Build Guide

MOJA FLINT LIBRARY

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www.moja.global

Contents

Introduction

The FLINT is an open-source C++ platform that provides tools to integrate multiple data types (including remote sensing) with FLINT-compatible modules to produce spatially-explicit calculations of greenhouse gas (GHG) emissions and other variables.

In practice, it is distributed as a library that is either served locally or as a Docker image.

This document provides a step by step guide for building the Moja FLINT Library for both the Local and Docker Based environments.

Requirements

This chapter highlights the hardware and software requirements for building Moja FLINT Libraries:

Hardware Requirements

a)	Recommended Hardware Specifications	
01.	Processor	Intel Core i7, Minimum, with Virtualization Support
02.	RAM	16GB, Minimum
03.	Hard Drive	1TB, Minimum

Refer to the following guides to audit how your hardware stacks against these recommendations:

- Annex A1 : Check Processor Capacity
- Annex A2 : Check RAM Capacity
- Annex A3 : Check Hard Drive Capacity
- Annex A4 : Check Support for Virtualization

Software Requirements

a) Recommended Operating Systems

01.	Windows 10 Pro	Latest Version
02.	Windows 10 Enterprise	Latest Version

Refer to the following guides to audit how your Operating System stacks against these recommendations:

- Annex C1 : Check Windows Version Edition
- Annex C2 : Check Windows Version Build Number

Please note that the information on the latest build of Windows 10 can be obtained from this page:

- https://support.microsoft.com/en-us/help/4464619/windows-10-update-history

b) Required Tools

01.	CMake	Latest Version
02.	Docker	Latest Version
03.	GIT	Latest Version
04.	Notepad++	Latest Version
05.	Visual Studio	Community 2019

c) Required Libraries

01.	Boost	Version 1.63.0
02.	Eigen	Version 3.3.3
03.	Moja	Latest Version
04.	OpenSSL	Version 1.1.0
05.	POCO	Version 1.7.7
06.	SQLite Amalgamation	Version 3170000
07.	Turtle	Version 1.3.0

Environment Preparation

This chapter highlights how to prepare the environment for building Moja Base Libraries.

Hardware Preparation

a)	Firmware Virtualization
01.	Check if the Firmware Virtualization is enabled
02.	Enable it if not

The following guides have been added as references for carrying out the above task:

- Annex A5 : Check Firmware Virtualization Enablement Status
- Annex B1 : Enable Firmware Virtualization

Operating System Preparation

a) Windows Version

01.	Check if the Windows version is the latest
02.	Update it if not

The following guides have been added as references for carrying out the above task:

- Annex C1 : Check Windows Version Edition
- Annex C2 : Check Windows Version Build Number
- Annex D1 : Update to the latest version of Windows 10

Please note that the information on the latest build of Windows 10 can be obtained from this page:

- https://support.microsoft.com/en-us/help/4464619/windows-10-update-history

b) Administrative Rights

01.	Check if the logged in user account has administrative rights
02.	Switch to an account that has administrative rights if not

The following guide has been added as a reference for carrying out the above task:

- Annex C4 : Check whether a user account has administrative privileges

c) Account Password

01.	Check if the logged in user account has a password
02.	Set it if not

The following guides have been added as a references for carrying out the above task:

- Annex C5 : Check whether a user account has a password
- Annex D2: Add a password to a user account

d) Windows Hyper-v Features

01.	Check whether Windows Hyper-V Features have been turned on
02.	Turn them on if not

The following guides have been added as a references for carrying out the above task:

- Annex C6 : Check whether Windows Hyper-V Features have been turned on
- Annex D3 : Turn on Windows Hyper-V Features

e)	**Port 445**
01.	Check whether Port 445 is open for TCP connections
02.	Open it if not

The following guides have been added as a references for carrying out the above task:

- Annex C7 : Check if port 445 is open for TCP connections
- Annex D4 : Open port 445 for TCP connections

Tools Installation

CMake

a)	**Pre Installation**
01.	Go to https://cmake.org/download/
02.	Download the latest CMake Binary Distribution for Windows

b)	**Steps**
⚠	The following installation steps were written with reference to CMake 3.17.0
01.	Right click the CMake installer and select **Install**
02.	Click **Next** to confirm that you want to proceed with the installation
03.	Acknowledge the license terms and Click **Next**
04.	Optionally select the second option to the add **CMake to the system PATH for all users**
05.	Optionally check the last option to create a **CMake Desktop Icon**
06.	Click **Next** to proceed
07.	Leave the install path unchanged to install CMake in the default location
08.	Click **Next** to proceed
09.	Click **Install** to begin the installation
10.	Click **Finish** to exit the installation

