

Travis C++ tutorial

Richèl Bilderbeek

April 17, 2016



Contents

1	Introduction	5
1.1	License	5
1.2	Continuous integration	5
1.3	Tutorial style	6
1.4	This tutorial	6
1.5	Acknowledgements	6
1.6	Collaboration	7
1.7	Feedback	7
2	Setting up the basic build	7
2.1	Create a GitHub online	7
2.2	Bring the git repository to your local computer	12
2.3	Create a Qt Creator project	13
2.4	Create the build bash scripts	15
3	The basic build	15
3.1	What is a C++98 'Hello world' program?	15
3.2	The Travis file	16
3.3	The build bash script	16
3.4	Qt Creator project file	17
3.5	C++ source file	18

4	Extending the build by one step	18
4.1	Use of debug and release build	19
4.1.1	What are debug and release builds?	19
4.1.2	The Travis file	19
4.1.3	The build bash scrips	20
4.1.4	The Qt Creator project file	20
4.1.5	The source files	21
4.2	Use of C++11	21
4.2.1	What is C++11?	21
4.2.2	The Travis file	21
4.2.3	The build bash scrips	23
4.2.4	The Qt Creator project file	23
4.2.5	The source files	24
4.2.6	What is noexcept?	24
4.3	Use of C++14	24
4.3.1	The Travis file	24
4.3.2	The build bash scrips	25
4.3.3	The Qt Creator project files	25
4.3.4	The source files	26
4.4	Adding Boost	26
4.4.1	What is Boost?	26
4.4.2	The Travis file	26
4.4.3	The build bash scrips	27
4.4.4	The Qt Creator project files	27
4.4.5	The source files	28
4.5	Adding Boost.Test	28
4.6	Use of clang	28
4.6.1	What is Clang?	28
4.6.2	The Travis file	28
4.6.3	The build bash scrip	29
4.6.4	The Qt Creator project files	29
4.6.5	The source files	30
4.7	Adding gcov and Codecov	30
4.7.1	What is gcov?	30
4.7.2	What is Codecov?	30
4.7.3	The Travis file	30
4.7.4	The build bash scrips	31
4.7.5	The Qt Creator project files	32
4.7.6	The source files	33
4.8	Adding profiling	33
4.9	Adding the Qt library	33
4.10	Adding the Qt4 library	34
4.10.1	What is Qt4?	34
4.10.2	The Travis file	34
4.10.3	What is xvfb?	34
4.10.4	The build bash scrips	35

4.10.5	The Qt Creator project files	35
4.10.6	The source files	35
4.11	Adding the Qt5 library	37
4.11.1	What is Qt5?	37
4.11.2	The Travis file	37
4.11.3	The build bash scrips	38
4.11.4	The Qt Creator project files	38
4.11.5	The source files	39
4.12	Adding QTest	41
4.13	Adding Rcpp	41
4.13.1	Build overview	42
4.13.2	The Travis file	42
4.13.3	The build bash scrips	43
4.13.4	The Qt Creator project files	44
4.13.5	The C++ and R source files	45
4.13.6	The C++-only source files	46
4.13.7	The R-only source files	46
4.14	Adding the SFML library	47
4.14.1	The Travis file	47
4.14.2	The build bash scrips	48
4.14.3	The Qt Creator project files	48
4.14.4	The source files	49
4.15	Adding the Urho3D library	49
4.15.1	Build overview	50
4.15.2	The Travis file	50
4.15.3	The build bash scrips	51
4.15.4	The Qt Creator project files	51
4.15.5	The source files	52
4.16	Adding the Wt library	53
4.16.1	The Travis file	53
4.16.2	The build bash scrips	53
4.16.3	The Qt Creator project files	54
4.16.4	The source files	54
5	Extending the build by two steps	56
5.1	Use of gcov in debug mode only	56
5.2	Qt and QTest	57
5.2.1	What is QTest?	57
5.2.2	Do not use Boost.Test to test graphical Qt applications . .	57
5.2.3	The Travis file	58
5.2.4	The build bash scrips	58
5.2.5	The Qt Creator project files	59
5.2.6	The source files	59
5.3	C++11 and Boost libraries	63
5.4	C++11 and Boost.Test	65
5.4.1	The function	66

5.4.2	Test build	67
5.4.3	Exe build	69
5.4.4	Build script	70
5.4.5	Travis script	71
5.5	C++11 and clang	71
5.6	C++11 and gcov	73
5.6.1	The Travis file	73
5.6.2	The build bash scrips	74
5.6.3	The Qt Creator project files	75
5.6.4	The source files	75
5.7	C++11 and Qt	76
5.8	C++11 and Rcpp	79
5.8.1	C++ and R: the C++ function	80
5.8.2	C++: main source file	81
5.8.3	C++: Qt Creator project file	81
5.8.4	C++: build script	83
5.8.5	R: the R function	83
5.8.6	R: The R tests	84
5.8.7	R: script to install packages	84
5.8.8	The Travis script	85
5.9	C++11 and SFML	86
5.10	C++11 and Urho3D	88
5.11	C++11 and Wt	93
5.12	C++14 and Boost libraries	98
5.13	C++14 and Boost.Test	100
5.13.1	The function	101
5.13.2	Test build	101
5.13.3	Exe build	103
5.13.4	Build script	104
5.13.5	Travis script	105
5.14	C++14 and Rcpp	105
6	Extending the build by multiple steps	105
6.1	C++11 and use of gcov in debug mode only	105
6.1.1	Build overview	105
6.1.2	The Travis file	106
6.1.3	The build bash scrips	107
6.1.4	The Qt Creator project files	108
6.1.5	The source files	109
6.2	C++11, Boost.Test and gcov	111
6.2.1	The function	111
6.2.2	Test build	111
6.2.3	Normal build	112
6.2.4	Build script	112
6.2.5	Travis script	113

7	Troubleshooting	114
7.1	fatal error: Rcpp.h: No such file or directory	114
References		114
7.2	Name	116
7.2.1	What is Name?	116
7.2.2	The Travis file	116
7.2.3	The build bash scrips	116
7.2.4	The Qt Creator project files	116
7.2.5	The source files	116

1 Introduction

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

1.1 License

This tutorial is licensed under Creative Commons license 4.0.



Figure 1: Creative Commons license 4.0

All C++ code is licensed under GPL 3.0.



Figure 2: GPL 3.0

1.2 Continuous integration

Collaboration can be scary: the other(s)¹ 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

¹if not you

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.

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.

From Travis to source Every build, I start from Travis CI its point of view: 'What do I have to do?'. Usually Travis CI has to call at least one build bash script. After describing the Travis file, I will show those build files. Those build files usually invoke Qt Creator project files, which in turn combine source files to executables. It may feel that the best is saved for last, but I'd disagree: this is a Travis tutorial. I also think it makes up for a better narrative, to go from big to small.

1.4 This tutorial

This tutorial is available online at 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.

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 these projects. Each project contains at least one, but usually multiple files. These files can be put on your own hard disc, USB stick, or other storage devices. They could also be put at a central place, which is called a repository, so potentially others can also access these. GitHub is such a file 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 3 shows the GitHub homepage, <https://github.com>.

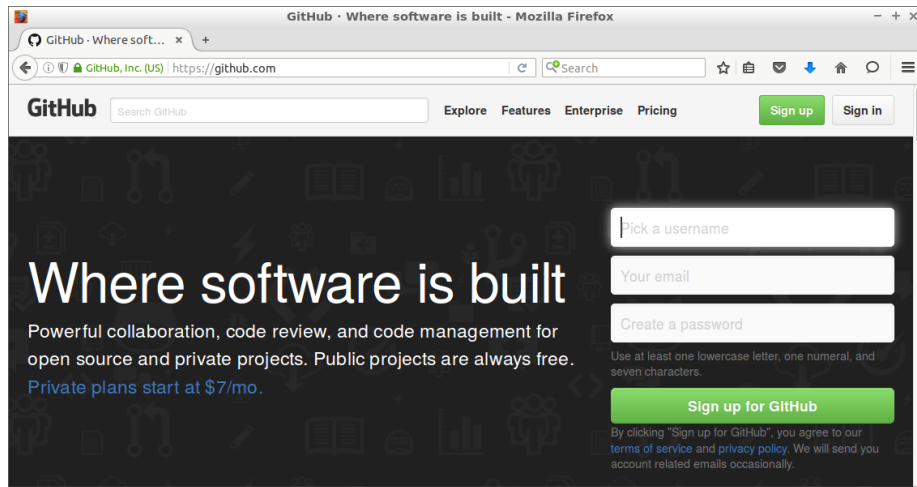


Figure 3: The GitHub homepage, <https://github.com>

Register Before you can create a new repository, you must register. Registration is free for open source projects, with an unlimited² amount of public repositories.

From the GitHub homepage, <https://github.com> (see figure 3), click the top right button labeled 'Sign up'. This will take you to the 'Join GitHub' page (see figure 4).

