

# Travis C++ tutorial

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# 1 Introduction

This is a Travis C++ tutorial, version 0.2.

## 1.1 License

This tutorial is licensed under Creative Commons license 4.0. All C++ code is licensed under GPL 3.0.



Figure 1: Creative Commons license 4.0

## 1.2 Continuous integration

Collaboration can be scary: the other(s)<sup>1</sup> may break the project worked on. The project can be of any type, not only programming, but also collaborative writing.

A good first step ensuring a pleasant experience is to use a version control system. A version control system keeps track of the changes in the project and allows for looking back in the project history when something has been broken.

The next step is to use an online version control repository, which makes the code easily accessible for all contributors. The online version control repository may also offer additional collaborative tools, like a place where to submit bug reports, define project milestones and allowing external people to submit requests, bug reports or patches.

Up until here, it is possible to submit a change that breaks the build.

A continuous integration tools checks what is submitted to the project and possibly rejects it when it does not satisfy the tests and/or requirements of the project. Instead of manually proofreading and/or testing the submission and mailing the contributor his/her addition is rejected is cumbersome at least. A continuous integration tool will do this for you.

---

<sup>1</sup>if not you

Now, if someone changes you project, you can rest assured that his/her submission does not break the project. Enjoy!

### 1.3 Tutorial style

This tutorial is aimed at the beginner.

**Introduction of new terms and tools** All terms and tools are introduced shortly once, by a 'What is' paragraph. This allows a beginner to have a general idea about what the term/tool is, without going in-depth. Also, this allows for those more knowledgeable to skim the paragraph.

**Repetitiveness** To allow skimming, most chapters follow the same structure. Sometimes the exact same wording is used. This is counteracted by referring to earlier chapters.

### 1.4 This tutorial

This tutorial is available online at [https://github.com/richelbilderbeek/travis\\_cpp\\_tutorial](https://github.com/richelbilderbeek/travis_cpp_tutorial). Of course, it is checked by Travis that:

- all the setups described work
- this document can be converted to PDF. For this, it needs the files from all of these setups

### 1.5 Acknowledgements

These people contributed to this tutorial:

- Kevin Ushey, for getting Rcpp11 and C++11 to work

### 1.6 Collaboration

I welcome collaboration for this tutorial, especially in getting the scripts as clean as possible. If you want to help scraping off some lines, I will be happy to make you a collaborator of some GitHubs.

### 1.7 Feedback

This tutorial is not intended to be perfect yet. For that, I need help and feedback from the community. All referenced feedback is welcome, as well as any constructive feedback.

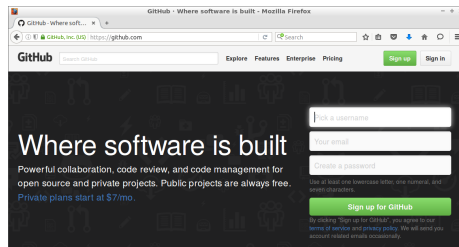


Figure 2: The GitHub homepage, <https://github.com>

## 2 Setting up the basic build

The basic build is more than just a collection of files. It needs to be set up. This chapter shows how to do so.

- Create a GitHub online
- Bring the git repository to your local computer
- Create a Qt Creator project
- Create the build bash scripts

### 2.1 Create a GitHub online

**What is GitHub?** GitHub is a site that creates websites around projects. It is said to host the project. This project contains one, but usually a collection of files, which is called a repository. GitHub also keeps track of the history of the project, which is also called version control. GitHub uses git as a version control software. In short: GitHub hosts git repositories.

Figure 2 shows the GitHub homepage, <https://github.com>.

**Register** Before you can create a new repository, you must register. Registration is free for open source projects, with an unlimited<sup>2</sup> amount of public repositories.

From the GitHub homepage, <https://github.com> (see figure 2), click the top right button labeled 'Sign up'. This will take you to the 'Join GitHub' page (see figure 3).

Filling this in should be as easy. After filling this in, you are taken to your GitHub profile page (figure 4).

**Creating a repository** From your GitHub profile page (figure 4), click on the plus ('Create new ...') at the top right, then click 'New repository' (figure 5).

---

<sup>2</sup>the maximum I have observed is a person that has 350 repositories

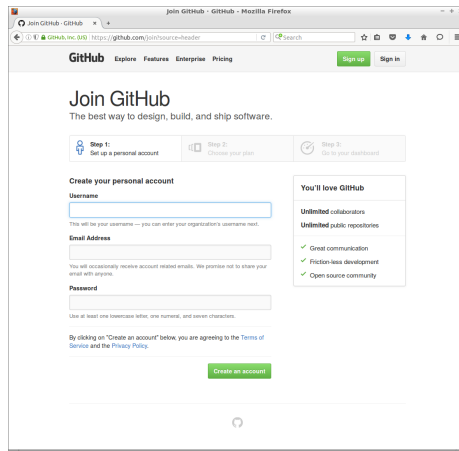


Figure 3: The join GitHub page

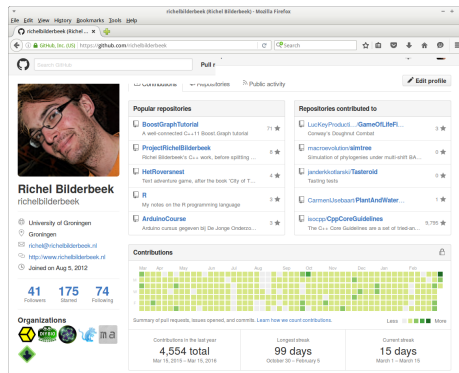


Figure 4: A GitHub profile page

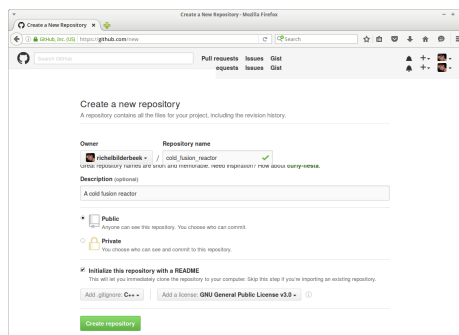


Figure 5: Create a GitHub repository

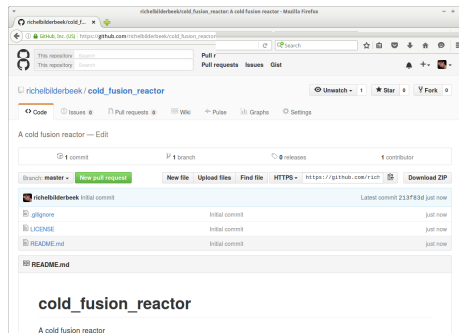


Figure 6: Created a GitHub repository



Figure 7: git logo

Do check 'Initialize this repository with a README', add a .gitignore with 'C++' and add a licence like 'GPL 3.0'.

You have now created your own online version controlled repository (figure 6)!

## 2.2 Bring the git repository to your local computer

**What is git?** git is a version control system.

**Using git** Go to the terminal and type the following line to download your repository:

```
git clone https://github.com/[your_name]/[your_repository]
```

Replace '[your\_name]' and '[your\_repository]' by your GitHub username and the repository name. For example, to download this tutorial its repository:

```
git clone https://github.com/richelbilderbeek/travis_cpp_tutorial
```

A new folder called '[your\_repository]' is created where you should work in.

## 2.3 Create a Qt Creator project

**What is Qt Creator?** Qt Creator is a C++ IDE

**Creating a new project** Project will have some defaults: GCC.



Figure 8: Qt creator logo



Figure 9: GCC logo

**What is a Qt Creator project file?** A Qt Creator project file contains the information how a Qt Creator project must be built. It commonly has the .pro file extension.

**What is qmake?** qmake is a tool to create makefiles.

**What is GCC?** GCC, the GNU Compiler Collection, is a collection of compilers, among other, the C++ compiler called g++.

**What is g++?** g++ is the C++ compiler that is part of the GCC.

**What is C++98?** C++98 is the first C++ standard in 1998.

**What is the STL?** The STL, the Standard Template Library, is the C++ standard library.

## 2.4 Create the build bash scripts

**What is bash?** 'bash' is a shell scripting language



### 3 The basic build

The basic build has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL only
- Code coverage: none
- Source: one single file, main.cpp
- Functionality: Show the text 'Hello world' on screen

First I will show the single C++ file this build is about:

---

**Algorithm 1** main.cpp

---

```
#include <iostream>

int main() {
    std::cout << "Hello_world\n";
}
```

---

All the code does is display the text 'Hello world', which is a traditional start for many programming languages. In more details:

- `#include <iostream>`  
Read a header file called 'iostream'
- `int main() { /* your code */ }`

The 'main' function is the starting point of a C++ program. Its body is between curly braces

- `std::cout << "Hello world\n";`

Show the text 'Hello world' on screen and go to the next line

The code is written in C++98. It does not use features from the newer C++ standards, but can be compiled under these newer standards. It will not compile under plain C.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 2** travis\_qmake\_gcc\_cpp98.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Wefc++ -Werror
```

---

This Qt Creator project file has the following elements

- `TEMPLATE = app`  
`CONFIG += console`  
`CONFIG -= app_bundle qt`

This is a typical setup for a standard console application

- `SOURCES += main.cpp`

The file 'main.cpp' is a source file, that has to be compiled

- `QMAKE_CXXFLAGS += -Wall -Wextra -Wefc++ -Werror`

The project is checked with all warnings ('-Wall'), with extra warnings ('-Wextra') and with the Effective C++ advices ('-Wefc++') enforced. A warning is treated as an error ('-Werror'). This forces you to write tidy code.

The bash build script to build this is:

---

**Algorithm 3** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp98
```

---

This build script calls

- `#!/bin/bash`

This line indicates the script is a bash script

- `qmake`

'qmake' is called to create a makefile

- `make`

'make' is called to compile the makefile

- `./travis_qmake_gcc_cpp98`

The created executable 'travis\_qmake\_gcc\_cpp98' is run

There is a potential error in the first and last step: the Qt Creator project file may be incorrect, or the executable will crash, possibly due to a failed test.

Setting up Travis is done by the following `.travis.yml`<sup>3</sup> file:

---

**Algorithm 4** `.travis.yml`

---

```
language: cpp
compiler: gcc
script: ./build.sh
```

---

This `.travis.yml` file has the following elements:

- `language: cpp`

The main programming language of this project is C++

- `compiler: gcc`

The C++ code will be compiled by the GCC

- `script: ./build.sh`

The script that Travis will run. In this case, it will execute the 'build.sh' bash script.

## 4 Extending the build by one step

The following chapter describe how to extend the build in one direction. These are:

- Use of C++11: see chapter 4.1
- Use of C++14: see chapter 4.2
- Use of Boost: see chapter 4.3
- Use of Boost.Test: see chapter 4.4
- Use of clang: see chapter 4.5
- Use of gcov and Codecov: see chapter 4.6

---

<sup>3</sup>the filename starts with a dot. This means it is a hidden file

- Use of gprof: see chapter 4.7
- Use of Qt: see chapter 4.8
- Use of Rcpp: see chapter 4.9
- Use of SFML: see chapter 4.10
- Use of Urho3D: see chapter 4.11
- Use of Wt: see chapter 4.12

## 4.1 Use of C++11

In this example, the basic build (chapter 3) is extended by using C++11.