Docker

a)	**Pre Installation**
01.	Complete the hardware preparation instructions as described earlier
02.	Complete the operating system preparation instructions as described earlier
03.	Go to https://www.docker.com/products/docker-desktop
04.	Download the Docker Desktop installer for Windows [1]

b)	**Steps**
⚠	The following installation steps were written with reference to Docker Desktop 2.2.0.3
01.	Right click the Docker Desktop installer and select **Run as administrator**
02.	Wait for Docker Desktop to download the required packages
03.	Leave the first checkbox checked to add a Docker Desktop shortcut to your desktop
04.	Click **OK** to proceed
05.	Wait for Docker Desktop to unpack its files and install
06.	Click **Close** to exit the installation

[1] This step will ask you to sign-in into your **docker hub** account. If you don't have one, please sign-up up for free here: https://hub.docker.com/signup

c)	**Configuration**
⚠	The following configuration steps were written with reference to Docker Desktop 2.2.0.3
01.	Double click the **Docker Desktop Shortcut** to start it
02.	Wait for Docker Desktop to notify you that its up and running and then proceed to the next step
03.	Go to the System Tray [2] and click the Docker Desktop icon [3]
04.	Select **Settings** on the pop-up menu
05.	Select the **Resources** menu on the Settings Window
06.	Click the **Advanced** Resource subcategory if not currently selected
07.	Increase the **Memory** available to Docker to at least 4GB
08.	Click the **File Sharing** Resource subcategory
09.	Select drive **C:** as the local drive you want to be available to your containers
10.	Click **Apply & Restart** to save the changes
11.	Close the settings window after Docker Desktop successfully restarts

[2] The System Tray is another name given to the Notification Area found at the right-side of the Windows Taskbar.
[3] If you cannot see the Docker Desktop icon at first glance, try looking for it in the pop-up drawer of the System Tray

Git

a)	**Pre Installation**
01.	Go to https://git-scm.com/downloads
02.	Download the latest Git binary release for Windows

b)	**Steps**
⚠	The following installation steps were written with reference to Git 2.26.0
01.	Right click the Docker Desktop installer and select **Run as administrator**
02.	Click **Install** to acknowledge the license terms and carry out the installation

c)	**Configuration** [4]
⚠	The following configuration steps were written with reference to Git 2.26.0
01.	Open the Windows 10 search tool
02.	Search for **Windows PowerShell**, open it and use it to execute the commands that follow (i) git config --global user.name "<your_user_name>" [5] (set your global username) (ii) git config --global user.email "<your_email@someservice.com>" [6] (set your global email)

[4] These steps assume that you have a Github Account. If you don't, please sign up here: https://github.com/join
[5] Replace the content in the angular bracket, including the bracket itself, with your github username
[6] Replace the content in the angular bracket, including the bracket itself, with your github email

Notepad++

a)	Pre Installation
01.	Go to https://notepad-plus-plus.org/downloads/
02.	Download the latest Notepad++ release for Windows

b)	Steps
⚠	The following installation steps were written with reference to Notepad++ 7.8.5
01.	Right click the Notepad++ installer and select **Run as administrator**
02.	Leave **English** as the selected language and click **OK**
03.	Click **Next** to confirm that you want to proceed with the installation
04.	Acknowledge the license terms and Click **Next**
05.	Leave the install path unchanged to install Notepad++ in the default location; click **Next**
06.	Leave the selected features unchanged to install the default components; click **Next**
07.	Click **Install** to carry out the installation
08.	Click **Finish** to complete the installation

Visual Studio

(a)	Pre Installation
02.	Go to https://my.visualstudio.com/Downloads [7]
03.	Type **Visual Studio Community 2019** in the **search downloads** field
04.	Press **Enter** and wait for Microsoft to retrieve the desired Visual Studio versions
05.	**Download** the installer of the latest version of Visual Studio Community 2019

(b)	Steps
⚠	The following installation steps were written with reference to Visual Studio Community 2019 (V 16.5)
01.	Right click the Visual Studio installer and select **Run as administrator**
02.	Click **Continue** and wait for the installer to prepare for the installation
03.	Check the **Desktop development with C++** option under the **Workloads** tab
04.	Check the **GitHub extension for Visual Studio** option under the **Individual components** tab [8]
05.	Click **Install** in the bottom right corner of the screen
06.	Wait for the installation to complete then restart the computer

[7] This will require you to sign in. You can sign in with any of your Microsoft accounts credentials e.g Skype credentials. You can alternatively sign in with your Github credentials

[8] The **GitHub extension for Visual Studio** option is located under the **Code tools** category

Libraries Installation

Adding the libraries that the Moja FLINT library depends upon into the local environment is vital if you plan on building the library locally. There are two ways to do this: i) Build the libraries manually into the local environment or ii) build the libraries into the local environment via the vcpkg tool.

When installing third party libraries we recommend using the vcpkg tool to get it right the first time round.

