AGH University of Science and Technology

Faculty of Physics and Applied Computer Science

Engineering thesis

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Web application developement using WebToolkit C++ on the example of a banking service

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Oświadczenie studenta

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Contents

Introduction

Software engineering is a very wide area of engineering which particularly concerns developing and maintaining programming products. A development process itself is a major challenge to all people involved, starting with engineers creating the code, continuing with product owners who are managing teams and coordinating the work flow and ending-up with managers who are setting the direction of the whole process.

The main motivation to create this thesis was simply to present a development process that includes basic and nowadays necessary tools which are significantly helpful in such process. Simultaneously creating a C++ web application was an equally important factor. To carry out the development and present all tools it was decided that an example C++ web application will be created with a GUI library in modern C++ called **Web Toolkit**.

Nowadays in a software engineering world there is a trend to migrate desktop applications to the internet, which has also impacted a lot GUI desktop libraries in decreasing their utilities. The secondary reason behind choosing C++ to create a web application, which is quite unusual, was to show the tremendous possibilities that this language still provides and to exhibit the capabilities of open source libraries shared among developers and engineers. The bottom line is - next chapters are a review of possibilities that C++-based web library provides.

1 Projects assumptions

1.1 Application's blue-print

The application is a single-page service run on a local server with an **http://localhost:8080/** address. After starting, logging panel appears, giving the user an opportunity to type their credentials and log-in.

The idea of the service is to provide basic functionalities of a banking service like for instance transferring money or checking their balance to the user. These required implementation of secure back-end layer with a database containing information about the users and transactions and a front-end layer which is transparent to the user.

Regarding the credentials a user will see different features after logging into the service. There might be many accounts created and held up in the database of the service but there are only two rights of access.

USER Transferring money and seeing current account's balance.

ADMIN Seeing details about every account in the service as well as having access to the logs from the application.

After user decides to quit the service, a possibility of logging out is provided and whilst doing that the application returns to the logging page where session is refreshed and database is updated. If the user was an administrator of the service, an access to the console logs that are gathering and sniffing network traffic like HTTP methods for RESTful APIs is also granted.

1.2 Programming environment

Developing any kind of programs usually requires specific environmental variables therefore a programmer's task is to choose a specific set of tools which will be the most handy during the process.

Regarding the specifics of the project, the chosen set of tools looks like following:

IDE Microsoft Visual Studio Community 2019,

LIBRARY Web Toolkit 4.3.1,

LIBRARY Boost C++ lib [latest version],

TOOL CMake VERSION 2.4,

TOOL Git BASH.

The application was developed under Windows 10 64-bit operating system, but it could have been developed under any other platform that is supported by WebToolkit library.

IDE - Integrated Development Environment

IDE is a program or a set of programs merged into one that usually gathers tools, libraries, debuggers, run time scripts and any other stuff necessary for the developer to write the code. The purpose of IDE is to allow easily and swiftly create code, but at the same time test it, compile it and run it in one place.

The advantage of this solution is that it gives the developer an opportunity to set up and scale his development environment adjusting it to the project needs. Usually IDE, as well as modern text editors, also support plugins which are nice addition to the program, like for instance syntax highlighters, semantics hints, code analyzers or refactoring scripts.

The chosen IDE for this project is **Microsoft Visual Studio Community 2019**. Web Toolkit library is supported on various platforms including Linux distributions (even less popular ones like ArchLinux, Slackware or Opensuse), Windows or other operating systems like Android, Raspberry Pi or even OS X. The consequence of choosing MSV IDE was using Windows platform and prebuilt Windows binaries of the WT library.

Microsoft Visual Studio is and IDE produced by Microsoft Company and it allows creating cross-platform software with graphical user interface. It basically supports every programming language but the basic package contains support for

- Microsoft Visual C#
- Microsoft Visual C++
- Microsoft Visual Basic
- Microsoft Visual J#
- Microsoft Visual Web Developer ASP.NET
- Microsoft Visual F#

MSVC also provides a lot of built-in features. A lot of them occurred to be significantly useful in the process of developing this application. A few most important ones are

- Debugger, Linker and Compiler
- Projects and Build Systems
- Writing and refactoring C++ code
- Code analysis overview
- Unit tests support
- Universal Windows Apps like command line appliactions

Boost C++ library

Boost is a collection of C++ libraries that enhances capabilities of C++ code development, which is also licensed by **Boost Software License**. For the project Boost is necessary to build Web Toolkit library as it's implementation uses Boost functionalities.

The most important features provided by Boost are

- Algorithms
- Concurrent programming
- Complex containers
- Correctness validating and enhanced unit testing
- Additional data structures (like bimap, fusion, tuple etc)
- High level programming and functional objects
- Parsers and graphs
- Meta-programming with templates

Boost library as a collection is not used in this project explicitly, as the application was developed in Microsoft Visual Studio environment with pre-built Windows binaries. However, for automation server, the project is built under linux machine where WebToolkit needs to be built manually, therefore boost is required. More details will be unveiled in "Automation server" chapter.