²the maximum I have observed is a person that has 350 repositories

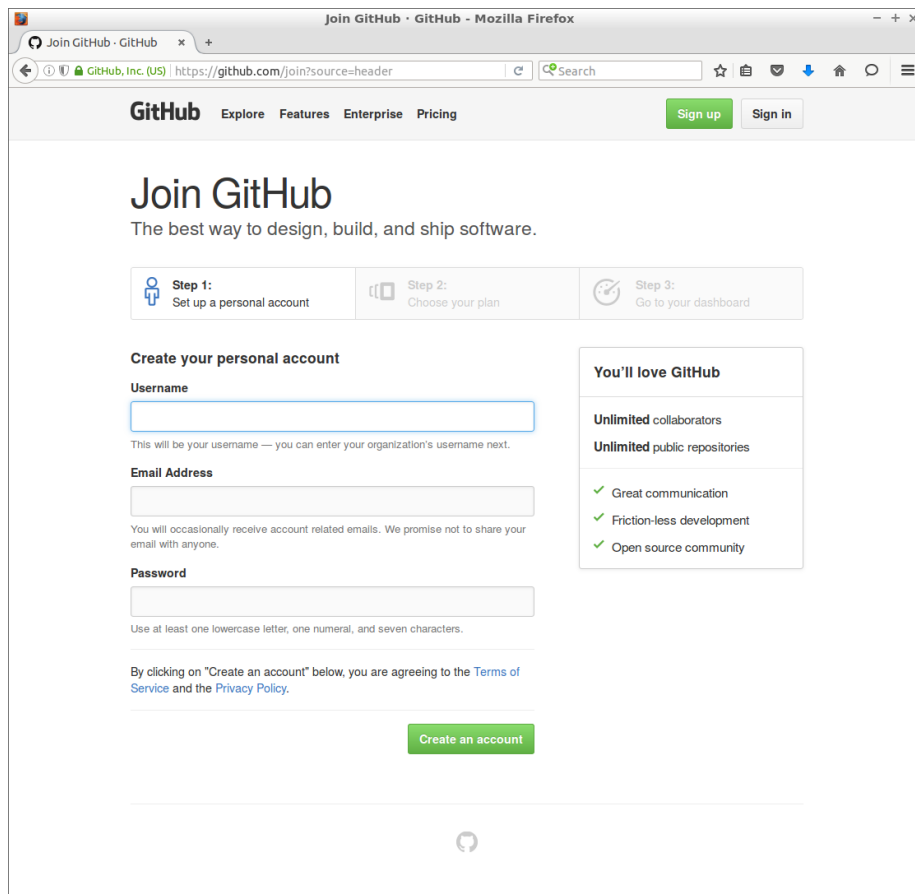


Figure 4: The join GitHub page

Filling this in should be as easy. After filling this in, you are taken to your GitHub profile page (figure 5).

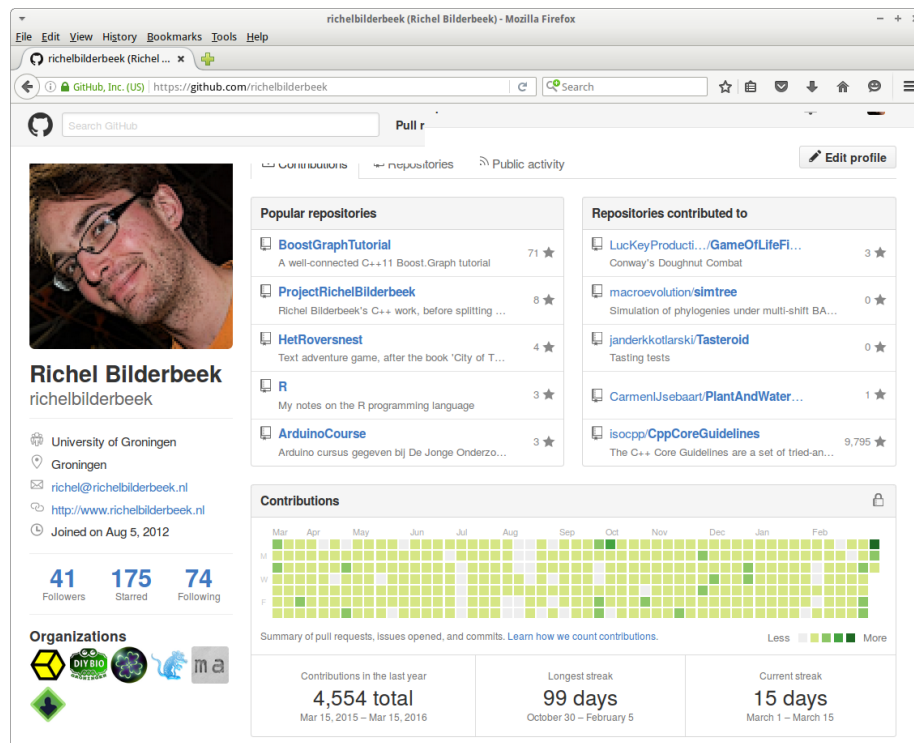


Figure 5: A GitHub profile page

Creating a repository From your GitHub profile page (figure 5), click on the plus ('Create new ...') at the top right, then click 'New repository' (figure 6).

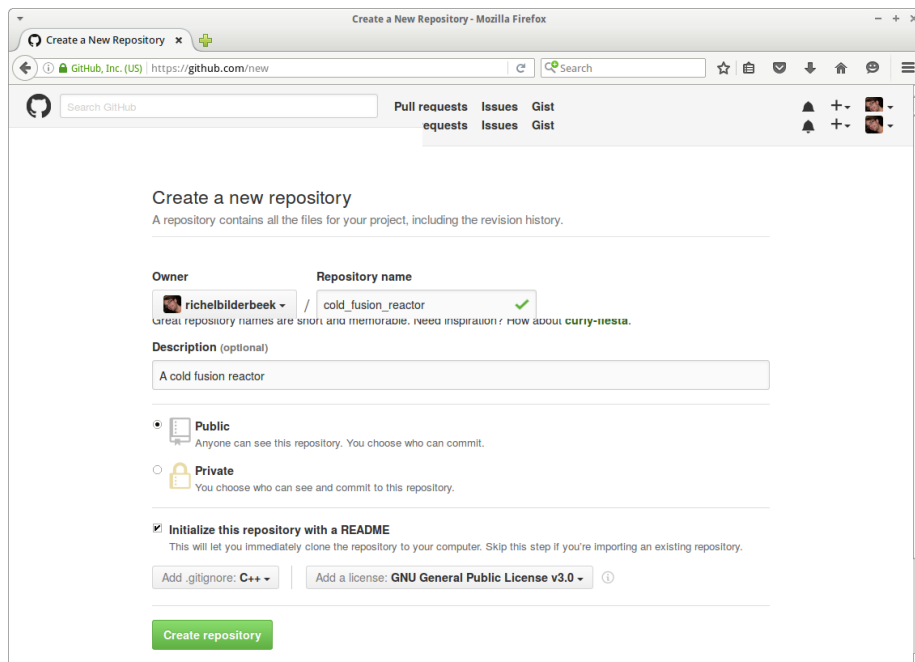


Figure 6: Create a GitHub repository

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

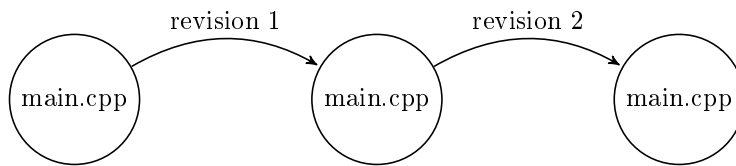


Figure 8: Multiple versions of main.cpp. git allows to always go back to each version of main

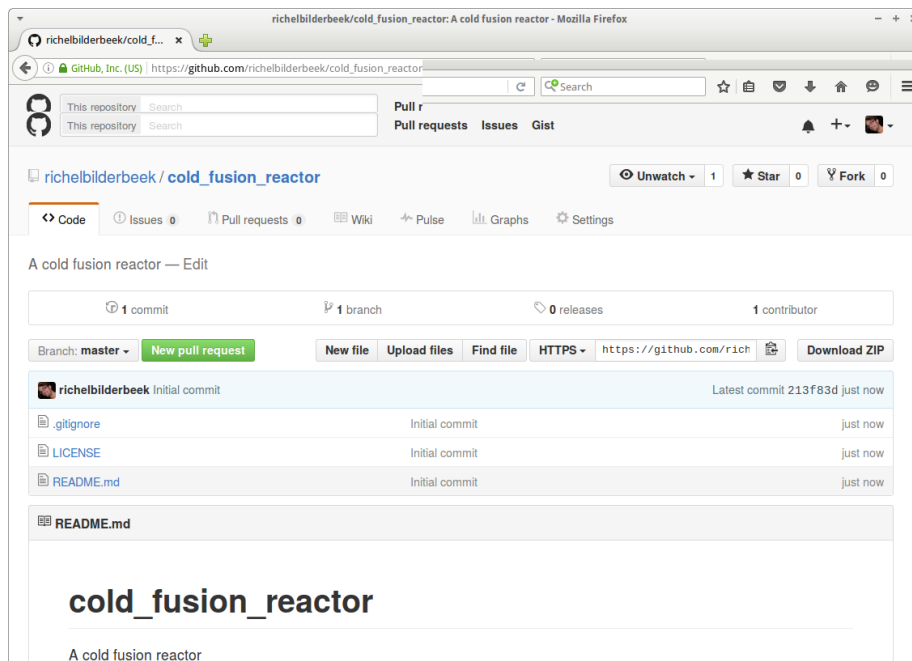


Figure 7: Created a GitHub repository

You have now created your own online version controlled repository (figure 7)!