> 💡 **Important**
>
> - See **Moja Base Libraries Build Guide** for instructions on how to build the third party libraries

Instructions

1. Local Build Instructions

The Moja FLINT Libraries are usually built into local environments to support the development of or the local running of Moja FLINT Implementations. This section provides a strategy for acquiring and building the Moja FLINT Libraries locally.

a)	**Getting the source code**
01.	Open the Windows 10 search tool
02.	Search for **Windows PowerShell** and open it
03.	Type cd c\ and **Enter** [9]
04.	Type New-Item -path "C:\Development\moja-global\" -type directory and **Enter** [10]
05.	Type cd "C:\Development\moja-global\" and **Enter** [11]
06.	Type git clone https://github.com/moja-global/FLINT.git and **Enter** [12]

[9] This will take you to the root of your c:\ drive if you are not already there
[10] This will create the folder tree "C:\Development\moja-global\" in one line if non-existent
[11] This will change the working directory to "C:\Development\moja-global\"
[12] This will clone Moja's FLINT repository into the current directory

b)	**Building the library**
01.	Open the Windows 10 search tool
02.	Search for **Windows PowerShell** and open it
03.	Type New-Item -path “C:\Development\moja-global\FLINT\Source\build" -type directory and **Enter** [13]
04.	Type cd “C:\Development\moja-global\FLINT\Source\build" and **Enter** [14]
05.	Type the following command and **Enter** [15] `cmake -G "Visual Studio 16 2019" ` `-DCMAKE_INSTALL_PREFIX=C:/Development/Software/moja ` `-DVCPKG_TARGET_TRIPLET=x64-windows ` `-DENABLE_TESTS=OFF ` `-DCMAKE_TOOLCHAIN_FILE=C:\Development\moja-global\vcpkg\scripts\buildsystems\vcpkg.cmake ` `..`
06.	You can now use the Visual Studio moja solution to install built versions of the Moja libraries

[13] This will create the folder tree "C:\Development\moja-global\FLINT\Source\build" in one line if non-existent
[14] This will change the working directory to "C:\Development\moja-global\FLINT\Source\build"
[15] This will create the Visual Studio Solution (2019)

2. Docker Build Instructions

The FLINT library and all its dependencies can be lumped together and conveniently distributed as a single Docker image. Officially, such an image is referred to as the Moja FLINT (Library) Image. Subsequent images that depend upon the FLINT Library i.e Moja FLINT Implementations, can then, with very little effort, extend this image and gain access to all its functionality.

This section provides a step by step guide on the preparation and building of the Moja FLINT Library Image.

2.1. Starting Off

2.1.1. Specify the Parent Image from which the image should be built:

```
FROM moja/baseimage:bionic
```

- The FLINT Docker Image should by design extend the Moja Base Image. This is because the Moja Base Image supplies all the libraries that the FLINT Docker Image needs to conduct a successful build. Please see the **Moja Base Libraries Build Guide** for more information about this.

2.1.2. Add a little metadata to describe the image:

```
LABEL project="=FLINT Examples"\
      image="FLINT Docker Image"\
      version="1.0"\
      maintainer="Moja Global <info@moja.global>"
```

- It's considered good practice to add a little description about our images so that users can learn more about them should they choose to run the "docker inspect" command. This is typically done through the use of Docker label commands.

2.1.3. Set the image's frontend to noninteractive:

```
ARG DEBIAN_FRONTEND=noninteractive
```

- Ubuntu has several interfaces that can be swapped at will. One of these interfaces: The noninteractive frontend, is considered an anti-frontend. It never interacts with its users at all. Instead, it chooses default answers for all of the questions asked. This makes it an ideal candidate for automatic installs.

2.1.4. Specify the number of CPUs that can be comfortably allocated for the build process:

```
ARG NUM_CPU=1
```

- This specification will come in handy when controlling the number of jobs that can be run concurrently via “make commands”.

2.1.5. Declare FLINT repository variables:

```
ARG TOKENIZED_FLINT_REPOSITORY_URL
ARG FLINT_REPOSITORY_BRANCH
```

- These should be supplied during build time.
- By Tokenized FLINT Repository URL, we mean a URL of the following structure: **https://<Personal_Access_Token>@github.com/moja-global/flint.git**

2.1.6. Declare FLINT Data Tools repository variables:

```
ARG TOKENIZED_FLINT_DATA_REPOSITORY_URL
ARG FLINT_DATA_REPOSITORY_BRANCH
```

- These should be supplied during build time.
- By Tokenized FLINT Data Repository URL, we mean a URL of the following structure: **https://<Personal_Access_Token>@github.com/moja-global/FLINT.data.git**

2.1.7. Specify the environmental variables needed by the FLINT:

```
ENV CURL_CA_BUNDLE /etc/ssl/certs/ca-certificates.crt
ENV GDAL_DATA=$ROOTDIR/share/gdal
ENV GDAL_HTTP_MERGE_CONSECUTIVE_RANGES YES
ENV GDAL_HTTP_MULTIPLEX YES
ENV GDAL_HTTP_VERSION 2
ENV LANG=C.UTF-8
ENV LC_ALL=C.UTF-8
ENV LD_LIBRARY_PATH $ROOTDIR/lib:$ROOTDIR/lib/x86_64-linux-gnu:$LD_LIBRARY_PATH
ENV PATH $ROOTDIR/bin:$PATH
ENV PYTHONPATH $ROOTDIR/lib:$PYTHONPATH
```

- **Appendix: Environmental Variables** provides a brief description of all these variables.

