Introduction to C Unit Testing (CUnit)

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Unit Testing

- Code that isn’t tested doesn’t work”
- “Code that isn’t regression tested suffers from code rot (breaks eventually)”
- A unit testing framework enables efficient and effective unit & regression testing

What is unit testing?

- Unit testing
  - Testing a ‘unit’ of code, usually a class
- Integration testing
  - Testing a module of code (e.g. a package)
- Application testing
  - Testing the code as the user would see it (black box)

Conventionally

- Ad hoc manner
  - Manual stimulation & observation
  - E.g. adding a main method to a class, which runs tests on the class
  - Uncomenting or deleting test code / drivers / printf /#ifdefs
  - Assert and debug builds
- ***Code that isn’t tested doesn’t work***
- “If code has no automated test case written for it to prove that it works, it must be assumed not to work.”

Regression testing

- New code and changes to old code can affect the rest of the code base
  - “Affect” sometimes means “break”
- *Regression = Relapsed to a less perfect or developed state.*
- **Regression testing:** Test that code has not regressed
- Regression testing is required for a stable, maintainable code base

Refactoring

- **Refactoring** is a behavior preserving transformation
- Refactoring is an excellent way to break code.
- Regression testing allows developers to refactor safely – if the refactored code passes the test suite, it works

Running automated tests

- Regression testing “must” be automated
  - This requires they report pass/fail results in a standardized way
- Daily (Nightly) builds and testing
  - Clean & check out latest build tree
  - Run tests
  - Put results on a web page & send mail (if tests fail)

Why formalize unit testing?

- Ad hoc manner
  - Uncommenting or deleting test code / drivers printf
  - Manual stimulation & observation
- Axiom:
  - Code that isn’t tested doesn’t work
  - “If code has no automated test case written for it to prove that it works, it must be assumed not to work.”

What is a testing framework?

- A test framework is a software tool for writing and running unit-tests
- provides reusable test functionality which:
  - Is easier to use
  - Is standardized
  - Enables automatic execution for regression tests

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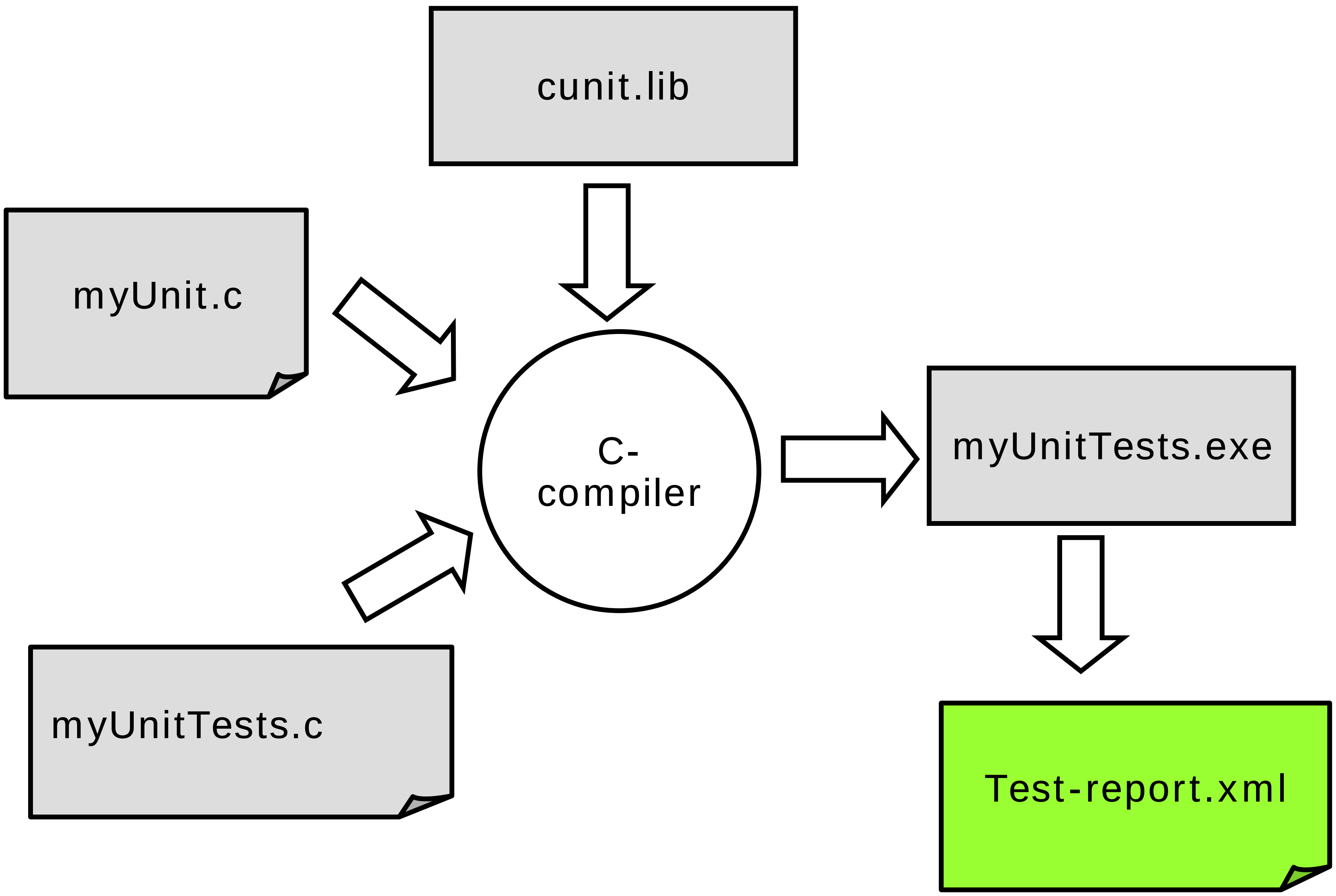
Why Unit-testing Framework