2.2 Bring the git repository to your local computer

What is git? git is a version control system. It allows you keep a history of a file its content in time. It is the more convenient alternative of making copies before each modification.



Figure 9: git logo

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. A new folder called '[your_repository]' is created where you should work in. For example, to download this tutorial its repository to a folder called 'travis_cpp_tutorial':

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

2.3 Create a Qt Creator project

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



Figure 10: Qt creator logo

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

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.

Two big circles: 'C++ Project' and 'executable'

Within first circle: two smaller circles: .cpp and .h

Arrow from first to second circle with text 'compiler, linker'

Figure 11: Overview of converting a C++ project to an executable

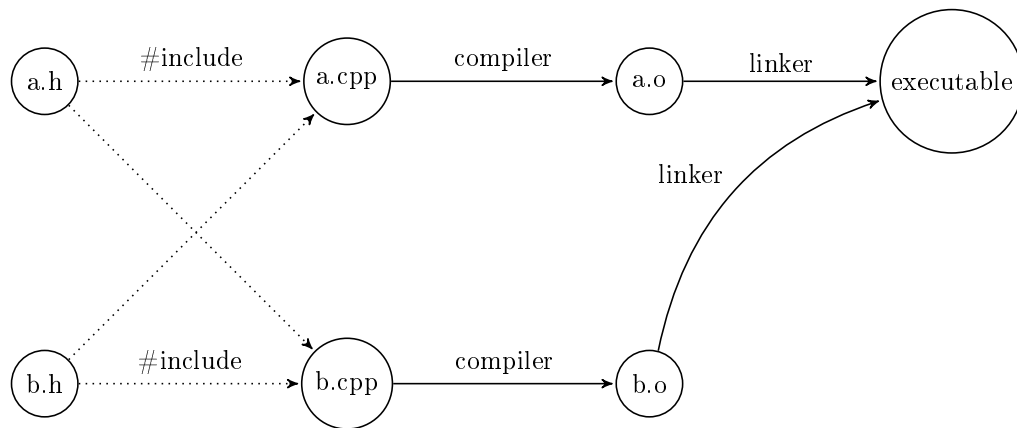


Figure 12: From files to executable. The compiler converts source (.cpp) files to object (.o) files. The linker uses these object files to create one executable

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

Two upper circles: '.pro' -> 'Makefile'

Two lower circles: '.cpp' and '.h', both -> to .pro, both dotted line to 'Makefile'

Figure 13: What qmake does

What is make? make is a tool that reads a makefile and creates an executable

'Makefile' -[make]> 'executable'

Figure 14: What make does

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



Figure 15: GCC logo

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

This basic build consists of a 'Hello World' program, written in C++98. It uses the Qt Creator default settings: Qt Creator will create a Qt Creator project file, which in turn will use GCC.

- What is a C++98 'Hello world' program? See chapter 3.1
- The Travis build file. See chapter 3.2
- The build script. See chapter 3.3
- The Qt Creator project file. See chapter 3.4
- The source file. See chapter 3.5

3.1 What is a C++98 'Hello world' program?

A 'Hello World' program shows the text 'Hello world' on the screen. It is a minimal program. Its purpose is to show that all machinery is in place to create an executable from C++ source code.

A listing of a 'Hello world' program is shown at algorithm 4. Here I go through each line:

- `#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

3.2 The Travis file

Travis CI is set up by a file called '.travis.yml'. The filename starts with a dot, which means it is a hidden file on UNIX systems. The extension 'yml' is an abbreviation of 'Yet another Markup Language'.

The '.travis.yml' file to build and run a 'Hello world' program looks like this:

Algorithm 1 .travis.yml

```
language: cpp
compiler: gcc
script:
- ./build.sh
- ./travis_qmake_gcc_cpp98
```

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 (What is GCC? See chapter 2.3)

- script:
 - ./build.sh
 - ./travis_qmake_gcc_cpp98

The script that Travis will run. In this case, it will execute the 'build.sh' bash script, that should build the executable. Then, the (hopefully) created executable called 'travis_qmake_gcc_cpp98' is run

This build script can fail in in two places:

1. The bash script can fail, which is discussed in chapter 3.3
2. The executable can return an error code. A 'Hello World' program is intended to return the error code for 'everything went fine'. Other programs in this tutorial return error codes depending on test cases. It may also be that dynamically linked libraries cannot be found, which crashes the program at startup

3.3 The build bash script

The bash build script used to build the executable of a 'Hello world' program looks like this:

Algorithm 2 build.sh

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

This build script calls:

- `#!/bin/bash`

This line indicates the script is a bash script. The `'#!'`, (also called the 'shebang') is a directive to use the executable at the absolute path following it. In this script, 'bash' is used, which resides in the `'/bin'` folder

- `qmake`

'qmake' is called to create a makefile (What is 'qmake'? See chapter 2.3) from the only Qt Creator project file. In this build, the name of this project file is omitted, as there is only one, but there are chapters in this tutorial where the project name is mentioned explicitly. Note that currently, qmake uses Qt4 (What is Qt4? see chapter 4.10.1)

- `make`

'make' is called to compile the makefile (What is 'make'? See chapter 2.3). In this build, 'make' is called without any arguments, but there are chapters in this tutorial where 'make' is called with arguments

This bash script can fail in two places:

1. If the Qt Creator project file is incorrectly formed, 'qmake' will fail, and as it cannot create a valid makefile
2. If the Qt Creator project file is incomplete (for example: by omitting libraries), 'make' will fail. 'qmake' has created a makefile, after which 'make' finds out that it cannot create an executable with that makefile

3.4 Qt Creator project file

The following Qt Creator project file is used in this 'Hello world' build:

Algorithm 3 travis_qmake_gcc_cpp98.pro

```
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror
```

This Qt Creator project file has the following elements:

- `SOURCES += main.cpp`

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

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

The project is checked with all warnings ('-Wall'), with extra warnings ('-Wextra') and with the Effective C++ [1] advices ('-Werror') enforced. A warning is treated as an error ('-Werror'). This forces you (and your collaborators) to write tidy code.

3.5 C++ source file

The single C++ source file used in this 'Hello world' build is:

Algorithm 4 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. See 3.1 for a line-by-line explanation. The code is written in C++98 (What is C++98? See chapter 2.3). 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.

4 Extending the build by one step

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

- Use a debug and release build: see chapter 4.1
- Use of C++11: see chapter 4.2
- Use of C++14: see chapter 4.3
- Use of Boost: see chapter 4.4
- Use of Boost.Test: see chapter 4.5
- Use of clang: see chapter 4.6
- Use of gcov and Codecov: see chapter 4.7

- Use of gprof: see chapter 4.8
- Use of Qt: see chapter 4.9
- Use of Qt4: see chapter 4.9
- Use of Qt5: see chapter 4.9
- Use of QTest: see chapter 4.12
- Use of Rcpp: see chapter 4.13
- Use of SFML: see chapter 4.14
- Use of Urho3D: see chapter 4.15
- Use of Wt: see chapter 4.16

4.1 Use of debug and release build

This example shows how to use Travis to create a debug and release build.

4.1.1 What are debug and release builds?

A debug build means that the executable is created in such a way that helps in debugging it. For example, assert statements are only present in debug builds.

A release build means that the executable is created in a way that allows it to run quicker and have a smaller file size. For example, assert statements are removed from the source code in a release build.

4.1.2 The Travis file

The Travis file has to do more things now, as it has to create and run two different builds.

Here is how that looks like:

Algorithm 5 .travis.yml

```
language: cpp
compiler: gcc

script:
- ./build_debug.sh
- ./travis_qmake_gcc_cpp98_debug_and_release
- ./clean.sh
- ./build_release.sh
- ./travis_qmake_gcc_cpp98_debug_and_release
```

This .travis.yml file is rather self-explanator: it builds a debug version, and runs it. After cleaning up, it builds a release version and runs it.

4.1.3 The build bash scripts

Both build modes have their own build script. They are very similar to the one described in chapter 3.3:

Algorithm 6 build_debug.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp98_debug_and_release.pro
make debug
```

Algorithm 7 build_release.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp98_debug_and_release.pro
make release
```

The only difference is the added extra parameter to 'make', which is 'debug' for the debug build, and 'release' for the release build.

4.1.4 The Qt Creator project file

The Qt Creator project file has to allow for the two different builds. It does so as follows:

Algorithm 8 travis_qmake_gcc_cpp98_debug_and_release.pro

```
SOURCES += main.cpp

# Debug and release mode
CONFIG += console debug_and_release
CONFIG(release, debug|release) {
    DEFINES += NDEBUG
}
```

Next to setting 'main.cpp' as the only source file, these lines are new:

- `CONFIG += console debug_and_release`
Create a debug and release makefiles
- `CONFIG(release, debug|release) {`
 `DEFINES += NDEBUG`
}

In the release makefile only, the preprocessor symbol 'NDEBUG' is #defined. This, among others, will remove all assert statements

4.1.5 The source files

This build uses a 'Hello world'-like program that shows and proves the mode in which it is built:

Algorithm 9 main.cpp

```
#include <cassert>
#include <iostream>

int main() {
    #ifdef NDEBUG
        std::cout << "Release_mode" << '\n';
        assert(1==2);
    #else
        std::cout << "Debug_mode" << '\n';
        assert(1+1==2);
    #endif
}
```

It will show in text the build type. Next to this, an assert is called. In release mode, the known-to-be-false assert statement is removed. In debug mode, the known-to-be-true assert statement is left in.