2.2. Adding the FLINT Library

2.2.1. Clone FLINT source code from the specified repository branch to a local directory:

```
RUN cd $ROOTDIR/src \
    && git clone --recursive --depth 1 -b ${FLINT_REPOSITORY_BRANCH} \
       ${TOKENIZED_FLINT_REPOSITORY_URL} moja.flint
```

2.2.2 Create a build directory under the repository's src folder and make it the working directory:

```
RUN mkdir -p moja.flint/Source/build \
    && cd moja.flint/Source/build
```

2.2.3. Build and install the FLINT, then clean up the source files:

```
RUN cmake \
      -DCMAKE_BUILD_TYPE=RELEASE \
      -DCMAKE_INSTALL_PREFIX=$ROOTDIR \
      -DENABLE_MOJA.MODULES.LIBPQ=ON \
      -DENABLE_MOJA.MODULES.GDAL=ON \
      -DENABLE_MOJA.CLI=ON \
      -DENABLE_TESTS:BOOL=OFF .. \
      -DBoost_USE_STATIC_LIBS=OFF \
      -DBUILD_SHARED_LIBS=ON .. \
      && make --quiet -j $NUM_CPU \
      && make --quiet install \
      && make clean \
      && cd $ROOTDIR \
      && rm -Rf /usr/local/src/*
```

2.2.4. Create a symbolic link between /usr/local/bin and the moja modules installed at /usr/local/lib/:

```
RUN ln -s /usr/local/lib/libmoja.modules.* /usr/local/bin
```

- A symbolic link, also known as a symlink or a soft link, is a special kind of file (entry) that points to the actual file or directory on a disk.

2.3. Adding the FLINT's Data Tools:

2.3.1. Clone FLINT data source code from the specified repository branch to a local directory:

```
RUN cd $ROOTDIR/src \
    && git clone --recursive --depth 1 -b ${FLINT_DAT_REPOSITORY_BRANCH} \
       ${TOKENIZED_FLINT_DATA_REPOSITORY_URL} FLINT.data
```

- Please note that the FLINT data repository, though so named, does not contain actual data. Instead, it contains Python tools to prepare data for the FLINT.

2.3.2. Change the working directory to the cloned repository's local directory:

```
RUN cd $ROOTDIR/src/FLINT.data
```

2.3.3. Build and install the FLINT Data tools, then clean up the source files:

```
RUN pip3 install .
    && cd $ROOTDIR \
    && rm -Rf /usr/local/src/*
```

2.4. Saving the image

Save the image as "Dockerfile.flint.bionic".

- Please don't include the quotes in the image name.

2.5. Building the image

2.5.1. Change the working directory to the directory with your Docker file.

- If you've been following the instructions in the previous chapter: preparing image, then this is the directory with the file named "Dockerfile.flint.bionic ".

2.5.2. Run the command below to build the image:

```
docker build -f Dockerfile.flint.bionic \
             --build-arg TOKENIZED_FLINT_REPOSITORY_URL=[FLINT_URL] \
             --build-arg FLINT_REPOSITORY_BRANCH=[FLINT_BRANCH] \
             --build-arg TOKENIZED_FLINT_DATA_REPOSITORY_URL=[FLINT_DATA_URL] \
             --build-arg FLINT_DATA_REPOSITORY_BRANCH=[FLINT_DATA_BRANCH] \
             -t moja/flint:bionic .
```

- The -f option specifies the name of the docker file to be built - in this case, "Dockerfile.flint.bionic" .

- The -t option specifies the name that the built image should be tagged with - in this case "moja/flint:bionic".

- The TOKENIZED_FLINT_REPOSITORY_URL argument specifies the URL of the FLINT GIT Repository with the user's Personal Access Token pre-appended.
  As such, it has the following structure:
  https://<Personal_Access_Token>@github.com/moja-global/flint.git.

- The FLINT_REPOSITORY_BRANCH argument specifies the branch of the FLINT repository whose source code should be checked out for the build.

- The TOKENIZED_FLINT_DATA_REPOSITORY_URL argument specifies the URL of the FLINT Data GIT Repository with the user's Personal Access Token pre-appended.
  As such, it has the following structure:
  https://<Personal_Access_Token>@github.com/moja-global/FLINT.data.git.

- The FLINT_DATA_REPOSITORY_BRANCH argument specifies the branch of the FLINT Data repository whose source code should be checked out for the build.

- The period, ".", at the end of the command specifies the location of the Docker file to be built - in this case the current directory.