- A test framework is a software tool for writing and running unit-tests
  - ☑ Most errors can be found by programmer
  - ☑ Lightweight tool that uses the same language and development environment as the programmer
  - ☑ Offers an easy, systematic, and comprehensive way of organizing and executing tests
    - It is practical to collect and re-use test cases
  - ☑ Automatic Regression Testing
  - ☑ GUI-test case browser/runner
  - ☑ Test report generation

CUnit Testing

- Each method is tested while developed
  - Create tests first
  - Start with simplest that works
  - Incrementally add code while testing
- Tests serve as benchmark
- Optimize and refactorize without worry

Basic Use of FrameWork



Creating a Test

- Implement test functions
- Run the test using a `TestRunner`
- Group multiple `TestCases` using `TestSuite`

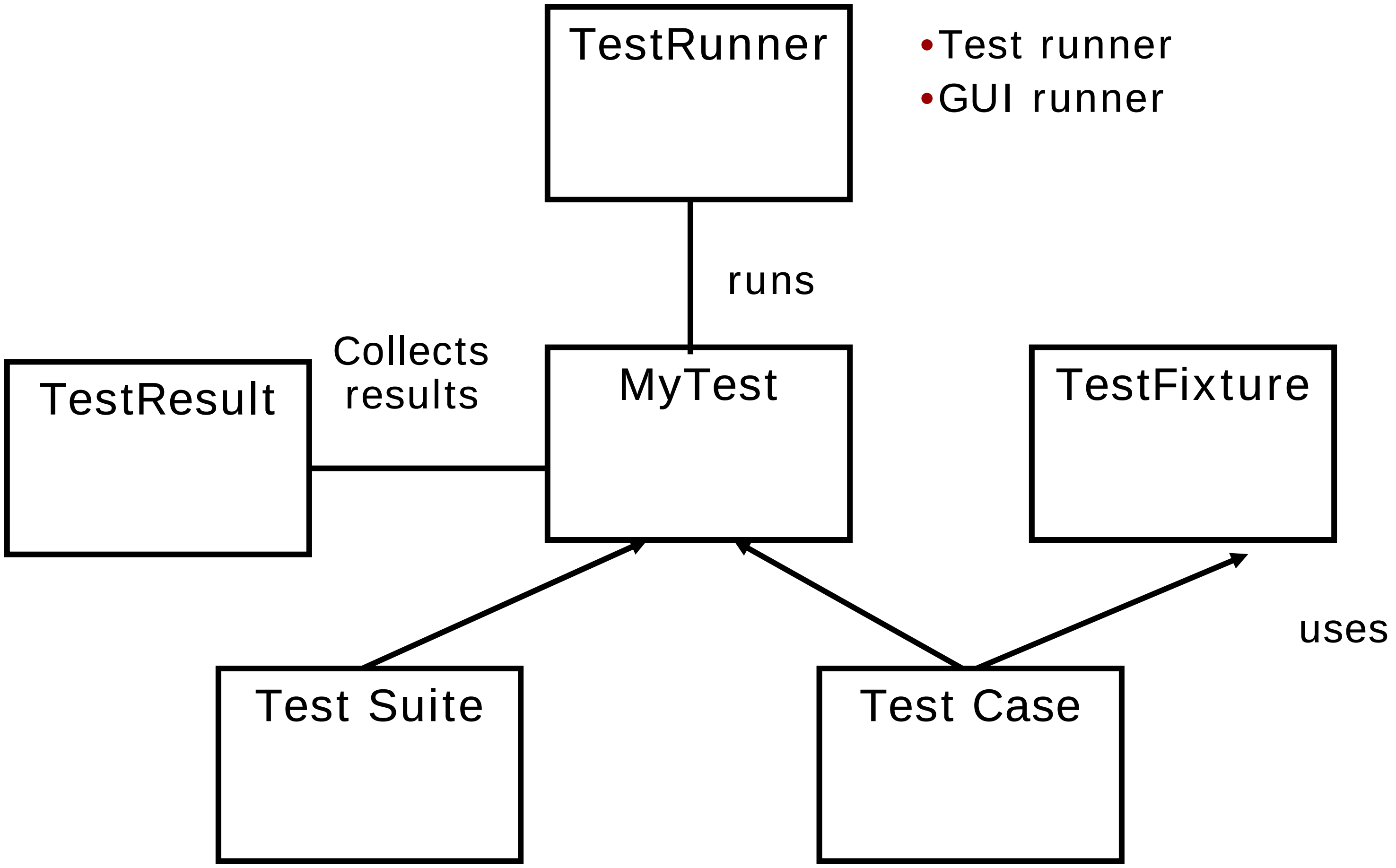
What is xUnit?