4.2 Use of C++11

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

4.2.1 What is C++11?

C++11 is the C++ standard formalized in 2011. Its working title was C++0x, as then it was assumed that the standard would be finished in 200x. C++11 is fully backwards compatible with C++98. One of the major new features of C++11 is the introduction of move semantics, which results in faster runtime code, by possibly reducing needless copies of objects. In my examples, I typically use the C++11 'noexcept' keyword. This is a modifier that specifies that a (member) function cannot throw an exception (and if it would, it would terminate the program).

4.2.2 The Travis file

The default Travis CI setup is not sufficient to use C++11 (yet). Travis CI by default uses a LTS repository, as these is the most stable and reliable. The

version of g++ in that repository is version 4.6.3, which does not support C++11. To use C++11, we will first add a fresher (less stable) repository. Then we can install g++-5, that does support C++11.

Here is how that looks like:

Algorithm 10 .travis.yml

```
sudo: require
language: cpp
compiler: gcc

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

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

script:
- ./build.sh
- ./travis_qmake_gcc_cpp11
```

This .travis.yml file has some new features:

- `sudo: require`

For this build, we need super user rights. When you need super user rights, the build will be slower.

- `before_install:`

The following events will take place before installation

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

A new apt repository is added. The '-yes' explicitly states that we are sure we want to do this. Without the '-yes' 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

In the script, the code is built and then run.

4.2.3 The build bash scripts

The bash build script is identical to the basic build script, as described in chapter 3.3:

Algorithm 11 build.sh

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

4.2.4 The Qt Creator project file

The Qt Creator project file by default calls 'g++' with its default C++ standard. In this build, we will have to let it call g++-5 with the C++11 standard:

Algorithm 12 travis_qmake_gcc_cpp11.pro

```
# Project files
SOURCES += main.cpp

# Compile at high warning levels, a warning is an error
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
```

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

Except for this, all is just the same.

4.2.5 The source files

This build uses a 'Hello world'-like program that uses C++11:

Algorithm 13 main.cpp

```
#include <iostream>

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

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

It will show the text 'Hello world' on screen.

The keyword 'noexcept' (What is noexcept? See chapter 4.2.6) does not exist in C++98 and it will fail to compile. This code will compile under newer versions of C++.

4.2.6 What is noexcept?

'noexcept' is a C++11 keyword. It is used to specify that a (member) function will not throw an exception. Would that function throw an exception anyhow, the program is terminated.

4.3 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 that was formalized in 2014. It is fully backwards compatible with C++11 and C++98. It does not have any major new features, and mostly extends C++11 features.

In my examples, I usually add digit separators: instead of '1000', in C++14 one can write '1'000', using a single quote as a separator. This will not compile in C++11.

4.3.1 The Travis file

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

Algorithm 14 .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
  - ./travis_qmake_gcc_cpp14
```

This .travis.yml file is the same as the C++11 build in chapter 4.2

4.3.2 The build bash scrips

The bash build script to build and run this:

Algorithm 15 build.sh

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

The bash script is identical to the basic build script (see chapter 3.3)

4.3.3 The Qt Creator project files

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

Algorithm 16 travis_qmake_gcc_cpp14.pro

```
SOURCES += main.cpp

# Compile with high warning levels, a warning is an error
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

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



Figure 16: Boost logo

The Qt Creator project file has the same lines as the C++11 build in chapter 4.2, except for that it uses one different `QMAKE_CXXFLAGS` item:

- `QMAKE_CXXFLAGS += -std=c++14`

Compile under C++14

4.3.4 The source files

The single C++ source file used is:

Algorithm 17 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.

4.4 Adding Boost

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

4.4.1 What is Boost?

Boost is a collection of C++ libraries

4.4.2 The Travis file

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

Algorithm 18 `.travis.yml`

```
language: cpp
compiler: gcc

addons:
  apt:
    packages: libboost-all-dev

script:
  - ./build.sh
  - ./travis_qmake_gcc_cpp98_boost
```

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

4.4.3 The build bash scripts

The bash build script to build and run this:

Algorithm 19 `build.sh`

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

The bash script is identical to the basic build script as in chapter 3.3.

4.4.4 The Qt Creator project files

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

Algorithm 20 `travis_qmake_gcc_cpp98_boost.pro`

```
SOURCES += main.cpp
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror
```

The Qt Creator project file has the same lines as the basic project in chapter 3.4.



Figure 17: clang logo

4.4.5 The source files

The single C++ source file used is:

Algorithm 21 main.cpp

```
#include <iostream>
#include <boost/version.hpp>

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

All the file does is display the version of Boost on the screens. It will only compile when the Boost libraries are present.

Currently, on Travis CI, the default Boost version is 1.46.1.

4.5 Adding Boost.Test

Adding only a testing framework does not work: it will not compile in C++98. Instead, this is covered in chapter 5.4.

4.6 Use of clang

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

4.6.1 What is Clang?

clang is a C++ compiler

4.6.2 The Travis file

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

Algorithm 22 .travis.yml

```
language: cpp
compiler: gcc

addons:
  apt:
    packages: clang

script:
  - ./build.sh
  - ./travis_qmake_clang_cpp98
```

This .travis.yml file uses the package clang (without needing sudo), compiles the program and then runs it.

4.6.3 The build bash scrip

The bash build script to build this:

Algorithm 23 build.sh

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

The bash script is identical to the basic bash script as described in chapter 3.3.

4.6.4 The Qt Creator project files

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

Algorithm 24 travis_qmake_clang_cpp98.pro

```
SOURCES += main.cpp

# Compile at a high warning level, a warning is an error
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

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



Figure 18: Codecov logo

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

4.6.5 The source files

The single C++ source file used is:

Algorithm 25 main.cpp

```
#include <iostream>

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

This is just a 'Hello world' program, as discussed in detail in chapter .

4.7 Adding gcov and Codecov

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

4.7.1 What is gcov?

gcov is a tool that works with GCC to analyse code coverage

4.7.2 What is Codecov?

Codecov works nice with GitHub and give nicer reports

4.7.3 The Travis file

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

Algorithm 26 .travis.yml

```
sudo: require
language: cpp
compiler: gcc

before_install:
- sudo pip install codecov

script:
- ./build.sh
- ./travis_qmake_gcc_cpp98_gcov
- ./get_code_cov.sh
- codecov
```

This .travis.yml file has some new features:

- `sudo: require`

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

4.7.4 The build bash scrips

The bash build script to build this:

Algorithm 27 build.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp98_gcov.pro
make
```

This build scripy is identical to the basic build its build script.
The bash build to measure the code coverage:

Algorithm 28 `get_code_cov.sh`

```
#!/bin/bash
GCOV_EXE=gcov # gcov and g++ versions must match
#GCOV_EXE=gcov-5 # gcov and g++ versions must match

OBJ_FILES_PATH=.

if [ ! -d "$OBJ_FILES_PATH" ]
then
    echo "Object_file_path_not_found_at_$OBJ_FILES_PATH"
    exit 1
fi

for filename in `find . | egrep '\.cpp'`; do $GCOV_EXE -n
    -o $OBJ_FILES_PATH $filename > /dev/null; done
```

This script ...

4.7.5 The Qt Creator project files

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

Algorithm 29 `travis_qmake_gcc_cpp98_gcov.pro`

```
SOURCES += main.cpp

# Compile with a high warning level, a warning is an error
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

4.7.6 The source files

The C++ source file used by the normal build is:

Algorithm 30 main.cpp

```
#include <iostream>

///Returns the value of x multiplied by 2, except for 42,
    which is multiplied by one
int do_magic(const int x)
{
    if (x == 42)
    {
        return 42;
    }
    return x * 2;
}

int main()
{
    std::cout << do_magic(2) << '\n';
    //Forgot to test do_magic(42)
}
```

It defines a function called 'do_magic'. It is called for the value two, but not for the value 42. Due to this, we expect to see an incomplete code coverage.

4.8 Adding profiling

4.9 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.



Figure 19: Qt logo

At this moment, there are two versions of Qt: Qt4 and Qt5. The GNU/Linux version Travis CI uses has Qt4. When this GNU/Linux distro changes, Qt5 will be the new (next) default.

4.10 Adding the Qt4 library

4.10.1 What is Qt4?

4.10.2 The Travis file

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

Algorithm 31 `.travis.yml`

```
language: cpp
compiler: gcc
```

```
# Start virtual X server, from https://docs.travis-ci.com/user/gui-and-headless-browsers/
before_script:
  - "export DISPLAY=:99.0"
  - "sh -e /etc/init.d/xvfb start"
  - sleep 3 # give xvfb some time to start
```

```
script:
  - ./build.sh
  - ./travis_qmake_gcc_cpp98_qt4
```

This `.travis.yml` file starts xvfb before the script. In the script, it builds the code first, before running the resulting executable.

4.10.3 What is xvfb?

xvfb is the virtual X server.