CMake

CMake is a cross platform tool that provides automatic management of compiler that builds the code of an application. It's role is to create a configuration for project files of popular programming environments, which then are used in a process of compilation. The main advantage of using CMake is it's independence of the compiler and the platform. However CMake as a standalone program creates files with rules for compilation dedicated to another program like IDE and it forms a unified building environment. CMake stands for *Cross-platform Make*.

The most important features provided by CMake are

- Platform independence
- Cross compilation
- Out-of-source building
- Building projects with complex catalog structure
- Unit testing support
- Detecting dependencies and outer libraries

This project required including CMake tool because of various dependencies and complex building due to including Web Toolkit and Boost.

To be able to explore favors that CMake offers one must create **CMakeLists.txt** file placed in the main catalog of the project. The core of this file is a simple scripting language that describes rules and defines variables telling the compiler how to link files and what should be the outcome of the compilation process.

Let's have an example project which structure looks like below

```
.
|-- CMakeLists.txt
|-- build
|-- include
|   \-- Student.h
\-- src
    |-- Student.cpp
    \-- mainapp.cpp
```

The content of ***.cpp** and ***.h** files is irrelevant here, at this point it could be any code. In the main directory we have a simple **CMakeLists.txt** which is used to build the project. The code of our CMakeLists script:

```
cmake_minimum_required(VERSION 2.8.9)
project(directory_test)

#Bring the headers, such as Student.h into the project
include_directories(include)

#Can manually add the sources using the set command as follows:
#set(SOURCES src/mainapp.cpp src/Student.cpp)

#However, the file(GLOB...) allows for wildcard additions:
file(GLOB SOURCES "src/*.cpp")

add_executable(testStudent ${SOURCES})
```

The most important things that above CMake will perform (in order from the top) are

- Include directories to let the CMake know where headers files with definitions are
- Sources are also set, but the line is commented out as each file needs to be manually added in place
- file() command to add source files to project's GLOB SOURCES
- add_executable() which uses SOURCES variable in order to build executable program

Now to invoke building using CMake:

```
$ mkdir build && cd build
$ cmake ..
$ make
$ ./testStudent
```

Commands above will create build directory. From there cmake will create **Makefile** containing references to all sources and headers, which ultimately will create an executable that is ready to be run. This as a very basic example of how **CMake** works. In next chapters there will be more details about **CMake** and what is the main concept behind basing on the one used in project.

Others

Git BASH tool and *Web Toolkit* library are described thoroughly in next chaptres.

2 WebToolkit C++ library

2.1 Library introduction

2.1.1 Introduction to Wt

2.1.2 Introduction to Wt::Dbo

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3.5 Automation server

3.5.1 GitHub CMake workflows

Example CMake file used in project

```
CMAKE_MINIMUM_REQUIRED(VERSION 2.4)
Project(ConsoleApplication1)

# If Visual Studio IDE
IF(MSVC_IDE)
# Copy user file
  FILE(COPY ${CMAKE_CURRENT_SOURCE_DIR}/${PROJECT_NAME}.vcxproj.user DESTINATION ${CMAKE
ENDIF(MSVC_IDE)

# If Eclipse IDE
IF(${CMAKE_EXTRA_GENERATOR} MATCHES ".*Eclipse.*")
IF(${CMAKE_BUILD_TYPE} STREQUAL "Debug")
# Copy debug user file
    FILE(COPY ${CMAKE_CURRENT_SOURCE_DIR}/${PROJECT_NAME}-debug.exe.launch DESTINATION $
ENDIF()
IF(${CMAKE_BUILD_TYPE} STREQUAL "Release")
# Copy release user file
```

```
    FILE(COPY ${CMAKE_CURRENT_SOURCE_DIR}/${PROJECT_NAME}-release.exe.launch DESTINATION
ENDIF()
ENDIF()

# Copy resources to build tree
# FILE(COPY ${CMAKE_CURRENT_SOURCE_DIR}/resources DESTINATION ${CMAKE_CURRENT_BINARY_DIR

SET(ConsoleApplication1_SRC src/Main.cpp)

# If Visual Studio IDE
IF(MSVC_IDE)
SET(ConsoleApplication1_SRC ${ConsoleApplication1_SRC} src/Main.cpp)
ENDIF(MSVC_IDE)

ADD_EXECUTABLE(ConsoleApplication1 ${ConsoleApplication1_SRC})

ADD_SUBDIRECTORY("wt-4.3.1/" "Wt 4.3.1 msvs2019 x64/lib/")
# Set Wt include and library paths
INCLUDE_DIRECTORIES("Wt 4.3.1 msvs2019 x64/include/")

INCLUDE_DIRECTORIES("include")
FILE(GLOB SOURCES "src/*.cpp")
ADD_EXECUTABLE(ConsoleApplication1 ${SOURCES})
TARGET_LINK_DIRECTORIES(ConsoleApplication1 PUBLIC "Wt 4.3.1 msvs2019 x64/lib/")

TARGET_LINK_LIBRARIES(ConsoleApplication1
  debug wtd optimized wt
  debug wthttpd optimized wthttp
  debug wtdbod optimized wtdbo
  debug wtdbosqlite3d optimized wtdbosqlite3
  )
```