- A set of “Frameworks” for programming and automated execution of test-cases
- X stands for programming language
  - Most Famous is J-UNIT for Java
  - But exists for almost all programming languages
  - C-unit, Cutest, Cpp-Unit, JUnit N-unit, ...
- A framework is a collection of classes, procedures, and macros

xUNIT principles

- Write test suite for each unit in the program.
- All test can be executed (automatically) at any time.
- For each program modification all tests must be passed before the modification is regarded as complete - regression testing
- Test First – implement later!
- Originally based on “eXtreme Programming” principles:
  - Lightweight software development methodology – by programmers for programmers
- TDD (Test Driven Development) cycle
  1. Write test case, and check it fails
  2. Write the new code
  3. Check that the test passes (and maybe refactor, re-test)

Core parts



- Test runner
- GUI runner

Concepts

- Assertions
  - Boolean expression that compares expected and actual results
  - The basic and smallest building-block
- Test Case
  - A composition of concrete test procedures
  - May contain several assertions and test for several test objectives
  - E.g all test of a particular function
- Test Suite
  - Collection of related test cases
  - Can be executed automatically in a single command

Test Case / suite

- A collection of concrete test methods
- A suite is a collection of test cases

```
// Registers the fixture into the 'registry'

CU_pSuite getTriangleSuite(){

CU_pSuite pSuite = NULL;

if ((NULL == CU_add_test(pSuite, "Tests classification of valid triangles", validClassification)) ||
 (NULL == CU_add_test(pSuite, "Tests classification of invalid triangles", invalidClassification)) ||
 (NULL == CU_add_test(pSuite, "Tests for string conversion", invalidClassification)) ||
 (NULL == CU_add_test(pSuite, "Tests triangle main driver", testCheckTriangle))
               ){ . . .}
```

Assertion Examples

-
  ```
  CU_ASSERT_EQUAL(rectangularTriangle,
  classifyTriangle(13,12,5) );
  ```

-
  ```
  int actual_val;
  CU_ASSERT(stringToInt("+0",&actual_val));
  CPPUNIT_ASSERT_EQUAL(0, actual_val );
  ```

-
  ```
  char* argv4[4]=  {programName,"1","1","2"};
  CU_ASSERT_EQUAL(string( "Isosceles Triangle"),
                string(checkTriangle(4,argv4)));
  ```