You can optionally update all other variables declared using the ARG directive at the build phase through the use of the --build-arg option. For example:

```
docker build -f Dockerfile.flint.bionic \
             --build-arg NUM_CPU=4 \
             --build-arg TOKENIZED_FLINT_REPOSITORY_URL=[FLINT_URL] \
             --build-arg FLINT_REPOSITORY_BRANCH=[FLINT_BRANCH] \
             --build-arg TOKENIZED_FLINT_DATA_REPOSITORY_URL=[FLINT_DATA_URL] \
             --build-arg FLINT_DATA_REPOSITORY_BRANCH=[FLINT_DATA_BRANCH] \
             -t moja/flint:bionic .
```

2.6. Conclusion

This guide illustrated how to prepare and build the Moja FLINT Library Image.

All the code associated with it is available at : https://github.com/moja-global/flint-examples.git.

This is a Docker-based project, so it should be easy to import and use as is

Annex A : Hardware Audits Reference

A1 : Check Processor Capacity

01.	Open the Windows 10 search tool
02.	Search for the **System Information** tool and open it
03.	Select **System Summary** menu on the **System Information** window
04.	Look for the **Processor** specification on the right pane

A2 : Check RAM Capacity

01.	Open the Windows 10 search tool
02.	Search for the **System Information** tool and open it
03.	Select the **System Summary** menu on the **System Information** window
04.	Look for the **Physical Memory** specifications on the right pane

A3 : Check Hard Drive Capacity

01.	Open the Windows 10 search tool
02.	Search for the **System Information** tool and open it
02.	Expand the **Components** category in the **System Information** window
03.	Expand the **Storage** subcategory under the **Components** category
04.	Click the Disks subcategory under the **Storage** subcategory
05.	Look for the **Size** specifications under the disk descriptions [16]

A4 : Check Support for Virtualization

01.	Open the Windows 10 search tool
02.	Search for the **Task Manager** tool and open it
03.	Open the **Performance** tab on the opened window [17]
04.	Look for a line that says **"Virtualization: (En/Dis)abled"** on the bottom-right side of the opened tab

[16] Watch out for multiple disk descriptions with different sizes when multiple Hard Drives are present
[17] You might have to click on **More details** to see this tab the very first time you open Task Manager

A5 : Check Firmware Virtualization Enablement Status

01.	Open the Windows 10 search tool
02.	Search for the **Task Manager** tool and open it
03.	Open the **Performance** tab on the opened window [18]
04.	Look for a line that says **“Virtualization: Enabled”** on the bottom-right side of the opened tab

[18] You might have to click on **More details** to see this tab the very first time you open Task Manager

Annex B : HW Configurations Reference

B1 : Enable Firmware Virtualization

01.	Restart the PC
02.	Press the key required to enter BIOs (See Appendix 4: Keys For Accessing BIOS settings)
03.	Navigate to either the **Advanced**, **Security** or the **Systems Configurations** tab
04.	Select **Virtualization** or **Virtualization Technology** and then press the **Enter** key [19]
05.	Select **Enabled** and then press the **Enter** key
06.	Press the **F10** key then select **Yes** and press the **Enter** key to save the changes and **Reboot** [20]

[19] On some Lenovo PCs, the Virtualization option will be found buried one level deeper under a **CPU Setup** option
[20] On some Sony PCs, you will need to navigate to a dedicated **Exit** tab to save changes and exit

Annex C : OS Audits Reference

C1 : Check the Windows Version Edition

01.	Open the Windows 10 search tool
02.	Search for the **System Information** tool and open it
03.	Select the **System Summary** menu on the **System Information** window
04.	Look for the **OS Name** specification on the right pane

C2 : Check the Windows Version Build Number

01.	Open the Windows 10 search tool
02.	Search for the **System Information** tool and open it
03.	Select the **System Summary** menu on the **System Information** window
04.	Look for the **Version** specification on the right pane

C3 : Check for the latest Windows Operating System

01.	Open https://en.wikipedia.org/wiki/List_of_Microsoft_Windows_versions
02.	Look for the latest Windows **Version, Edition** and **Build Number**

C4 : Check whether a user account has administrative privileges

01.	Open the Windows 10 search tool
02.	Search for the **Manage your account** tool and open it
03.	Look for the word "**Administrator**" underneath the **account** name

C5 : Check whether a user account has a password

01.	Open the Windows 10 search tool
02.	Search for the **Manage your account** tool and open it
03.	Click the **Sign-in options** on the left pane of the opened window
04.	Scroll down to the **Password** section on the right pane of the opened window
05.	Look for a statement that says "**Sign in with your account's password**" underneath it

C6 : Check whether Windows Hyper-V features are turned on

01.	Open the Windows 10 search tool
02.	Search for the **Turn Windows features on or off** tool and open it
03.	Locate the Hyper-V section and find out if it's checked