**What is C++11?** C++11 is a C++ standard

**Specifications** The chapter has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL only
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 5** main.cpp

---

```
#include <iostream>

void f() noexcept {
    std::cout << "Hello_world\n";
}

int main() { f(); }
```

---

This is a C++11 version of a 'Hello world' program. The keyword 'noexcept' does not exist in C++98 and it will fail to compile. This code will compile under newer versions of C++.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 6** travis\_qmake\_gcc\_cpp11.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3, except for:

- `QMAKE_CXX = g++-5`

Set the C++ compiler to use g++ version 5, which is a newer version than currently used by default

- `QMAKE_LINK = g++-5`

Set the C++ linker to use g++ version 5, which is a newer version than currently used by default

- `QMAKE_CC = gcc-5`

Set the C compiler to use gcc version 5, which is a newer version than currently used by default

- `QMAKE_CXXFLAGS += -std=c++11`

Compile under C++11

The bash build script to build and run this:

---

**Algorithm 7** build.sh

---

```
qmake
make
./travis_qmake_gcc_cpp11
```

---

The bash script has the same lines as the basic project in chapter 3. Setting up Travis is done by the following .travis.yml:

---

**Algorithm 8** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc
before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq
install: sudo apt-get install -qq g++-5
script: ./build.sh
```

---

This .travis.yml file has some new features:

- `before_install:`

The following events will take place before installation

- `- sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test`

A new apt repository is added. The '-y' explicitly states that we are sure we want to do this. Without the '-y' flag, Travis will be prompted if it is sure it wants to add this repository. This would break the build.

- `- sudo apt-get update -qq`

After adding the new apt repository, then the current repositories need to be updated. The '-qq' means that this happens quietly; with the least amount of output.

- `install: sudo apt-get install -qq g++-5`

Install g++-5, which is a newer version of GCC than is installed by default

## 4.2 Use of C++14

In this example, the basic build (chapter 3) is extended by using C++14.

**What is C++14?** C++14 is a C++ standard.

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++14
- Libraries: STL only

- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 9** main.cpp

---

```
#include <iostream>

auto f() noexcept {
    return "Hello_world\n";
}

int main() {
    std::cout << f();
}
```

---

This is a simple C++14 program that will not compile under C++11.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 10** travis\_qmake\_gcc\_cpp14.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++14
```

---

The Qt Creator project file has the same lines as the C++11 build in chapter 4.1, except for that it uses one different QMAKE\_CXXFLAGS item:

- QMAKE\_CXXFLAGS += -std=c++14

Compile under C++14

The bash build script to build and run this:



Figure 10: Boost logo

---

**Algorithm 11** build.sh

---

```
qmake
make
./travis_qmake_gcc_cpp14
```

---

The bash script has the same lines as the C++11 build in chapter 4.1  
Setting up Travis is done by the following .travis.yml:

---

**Algorithm 12** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc
before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq
install: sudo apt-get install -qq g++-5
script: ./build.sh
```

---

This .travis.yml file is the same as the C++11 build in chapter 4.1

### 4.3 Adding Boost

In this example, the basic build (chapter 3) is extended by also using the Boost libraries.

**What is Boost?** Boost is a collection of C++ libraries

#### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL and Boost
- Code coverage: none



- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 13** main.cpp

---

```
#include <boost/graph/adjacency_list.hpp>

int main() {
    const boost::adjacency_list<> g;
}
```

---

All the file does is to create an empty graph, from the Boost.Graph library. It will only compile when the Boost libraries are present.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 14** travis\_qmake\_gcc\_cpp98\_boost.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build and run this:

---

**Algorithm 15** build.sh

---

```
qmake
make
./travis_qmake_gcc_cpp98_boost
```

---

The bash script has the same lines as the basic project in chapter 3. Setting up Travis is done by the following .travis.yml:



Figure 11: clang logo

---

**Algorithm 16** .travis.yml

---

```
language: cpp
compiler: gcc
addons:
  apt:
    packages: libboost-all-dev
script: ./build.sh
```

---

This .travis.yml file has one new feature:

- addons:  
  apt:  
    packages: libboost-all-dev

This makes Travis aware that you want to use the aptitude package 'libboost-all-dev'. Note that this code cannot be put on one line: it has to be indented similar to this

## 4.4 Adding Boost.Test

Adding only a testing framework does not work: it will not compile in C++98. Instead, this is covered in chapter 5.2.

## 4.5 Use of clang

In this example, the basic build (chapter 3) is compiled by the clang compiler.

**What is clang?** clang is a C++ compiler

### Specifications

- Build system: qmake
- C++ compiler: clang
- C++ version: C++98

- Libraries: STL
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 17** main.cpp

---

```
#include <iostream>

int main() {
    std::cout << "Hello_world\n";
}
```

---

All the file does is ...

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 18** travis\_qmake\_clang\_cpp98.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# clang
QMAKE_CXX = clang++
QMAKE_LINK = clang++
QMAKE_CC = clang
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build and run this:

---

**Algorithm 19** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_clang_cpp98
```

---

The bash script has the same lines as the basic project in chapter 3.



Figure 12: Codecov logo

Setting up Travis is done by the following `.travis.yml`:

---

**Algorithm 20** `.travis.yml`

---

```
language: cpp
compiler: gcc
sudo: true

install:
  - sudo apt-get install clang

script:
  - ./build.sh
```

---

This `.travis.yml` file has ...

## 4.6 Adding code coverage

In this example, the basic build (chapter 3) is extended by calling `gcov` and using `codecov` to show the code coverage.

**What is `gcov`?** `gcov` is a tool that works with GCC to analyse code coverage

**What is `Codecov`?** `Codecov` works nice with GitHub and give nicer reports

**Build overview** This will be a more complex build, consisting of two projects:

- The regular project that just runs the code
- The project that measures code coverage

The filenames are shown in this figure:

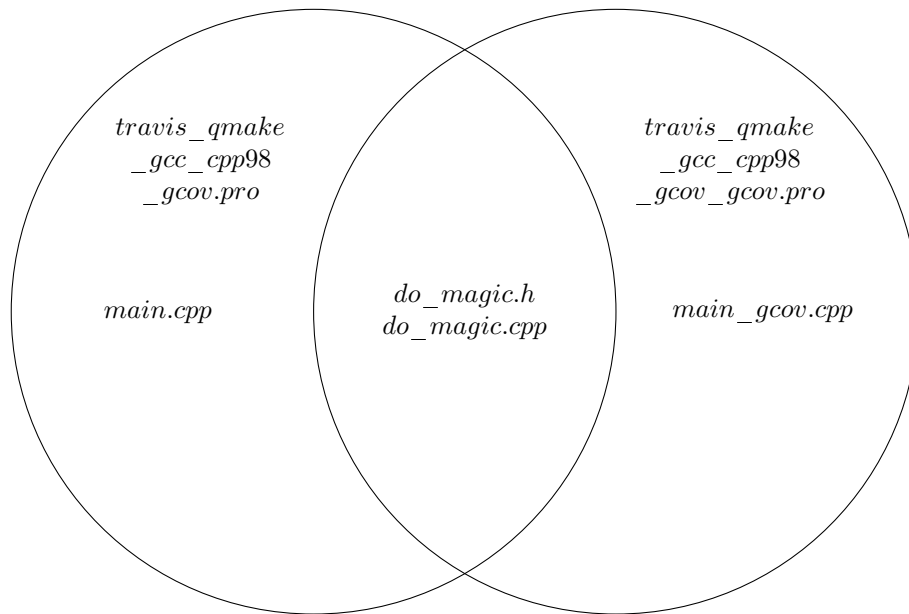


Figure 13: Venn diagram of the files uses in this build

**Specifications** The basic build has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL only
- Code coverage: yes
- Source: multiple files

**Common files** Both builds use the following code:

---

**Algorithm 21** *do\_magic.h*

---

```
#ifndef DO_MAGIC_H
#define DO_MAGIC_H

int do_magic(const int x);

#endif // DO_MAGIC_H
```

---

And its implementation:

---

**Algorithm 22** do\_magic.cpp

---

```
#include "do_magic.h"

int do_magic(const int x)
{
    if (x == 42)
    {
        return 42;
    }
    if (x == 314)
    {
        return 314;
    }
    return x * 2;
}
```

---

**Normal build main function** The C++ source file used by the normal build is:

---

**Algorithm 23** main.cpp

---

```
#include "do_magic.h"
#include <iostream>

int main() {
    std::cout << do_magic(123) << '\n';
}
```

---

**Normal build Qt Crator project file** This normal is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 24** travis\_qmake\_gcc\_cpp98\_gcov.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp do_magic.cpp
HEADERS += do_magic.h

QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror
```

---

**Code coverage main function** The C++ source file used by the normal build is:

---

**Algorithm 25** main.cpp

---

```
#include "do_magic.h"

int main()
{
    if (do_magic(2) != 4) return 1;
    if (do_magic(42) != 42) return 1;
    //Forgot to test do_magic(314)
}
```

---

**Code coverage build Qt Crator project file** This normal is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 26** travis\_qmake\_gcc\_cpp98\_gcov.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main_gcov.cpp do_magic.cpp
HEADERS += do_magic.h
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# gcov
QMAKE_CXXFLAGS += -fprofile-arcs -ftest-coverage
LIBS += -lgcov
```

---

The Qt Creator project file has two new lines:

- `QMAKE_CXXFLAGS += -fprofile-arcs -ftest-coverage`

Let the C++ compiler add coverage information

- `LIBS += -lgcov`

Link against the gcov library

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 27** build.sh

---

```
#!/bin/bash
echo "Normal_run"
qmake travis_qmake_gcc_cpp98_gcov.pro
make
./travis_qmake_gcc_cpp98_gcov
./clean.sh
echo "Coverage_run"
qmake travis_qmake_gcc_cpp98_gcov_gcov.pro
make
./travis_qmake_gcc_cpp98_gcov_gcov
gcov main_gcov.cpp
gcov do_magic.cpp
cat main_gcov.cpp.gcov
cat do_magic.cpp.gcov
```

---

The new step is after having run the executable,

- `gcov main_gcov.cpp`

Let gcov create a coverage report

- `cat main_gcov.cpp.gcov`

Show the file 'main.cpp.gcov', which contains the coverage of 'main.cpp'

**Travis script** Setting up Travis is done by the following .travis.yml:

---

**Algorithm 28** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc
before_install: sudo pip install codecov
script: ./build.sh
after_success: codecov
```

---

This .travis.yml file has some new features:

- `sudo: true`

Travis will give super user rights to the script. This will slow the build time, but it is inevitable for the next step

- `before_install: sudo pip install codecov`





Figure 14: Qt logo

Travis will use pip to install codecov using super user rights

- `after_success: codecov`

After the script has run successfully, codecov is called

## 4.7 Adding profiling

## 4.8 Adding the Qt library

In this example, the basic build (chapter 3) is extended by also using the Qt library.

**What is Qt?** Qt (pronounce cute') is a library to create C++ GUI's.

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL and Qt
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 29** main.cpp

---

```
#include <fstream>
#include <iostream>
#include <QFile>

int main()
{
    const std::string filename = "HelloWorld.png";
    QFile f(":/images/HelloWorld.png");
    if (QFile::exists(filename.c_str()))
    {
        std::remove(filename.c_str());
    }
    f.copy("HelloWorld.png");
    if (!QFile::exists(filename.c_str()))
    {
        std::cerr << "filename_" << filename << "_must_be_created\n";
        return 1;
    }
}
```

---

All the file does ...

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 30** travis\_qmake\_gcc\_cpp98\_qt.pro

---

```
QT      += core gui
greaterThan(QT_MAJOR_VERSION, 4): QT += widgets
TEMPLATE = app

SOURCES += main.cpp

RESOURCES += \
    travis_qmake_gcc_cpp98_qt.qrc
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:



Figure 15: R logo

---

**Algorithm 31** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp98_qt
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following .travis.yml:

---

**Algorithm 32** .travis.yml

---

```
language: cpp
compiler: gcc
script: ./build.sh
```

---

This .travis.yml file has ...

