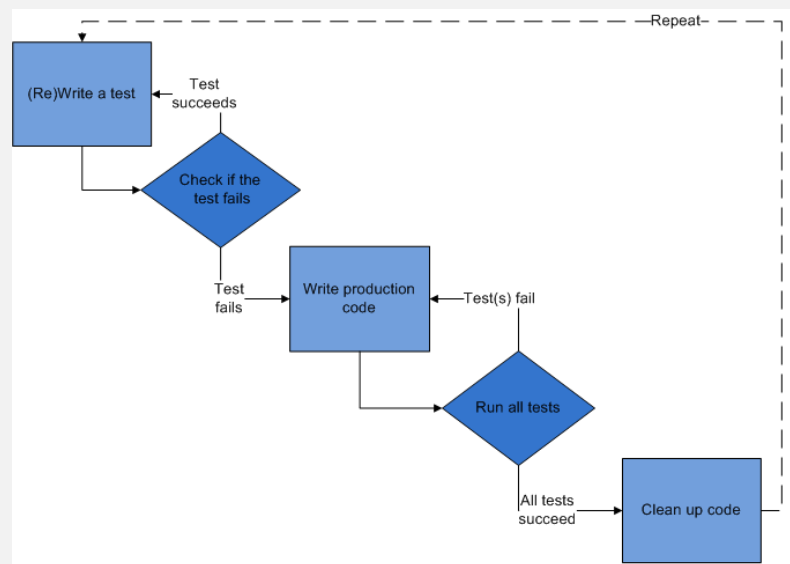
- Of course, you can never do a complete testing coverage in the unit test, because it is too time consuming
- However, you can try to write **a few** meaningful tests
- for example, checking boundary conditions (the source of most errors)
  - what if the function needs a file, and the file does not exist?
  - what if I try to extract from an empty container?
  - what if I pass a negative value (while the function expects a positive one?)
  - etc.
  - Also, check a couple of “normal” cases
- Of course, testing can never completely substitute debugging
  - Since you cannot be exhaustive, it may happen that your tests do not spot a subtle bug
  - Don't worry: when you discover it by debugging, add immediately a unit test to checks that the error will never occur again in future modifications

## Other advantages

- When writing tests, you concentrate on the interface
  - while writing tests, you wear the “client hat”
  - while writing code, you wear the “implementer hat”
  - writing tests is similar to writing a specification for the code
- The test is useful as “documentation”
  - If you want to know how to use a function, you can sometimes look at the test
- You have a clear point at which you are done: when the all tests work!

## Test Driven Development

- The practice of writing tests first is called *Test Driven Development* (TDD), and it is one of the main points of the Extreme Programming (XP) methodology proposed by Kent Beck



- Another related practice is Continuous Integration
  - This consists in automatic compilation, testing and commit in the repository in one development cycle
  - committing on the server automatically compiles and test the code
  - therefore, an integration step is performed at every commit!
- Of course, an appropriate tool support is needed to automate all steps
- Also, a certain rigorous and structured approach is needed to impose the practice to all programmers