4.10.4 The build bash scrips

The bash build script to build this:

Algorithm 32 build.sh

```
#!/bin/bash
qmake-qt4
make
```

The bash script is close to the bash script of the basic build (see chapter 3.3). Instead of calling 'qmake', however, it explicitly calls 'qmake-qt4'.

4.10.5 The Qt Creator project files

This project is compiled from the following Qt Creator project file:

Algorithm 33 travis_qmake_gcc_cpp98_qt4.pro

```
QT      += core gui

# Cannot use -Weffc++ with Qt4
QMAKE_CXXFLAGS += -Wall -Wextra -Werror

SOURCES += main.cpp
SOURCES += my_dialog.cpp
FORMS    += my_dialog.ui
HEADERS  += my_dialog.h

RESOURCES += travis_qmake_gcc_cpp98_qt4.qrc
```

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

4.10.6 The source files

The C++ source files used are:
main function:

Algorithm 34 main.cpp

```
#include <QApplication>
#include "my_dialog.h"

int main(int argc, char *argv[])
{
    QApplication a(argc, argv);
    my_dialog d;
    d.show();
    return a.exec();
}
```

my_dialog header:

Algorithm 35 my_dialog.h

```
#ifndef MY_DIALOG_H
#define MY_DIALOG_H

#include <QDialog>

namespace Ui {
    class my_dialog;
}

class my_dialog : public QDialog
{
    Q_OBJECT

public:
    explicit my_dialog(QWidget *parent = 0);
    ~my_dialog();

private:
    Ui::my_dialog *ui;
};

#endif // MY_DIALOG_H
```

my_dialog implementation:

Algorithm 36 my_dialog.cpp

```
#include "my_dialog.h"
#include "ui_my_dialog.h"
#include <QTimer>

my_dialog::my_dialog(QWidget *parent) :
    QDialog(parent),
    ui(new Ui::my_dialog)
{
    ui->setupUi(this);
    QTimer * const timer(new QTimer(this));
    connect(timer, SIGNAL(timeout()), this, SLOT(close()));
    timer->setInterval(1000);
    timer->start();
}

my_dialog::~my_dialog()
{
    delete ui;
}
```

4.11 Adding the Qt5 library

4.11.1 What is Qt5?

4.11.2 The Travis file

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

Algorithm 37 .travis.yml

```
sudo: require
language: cpp
compiler: gcc

# From http://stackoverflow.com/questions/25737062/travis-ci-for-a-qt5-project#25743300
before_install:
  - sudo add-apt-repository --yes ppa:ubuntu-sdk-team/ppa
  - sudo apt-get update -qq

# From http://stackoverflow.com/questions/25737062/travis-ci-for-a-qt5-project#25743300
install:
  - sudo apt-get install qtbase5-dev qtdeclarative5-dev libqt5webkit5-dev libsqlite3-dev
  - sudo apt-get install qt5-default qttools5-dev-tools

# Start virtual X server, from https://docs.travis-ci.com/user/gui-and-headless-browsers/
before_script:
  - "export DISPLAY=:99.0"
  - "sh -e /etc/init.d/xvfb start"
  - sleep 3 # give xvfb some time to start

script:
  - ./build.sh
  - ./travis_qmake_gcc_cpp98_qt5
```

This .travis.yml file ...

4.11.3 The build bash scrips

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

Algorithm 38 build.sh

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

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

4.11.4 The Qt Creator project files

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

Algorithm 39 travis_qmake_gcc_cpp98_qt5.pro

```
QT      += core gui widgets

# Use highest warning level, a warning is an error.
# Cannot use -Weffc++ with Qt5
QMAKE_CXXFLAGS += -Wall -Wextra -Werror

SOURCES += main.cpp

SOURCES += my_qt5_dialog.cpp
FORMS    += my_qt5_dialog.ui
HEADERS  += my_qt5_dialog.h

RESOURCES += travis_qmake_gcc_cpp98_qt5.qrc
```

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

4.11.5 The source files

The C++ source files used are:
main function:

Algorithm 40 main.cpp

```
#include <QApplication>
#include "my_qt5_dialog.h"

int main(int argc, char *argv[])
{
    QApplication a(argc, argv);
    my_qt5_dialog d;
    d.show();
    return a.exec();
}
```

my_dialog header:

Algorithm 41 my_qt5_dialog.h

```
#ifndef MY_DIALOG_H
#define MY_DIALOG_H

#include <QDialog>

namespace Ui {
    class my_qt5_dialog;
}

class my_qt5_dialog : public QDialog
{
    Q_OBJECT

public:
    explicit my_qt5_dialog(QWidget *parent = 0);
    ~my_qt5_dialog();

private:
    Ui::my_qt5_dialog *ui;
};

#endif // MY_DIALOG_H
```

my_dialog implementation:



Figure 20: R logo

Algorithm 42 my_qt5_dialog.cpp

```
#include "my_qt5_dialog.h"
#include "ui_my_qt5_dialog.h"
#include <QTimer>

my_qt5_dialog::my_qt5_dialog(QWidget *parent) :
    QDialog(parent),
    ui(new Ui::my_qt5_dialog)
{
    ui->setupUi(this);
    QTimer * const timer(new QTimer(this));
    connect(timer,&QTimer::timeout, this, &my_qt5_dialog::
        close); //Qt5 syntax
    timer->setInterval(1000);
    timer->start();
}

my_qt5_dialog::~my_qt5_dialog()
{
    delete ui;
}
```

4.12 Adding QTest

One cannot use QTest without Qt. Because this thus takes two steps, this is covered in chapter .

4.13 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

4.13.1 Build overview

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

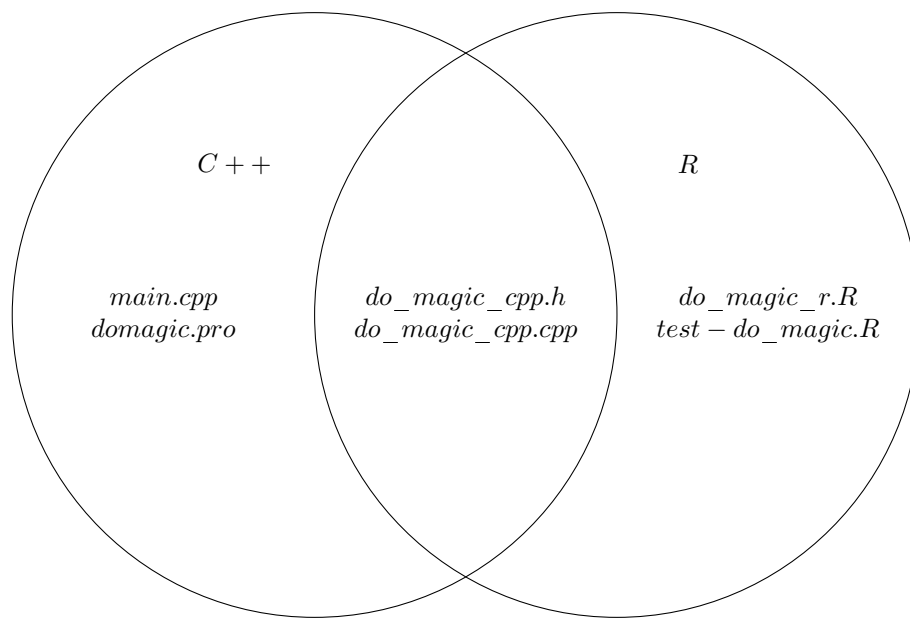


Figure 21: Venn diagram of the files uses in this build

4.13.2 The Travis file

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

Algorithm 43 .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.

4.13.3 The build bash scripts

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

Algorithm 44 build_cpp.sh

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

This script ...
This R build script installs the R packages.

Algorithm 45 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")
```

4.13.4 The Qt Creator project files

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

Algorithm 46 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.

4.13.5 The C++ and R source files

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 47 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 48 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.

4.13.6 The C++-only source files

The C++ program has a normal main function:

Algorithm 49 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.

4.13.7 The R-only source files

The R function 'do_magic_r' calls the C++ function 'do_magic_cpp':

Algorithm 50 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

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

Algorithm 51 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.

4.14 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

4.14.1 The Travis file

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



Figure 22: SFML logo

Algorithm 52 .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`

This makes Travis install the needed package.

4.14.2 The build bash scripts

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

Algorithm 53 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.

4.14.3 The Qt Creator project files

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



Figure 23: Urho3D logo

Algorithm 54 `travis_qmake_gcc_cpp98_sfml.pro`

```
SOURCES += main.cpp

# Compile with high warning levels, a warning is an error
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# SFML
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.

4.14.4 The source files

The single C++ source file used is:

Algorithm 55 `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.

4.15 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.

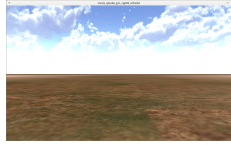


Figure 24: Screenshot of travis_qmake_gcc_cpp98_urho3d

4.15.1 Build overview

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

4.15.2 The Travis file

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
  - 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 ...

4.15.3 The build bash scrips

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

Algorithm 57 `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.

4.15.4 The Qt Creator project files

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

Algorithm 58 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.

4.15.5 The source 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



Figure 25: Wt logo

4.16 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.

4.16.1 The Travis file

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

Algorithm 59 `.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 ...