## 4.9 Adding Rcpp

In this example, the basic build (chapter 3) is extended by also using the Rcpp library/package.

**What is R?** R is a programming language.

**What is Rcpp?** Rcpp is a package that allows to call C++ code from R

**Specifications** The chapter has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL and Rcpp

- Code coverage: none
- Source: multiple files

The build will be complex: I will show the C++ build and the R build separately

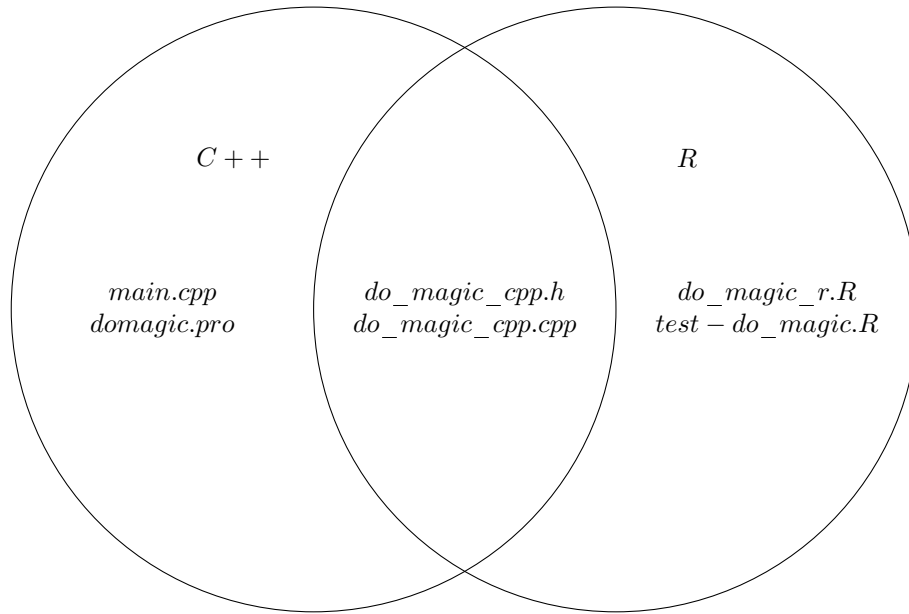


Figure 16: Venn diagram of the files uses in this build

#### 4.9.1 C++ and R: the C++ function

Both C++ and R use this function. It is called 'do\_magic\_cpp'. It is declared in the header file 'do\_magic\_cpp.h', as shown here:

---

**Algorithm 33** src/do\_magic\_cpp.h

---

```
#ifndef DO_MAGIC_CPP_H
#define DO_MAGIC_CPP_H

int do_magic_cpp(const int x);

#endif // DO_MAGIC_CPP_H
```

---

The header file consists solely of #include guards and the declaration of the function 'do\_magic\_cpp'.

The function 'do\_magic\_cpp' is implemented in the implementation file 'do\_magic\_cpp.cpp', as shown here:

---

**Algorithm 34** src/do\_magic\_cpp.cpp

---

```
#include "do_magic_cpp.h"

// ' Does magic
// ' @param x Input
// ' @return Magic value
// ' @export
// [[Rcpp::export]]
int do_magic_cpp(const int x)
{
    return x * 2;
}
```

---

This implementation file has gotten rather elaborate, thanks to Rcpp and documentation. This is because it has to be callable from both C++ and R and satisfy the requirement from both languages.

#### 4.9.2 C++: main source file

The C++ program has a normal main function:

---

**Algorithm 35** main.cpp

---

```
#include "do_magic_cpp.h"

int main()
{
    if (do_magic_cpp(2) != 4) return 1;
}
```

---

All it does is a simple test of the 'do\_magic\_cpp' function.

#### 4.9.3 C++: Qt Creator project file

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 36** domagic.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle
CONFIG -= qt

INCLUDEPATH += src

INCLUDEPATH += /home/p230198/R/x86_64-pc-linux-gnu-library/3.2/Rcpp/include
INCLUDEPATH += /home/riche1/R/i686-pc-linux-gnu-library/3.2/Rcpp/include
INCLUDEPATH += /usr/share/R/include/

SOURCES += \
    src/do_magic_cpp.cpp \
    main.cpp

HEADERS += \
    src/do_magic_cpp.h

LIBS += -lR
```

---

The name of the Qt Creator project file is 'domagic' as it follows the same naming as the R project. It add the R and Rcpp and src folders to its include path and links to R.

#### 4.9.4 The C++ build script

The C++ build script is the regular canon of qmake, make and executable call.

---

**Algorithm 37** build\_cpp.sh

---

```
#!/bin/bash
qmake
make
./domagic
```

---

This script ...

#### 4.9.5 R: the R function

The R function 'do\_magic\_r' calls the C++ function 'do\_magic\_cpp':

---

**Algorithm 38** R/do\_magic\_r.R

---

```
#' Does magic
#' @param x Input
#' @return Magic value
#' @export
#' @useDynLib domagic
#' @importFrom Rcpp sourceCpp
do_magic_r <- function(x) {
  return(do_magic_cpp(x))
}
```

---

Next to this, it is just Roxygen2 documentation

#### 4.9.6 R: The R tests

R allows for easy testing using the 'testthat' package. A test file looks as such:

---

**Algorithm 39** tests/testthat/test-do\_magic\_r.R

---

```
context("do_magic")

test_that("basic use", {
  expect_equal(do_magic_r(2), 4)
  expect_equal(do_magic_r(3), 6)
  expect_equal(do_magic_r(4), 8)

  expect_equal(domagic::do_magic_cpp(2), 4)
  expect_equal(domagic::do_magic_cpp(3), 6)
  expect_equal(domagic::do_magic_cpp(4), 8)
})
```

---

The tests call both the R and C++ functions with certain inputs and checks if the output matches the expectations.

#### 4.9.7 The R script to install packages

The C++ build script is the regular canon of qmake, make and executable call.

---

**Algorithm 40** build\_cpp.sh

---

```
install.packages("Rcpp", repos = "http://cran.uk.r-  
project.org")  
install.packages("knitr", repos = "http://cran.uk.r-  
project.org")  
install.packages("testthat", repos = "http://cran.uk.r-  
project.org")  
install.packages("rmarkdown", repos = "http://cran.uk.r-  
project.org")
```

---

#### 4.9.8 The Travis script

Setting up Travis is done by the following .travis.yml:



---

**Algorithm 41** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc

before_install:
  - sudo add-apt-repository -y ppa:marutter/rrutter # For R
  - sudo apt-get update -qq

install:
  - sudo apt-get install -qq r-base r-base-dev # For R
  - sudo apt-get install -qq lyx # For pdflatex
  - sudo apt-get install -qq texlive # For pdflatex

script:
  # C++
  - ./build_cpp.sh
  # R wants all non-R files gone...
  - ./clean.sh
  - sudo Rscript install_r_packages.R
  - rm .gitignore
  - rm src/.gitignore
  - rm .travis.yml
  - rm -rf .git
  - rm -rf ..Rcheck
  # Now R is ready to go
  - R CMD check .

after_failure:
  # fatal error: Rcpp.h: No such file or directory
  - find / -name 'Rcpp.h'
  # R logs
  - cat /home/travis/build/richelbilderbeek/travis_qmake_gcc_cpp98_rcpp/..Rcheck/00install.out
```

---

This .travis.yml file is longer than usual, as it both compiles and runs the C++ and R code.

#### 4.9.9 fatal error: Rcpp.h: No such file or directory

Add these line to the .travis.yml file to find Rcpp.h:

```
after_failure:
  # fatal error: Rcpp.h: No such file or directory
  - find / -name 'Rcpp.h'
```



Figure 17: SFML logo

You can then add the folder found to the INCLUDEPATHS of the Qt Create project file.

## 4.10 Adding the SFML library

In this example, the basic build (chapter 3) is extended by also using the SFML library.

**What is SFML?** SFML ('Simple and Fast Multimedia Library') is a library very suitable for 2D game development

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL and SFML
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 42** main.cpp

---

```
#include <SFML/Graphics.hpp>

int main()
{
    ::sf::RectangleShape shape(::sf::Vector2f(100.0,250.0))
    ;
    if (shape.getSize().x < 50) return 1;
}
```

---

All the file does is to create an empty graph, from the Boost.Graph library. It will not compile without the SFML libraries absent.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 43** travis\_qmake\_gcc\_cpp98\_sfml.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt

SOURCES += main.cpp

QMAKE_CXXFLAGS += -Wall -Wextra -Werror

LIBS += -lsfml-graphics -lsfml-window -lsfml-system -lsfml-audio
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 44** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp98_sfml
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following .travis.yml:

---

**Algorithm 45** .travis.yml

---

```
language: cpp
compiler: gcc
sudo: true

before_install:
- sudo apt-add-repository ppa:sonkun/sfml-development -y
- sudo apt-get update -qq

install:
- sudo apt-get install libsfml-dev

script:
- ./build.sh
```

---

This .travis.yml file has one new feature:

- install: sudo apt-get install libsfml-dev



Figure 18: Urho3D logo

This makes Travis install the needed package.

## 4.11 Adding the Urho3D library

In this example, the basic build (chapter 3) is extended by also using the Urho3D library.