C7 : Check if port 445 is open for TCP connections

01.	Open the Windows 10 search tool
02.	Search for the **Windows Defender Firewall** tool and open it
03.	Click **Advanced settings** on the left pane of the **Windows Defender Firewall** window
04.	Click the **Inbound Rules** category on the left pane of the newly popped up window
05.	Locate the **Local Port** column on the newly opened **Inbound Rules** table
06.	Scroll down this **Local Port** column and see whether there's a TCP entry for port 445
07.	Click the **Outbound Rules** category on the left pane of the newly popped up window
08.	Locate the **Remote Port** column on the newly opened **Outbound Rules** table
09.	Scroll down this **Remote Port** column and see whether there's a TCP entry for port 445

Annex D : OS Configurations Reference

D1 : Update to the latest version of Windows 10

01.	Go to https://www.microsoft.com/en-us/software-download/windows10
02.	Click the **Update now** button to download the **Windows 10 Update Assistant**
03.	Right click the downloaded **Windows 10 Update Assistant** and select **Run as administrator**
04.	Click **Update Now** on the newly opened window
05.	Click **Next** after the PC is ascertained as being compatible with the update
06.	Click **Minimise** to optionally have the update run in the background
07.	Click **Restart now** to restart your PC when the update is complete

D2 : Add a password to a user account

01.	Open the Windows 10 search tool
02.	Search for the **Manage your account** tool and open it
03.	Click the **Sign-in options** on the left pane of the opened window
04.	Scroll down to the **Password** section on the right pane of the opened window
05.	Click the **Add** button underneath it
06.	Enter the password and password hint details and click **Next**
07.	Click **Finish**

D3 : Turn on Windows Hyper-V features

01.	Open the Windows 10 search tool
02.	Search for the **Turn Windows features on or off** tool and open it
03.	Locate the Hyper-V section
04.	Check it and click **OK**
05.	Click **Restart now** to finish installing the requested changes

D4 : Open port 445 for TCP connections

01.	Open the Windows 10 search tool
02.	Search for the **Windows Defender Firewall** tool and open it
03.	Click **Advanced settings** on the left pane of the **Windows Defender Firewall** window
04.	Click the **Inbound Rules** category on the leftmost pane of the newly popped up window
05.	Click the **New Rule** option on the rightmost pane of the newly popped up window
06.	Select **Port** as the type of rule to be created
07.	Click **Next**
08.	Select **TCP** as the protocol of the rule to created
09.	Select **Specific local ports** and enter **445** as the port that the rule should be apply to
10.	Click **Next**
11.	Select **Allow the connection** as the action to take when a connection matches the conditions
12.	Check **Domain, Private and Public** to have the rule apply to each of these profiles
13.	Click **Next**
14.	Enter **Docker** as the name of the rule and click **Finish**
15.	Repeat Steps 04 to 14 for **Outbound Rules**

Appendix 1 : Basic Dependencies

Dependency	About
bash-completion	Programmable completion for the bash shell. This package extends bash's standard completion behavior to achieve complex command lines with just a few keystrokes. It was conceived to produce programmable completion routines for the most common Linux/UNIX commands, reducing the amount of typing sysadmins and programmers need to do on a daily basis.
build-essential	Informational list of build-essential packages. This package contains an informational list of packages which are considered essential for building Debian packages. It also depends on the packages on that list, to make it easy to have the build-essential packages installed.
doxygen	Documentation generation tool. Doxygen is a documentation system for C, C++, Java, Objective-C, Python, IDL and to some extent PHP, C#, and D. It can generate an on-line class browser (in HTML) and/or an off-line reference manual (in LaTeX) from a set of documented source files.
doxygen-latex	Doxygen dependency package. Adds dependencies for all LaTeX packages required to build documents using the default stylesheet.
git	Fast, scalable, distributed version control system. This package provides the git main components with minimal dependencies.
gdb	GNU Debugger. GDB is a source-level debugger, capable of breaking programs at any specific line, displaying variable values, and determining where errors occurred. Currently, gdb supports C, C++, D, Objective-C, Fortran, Java, OpenCL C, Pascal, assembly, Modula-2, Go, and Ada. A must-have for any serious programmer.
graphviz	Open source graph visualization software. Graph visualization is a way of representing structural information as diagrams of abstract graphs and networks. This package contains graph visualization command-line tools.