4.16.2 The build bash scrips

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

Algorithm 60 `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.

4.16.3 The Qt Creator project files

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

Algorithm 61 travis_qmake_gcc_cpp98_wt.pro

```
SOURCES += main.cpp

# Compile with high warning levels, a warning is an error
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

# Wt
LIBS += \
    -lboost_date_time \
    -lboost_filesystem \
    -lboost_program_options \
    -lboost_regex \
    -lboost_signals \
    -lboost_system
LIBS += -lwt -lwthttp
DEFINES += BOOST_SIGNALS_NO_DEPRECATED_WARNING
```

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

4.16.4 The source files

The single C++ source file used is:

Algorithm 62 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.drawPoint(x,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.

5 Extending the build by two steps

You will probably want to combine the single ingredients in the previous chapters. This will also result in more complex project setups. In this chapter, such setups will be described:

- Use of gcov in debug mode only: see chapter 5.1
- Use of Qt and QTest: see chapter
- Use of C++11 and Boost: see chapter 5.3
- Use of C++11 and Boost.Test: see chapter 5.4
- Use of C++14 and Boost: see chapter 5.12

5.1 Use of gcov in debug mode only

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

- The release build that just runs the code
- The debug build that measures code coverage

The filenames are shown in this figure:

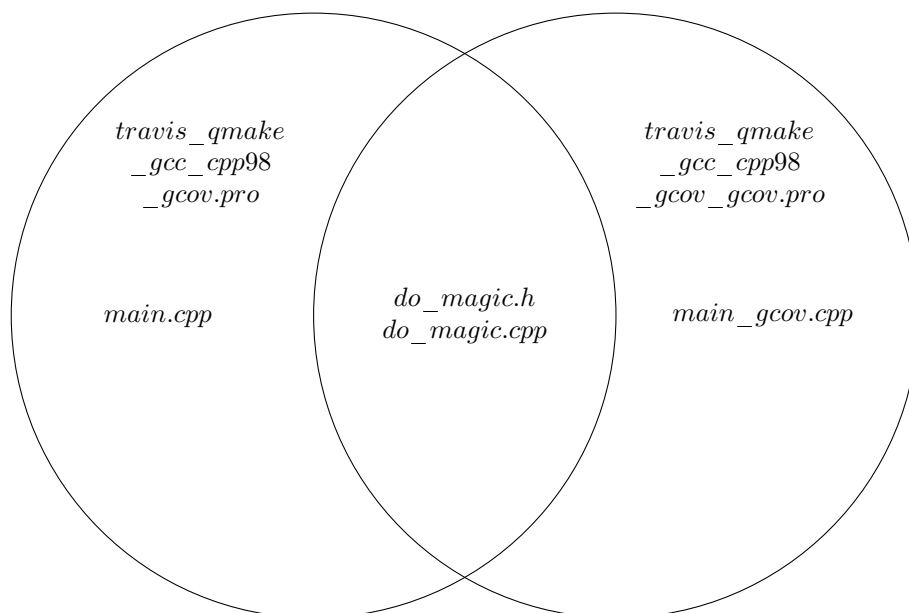


Figure 26: Venn diagram of the files uses in this build

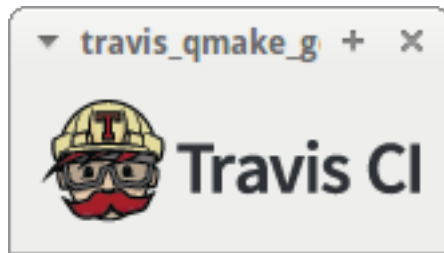


Figure 27: The application

5.2 Qt and QTest

This build is about a Qt dialog that displays an image (using a Qt resource). When the key 'x' is pressed, it should close.

The normal build is just that application.

The test build tests if the application indeed closes upon a press of the 'x' key. Its primary output is test report. During the test, the dialog will show up shortly.

In this build, only one dialog is tested. For a build that has more dialogs, see chapter .

5.2.1 What is QTest?

QTest is the Qt testing framework

5.2.2 Do not use Boost.Test to test graphical Qt applications

The Boost.Test library (see chapter 5.4) works great with console (that is: non-graphical) applications. But is is tedious to let it test graphical Qt classes.

Why is this tedious? Because Qt has its own Qt way, that works best in that way. QTest will process the QApplication event queue and have many privileges. Using Boost.Test will make you responsible to do yourself what Qt normally does for you in the back, such as emptying the QApplication event queue. Next to this, you will have to make some member functions public (e.g. keyPressedEvent) to allow your tests to use these.

5.2.3 The Travis file

Algorithm 63 .travis.yml

```
language: cpp
compiler: gcc

# Start virtual X server
before_script:
  - "export DISPLAY=:99.0"
  - "sh -e /etc/init.d/xvfb start"
  - sleep 3 # give xvfb some time to start

script:
  - ./build_test.sh
  - ./travis_qmake_gcc_cpp98_qt_qtest_test
  - ./build_normal.sh
```

Because this application uses graphics, we need to start a virtual X server on Travis CI (see <https://docs.travis-ci.com/user/gui-and-headless-browsers>), before the tests run.

In the script, the testing executable is created and run. The test results will be visible in Travis CI.

After the test, the normal executable is created. The normal executable is not run, as it requires user input. This means that on Travis CI, it would run forever, wouldn't Travis CI detect this and indicate a failure.

5.2.4 The build bash scripts

There need to be two bash scripts, one for building the testing executable, one for building the normal program. Both are as short as can be:

Algorithm 64 build_test.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp98_qt_qtest_test.pro
make
```

Algorithm 65 build_normal.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp98_qt_qtest.pro
make
```

5.2.5 The Qt Creator project files

There need to be two Qt Creator scripts, one for building the testing executable, one for building the normal program. Both are as short as can be. The only difference is that the testing project file uses 'QT += testlib'.

Test:

Algorithm 66 travis_qmake_gcc_cpp98_qt_qtest_test.pro

```
# Shared files
SOURCES += my_dialog.cpp
FORMS += my_dialog.ui
HEADERS += my_dialog.h
RESOURCES += travis_qmake_gcc_cpp98_qt_qtest.qrc

# Unique files
SOURCES += qtmain_test.cpp
SOURCES += my_dialog_test.cpp
HEADERS += my_dialog_test.h

# Qt
QT      += core gui
greaterThan(QT_MAJOR_VERSION, 4): QT += widgets

# QTest
QT += testlib
```

Normal:

Algorithm 67 travis_qmake_gcc_cpp98_qt_qtest.pro

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

# Shared files
SOURCES += my_dialog.cpp
FORMS += my_dialog.ui
HEADERS += my_dialog.h
RESOURCES += travis_qmake_gcc_cpp98_qt_qtest.qrc

# Unique files
SOURCES += qtmain.cpp
```

5.2.6 The source files

The dialog This is the source of dialog:

Algorithm 68 my_dialog.h

```
#ifndef MY_DIALOG_H
#define MY_DIALOG_H

#include <QDialog>

namespace Ui { class my_dialog; }

class my_dialog : public QDialog {
    Q_OBJECT

public:
    explicit my_dialog(QWidget *parent = 0);
    ~my_dialog();

protected:
    void keyPressEvent(QKeyEvent *);

private:
    Ui::my_dialog *ui;
};

#endif // MY_DIALOG_H
```

The only added line, is the 'keyPressEvent'.

Algorithm 69 my_dialog.cpp

```
#include "my_dialog.h"
#include <QKeyEvent>
#include "ui_my_dialog.h"

my_dialog::my_dialog(QWidget *parent) :
    QDialog(parent),
    ui(new Ui::my_dialog) {
    ui->setupUi(this);
}

my_dialog::~my_dialog() {
    delete ui;
}

void my_dialog::keyPressEvent(QKeyEvent *e) {
    if (e->key() == Qt::Key_X) close();
}
```

Here we can see that when 'x' is pressed, the application will close.

The main function of the normal executable Most graphical Qt applications have this main function:

Algorithm 70 qtmain.cpp

```
#include <QApplication>
#include "my_dialog.h"

int main(int argc, char* argv[]) {
    QApplication a(argc, argv);
    my_dialog d;
    d.exec();
    return a.exec();
}
```

This main is given as default when creating a new graphical Qt application.

The main function of the testing executable The QTest framework collects all tests and calls these within a QTest-generated main function. This leaves us little left to write (which is awesome):

Algorithm 71 qtmain_test.cpp

```
#include <QtTest/QtTest>
#include "my_dialog_test.h"

QTEST_MAIN(my_dialog_test)
```

The class for the tests Here comes in the QTest architecture: for each test suite we will have to create a class:

Algorithm 72 my_dialog_test.h

```
#ifndef MY_DIALOG_TEST_H
#define MY_DIALOG_TEST_H

#include <QtTest/QtTest>

class my_dialog_test: public QObject
{
    Q_OBJECT
private slots:
    void close_with_x();
};

#endif // MY_DIALOG_TEST_H
```

Here we create a class called 'my_dialog_test'. The fit into the QTest framework each test suite

- must be a derived class from QObject
- the header file must include the 'QtTest' header file

where each member function is a tests.

The implementation of each test can be seen in the implementation file:

Algorithm 73 my_dialog_test.cpp