**What is Urho3D?** Urho3D is a library to create C++ 3D games.

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL and Urho3D
- Code coverage: none
- Source: multiple files

The C++ source files are too big to show here. Their names are:

- cameramaster.h
- cameramaster.cpp
- inputmaster.h
- inputmaster.cpp
- mastercontrol.h
- mastercontrol.cpp

The files will work together to create the following 3D world:

The files are compiled with qmake from the following Qt Creator project file:

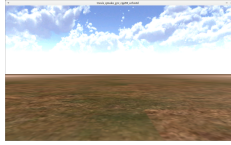


Figure 19: Screenshot of travis\_qmake\_gcc\_cpp98\_urho3d

---

**Algorithm 46** travis\_qmake\_gcc\_cpp98\_urho3d.pro

---

```
SOURCES += \
    mastercontrol.cpp \
    inputmaster.cpp \
    cameramaster.cpp

HEADERS += \
    mastercontrol.h \
    inputmaster.h \
    cameramaster.h

# C++98
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -Wall -Wextra -Werror

# Qt resources emit a warning
QMAKE_CXXFLAGS += -Wno-unused-variable

# Urho3D
INCLUDEPATH += \
    ../travis_qmake_gcc_cpp98_urho3d/Urho3D/include \
    ../travis_qmake_gcc_cpp98_urho3d/Urho3D/include/Urho3D/ThirdParty
LIBS += ../travis_qmake_gcc_cpp98_urho3d/Urho3D/lib/libUrho3D.a
LIBS += -lpthread -lSDL -ldl -lGL
```

---

- The Qt Creator project file has the same lines as the basic project in chapter 3.
3. The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 47** build.sh

---

```
#!/bin/bash
./Urho3d.sh
#ln -s ./Urho3D/bin/Data
#ln -s ./Urho3D/bin/CoreData
qmake travis_qmake_gcc_cpp98_urho3d.pro
make
#./travis_qmake_gcc_cpp98_urho3d
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following .travis.yml:

---

**Algorithm 48** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc

before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq

install:
  - sudo apt-get install -qq g++-5
  - sudo apt-get install libx11-dev libxrandr-dev libasound2-dev libgl1-mesa-dev
  - sudo apt-get install libsdl1.2-dev libsdl-image1.2-dev libsdl-mixer1.2-dev libsdl-ttf2.0-dev

addons:
  apt:
    sources:
      - boost-latest
      - ubuntu-toolchain-r-test
    packages:
      - gcc-5
      - g++-5
      - libboost1.55-all-dev

script:
  - ./build.sh

# - sudo apt-get install libboost-all-dev
```

---

This .travis.yml file has ...



Figure 20: Wt logo

## 4.12 Adding the Wt library

In this example, the basic build (chapter 3) is extended by also using the Wt library.

**What is Wt?** Wt (pronounce 'witty') is a library to create C++ websites.

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++98
- Libraries: STL and Wt
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 49** main.cpp

---

```
#pragma GCC diagnostic push
#pragma GCC diagnostic ignored "-Weffc++"
#include <boost/program_options.hpp>
#include <boost/signals2.hpp>
#include <Wt/WApplication>
#include <Wt/WContainerWidget>
#include <Wt/WEnvironment>
#include <Wt/WPaintDevice>
#include <Wt/WPaintedWidget>
#include <Wt/WPainter>
#include <Wt/WPushButton>
#pragma GCC diagnostic pop

struct WtWidget : public Wt::WPaintedWidget
{
    WtWidget()
    {
        this->resize(32,32);
    }
protected:
    void paintEvent(Wt::WPaintDevice *paintDevice)
    {
        Wt::WPainter painter(paintDevice);
        for (int y=0; y!=32; ++y)
        {
            for (int x=0; x!=32; ++x)
            {
                painter.setPen(
                    Wt::WPen(
                        Wt::WColor(
                            ((x+0) * 8) % 256,
                            ((y+0) * 8) % 256,
                            ((x+y) * 8) % 256)));
                //Draw a line of one pixel long
                painter.drawLine(x,y,x+1,y);
                //drawPoint yiels too white results
                //painter.drawLine(x,y,x+1,y);
            }
        }
    }
};

struct WtDialog : public Wt::WContainerWidget
{
    WtDialog()
    : m_widget(new WtWidget)
    {
        this->addWidget(m_widget);
    }
private:
    WtDialog(const WtDialog&); //delete
    WtDialog& operator=(const WtDialog&); //delete
    WtWidget * const m_widget;
};
```



All the file does is to create an empty graph, from the Boost.Graph library. It will not compile without the SFML libraries absent.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 50** `travis_qmake_gcc_cpp98_wt.pro`

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

LIBS += \
    -lboost_date_time \
    -lboost_filesystem \
    -lboost_program_options \
    -lboost_regex \
    -lboost_signals \
    -lboost_system

LIBS += -lwt -lwthttp

SOURCES += main.cpp

DEFINES += BOOST_SIGNALS_NO_DEPRECATED_WARNING
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 51** `build.sh`

---

```
#!/bin/bash
qmake
make
# ./travis_qmake_gcc_cpp98_wt # Do not run: this will
    start a server
```

---

The bash script has the same lines as the basic project in chapter 3. Setting up Travis is done by the following `.travis.yml`:

---

**Algorithm 52** `.travis.yml`

---

```
language: cpp
compiler: gcc
addons:
  apt:
    packages: libboost-all-dev
install: sudo apt-get install witty-dev
script: ./build.sh
```

---

This `.travis.yml` file has ...

## 5 Extending the build by two steps

The following chapter describe how to extend the build in two directions. These are:

- Use of C++11 and Boost: see chapter 5.1
- Use of C++11 and Boost.Test: see chapter 5.2
- Use of C++14 and Boost: see chapter 5.10

### 5.1 C++11 and Boost libraries

In this example, the basic build (chapter 3) is extended by also using the Boost libraries.

The chapter has the following specs:

- Build system: `qmake`
- C++ compiler: `gcc`
- C++ version: `C++11`
- Libraries: `STL` and `Boost`
- Code coverage: `none`
- Source: one single file, `main.cpp`

The single C++ source file used is:

---

**Algorithm 53** main.cpp

---

```
#include <boost/graph/adjacency_list.hpp>

int f() noexcept {
    boost::adjacency_list<> g;
    boost::add_vertex(g);
    return boost::num_vertices(g);
}

int main() {
    if (f() != 1) return 1;
}
```

---

All the file does is to create an empty graph, from the Boost.Graph library. It will not compile without the Boost libraries absent.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 54** travis\_qmake\_gcc\_cpp11\_boost.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build and run this:

---

**Algorithm 55** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp11_boost
```

---

The bash script has the same lines as the basic project in chapter 3.

Setting up Travis is done by the following .travis.yml:

---

**Algorithm 56** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc
before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq
install: sudo apt-get install -qq g++-5
addons:
  apt:
    packages: libboost-all-dev
script: ./build.sh
```

---

This .travis.yml file has ...

## 5.2 C++11 and Boost.Test

This project consists out of two projects:

- travis\_qmake\_gcc\_cpp11\_boost\_test.pro: the real code
- travis\_qmake\_gcc\_cpp11\_boost\_test\_test.pro: the tests

Both projects center around a function called 'add', which is located in the 'my\_function.h' and 'my\_function.cpp' files, as shown here:

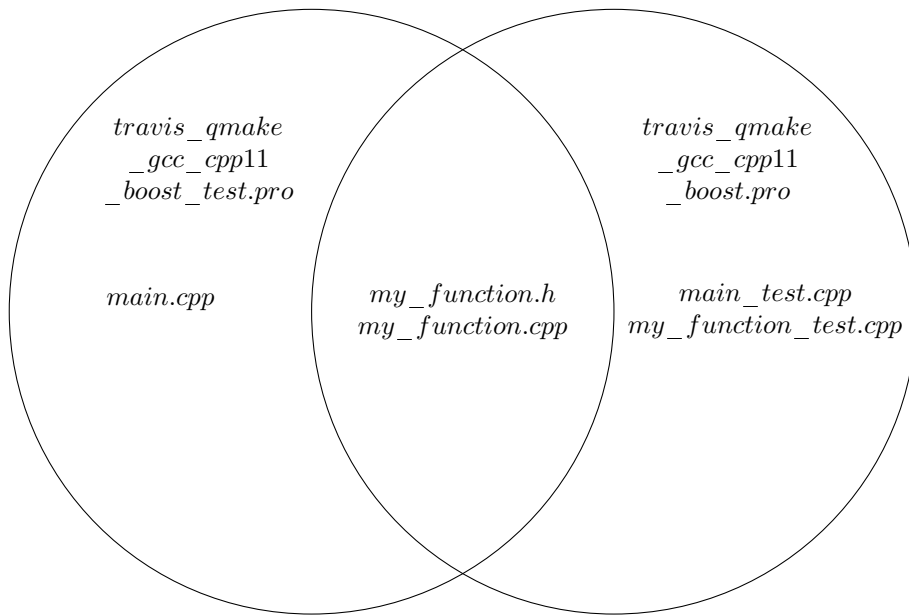


Figure 21: Venn diagram of the files uses in this build

Both of these are compiled both in release and debug mode.

**Specifics** The basic build has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL and Boost, demonstrating Boost.Test
- Code coverage: none
- Source: multiple files: *main.cpp*, *my\_function.h*, *my\_function.cpp*, *test\_my\_function.cpp*

### 5.2.1 The function

First the function that is (1) tested by the test build (2) called by the real build, is shown here:

---

**Algorithm 57** my\_function.h

---

```
#ifndef MY_FUNCTIONS_H
#define MY_FUNCTIONS_H

int add(const int i, const int j) noexcept;

#endif // MY_FUNCTIONS_H
```

---

This header file has the `#include` guards and the declaration of the function 'add'. It takes two integer values as an argument and returns an int.

Its definition is shown here:

---

**Algorithm 58** my\_function.cpp

---

```
#include "my_functions.h"

int add(const int i, const int j) noexcept
{
    return i + j;
}
```

---

Perhaps it was expected that 'add' adds the two integers

### 5.2.2 Test build

The test build is the build that tests the function. It does not have a 'main.cpp' as the exe build has, but uses 'test\_my\_functions.cpp' as its main source file. This can be seen in the Qt Creator project file:

---

**Algorithm 59** travis\_qmake\_gcc\_cpp11\_boost\_test\_test.pro

---

```
CONFIG += console debug_and_release
CONFIG -= app_bundle
QT -= core gui
TEMPLATE = app

CONFIG(release, debug|release) {
    DEFINES += NDEBUG
}

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -Wall -Wextra -Werror -std=c
                ++11

HEADERS += my_functions.h
SOURCES += my_functions.cpp \
            main_test.cpp \
            my_functions_test.cpp

LIBS += -lboost_unit_test_framework
```

---

Note how this Qt Creator project file links to the Boost unit test framework.  
Its main source file is shown here:

---

**Algorithm 60** main\_test.cpp

---

```
#define BOOST_TEST_DYN_LINK
#define BOOST_TEST_MODULE my_functions_test_module
#include <boost/test/unit_test.hpp>

//No main needed, BOOST_TEST_DYN_LINK creates it
```

---

It uses the Boost.Test framework to automatically generate a main function and test suite. An empty file is created, so Travis can verify there has been built both a debug and release mode.