libcurl4-gnutls-dev	Development files and documentation for libcurl (GnuTLS flavour). libcurl is an easy-to-use client-side URL transfer library, supporting DICT, FILE, FTP, FTPS, GOPHER, HTTP, HTTPS, IMAP, IMAPS, LDAP, LDAPS, POP3, POP3S, RTMP, RTSP, SCP, SFTP, SMTP, SMTPS, TELNET and TFTP. libcurl supports SSL certificates, HTTP POST, HTTP PUT, FTP uploading, HTTP form based upload, proxies, cookies, user+password authentication (Basic, Digest, NTLM, Negotiate, Kerberos), file transfer resume, http proxy tunneling and more.
libeigen3-dev	Lightweight C++ template library for linear algebra. Eigen 3 is a lightweight C++ template library for vector and matrix math, a.k.a. linear algebra. Unlike most other linear algebra libraries, Eigen 3 focuses on the simple mathematical needs of applications.
libgeos-dev	Geometry engine for GIS. GEOS provides a spatial object model and fundamental geometric functions. It implements the geometry model defined in the OpenGIS Consortium Simple Features Specification for SQL.
libhdf4-alt-dev	Hierarchical Data Format development files (without NetCDF). HDF is a multi-object file format for storing and transferring graphical and numerical data mainly used in scientific computing. HDF supports several different data models, including multidimensional arrays, raster images, and tables. Each defines a specific aggregate data type and provides an API for reading, writing, and organizing the data and metadata.
libhdf5-serial-dev	Packages providing libhdf5-serial-dev This is a virtual package.
libnetcdf-dev	Creation, access, and sharing of scientific data. NetCDF (network Common Data Form) is a set of interfaces for array-oriented data access and a freely distributed collection of data access libraries for C, Fortran, C++, Java, and other languages. The netCDF libraries support a machine-independent format for representing scientific data. Together, the interfaces, libraries, and format support the creation, access, and sharing of scientific data.
libpoppler-dev	PDF rendering library. Poppler is a PDF rendering library based on Xpdf PDF viewer.
libpq-dev	Header files for libpq5 (PostgreSQL library). Header files and static library for compiling C programs to link with the libpq library in order to communicate with a PostgreSQL database backend.
libproj-dev	Cartographic projection library.

	Proj and invproj perform respective forward and inverse transformation of cartographic data to or from Cartesian data with a wide range of selectable projection functions (over 100 projections).
libspatialite-dev	Geospatial extension for SQLite. The SpatiaLite extension enables SQLite to support spatial (geometry) data in a way conformant to OpenGis specifications, with both WKT and WKB formats.
libssl-dev	Secure Sockets Layer toolkit. This package is part of the OpenSSL project's implementation of the SSL and TLS cryptographic protocols for secure communication over the Internet. It contains development libraries, header files, and manpages for libssl and libcrypto.
libxml2-dev	Development files for the GNOME XML library. XML is a metalanguage to let you design your own markup language. A regular markup language defines a way to describe information in a certain class of documents (eg HTML). XML lets you define your own customized markup languages for many classes of documents. It can do this because it's written in SGML, the international standard metalanguage for markup languages.
nasm	General-purpose x86 assembler. Netwide Assembler: NASM will currently output flat-form binary files, a.out, COFF and ELF Unix object files, and Microsoft 16-bit DOS and Win32 object files.
openssl	Secure Sockets Layer toolkit - cryptographic utility. This package is part of the OpenSSL project's implementation of the SSL and TLS cryptographic protocols for secure communication over the Internet. It contains the general-purpose command line binary /usr/bin/openssl, useful for cryptographic operations.
postgis	Geographic objects support for PostgreSQL. PostGIS adds support for geographic objects to the PostgreSQL object-relational database. In effect, PostGIS "spatially enables" the PostgreSQL server, allowing it to be used as a backend spatial database for geographic information systems (GIS).
postgresql-client-10	Front-end programs for PostgreSQL This metapackage always depends on the currently supported database client package for PostgreSQL.
python3-dev	Header files and a static library for Python (default).

	Header files, a static library and development tools for building Python modules, extending the Python interpreter or embedding Python in applications.
python3-numpy	Fast array facility to the Python 3 language. Numpy contains a powerful N-dimensional array object, sophisticated (broadcasting) functions, tools for integrating C/C++ and Fortran code, and useful linear algebra, Fourier transform, and random number capabilities.
python3-pip	Python package installer. pip is the Python package installer. It integrates with virtualenv, doesn't do partial installs, can save package state for replaying, can install from non-egg sources, and can install from version control repositories.
software-properties-common	Manages the repositories that you install software from (common). This software provides an abstraction of the used apt repositories. It allows you to easily manage your distribution and independent software vendor software sources.
sqlite3	Command line interface for SQLite 3. SQLite is a C library that implements an SQL database engine. Programs that link with the SQLite library can have SQL database access without running a separate RDBMS process.
wget	Retrieves files from the web. Wget is a network utility to retrieve files from the web using HTTP(S) and FTP, the two most widely used internet protocols. It works non-interactively, so it will work in the background, after having logged off. The program supports recursive retrieval of web-authoring pages as well as FTP sites.