Test Cases Imp.

```
void validClassification(){
 CU_ASSERT_EQUAL(rectangularTriangle, classifyTriangle(13,12,5) );
 CU_ASSERT_EQUAL(scaleneTriangle, classifyTriangle(15,10,5) );

..
```

Driver File

```
int RunAllTests(void)
{
 CU_pSuite pSuite = NULL;
 pSuite=getTriangleSuite();

  CU_set_output_filename("TriangleTest");
  CU_list_tests_to_file();
  CU_automated_run_tests();
}

int main(int argc, char* argv[])
{
        return RunAllTests();
}
```

Test suite

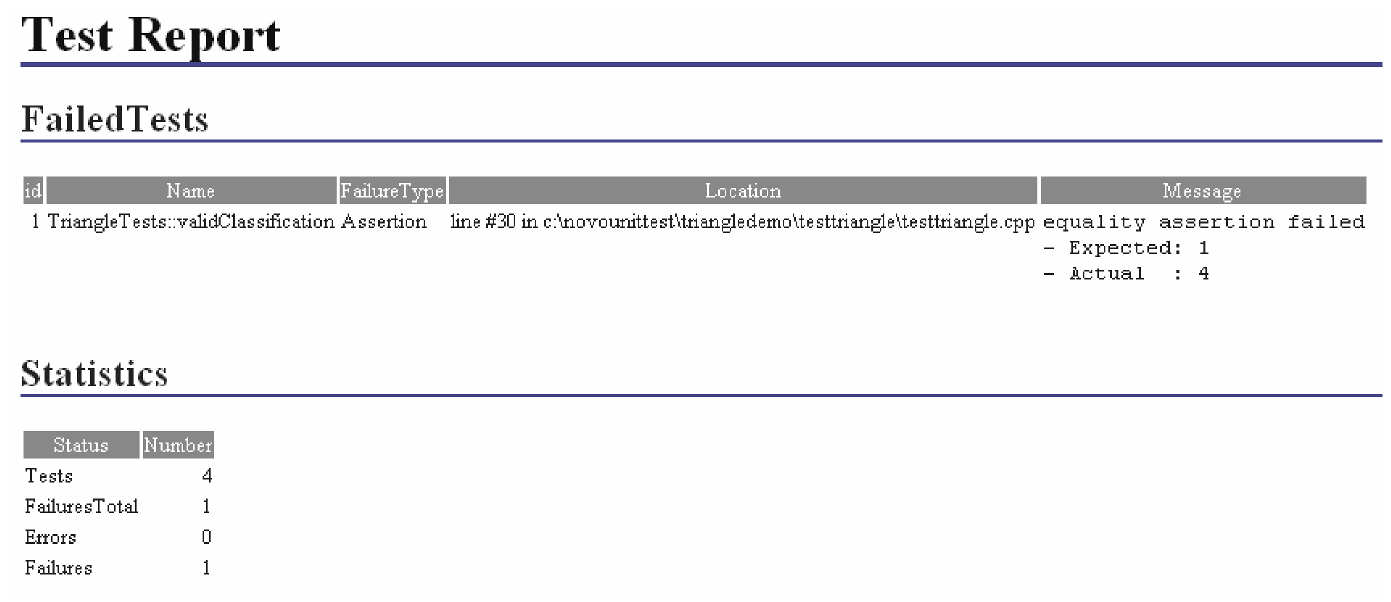
- Collection of test cases (or other test suites) in a logical unit
- Test Suites can be executed automatically

Test Reports

```
C:\NovoUnitTest\TriangleDemo\cppunitDemo>Debug\cppunitDemo.exe
.F...

c:\novounittest\triangledemo\testtriangle\testtriangle.cpp(30):Assertion
Test name: TriangleTests::validClassification
equality assertion failed
- Expected: 1
- Actual  : 4

Failures !!!
Run: 4   Failure total: 1   Failures: 1   Errors: 0
```