Its main testing file file is shown here:

---

**Algorithm 61** my\_functions\_test.cpp

---

```
#include <boost/test/unit_test.hpp>
#include "my_functions.h"

BOOST_AUTO_TEST_CASE(add_works)
{
    BOOST_CHECK(add(1, 1) == 2);
    BOOST_CHECK(add(1, 2) == 3);
    BOOST_CHECK(add(1, 3) == 4);
    BOOST_CHECK(add(1, 4) == 5);
}
```

---

It tests the function 'add'.

### 5.2.3 Exe build

The 'exe' build' is the build that uses the function.

---

**Algorithm 62** main.cpp

---

```
#include "my_functions.h"
#include <iostream>

int main() {
    std::cout << add(40, 2) << '\n';
}
```

---

Next to using the function 'add', also a file is created, so Travis can verify there has been built both a debug and release mode.

This single file is compiled with qmake from the following Qt Creator project file:



---

**Algorithm 63** travis\_qmake\_gcc\_cpp11\_boost\_test.pro

---

```
CONFIG += console debug_and_release
CONFIG -= app_bundle
QT -= core gui
TEMPLATE = app

CONFIG(release, debug|release) {
    DEFINES += NDEBUG
}

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror -std=c++11

SOURCES += main.cpp my_functions.cpp
HEADERS += my_functions.h
```

---

Note how this Qt Creator project file does not link to the Boost unit test framework.

#### 5.2.4 Build script

The bash build script to build, test and run this:

---

**Algorithm 64** build.sh

---

```
#!/bin/bash
qmake travis_qmake_gcc_cpp11_boost_test.pro
make debug
./travis_qmake_gcc_cpp11_boost_test

qmake travis_qmake_gcc_cpp11_boost_test.pro
make release
./travis_qmake_gcc_cpp11_boost_test

qmake travis_qmake_gcc_cpp11_boost_test_test.pro
make debug
./travis_qmake_gcc_cpp11_boost_test_test

qmake travis_qmake_gcc_cpp11_boost_test_test.pro
make release
./travis_qmake_gcc_cpp11_boost_test_test
```

---

In this script both projects are compiled in both debug and release mode. All four executables are run.

### 5.2.5 Travis script

Setting up Travis is done by the following `.travis.yml`:

---

**Algorithm 65** `.travis.yml`

---

```
sudo: true
language: cpp
compiler: gcc
addons:
  apt:
    packages: libboost-all-dev
before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq
install: sudo apt-get install -qq g++-5
script: ./build.sh
```

---

This `.travis.yml` file has ...

## 5.3 C++11 and clang

In this example, the basic build (chapter 3) is extended by using clang and C++11.

The chapter has the following specs:

- Build system: qmake
- C++ compiler: clang
- C++ version: C++11
- Libraries: STL only
- Code coverage: none
- Source: one single file, `main.cpp`

The single C++ source file used is:

---

**Algorithm 66** main.cpp

---

```
#include <iostream>

void f() noexcept {
    std::cout << "Hello_world\n";
}

int main() {
    f();
}
```

---

All the file does is to create an empty graph, from the Boost.Graph library. It will not compile without the Boost libraries absent.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 67** travis\_qmake\_clang\_cpp11.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# clang
QMAKE_CXX = clang++
QMAKE_LINK = clang++
QMAKE_CC = clang
QMAKE_CXXFLAGS += -std=c++11
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build and run this:

---

**Algorithm 68** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_clang_cpp11
```

---

The bash script has the same lines as the basic project in chapter 3. Setting up Travis is done by the following .travis.yml:

---

**Algorithm 69** `.travis.yml`

---

```
language: cpp
compiler: gcc
sudo: true

install:
  - sudo apt-get install clang

script:
  - ./build.sh
```

---

This `.travis.yml` file has ...

## 5.4 C++11 and gcov

In this example, the C++98 build with gcov (chapter 4.6) is extended by using C++11.

**Build overview** This will be a more complex build, consisting of two projects:

- The regular project that just runs the code
- The project that measures code coverage

The filenames are shown in this figure:

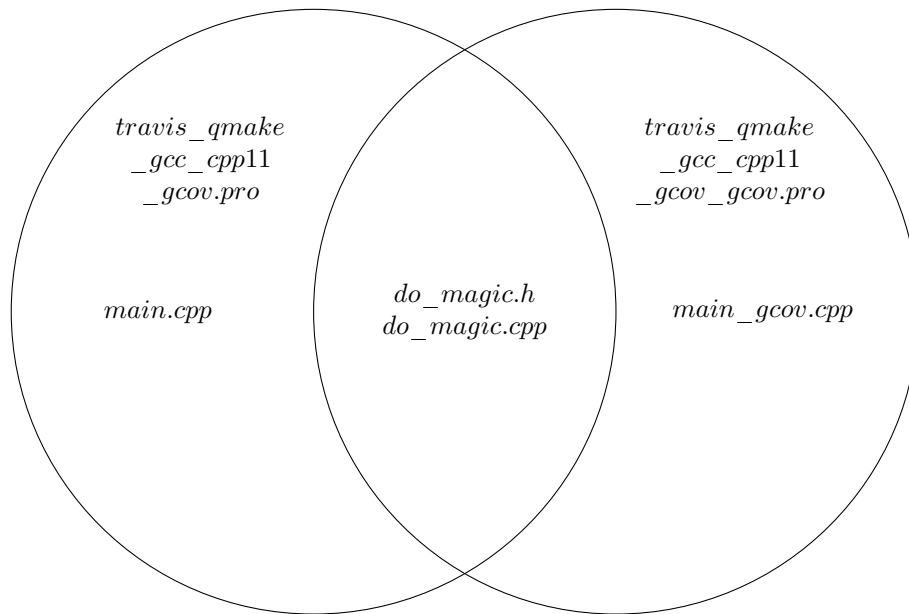


Figure 22: Venn diagram of the files uses in this build

**Specifications** The basic build has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL only
- Code coverage: yes
- Source: multiple files

**Common files** Both builds use the following code:

---

**Algorithm 70** *do\_magic.h*

---

```
#ifndef DO_MAGIC_H
#define DO_MAGIC_H

int do_magic(const int x) noexcept;

#endif // DO_MAGIC_H
```

---

And its implementation:

---

**Algorithm 71** do\_magic.cpp

---

```
#include "do_magic.h"

int do_magic(const int x) noexcept
{
    if (x == 42)
    {
        return 42;
    }
    if (x == 314)
    {
        return 314;
    }
    return x * 2;
}
```

---

**Normal build main function** The C++ source file used by the normal build is:

---

**Algorithm 72** main.cpp

---

```
#include "do_magic.h"
#include <iostream>

int main() {
    std::cout << do_magic(123) << '\n';
}
```

---

**Normal build Qt Crator project file** This normal is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 73** travis\_qmake\_gcc\_cpp11\_gcov.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp do_magic.cpp
HEADERS += do_magic.h
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# C++11
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11
```

---

**Code coverage main function** The C++ source file used by the normal build is:

---

**Algorithm 74** main.cpp

---

```
#include "do_magic.h"

int main()
{
    if (do_magic(2) != 4) return 1;
    if (do_magic(42) != 42) return 1;
    //Forgot to test do_magic(314)
}
```

---

**Code coverage build Qt Creator project file** This normal is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 75** travis\_qmake\_gcc\_cpp11\_gcov.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main_gcov.cpp do_magic.cpp
HEADERS += do_magic.h
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# gcov
QMAKE_CXXFLAGS += -fprofile-arcs -ftest-coverage
LIBS += -lgcov

# C++11
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11
```

---

The Qt Creator project file has two new lines:

- `QMAKE_CXXFLAGS += -fprofile-arcs -ftest-coverage`

Let the C++ compiler add coverage information

- `LIBS += -lgcov`

Link against the gcov library

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 76** build.sh

---

```
#!/bin/bash
echo "Normal_run"
qmake travis_qmake_gcc_cpp11_gcov.pro
make
./travis_qmake_gcc_cpp11_gcov
./clean.sh
echo "Coverage_run"
qmake travis_qmake_gcc_cpp11_gcov_gcov.pro
make
./travis_qmake_gcc_cpp11_gcov_gcov
gcov-5 main_gcov.cpp
gcov-5 do_magic.cpp
cat main_gcov.cpp.gcov
cat do_magic.cpp.gcov
```

---



The new step is after having run the executable,

- `gcov main_gcov.cpp`

Let gcov create a coverage report

- `cat main_gcov.cpp.gcov`

Show the file 'main.cpp.gcov', which contains the coverage of 'main.cpp'

**Travis script** Setting up Travis is done by the following .travis.yml:

---

**Algorithm 77** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc

before_install:
- sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
- sudo apt-get update -qq
- sudo pip install codecov

install:
- sudo apt-get install -qq g++-5

script: ./build.sh

after_success: codecov
```

---

This .travis.yml file has some new features:

- `sudo: true`

Travis will give super user rights to the script. This will slow the build time, but it is inevitable for the next step

- `before_install: sudo pip install codecov`

Travis will use pip to install codecov using super user rights

- `after_success: codecov`

After the script has run successfully, codecov is called

## 5.5 C++11 and Qt

In this example, the basic build (chapter 3) is extended by both adding C++11 and the Qt library.

## Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL and Qt
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

### Algorithm 78 main.cpp

---

```
#include <fstream>
#include <iostream>
#include <QFile>

std::string get_filename() noexcept {
    return "HelloWorld.png";
}

int main()
{
    const std::string filename = get_filename();
    QFile f(":/images/HelloWorld.png");
    if (QFile::exists(filename.c_str()))
    {
        std::remove(filename.c_str());
    }
    f.copy("HelloWorld.png");
    if (!QFile::exists(filename.c_str()))
    {
        std::cerr << "filename_" << filename << "_must_be_
        created\n";
        return 1;
    }
}
```

---

All the file does ...