Appendix 2 : Core Dependencies

Dependency	About
boost	Free, peer-reviewed, portable C++ source libraries. boost libraries are a collection of C++ libraries that provide support for standard tasks and structures such as linear algebra, pseudorandom number generation, multithreading, image processing, regular expressions, and unit testing..
cmake	Build process manager. CMake is an open-source, cross-platform family of tools designed to build, test and package software.
fmt	A modern formatting library. {fmt} is an open-source formatting library for C++ that can be used as a safe and fast alternative to (s)printf and iostreams
gdal	Raster and Vector translation library. GDAL is a translator library for raster and vector geospatial data formats that is released under an X/MIT style Open Source License by the Open Source Geospatial Foundation.
poco	C++ libraries for building network- and internet-based applications. The POrtable COmponents (POCO) C++ Libraries are a set of cross-platform C++ libraries for developing computer network-centric, portable applications in C++.
rabbitmq-c	This is a C-language AMQP client library for use with v2.0+ of the RabbitMQ broker. RabbitMQ is an open-source message-broker software that originally implemented the Advanced Message Queuing Protocol (AMQP) and has since been extended with a plug-in architecture to support Streaming Text Oriented Messaging Protocol (STOMP), Message Queuing Telemetry Transport (MQTT), and other protocols.
SimpleAmqpClient	C++ wrapper around the rabbitmq-c C library SimpleAmqpClient is an easy-to-use C++ wrapper around the rabbitmq-c C library
sqlite	Database engine.

	SQLite is a C-language library that implements a small, fast, self-contained, high-reliability, full-featured, SQL database engine.
turtle	Mock object library. Turtle is a C++ mock object library based on Boost with a focus on usability, simplicity and flexibility.
zipper	C++ wrapper around minizip compression library. Zipper is a reliable, simple and flexible compression library that supports all kinds of inputs and outputs. Moreover it allows the compression of files into memory instead of being restricted to file compression only, and using data from memory instead of just files as well.

Appendix 3: Environmental Variables

Variable	About
CURL_CA_BUNDLE	CURL_CA_BUNDLE is an environmental variable used to specify a custom Certificate Authority (CA) certificate path.
GDAL_DATA	GDAL_DATA is an environment variable used to specify location of supporting files used by GDAL libraries as well as GDAL and OGR utilities.
GDAL_HTTP_MERGE_ CONSECUTIVE_RANGES	GDAL_HTTP_MERGE_CONSECUTIVE_RANGES is an environment variable used to specify if ranges of a single ReadMultiRange request that are consecutive should be merged into a single request
GDAL_HTTP_MULTIPLEX	GDAL_HTTP_MULTIPLEX is an environment variable used to specify if multiplexing can be used to download multiple ranges in parallel, during ReadMultiRange requests that can be emitted by the GeoTIFF driver
GDAL_HTTP_VERSION	GDAL_HTTP_VERSION is an environment variable used to specify which HTTP version to use
LANG	LANG is an environment variable used to specify a locale
LC_ALL	LC_ALL is an environment variable used to override all LC_xxx environmental variables. LC_xxx environment variables e.g. LC_CTYPE, LC_NUMERIC, LC_TIME, LC_COLLATE, LC_MONETARY, LC_MESSAGES, and so on, are the environment variables meant to override LANG and affect a single locale category only
LD_LIBRARY_PATH	LD_LIBRARY_PATH is an environment variable used to specify a list of directories in which to search for Executable and Linkable Format (ELF) libraries at execution time
PATH	PATH is an environment variable used to specify to the shell which directories to search for executable files (i.e., ready-to-run programs) in response to commands issued by a user
PYTHONPATH	PYTHONPATH is an environment variable used to specify additional directories where python will look for modules and packages

Appendix 4: Keys For Accessing BIOS settings

Manufacturer	F1	F2	F3	F6	F10	F11	F12	ESC	INS	DEL
Acer	A	**C**								**C**
Asus		**C**							A	A
DELL	A	**C**	A				A			A
HP	A	A		A	**C**	A	A	**C**		
Lenovo	**C**	**C**								
Sony	A	**C**	**C**							
Toshiba	A	C						A		

Where C = Most Common and A = Alternative

Abbreviations

Abbreviation	Meaning
CEIP	Customer Experience Improvement Program
CPU	Central Processing unit
FLINT	Full Lands Integration Tool
HW	Hardware
OS	Operating System
RAM	Random Access Memory
TCP	Transmission Control Protocol
URL	Uniform Resource Locator

References

Basic Dependencies:

Ubuntu Packages	https://packages.ubuntu.com/

Core Dependencies:

Boost C++ Libraries	https://www.boost.org/
CMake	https://cmake.org/
fmtlib/fmt	https://github.com/fmtlib/fmt
GDAL	https://gdal.org/
POCO	https://pocoproject.org/
RabbitMQ C	https://github.com/alanxz/rabbitmq-c
SimpleAmqpClient	https://github.com/alanxz/SimpleAmqpClient
SQLite	https://www.sqlite.org/index.html
Turtle	http://turtle.sourceforge.net/
Zipper	https://github.com/sebastiandev/zipper