

## **Engineering thesis**

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major: **applied computer science**

# **Web application development using WebToolkit C++ on the example of a banking service**

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# 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 developers 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.

To carry out the development and present all tools it was decided that an example application will be a C++ web application 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. Foreground 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.

The following contents was divided into five chapters describing the development process and the application itself with bottom line two chapters summarizing thesis and listing literature.

# 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 to the user basic functionalities of a banking service like for instance transferring money or checking their balance. Those required implementing 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 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** Sees details about every account in the service as well as has access to the logs from the application.

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

## 1.2 Programming environment

Developing any kind of programs usually requires specific environmental variables therefore a programmers 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:

**IDE** Microsoft Visual Studio Community 2019

**LIBRARY** Web Toolkit 4.3.1

**LIBRARY** Boost C++ lib

**TOOL** CMake

**TOOL** Git BASH

## 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 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 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#

## Boost C++ library

Boost is a collection of C++ libraries that enhances capabilities of development C++ code, 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

## CMake

CMake is a cross platform tool that provides automatic management of compiling 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 itself is not a standalone program, instead by creating files with rules for compilation dedicated to another program like IDE 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 exploit 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 links files and what should be the outcome of the compilation process.

## Others

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

## 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_CURRENT_BINARY_DIR})
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 ${CMAKE_CURRENT_BINARY_DIR})
ENDIF()
IF(${CMAKE_BUILD_TYPE} STREQUAL "Release")
# Copy release user file
FILE(COPY ${CMAKE_CURRENT_SOURCE_DIR}/${PROJECT_NAME}-release.exe.launch DESTINATION ${CMAKE_CURRENT_BINARY_DIR})
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
)
```



## 2 WebToolkit C++ library

### 2.1 Library introduction

#### 2.1.1 Introduction to Wt

#### 2.1.2 Introduction to Wt::Dbo

#### 2.1.3 Introduction to Wt::Auth

### 2.2 Widgets gallery

### 2.3 Library overview

## 3 DevOps layer

### 3.1 Distributed version-control system

#### 3.1.1 GitHub

#### 3.1.2 BitBucket

### 3.2 Proprietary issue tracking

#### 3.2.1 JIRA Software

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### 3.3 Containers

#### 3.3.1 Docker

#### 3.3.2 Kubernetes

#### 3.3.3 Containers vs OS-level virtualization

### 3.4 Automation server

#### 3.4.1 GitHub CMake workflows

#### 3.4.2 CircleCI

#### 3.4.3 Jenkins

## 4 Implementation

### 4.1 Server side session

### 4.2 Logging panel

### 4.3 Database

### 4.4 User features

#### 4.4.1 Transferring money

#### 4.4.2 Checking user balance

### 4.5 Admin features

#### 4.5.1 Listing all users

#### 4.5.2 Access to server logs

### 4.6 Modern C++ features