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 79** `travis_qmake_gcc_cpp11_qt.pro`

---

```
QT      += core gui
greaterThan(QT_MAJOR_VERSION, 4): QT += widgets
TEMPLATE = app

SOURCES += main.cpp

RESOURCES += \
    travis_qmake_gcc_cpp11_qt.qrc

# C++11
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11

# Thanks to Qt
QMAKE_CXXFLAGS += -Wno-unused-variable
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 80** `build.sh`

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp11_qt
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following `.travis.yml`:

---

**Algorithm 81** .travis.yml

---

```
language: cpp
compiler: gcc

before_install:
- sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test # C++11
- sudo apt-get update -qq

install:
- sudo apt-get install -qq g++-5 # C++11

script:
- ./build.sh
```

---

This .travis.yml file has ...

## 5.6 C++11 and Rcpp

In this example, the basic build (chapter 3) is extended by also using the Rcpp library/package.

**Specifications** The chapter has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL and Rcpp
- Code coverage: none
- Source: multiple files

The build will be complex: I will show the C++ build and the R build separately

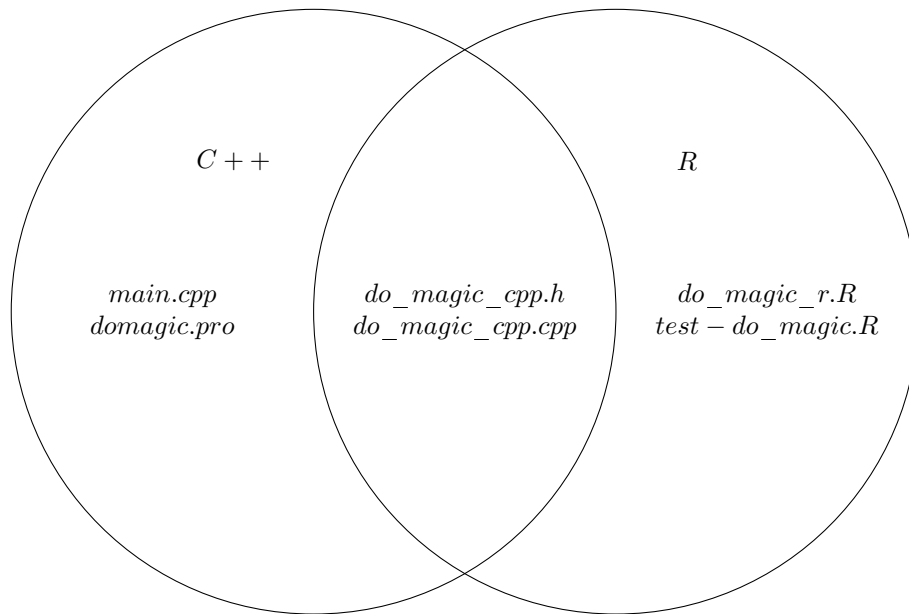


Figure 23: Venn diagram of the files uses in this build

### 5.6.1 C++ and R: the C++ function

This Travis CI project is centered around the function 'do\_magic\_cpp'. I use the extension '\_cpp' to indicate it is a C++ function. The function 'do\_magic\_cpp' is used by both C++ and R. It is declared in the header file 'do\_magic\_cpp.h', as shown here:

---

**Algorithm 82** src/do\_magic\_cpp.h

---

```
#ifndef DO_MAGIC_CPP_H
#define DO_MAGIC_CPP_H

int do_magic_cpp(const int x) noexcept;

#endif // DO_MAGIC_CPP_H
```

---

The header file consists solely of #include guards and the declaration of the function 'do\_magic\_cpp'. The C++11 keyword 'noexcept' will make the build fail to compile under C++98, but will compile under C++11 and later versions of C++.

The function 'do\_magic\_cpp' is implemented in the implementation file 'do\_magic\_cpp.cpp', as shown here:

---

**Algorithm 83** src/do\_magic\_cpp.cpp

---

```
#include "do_magic_cpp.h"

// ' Does magic
// ' @param x Input
// ' @return Magic value
// [[Rcpp::export]]
int do_magic_cpp(const int x) noexcept {
    return x * 2;
}
```

---

This source file is very simple. Most lines are dedicated to the C++ roxygen2 documentation. Omitting this documentation will fail the R package to build, as this documentation is mandatory. Note that

```
// [[Rcpp::export]]
needs to be written exactly as such.
```

### 5.6.2 C++: main source file

The C++ program has a normal main function:

---

**Algorithm 84** main.cpp

---

```
#include "do_magic_cpp.h"

int main() {
    if (do_magic_cpp(2) != 4) return 1;
}
```

---

All it does is a simple test of the 'do\_magic\_cpp' function.

### 5.6.3 C++: Qt Creator project file

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 85** domagic.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle
CONFIG -= qt

# C++11
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11

# Shared C++11 files
INCLUDEPATH += src
SOURCES += src/do_magic_cpp.cpp
HEADERS += src/do_magic_cpp.h

# Rcpp, adapted from script from Dirk Eddelbuettel and Romain Francois
R_HOME = $$system(R RHOME)
RCPPINCL = $$system($$R_HOME/bin/Rscript -e \"Rcpp:::CxxFlags\\(\\)\\")
INCLUDEPATH += RCPPINCL

# Rcpp does not play nice with -Weffc++
QMAKE_CXXFLAGS += -Wall -Wextra -Werror

# C++11-only files
SOURCES += main.cpp

# R
LIBS += -lR
```

---

Here is what the sections do:

- `# Shared C++11 files`  
`INCLUDEPATH += src`  
`SOURCES += src/do_magic_cpp.cpp`  
`HEADERS += src/do_magic_cpp.h`

These files are shared by the C++11 and R project

- `# Rcpp, adapted from script from Dirk Eddelbuettel and Romain Francois`  
`R_HOME = $$system(R RHOME)`  
`RCPPINCL = $$system($$R_HOME/bin/Rscript -e \"Rcpp:::CxxFlags\\(\\)\\")`  
`INCLUDEPATH += RCPPINCL`

```
# Rcpp does not play nice with -Weffc++
QMAKE_CXXFLAGS += -Wall -Wextra -Werror
```

Let Rcpp be found by and compile cleanly. To do so, the '-Weffc++' warnings have to be omitted

- # C++11-only files  
SOURCES += main.cpp

This contains the main function that is only used by the C++11-only build

- # R  
LIBS += -lR

Link to the R language libraries

#### 5.6.4 C++: build script

The C++ bash build script is straightforward.

---

##### Algorithm 86 build\_cpp.sh

---

```
#!/bin/bash
qmake
make
./domagic
```

---

This script is already described in the C++98 and Rcpp chapter (chapter 4.9, algorithm 37).

#### 5.6.5 R: the R function

The R function 'do\_magic\_r' calls the C++ function 'do\_magic\_cpp':

---

##### Algorithm 87 R/do\_magic\_r.R

---

```
#' Does magic
#' @param x Input
#' @return Magic value
#' @export
#' @useDynLib domagic
#' @importFrom Rcpp sourceCpp
do_magic_r <- function(x) {
  return(do_magic_cpp(x))
}
```

---



Must lines are dedicated to Roxygen2 documentation. Omitting this documentation will fail the R package to build, as this documentation is mandatory.

### 5.6.6 R: The R tests

R allows for easy testing using the 'testthat' package. A test file looks as such:

---

**Algorithm 88** tests/testthat/test-do\_magic\_r.R

---

```
context("do_magic")

test_that("basic use", {
  expect_equal(do_magic_r(2), 4)
  expect_equal(do_magic_r(3), 6)
  expect_equal(do_magic_r(4), 8)

  expect_equal(domagic::do_magic_cpp(2), 4)
  expect_equal(domagic::do_magic_cpp(3), 6)
  expect_equal(domagic::do_magic_cpp(4), 8)
})
```

---

The tests call both the R and C++ functions with certain inputs and checks if the output matches the expectations. It may be a good idea to only call the R function from here, and move the C++ function tests to a C++ testing suite like Boost.Test.

### 5.6.7 R: script to install packages

---

**Algorithm 89** install\_r\_packages.sh

---

```
install.packages("Rcpp", repos = "http://cran.uk.r-
project.org")
install.packages("knitr", repos = "http://cran.uk.r-
project.org")
install.packages("testthat", repos = "http://cran.uk.r-
project.org")
install.packages("rmarkdown", repos = "http://cran.uk.r-
project.org")
```

---

To compile the C++ code, Rcpp needs to be installed. The R package needs the other packages to work. An R code repository from the UK was used: without supply an R code repository, Travis will be asked to pick one, which it cannot.

### 5.6.8 The Travis script

Setting up Travis is done by the following .travis.yml:

---

**Algorithm 90** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc

before_install:
- sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test # C++11
- sudo add-apt-repository -y ppa:marutter/rrutter # R
- sudo apt-get update -qq

install:
- sudo apt-get install -qq g++-5 # C++11
- sudo apt-get install -qq r-base r-base-dev # R
- sudo apt-get install -qq lyx texlive # pdflatex, used by knitr
- sudo Rscript install_r_packages.R # Rcpp

script:
# C++
- ./build_cpp.sh
# R wants all non-R files gone...
- ./clean.sh
- rm .gitignore
- rm src/.gitignore
- rm .travis.yml
- rm -rf .git
- rm -rf ..Rcheck
# Now R is ready to go
- R CMD check .
```

---

This .travis.yml file is rather extensive:

- sudo: true  
language: cpp  
compiler: gcc

The default language used has to be C++

- before\_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test # C++11
  - sudo add-apt-repository -y ppa:marutter/rrutter # R
  - sudo apt-get update -qq

Before installation, Travis has to add to apt repositories, one for C++11 and one for the R version used by CRAN

- `install` :
  - `sudo apt-get install -qq g++-5 # C++11`
  - `sudo apt-get install -qq r-base r-base-dev # R`
  - `sudo apt-get install -qq lyx texlive # pdflatex, used by knitr`
  - `sudo Rscript install_r_packages.R # Rcpp`

Travis has to install the prerequisites for C++11, R, pdflatex (used by R's knitr) and some R packages

- `script` :
  - `# C++`
  - `./build_cpp.sh`
  - `# R wants all non-R files gone...`
  - `./clean.sh`
  - `rm .gitignore`
  - `rm src/.gitignore`
  - `rm .travis.yml`
  - `rm -rf .git`
  - `rm -rf ..Rcheck`
  - `# Now R is ready to go`
  - `R CMD check .`

The script consists out of a build and run of the C++11 code, cleaning up for R, then building an R package

## 5.7 C++11 and SFML

In this example, the basic build (chapter 3) is extended by both adding C++11 and the SFML library.

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL and SFML
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 91** main.cpp

---

```
#include <SFML/Graphics/RectangleShape.hpp>

int main()
{
    ::sf::RectangleShape shape(::sf::Vector2f(100.0,250.0))
    ;
    if (shape.getSize().x < 50) return 1;
}
```

---

All the file does ...

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 92** travis\_qmake\_gcc\_cpp11\_sfml.pro

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt

SOURCES += main.cpp

QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11

LIBS += -lsfml-graphics -lsfml-window -lsfml-system -lsfml-audio
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 93** build.sh

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp11_sfml
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following .travis.yml:

---

**Algorithm 94** .travis.yml

---

```
language: cpp
compiler: gcc
sudo: true

before_install:
- sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
- sudo apt-add-repository ppa:sonkun/sfml-development -y
- sudo apt-get update -qq

install:
- sudo apt-get install -qq g++-5
- sudo apt-get install libsfml-dev

script:
- ./build.sh
```

---

This .travis.yml file has ...

## 5.8 C++11 and Urho3D

In this example, the basic build (chapter 3) is extended by both adding C++11 and the Urho3D library.

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL and Urho3D
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 95** mastercontrol.cpp

---