```
#include "my_dialog_test.h"
#include "my_dialog.h"

void my_dialog_test::close_with_x()
{
    my_dialog d;
    d.show();
    QVERIFY(d.isVisible());
    QTest::keyClick(&d, Qt::Key_X, Qt::NoModifier, 100);
    QVERIFY(d.isHidden());
}
```

The 'QVERIFY' macro is used by the QTest framework to do a single check, which will end up in the test report. The QTest has some privileges, as it can directly click keys on the form, also when the 'keyPressEvent' isn't public.

5.3 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 74 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 75 travis_qmake_gcc_cpp11_boost.pro

```
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 76 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 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
install: sudo apt-get install -qq g++-5
addons:
  apt:
    packages: libboost-all-dev
script: ./build.sh
```

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

5.4 C++11 and Boost.Test

Boost.Test works great for console applications. If you use a GUI library like Qt, using QTest is easier (see chapter 5.2)

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:

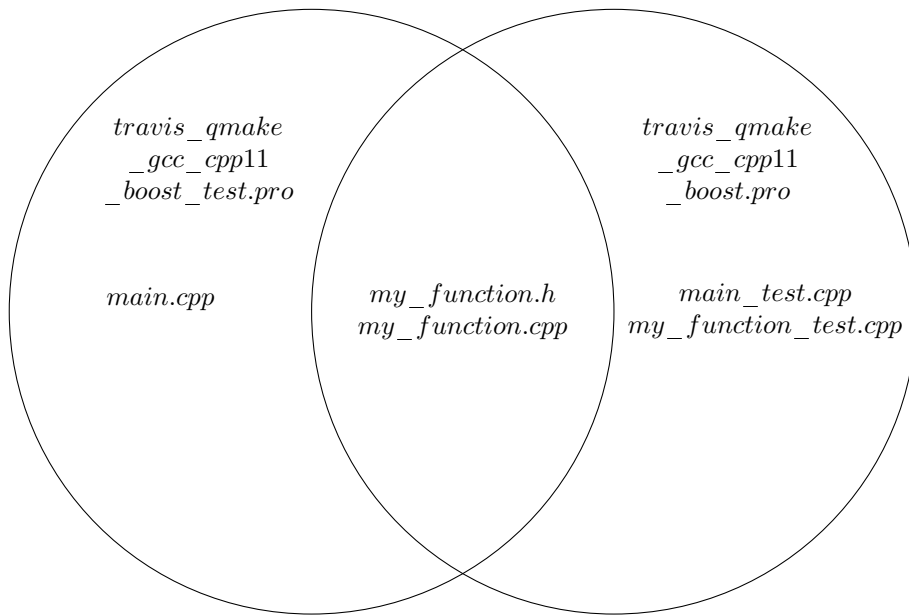


Figure 28: Venn diagram of the files uses in this build

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*

5.4.1 The function

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

Algorithm 78 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 79 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

5.4.2 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 80 travis_qmake_gcc_cpp11_boost_test_test.pro

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

# Shared files
HEADERS += my_functions.h
SOURCES += my_functions.cpp

# Unique files
SOURCES += main_test.cpp my_functions_test.cpp

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

# Debug and release build
CONFIG(debug, debug|release) {
    DEFINES += NDEBUG
}

# Boost.Test
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 81 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 82 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'.

5.4.3 Exe build

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

Algorithm 83 main.cpp

```
#include "my_functions.h"
#include <iostream>
#include <vector> //Does this make Travis CI fail?

int main() {
    std::cout << add(40,2) << '\n';
    std::vector<int> v;
    std::cout << v.empty() << '\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 84 `travis_qmake_gcc_cpp11_boost_test.pro`

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

CONFIG += console debug_and_release
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
```

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

5.4.4 Build script

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

Algorithm 85 `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.

5.4.5 Travis script

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

Algorithm 86 .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 ...

5.5 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 87 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 88 travis_qmake_clang_cpp11.pro

```
SOURCES += main.cpp

# High warning level, warning is error
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

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

# C++11
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 89 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 90 `.travis.yml`

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

install:
  - sudo apt-get install clang

script:
  - ./build.sh
```

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

5.6 C++11 and gcov

In this example, the C++98 build with gcov (chapter 4.7) is extended by using C++11.

5.6.1 The Travis file

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

Algorithm 91 .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
- sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-5 90
- sudo update-alternatives --install /usr/bin/gcov gcov /usr/bin/gcov-5 90

before_script:
# Versions of g++ and gcov must match
- g++ --version
- gcov --version

script:
- ./build.sh
- ./travis_qmake_gcc_cpp11_gcov
- ./get_code_cov.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

5.6.2 The build bash scripts

The bash build script to build this:

Algorithm 92 build_debug.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp11_gcov.pro
make
```

The new step is ...

5.6.3 The Qt Creator project files

Release:

Algorithm 93 travis_qmake_gcc_cpp11_gcov.pro

```
SOURCES += main.cpp

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
```

This ...

5.6.4 The source files

The C++ source file used:

Algorithm 94 main.cpp

```
#include <iostream>

///Returns the value of x multiplied by 2, except for 42,
    which is multiplied by one
int do_magic(const int x)
{
    if (x == 42)
    {
        return 42;
    }
    return x * 2;
}

int main()
{
    std::cout << do_magic(2) << '\n';
    //Forgot to test do_magic(42)
}
```

5.7 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 95 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 96 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 97 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 98 .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 ...

5.8 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

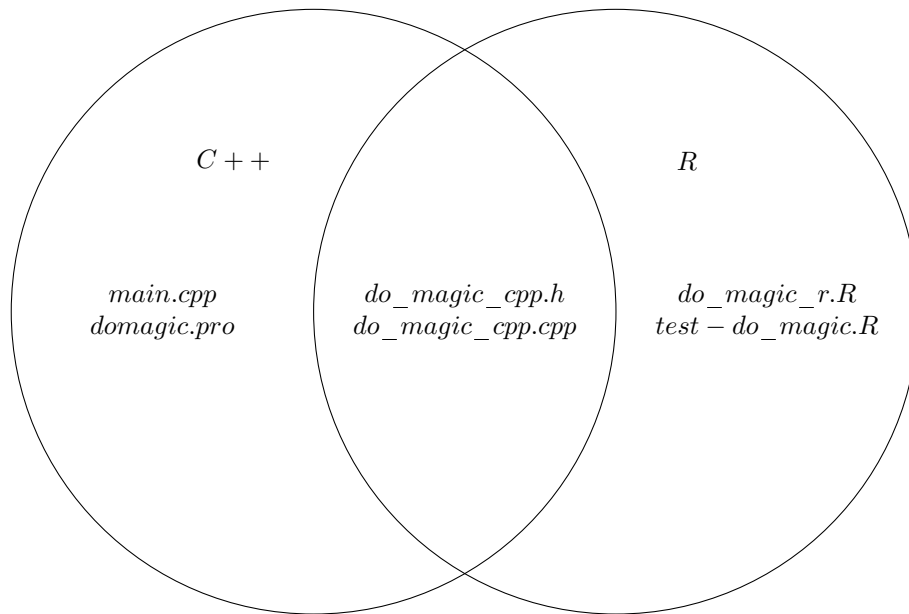


Figure 29: Venn diagram of the files uses in this build

5.8.1 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 99 src/do_magic_cpp.h

```

#ifndef DO_MAGIC_CPP_H
#define DO_MAGIC_CPP_H

// ' Does magic
// ' @param x Input
// ' @return Magic value
// [[Rcpp::export]]
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 100 src/do_magic_cpp.cpp

```
#include "do_magic_cpp.h"

// #include <Rcpp.h>

// using namespace Rcpp;

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.
```

5.8.2 C++: main source file

The C++ program has a normal main function:

Algorithm 101 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.

5.8.3 C++: Qt Creator project file

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

Algorithm 102 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

5.8.4 C++: build script

The C++ bash build script is straightforward.

Algorithm 103 build_cpp.sh

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

This script is already described in the C++98 and Rcpp chapter (chapter 4.13, algorithm 44).

5.8.5 R: the R function

The R function 'do_magic_r' calls the C++ function 'do_magic_cpp':

Algorithm 104 R/do_magic_r.R

```
#' @useDynLib domagic
#' @importFrom Rcpp sourceCpp
NULL

#' Does magic
#' @param x Input
#' @return Magic value
#' @export
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.

5.8.6 R: The R tests

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

Algorithm 105 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(do_magic_cpp(2), 4)
  expect_equal(do_magic_cpp(3), 6)
  expect_equal(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.

5.8.7 R: script to install packages

Algorithm 106 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.

5.8.8 The Travis script

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

Algorithm 107 .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 .

after_success:
  - cat /home/travis/build/richelbilderbeek/travis_qmake_gcc_cpp11_rcpp/..Rcheck/00check.log

after_failure:
  - cat /home/travis/build/richelbilderbeek/travis_qmake_gcc_cpp11_rcpp/..Rcheck/00check.log
```

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/rutter # 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

5.9 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 108 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 109 travis_qmake_gcc_cpp11_sfml.pro

```
SOURCES += main.cpp

# Compile with highest warning level, a warning is an error
QMAKE_CXXFLAGS += -Wall -Wextra -Weffc++ -Werror

QMAKE_CXX = g++-5
QMAKE_LINK = g++-5
QMAKE_CC = gcc-5

# C++11
QMAKE_CXXFLAGS += -std=c++11

# SFML
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 110 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 111 .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 ...