Test Report

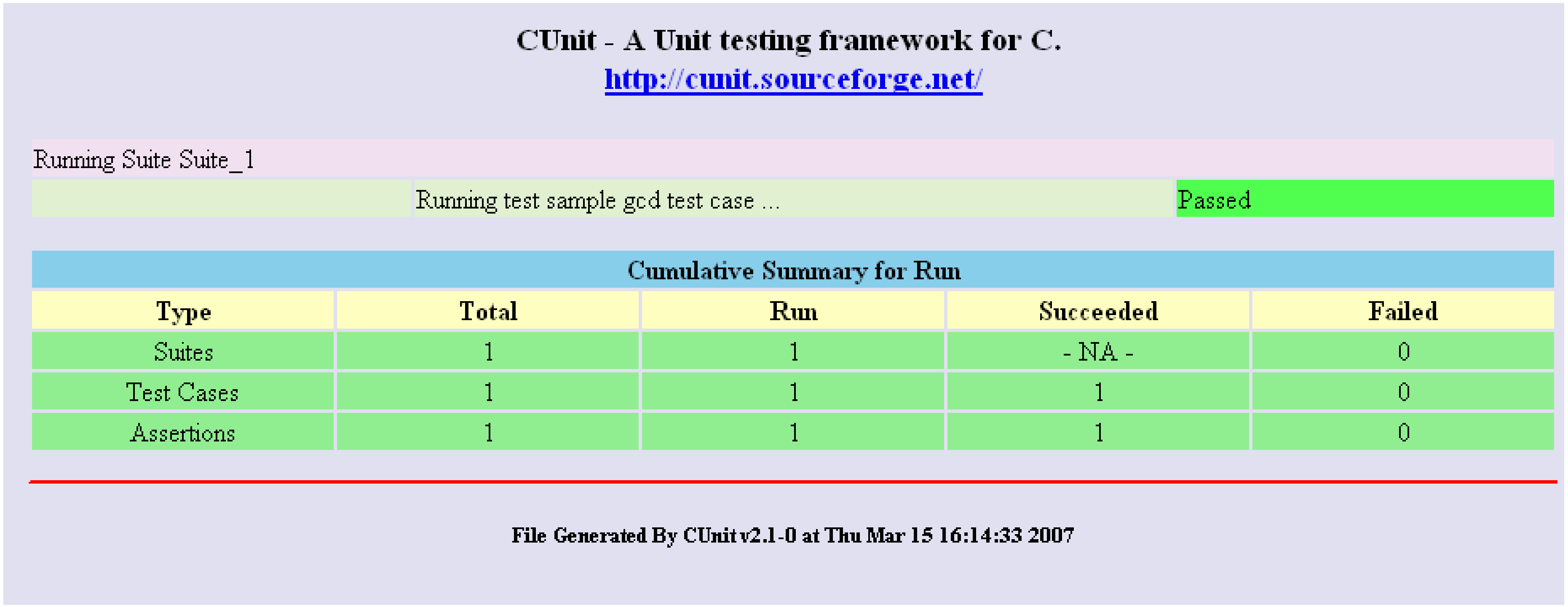
FailedTests

id	Name	FailureType	Location	Message
1	TriangleTests::validClassification	Assertion	line #30 in c:\novounittest\triangledemo\testtriangle\testtriangle.cpp	equality assertion failed - Expected: 1 - Actual : 4

Statistics

Status	Number
Tests	4
FailuresTotal	1
Errors	0
Failures	1

Test Runner XML file



CUnit - A Unit testing framework for C.
http://cunit.sourceforge.net/

Running Suite Suite_1

	Running test sample gcd test case ...	Passed

Cumulative Summary for Run

Type	Total	Run	Succeeded	Failed
Suites	1	1	- NA -	0
Test Cases	1	1	1	0
Assertions	1	1	1	0

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Advice: xUnit style

- Test cases exhibits isolation
- Sets up an independent environment / scenario and perform a distinct check
- One check per test method $\Rightarrow$ one **`assert`** per test method
- BUT consider amount of test code declarations to be written (when a assert fails the test method is stopped and no further asserts are checked).
- Test expected errors and exceptions

Advice: Application

- Design and program for testability
- Directly applicable to
    - Pure function libraries
    - API
- (With some footwork also user interfaces, network-, web-, and database applications)

Advice: Version Control

- Keep test code in a separate directory
- Keep both tests-sources and implemenation-source in version control
- Don’t checkin unless version passes all tests

Conclusions

- Code that isn't tested doesn't work"
- "Code that isn't regression tested suffers from code rot (breaks eventually)"
- A unit testing framework enables efficient and effective unit & regression testing
- Use xUNIT to store and maintain all the small tests that you write anyway
- Write tests instead of playing with debugger and printf – tests can be automatically repeated