```
#include <string>
#include <vector>

#include <QFile>

#pragma GCC diagnostic push
#pragma GCC diagnostic ignored "-Weffc++"
#pragma GCC diagnostic ignored "-Wunused-parameter"
#pragma GCC diagnostic ignored "-Wunused-variable"
#pragma GCC diagnostic ignored "-Wstrict-aliasing"
#define BT_INFINITY

#include <Urho3D/Urho3D.h>

#include <Urho3D/Audio/Sound.h>
#include <Urho3D/Audio/SoundSource.h>
#include <Urho3D/Core/CoreEvents.h>
#include <Urho3D/DebugNew.h>
#include <Urho3D/Engine/Console.h>
#include <Urho3D/Engine/DebugHud.h>
#include <Urho3D/Engine/Engine.h>
#include <Urho3D/Graphics/Camera.h>
#include <Urho3D/Graphics/DebugRenderer.h>
#include <Urho3D/Graphics/Geometry.h>
#include <Urho3D/Graphics/Graphics.h>
#include <Urho3D/Graphics/IndexBuffer.h>
#include <Urho3D/Graphics/Light.h>
#include <Urho3D/Graphics/Material.h>
#include <Urho3D/Graphics/Model.h>
#include <Urho3D/Graphics/Octree.h>
#include <Urho3D/Graphics/OctreeQuery.h>
#include <Urho3D/Graphics/RenderPath.h>
#include <Urho3D/Graphics/Skybox.h>
#include <Urho3D/Graphics/StaticModel.h>
#include <Urho3D/Graphics/VertexBuffer.h>
#include <Urho3D/IO/FileSystem.h>
#include <Urho3D/IO/Log.h>
#include <Urho3D/Physics/CollisionShape.h>
#include <Urho3D/Physics/PhysicsWorld.h>
#include <Urho3D/Resource/ResourceCache.h>
#include <Urho3D/Resource/Resource.h>
#include <Urho3D/Resource/XMLFile.h>
#include <Urho3D/Scene/SceneEvents.h>
#include <Urho3D/Scene/Scene.h>
#include <Urho3D/UI/Font.h>
#include <Urho3D/UI/Text.h>

#pragma GCC diagnostic pop

#include "mastercontrol.h"
#include "cameramaster.h"
#include "inputmaster.h"
```

```
DEFINE_APPLICATION_MAIN(MasterControl);
```

All the file does ...

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 96** travis\_qmake\_gcc\_cpp11\_urho3d.pro

---

```
# g++-5
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -Wall -Wextra -Werror -std=c++11

SOURCES += \
    mastercontrol.cpp \
    inputmaster.cpp \
    cameramaster.cpp

HEADERS += \
    mastercontrol.h \
    inputmaster.h \
    cameramaster.h

QMAKE_CXXFLAGS += -Wno-unused-variable

# Urho3D
INCLUDEPATH += \
    ../travis_qmake_gcc_cpp11_urho3d/Urho3D/include \
    ../travis_qmake_gcc_cpp11_urho3d/Urho3D/include/Urho3D/ThirdParty

LIBS += \
    ../travis_qmake_gcc_cpp11_urho3d/Urho3D/lib/libUrho3D.a

LIBS += \
    -lpthread \
    -lSDL \
    -ldl \
    -lGL

# -lSDL2 \ #otherwise use -lSDL
#DEFINES += RIBI_USE_SDL_2
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 97** build.sh

---

```
#!/bin/bash
./Urho3d.sh
#ln -s ./Urho3D/bin/Data
#ln -s ./Urho3D/bin/CoreData
qmake travis_qmake_gcc_cpp11_urho3d.pro
make
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following .travis.yml:

---

**Algorithm 98** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc

before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq

install:
  - sudo apt-get install -qq g++-5
  - sudo apt-get install libx11-dev libxrandr-dev libasound2-dev libgl1-mesa-dev
  - sudo apt-get install libsdl1.2-dev libsdl-image1.2-dev libsdl-mixer1.2-dev libsdl-ttf2.0-dev

addons:
  apt:
    sources:
      - boost-latest
      - ubuntu-toolchain-r-test
    packages:
      - gcc-5
      - g++-5
      - libboost1.55-all-dev

script:
  - ./build.sh

# - sudo apt-get install libboost-all-dev
```

---

This .travis.yml file has ...



## 5.9 C++11 and Wt

In this example, the basic build (chapter 3) is extended by both adding C++11 and the Wt library.

DOES NOT WORK YET

### Specifications

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++11
- Libraries: STL and Wt
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 99** main.cpp

---

```
#pragma GCC diagnostic push
#pragma GCC diagnostic ignored "-Weffc++"
#include <boost/program_options.hpp>
#include <boost/signals2.hpp>
#include <Wt/WApplication>
#include <Wt/WContainerWidget>
#include <Wt/WEnvironment>
#include <Wt/WPaintDevice>
#include <Wt/WPaintedWidget>
#include <Wt/WPainter>
#include <Wt/WPushButton>
#pragma GCC diagnostic pop

struct WtWidget : public Wt::WPaintedWidget
{
    WtWidget()
    {
        this->resize(32,32);
    }
protected:
    void paintEvent(Wt::WPaintDevice *paintDevice)
    {
        Wt::WPainter painter(paintDevice);
        for (int y=0; y!=32; ++y)
        {
            for (int x=0; x!=32; ++x)
            {
                painter.setPen(
                    Wt::WPen(
                        Wt::WColor(
                            ((x+0) * 8) % 256,
                            ((y+0) * 8) % 256,
                            ((x+y) * 8) % 256)));
                //Draw a line of one pixel long
                painter.drawLine(x,y,x+1,y);
                //drawPoint yiels too white results
                //painter.drawLine(x,y,x+1,y);
            }
        }
    }
};

struct WtDialog : public Wt::WContainerWidget
{
    WtDialog()
    : m_widget(new WtWidget)
    {
        this->addWidget(m_widget);
    }
    WtDialog(const WtDialog&) = delete;
    WtDialog& operator=(const WtDialog&) = delete;
private:
    WtWidget * const m_widget;
};
```

All the file does ...

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 100** travis\_qmake\_gcc\_cpp11\_wt.pro

---

```
QT      += core
QT      -= gui
CONFIG  += console
CONFIG  -= app_bundle
TEMPLATE = app

QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

LIBS += \
    -lboost_date_time \
    -lboost_filesystem \
    -lboost_program_options \
    -lboost_regex \
    -lboost_signals \
    -lboost_system

LIBS += -lwt -lwthttp

SOURCES += main.cpp

DEFINES += BOOST_SIGNALS_NO_DEPRECATED_WARNING

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build this, run this and measure the code coverage:

---

**Algorithm 101** build.sh

---

```
#!/bin/bash
qmake
make
# ./travis_qmake_gcc_cpp11_wt # Do not run: this will
    start a server
```

---

The bash script has the same lines as the basic project in chapter 3. Setting up Travis is done by the following `.travis.yml`:

---

**Algorithm 102** .travis.yml

---

```
language: cpp
compiler: gcc
sudo: true

addons:
  apt:
    sources:
      #- boost-latest
      - ubuntu-toolchain-r-test
    packages:
      - gcc-5
      - g++-5
      #- libboost1.55-all-dev
      #- libboost1.46-all-dev
      #- libwt-dev
      #- witty-dev
      #- witty
      #- witty-doc
      #- witty-dbg
      #- witty-examples

before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo add-apt-repository -y ppa:pgquiles/wt
  - sudo apt-get update -qq

install:
  - sudo apt-get install -qq g++-5
  - sudo apt-get install witty witty-dbg witty-dev witty-doc
  #- sudo apt-get install libboost-serialization1.46-dev
  #- sudo apt-get install libboost-date-time1.46-dev
  #- sudo apt-get install libboost-date-time-dev
  #- sudo apt-get install libboost-filesystem-dev
  #- sudo apt-get install libboost-regex-dev
  #- sudo apt-get install libboost-signals-dev
  #- sudo apt-get install libboost-thread-dev
  #- sudo apt-get install libboost-dev
  #- sudo apt-get install libwt-dev
  #- sudo apt-get install witty-dev
  #- sudo apt-get install libboost1.46-dev
  #- sudo apt-get install libboost1.55-dev
  #- sudo apt-get install libwt-dev
  #- sudo apt-get install -qq witty-dev

script:
  - apt-cache search libboost
  - apt-cache search witty
  - apt-cache search libwt
  - ./build.sh
```

This .travis.yml file has ...

## 5.10 C++14 and Boost libraries

In this example, the basic build (chapter 3) is extended by also using the Boost libraries.

The chapter has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++14
- Libraries: STL and Boost
- Code coverage: none
- Source: one single file, main.cpp

The single C++ source file used is:

---

**Algorithm 103** main.cpp

---

```
#include <boost/graph/adjacency_list.hpp>

auto f() noexcept
{
    boost::adjacency_list<> g;
    boost::add_vertex(g);
    return boost::num_vertices(g);
}

int main() {
    if (f() != 1) return 1;
}
```

---

All the file does is to create an empty graph, from the Boost.Graph library. It will not compile without the Boost libraries absent.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 104** `travis_qmake_gcc_cpp14_boost.pro`

---

```
TEMPLATE = app
CONFIG += console
CONFIG -= app_bundle qt
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++14
```

---

The Qt Creator project file has the same lines as the basic project in chapter 3.

The bash build script to build and run this:

---

**Algorithm 105** `build.sh`

---

```
#!/bin/bash
qmake
make
./travis_qmake_gcc_cpp14_boost
```

---

The bash script has the same lines as the basic project in chapter 3.  
Setting up Travis is done by the following `.travis.yml`:

---

**Algorithm 106** `.travis.yml`

---