5.10 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 112 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 113 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 114 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 115 .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 ...

5.11 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 116 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 117 `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 118 `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 119 .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 ...

5.12 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 120 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 121 `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 122 `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 123 `.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 ...

5.13 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:

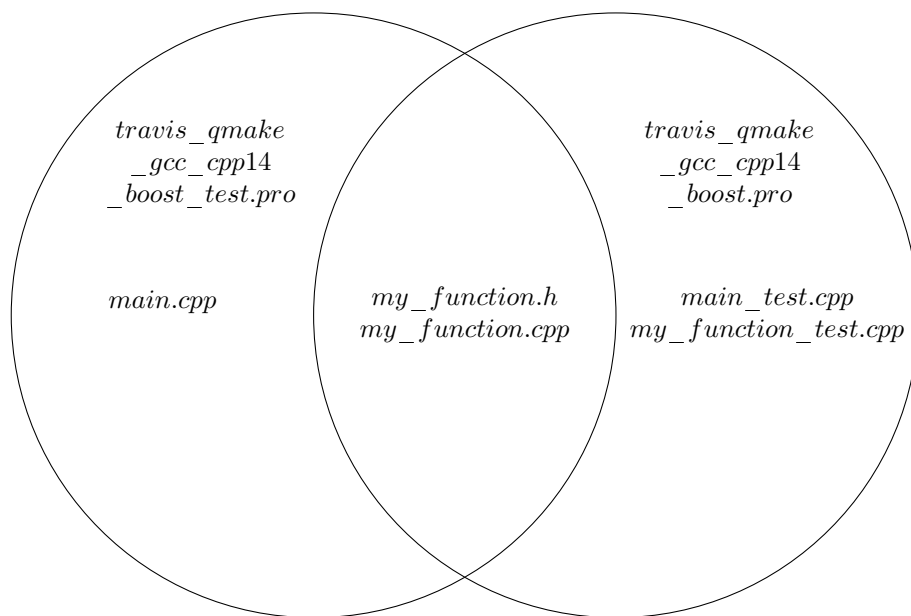


Figure 30: Venn diagram of the files uses in this build

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`

5.13.1 The function

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

Algorithm 124 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 125 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

5.13.2 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 126 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 -Weffc++ -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 127 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 128 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'.

5.13.3 Exe build

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

Algorithm 129 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 130 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.

5.13.4 Build script

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

Algorithm 131 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 132 build_test.sh

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

5.13.5 Travis script

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

Algorithm 133 .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 ...

5.14 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 and use of gcov in debug mode only

In this example, the C++98 build with gcov (chapter 4.7) is extended by using C++11.

6.1.1 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:

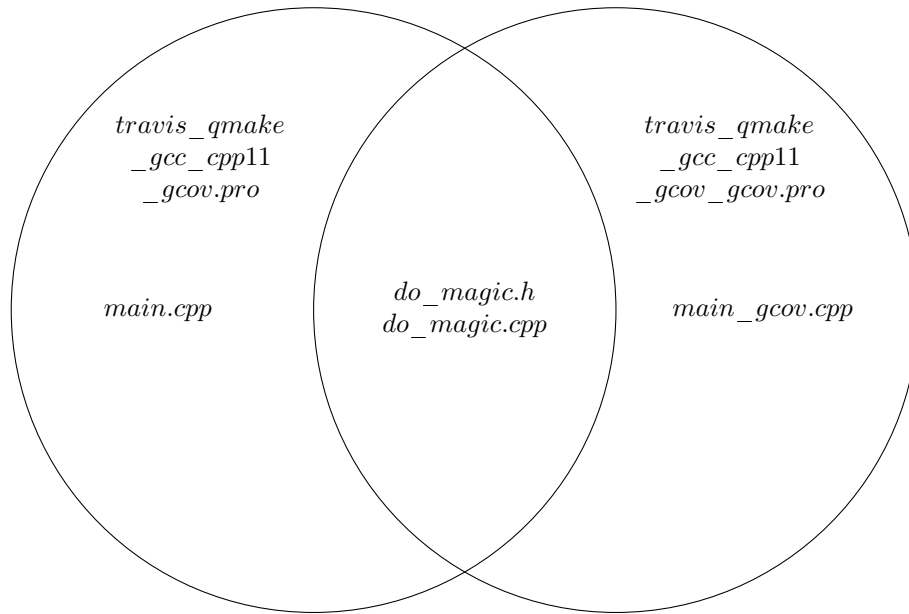


Figure 31: Venn diagram of the files uses in this build

6.1.2 The Travis file

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

Algorithm 134 .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_debug.sh
- ./travis_qmake_gcc_cpp11_debug_gcov_gcov
- ./get_code_cov.sh
- codecov
- ./clean.sh
- ./build_release.sh
- ./travis_qmake_gcc_cpp11_debug_gcov
```

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

6.1.3 The build bash scrips

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

Algorithm 135 build_debug.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp11_debug_gcov_gcov.pro
make
```

The new step is ...

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

Algorithm 136 build_release.sh

```
#!/bin/bash
qmake travis_qmake_gcc_cpp11_debug_gcov.pro
make
```

This is ...

6.1.4 The Qt Creator project files

Release:

Algorithm 137 travis_qmake_gcc_cpp11_debug_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
```

Debug with gcov:

Algorithm 138 `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

6.1.5 The source files

Common files Both builds use the following code:

Algorithm 139 `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 140 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;
}
```

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

Algorithm 141 main.cpp

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

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

Debug and gcov main function The C++ source file used by the normal build is:

Algorithm 142 main_gcov.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)
}
```

6.2 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:

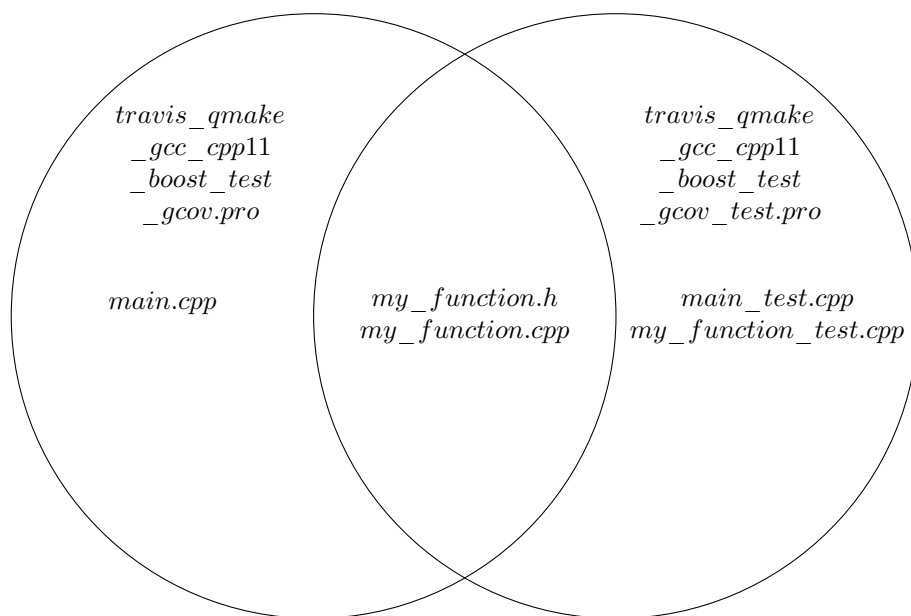


Figure 32: Venn diagram of the files uses in this build

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

6.2.1 The function

Same

6.2.2 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 143 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 -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.

6.2.3 Normal build

The normal build is identical.

6.2.4 Build script

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

Algorithm 144 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 exectables are run.

6.2.5 Travis script

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

Algorithm 145 .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 ...

7 Troubleshooting

7.1 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'
```

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

References

- [1] Scott Meyers. *Effective C++: 55 specific ways to improve your programs and designs*. Pearson Education, 2005.

Index

 /bin/bash, 17
#define, 21
-Wall, 18
-Weffc++, 18
-Werror, 18
-Wextra, 18
.pro, 13

assert, remove, 21

bash, 15
Boost, 26

C++0x, 21
C++11, 21
C++14, 24
C++98, 15
clang, 28
Codecov, 30

debug build, 19

g++, 14
GCC, 14
gcov, 30
git, 12
GitHub, 7
GitHub, creating a repository, 10
GitHub, registration, 8

Hello world, 18

make, 14, 17
Makefile, 17

NDEBUG, 21
noexcept, 24

qmake, 14, 17
qmake-qt4, 35
QMAKE_CXXFLAGS, 18
Qt, 33
Qt Creator, 13
Qt Creator project file, 13
Qt Creator, create new project, 13
Qt4, 34
Qt5, 37

R, 41
Rcpp, 41
release build, 19
remove assert, 21

SFML, 47
shebang, 17
SOURCES, 18
STL, 15
sudo, 22
sudo: require, 22

Urho3D, 49

Wt, 53

xvfb, 34

Yet Another Markup Language, 16
yml, 16

7.2 Name

7.2.1 What is Name?

7.2.2 The Travis file

7.2.3 The build bash scrips

7.2.4 The Qt Creator project files

7.2.5 The source files