```
sudo: true
language: cpp
compiler: gcc
before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq
install: sudo apt-get install -qq g++-5
addons:
  apt:
    packages: libboost-all-dev
script: ./build.sh
```

---

This `.travis.yml` file has ...

## 5.11 C++14 and Boost.Test

This project consists out of two projects:

- `travis_qmake_gcc_cpp14_boost_test.pro`: the real code
- `travis_qmake_gcc_cpp14_boost_test_test.pro`: the tests

Both projects center around a function called 'add', which is located in the 'my\_function.h' and 'my\_function.cpp' files, as shown here:

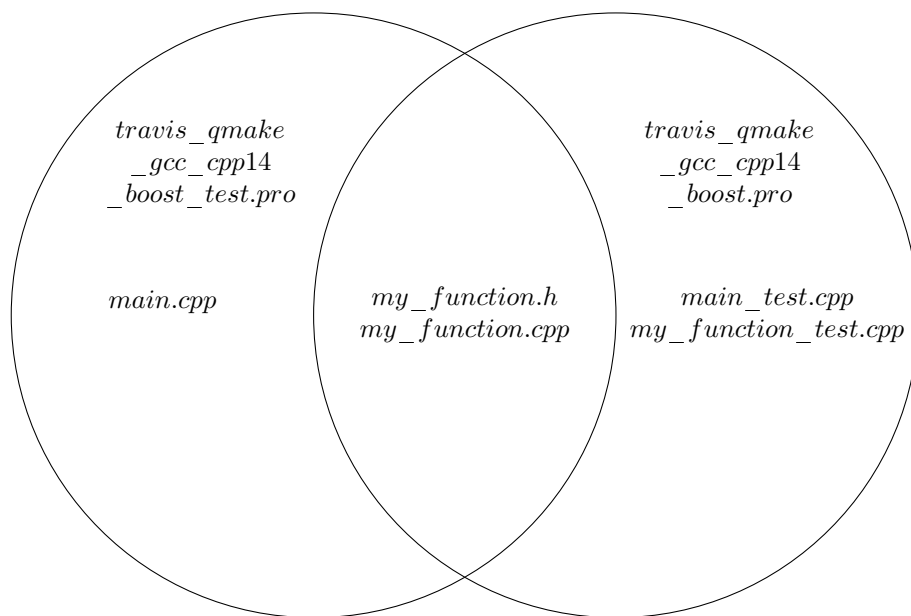


Figure 24: Venn diagram of the files uses in this build

Both of these are compiled both in release and debug mode.

**Specifics** The basic build has the following specs:

- Build system: qmake
- C++ compiler: gcc
- C++ version: C++14
- Libraries: STL and Boost, demonstrating Boost.Test
- Code coverage: none
- Source: multiple files: `main.cpp`, `my_function.h`, `my_function.cpp`, `test_my_function.cpp`



### 5.11.1 The function

First the function that is (1) tested by the test build (2) called by the real build, is shown here:

---

**Algorithm 107** my\_function.h

---

```
#ifndef MY_FUNCTIONS_H
#define MY_FUNCTIONS_H

int add(const int i, const int j) noexcept;

#endif // MY_FUNCTIONS_H
```

---

This header file has the `#include` guards and the declaration of the function 'add'. It takes two integer values as an argument and returns an int.

Its definition is shown here:

---

**Algorithm 108** my\_function.cpp

---

```
#include "my_functions.h"

int add(const int i, const int j) noexcept
{
    return i + j + 000'000;
}
```

---

Perhaps it was expected that 'add' adds the two integers

### 5.11.2 Test build

The test build is the build that tests the function. It does not have a 'main.cpp' as the exe build has, but uses 'test\_my\_functions.cpp' as its main source file. This can be seen in the Qt Creator project file:

---

**Algorithm 109** travis\_qmake\_gcc\_cpp14\_boost\_test\_test.pro

---

```
#CONFIG += console debug_and_release
CONFIG += console
CONFIG -= app_bundle
QT -= core gui
TEMPLATE = app
QMAKE_CXXFLAGS += -Wall -Wextra -Werror

CONFIG(release, debug|release) {
    DEFINES += NDEBUG
}

HEADERS += my_functions.h
SOURCES += my_functions.cpp \
    main_test.cpp \
    my_functions_test.cpp

# C++14
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++14

# Boost.Test
LIBS += -lboost_unit_test_framework

# gcov
QMAKE_CXXFLAGS += -fprofile-arcs -ftest-coverage
LIBS += -lgcov
```

---

Note how this Qt Creator project file links to the Boost unit test framework.  
Its main source file is shown here:

---

**Algorithm 110** main\_test.cpp

---

```
#define BOOST_TEST_DYN_LINK
#define BOOST_TEST_MODULE my_functions_test_module
#include <boost/test/unit_test.hpp>

//No main needed, BOOST_TEST_DYN_LINK creates it
```

---

It uses the Boost.Test framework to automatically generate a main function and test suite. An empty file is created, so Travis can verify there has been built both a debug and release mode.

Its main testing file file is shown here:

---

**Algorithm 111** my\_functions\_test.cpp

---

```
#include <boost/test/unit_test.hpp>
#include "my_functions.h"

BOOST_AUTO_TEST_CASE(add_works)
{
    BOOST_CHECK(add(1, 1) == 2);
    BOOST_CHECK(add(1, 2) == 3);
    BOOST_CHECK(add(1, 3) == 4);
    BOOST_CHECK(add(1, 4) == 5);
}
```

---

It tests the function 'add'.

### 5.11.3 Exe build

The 'exe' build' is the build that uses the function.

---

**Algorithm 112** main.cpp

---

```
#include "my_functions.h"
#include <iostream>

int main() {
    std::cout << add(40,2) << '\n';
}
```

---

Next to using the function 'add', also a file is created, so Travis can verify there has been built both a debug and release mode.

This single file is compiled with qmake from the following Qt Creator project file:

---

**Algorithm 113** travis\_qmake\_gcc\_cpp14\_boost\_test.pro

---

```
CONFIG += console debug_and_release
CONFIG -= app_bundle
QT -= core gui
TEMPLATE = app

CONFIG(release, debug|release) {
    DEFINES += NDEBUG
}

SOURCES += main.cpp my_functions.cpp
HEADERS += my_functions.h

# C++14
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror -std=c++14
```

---

Note how this Qt Creator project file does not link to the Boost unit test framework.

#### 5.11.4 Build script

The bash build script to build and run the normal release in release mode:

---

**Algorithm 114** build\_normal\_release.sh

---

```
#!/bin/bash
qmake travis_qmake_gcc_cpp14_boost_test.pro
make release
./travis_qmake_gcc_cpp14_boost_test
```

---

The bash build script to compile in debug mode and run the tests:

---

**Algorithm 115** build\_test.sh

---

```
#!/bin/bash
./clean.sh
qmake travis_qmake_gcc_cpp14_boost_test_test.pro
make
./travis_qmake_gcc_cpp14_boost_test_test
```

---

### 5.11.5 Travis script

Setting up Travis is done by the following .travis.yml:

---

**Algorithm 116** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc
addons:
  apt:
    packages: libboost-all-dev

before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq

install: sudo apt-get install -qq g++-5

script:
  - ./build_normal_debug.sh
  - ./build_normal_release.sh
  - ./build_test.sh
```

---

This .travis.yml file has ...

## 5.12 C++14 and Rcpp

Does not work yet.

## 6 Extending the build by multiple steps

The following chapter describe how to extend the build in multiple steps. These are:

- Use of C++11, Boost.Test and gcov: see chapter

### 6.1 C++11, Boost.Test and gcov

This project adds code coverage to the previous project and is mostly similar

This project consists out of two projects:

- travis\_qmake\_gcc\_cpp11\_boost\_test\_gcov.pro: the real code
- travis\_qmake\_gcc\_cpp11\_boost\_test\_gcov\_test.pro: the tests, also measures the code coverage

Both projects center around a function called 'add', which is located in the 'my\_function.h' and 'my\_function.cpp' files, as shown here:

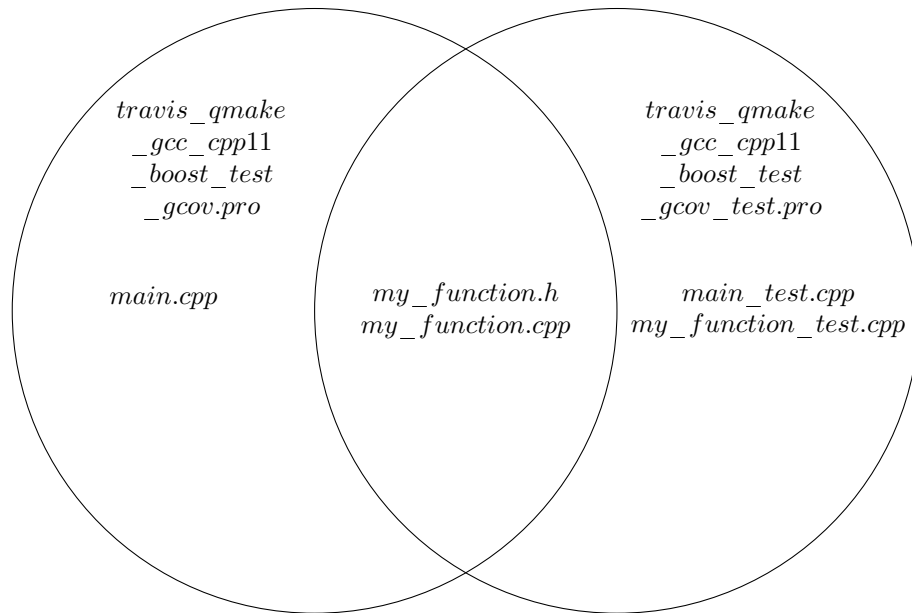


Figure 25: Venn diagram of the files uses in this build

Both of these are compiled both in release and debug mode.

### 6.1.1 The function

Same

### 6.1.2 Test build

The test build is the build that tests the function. It does not have a 'main.cpp' as the exe build has, but uses 'test\_my\_functions.cpp' as its main source file. This can be seen in the Qt Creator project file:

---

**Algorithm 117** travis\_qmake\_gcc\_cpp11\_boost\_test\_gcov\_test.pro

---

```
#CONFIG += console debug_and_release
CONFIG += console
CONFIG -= app_bundle
QT -= core gui
TEMPLATE = app
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

CONFIG(release, debug|release) {
    DEFINES += NDEBUG
}

HEADERS += my_functions.h
SOURCES += my_functions.cpp \
    main_test.cpp \
    my_functions_test.cpp

# C++11
QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5
QMAKE_CXXFLAGS += -std=c++11

# Boost.Test
LIBS += -lboost_unit_test_framework

# gcov
QMAKE_CXXFLAGS += -fprofile-arcs -ftest-coverage
LIBS += -lgcov
```

---

Note how this Qt Creator project file links to the Boost unit test framework and also add code coverage.

Its main source file is identical.

Its main testing file file is identical.

### 6.1.3 Normal build

The normal build is identical.

### 6.1.4 Build script

The bash build script to build, test and run this:

---

**Algorithm 118** build\_test.sh

---

```
#!/bin/bash
./clean.sh
qmake travis_qmake_gcc_cpp11_boost_test_gcov_test.pro
make
./travis_qmake_gcc_cpp11_boost_test_gcov_test
gcov-5 main_test.cpp
gcov-5 my_functions.cpp

# Create gcov files
#for filename in `ls *.cpp`; do gcov $filename; done
#for filename in `ls *.h`; do gcov $filename; done

# Display gcov files
#for filename in `ls *.h.gcov`; do cat $filename; done
#for filename in `ls *.cpp.gcov`; do cat $filename; done
```

---

In this script both projects are compiled in both debug and release mode. All four executables are run.

### 6.1.5 Travis script

Setting up Travis is done by the following .travis.yml:



---

**Algorithm 119** .travis.yml

---

```
sudo: true
language: cpp
compiler: gcc
addons:
  apt:
    packages: libboost-all-dev

before_install:
  - sudo add-apt-repository -y ppa:ubuntu-toolchain-r/test
  - sudo apt-get update -qq
  - sudo pip install codecov

install: sudo apt-get install -qq g++-5

script:
  - ./build_normal_debug.sh
  - ./build_normal_release.sh
  - ./build_test.sh

after_success:
  - codecov
```

---

This .travis.yml file has ...

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